# GREATER SAGE-GROUSE CONSERVATION ASSESSMENT AND STRATEGY FOR OREGON

3rd Edition
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## Authors

Mikal Cline – *ODFW Upland Game Bird Coordinator, Salem, OR*

Skyler Vold – *ODFW Sage-grouse Conservation Coordinator, Hines, OR*

Greg Jackle – *ODFW Acting Sage-grouse Mitigation Coordinator, Salem, OR*

*The authors recognize and appreciate the previous authors of the 2006 and 2011 versions of this document and acknowledge that some verbiage has been carried forward to this version.*

## Contributors

*The following individuals contributed significantly to the development and review of the 2025 plan. The authors are grateful for the time and expertise of this team.*

| | |
|---|---|
| Chad S. Boyd…………..… | *Research Leader/Rangeland Ecologist, USDA-ARS, EOARS* |
| Julia Burco, DVM………... | *Wildlife Veterinarian, ODFW* |
| Jacqueline Cupples……….. | *Sagebrush Ecosystem Coordinator, USFWS* |
| Rachael Davee……………. | *Partnership Coordinator, SageCon Partnership* |
| Jonathan Dinkins……..….. | *Associate Professor, Dept. of Animal and Rangeland Sciences, OSU* |
| Chris Domschke………….. | *Sage-grouse Biologist, Wildlife Program Lead, OR/WA BLM* |
| Cameron Duquette……….. | *Rangeland Scientist, The Nature Conservancy, EOARS* |
| Lee Foster………………… | *Harney District Wildlife Biologist, ODFW* |
| Colin Gillin, DVM……….. | *State Wildlife Veterinarian, ODFW* |
| Bernadette Graham-Hudson | *Wildlife Division Administrator, ODFW* |
| Monty Gregg……………... | *Forest Wildlife Biologist, Ochoco NF, USDA Forest Service* |
| Kimberly Haab …………... | *Wildlife Biologist, Sheldon-Hart Mountain NWR Complex, USFWS* |
| Christian Hagen …………. | *Associate Professor, Dept. of Fisheries, Wildlife & Cons. Sciences, OSU* |
| Joe Kline ………………… | *Basin Resource Conservationist for Technology, NRCS* |
| Philip Milburn …………… | *District Manager, Klamath & Malheur Watersheds, ODFW* |
| John O'Keeffe …………… | *Oregon rancher, permittee, and landowner* |
| Branden Pursinger ……….. | *Legislative Affairs Manager, Association of Oregon Counties* |
| Sarah Reif………………… | *Habitat Division Administrator, ODFW* |
| Vanessa Schroeder………... | *Senior Faculty Research Assistant, EOARS and OSU Extension Service* |
| Tom Segal………………... | *Wildlife Habitat Biologist, ODFW* |
| Kelli Van Norman………... | *Oregon BLM Sage-grouse Plan Implementation Coordinator (retired)* |
| Alexander Vencill………… | *Wildlife GIS Analyst, ODFW* |
| Julie Vold…………………. | *Fish and Wildlife Biologist, USFWS* |
| Emily Weidner…………… | *Fish and Wildlife Biologist, USFWS* |
| Brian Wilk………………... | *Fish and Wildlife Biologist, USFWS* |
| Brian Wolfer……………… | *Wildlife Division Deputy Administrator, ODFW* |

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## Executive Summary

Greater sage-grouse (sage-grouse; *Centrocercus urophasianus)* conservation has been a concern in Oregon for more than a century. In the *Game and Forestry Warden Report* to the 1903 Oregon Legislature, the authors stated, "Sage hens are getting scarcer each year, and their complete extinction can not be a matter of more than a few years". By 1905, Oregon had outlawed the sale of wildlife and required residents to purchase a $1 hunting license. In 1923, a meeting was held in Lakeview, Oregon, including several local ranchers, stemming from concern for pronghorn antelope and sage-grouse. This meeting initiated a process that would lead to the creation of the Hart Mountain National Antelope Refuge in 1936. Efforts to conserve and manage sage-grouse in Oregon have continued since this time.

The Oregon Department of Fish and Wildlife (ODFW or the department) is responsible for the management of the state's wildlife resources, and in this document, we outline our strategy for the conservation of sage-grouse. Oregonians have always valued the iconic bird and the vastness of the sagebrush sea that the species represents. While challenges to sage-grouse populations and their habitats are often daunting, people, partnerships, and agencies are working together to conserve this bird. Conservation and management actions guided by scientific research are continuously ongoing to address the threats to Oregon's sage-grouse populations and help protect this species for enjoyment by future generations of Oregonians.

This document represents the 3rd version of the *Oregon Greater Sage-Grouse Conservation Assessment and Strategy* (or "CAAS"). The original edition was approved in 2005, followed by an update in 2011. There have been many research and regulatory advancements since 2011, yet the threats to sage-grouse populations and habitats continue to expand under a changing landscape and climate. Here we provide the most current guidance on ODFW's roles and responsibilities related to sage-grouse management in the context of the multi-partner effort to manage the species. This updated CAAS represents a departure from previous versions due to the adoption of the *2015 Oregon Sage-grouse Action Plan,* a product of the Oregon Sage-Grouse Conservation Partnership, which elevated many of the concepts in the 2011 CAAS beyond the scope of a single agency. To avoid unnecessary duplication or conflicting information, the 2025 CAAS describes ODFW's specific responsibilities under the umbrella of the 2015 Action Plan.

Due to the dynamic nature of the information and data used by the department to conserve and manage Oregon's sage-grouse populations, the CAAS is underpinned by the best available science in the framework of adaptive management. A synopsis of the document is provided here.

**Section 1: Introduction--** We provide background information and discuss the need for revising the CAAS, including the relationship between this document and the 2015 *Oregon Sage-grouse Action Plan*. We define the roles and responsibilities of ODFW, which provides the outline for the CAAS.

**Section 2: Leveraging Science to Address Threats to Sage-grouse—**We highlight relevant research advancements that inform our understanding of threats to sage-grouse populations and their habitats. We identify the intertwined threats of wildfire, invasive annual grasses, and conifer encroachment as the most prominent, landscape-scale concerns. Conservation partners have

recognized the need to better prioritize conservation efforts and protect remaining high-quality habitat, which led the NRCS to describe a new proactive strategy for sagebrush rangeland conservation with the motto, "Defend the Core, Grow the Core, Mitigate Impacts". Oregon researchers put this strategy into practice, developing a hands-on prioritization framework called "Threat-Based Land Management". This framework provides guidance for conserving and protecting the most important core habitats first, then improving habitats from that core while mitigating threats of incursion from degraded habitats. Aided by improvements to remote-sensing technology and habitat models, "Threat-Based Strategic Conservation" utilizes "Threat-Based Ecostates" and provides a toolbox to address threats and take conservation action at management-relevant scales. These ecostates will be revisited in Section 5 as an improved method to monitor sagebrush habitat at multiple scales. The CAAS affirms this approach as the basis for effective habitat conservation prioritization given limited resources.

**Section 3: Monitoring Oregon's Sage-grouse Populations—**This section describes ODFW's monitoring and assessment of Oregon's sage-grouse populations, including three important advancements since the 2011 CAAS. First, ODFW collaborated with USGS to develop an updated population model which accounts for imperfect detection, variable rates of male lek attendance, and presently unknown leks. The updated model revealed that our previous population model was underestimating sage-grouse population sizes in Oregon by ~30–40%. Importantly, the updated model does not change the overall population trends, continuing to show long-term population declines at the statewide scale. In this section, we affirm the 2003 estimated population as ODFW's baseline population goal, and based on the new population model, the updated goal is to manage sage-grouse statewide to maintain or enhance their distribution and abundance oscillating around the 2003 spring breeding population level, approximately 53,000 birds, over the next 50 years. Secondly, we present PAC-scale population trends for each of Oregon's sage-grouse Priority Area for Conservation (PACs), which are ODFW's biologically significant management units for sage-grouse, as described in Section 4. As such, ODFW's updated population objectives are to manage Oregon's sage-grouse populations to maintain stable or increasing population trends statewide and at the PAC-scale This represents a departure from the 2011 CAAs, where finer-scale population analyses were based on administrative boundaries, specifically, BLM Districts. Finally, we provide an updated and comprehensive list of lek conservation status definitions to include all possible lek situations, regardless of survey history. The updated definitions expand the survey period from 7 years to 10 years for determining lek occupancy status, which is more likely to capture an entire nadir-to-nadir (trough-to-trough) population cycle.

**Section 4: Mapping Oregon's Sage-grouse Range—**This section upholds ODFW's core area approach to sage-grouse conservation and presents the updated core and low-density habitat maps. Following an extensive partner and public review process, these updated maps were approved by the Oregon Fish and Wildlife Commission in December 2023, prior to the CAAS update. The updated habitat map delineates the areas necessary to conserve 90% of Oregon's sage-grouse population and is used by the ODFW Greater Sage-Grouse Habitat Mitigation Program to mitigate impacts of large-scale development to significant sage-grouse habitat, and by DLCD as a Goal 5 resource, of which land use rules are applied. Oregon's significant sage-grouse habitat map is also used to help land managers (e.g., private landowners, BLM, DSL, and others) prioritize habitat restoration and uplift efforts to benefit local sage-grouse populations.

**Section 5: Monitoring Oregon's Sage-grouse Range—** This section provides an assessment of Oregon's sage-grouse habitat utilizing remote-sensing tools, particularly "Threat-Based Ecostates". The 2011 CAAS set habitat objectives based on sagebrush structure classes, which were biologically relevant but difficult to assess. Utilizing ecostates allows a more rapid assessment of habitat quality, accounting for understory quality in addition to sagebrush and perennial grass cover. We establish a habitat objective to manage a minimum of 70% of Oregon's sage-grouse range in Ecostates A (good condition shrubland), A-C (intermediate condition shrubland), and B (good condition grassland) at both the statewide and PAC scales. This objective acknowledges the dynamic nature of disturbances on the landscape, and with at least 70% of sage-grouse habitat in higher quality ecostates, the species can meet its life history needs.

**Section 6: Cooperation and Collaboration—** Here we outline the important cooperative and collaborative partnerships working to conserve sage-grouse and their habitats in Oregon. We clarify the roles of ODFW, the Sage-Grouse Conservation Partnership (SageCon), and the Sage-grouse Local Implementation Teams (LITs) within the structure of the CAAS and the *Oregon Sage-Grouse Action Plan*.

**Section 7: Sage-grouse Regulatory Mechanisms—**This section outlines the regulatory mechanisms for sage-grouse habitat protection which are now in place and provides an overview of mitigation protocols for large-scale development in sage-grouse habitat. The Sage-grouse Mitigation Program was not yet established when the CAAS was last updated in 2011.

**Section 8: Sage-grouse Management Protocols—**This section outlines protocols and best management practices associated with sage-grouse harvest, conservation translocation, and trapping and marking, and provides a position statement on captive rearing.

**Section 9: Summary and Recommendations—**Finally, we summarize our findings and present recommendations from the previous sections for quick reference.

Sage-grouse are experiencing compounding threats on a landscape scale, and populations in Oregon have responded to decreased habitat quantity and quality as evidenced by long-term declines. Yet, dedicated managers and researchers continue to build the foundation for recovery. ODFW has increased monitoring effort significantly since 2017 and discovered many previously unknown leks. The Department supports cutting edge research that shows how our sage-grouse populations utilize the landscape seasonally and respond to threats such as fire, conifer expansion, and avian predation. These projects have also highlighted important connectivity habitats that are now incorporated into ODFW's updated core and low-density habitat map. Oregon has strong habitat protections which have limited large-scale development in important habitats and require no net loss of habitat when development is unavoidable. Partnerships and collaborations, including SageCon and Oregon's Sage-grouse Local Implementation Teams, ensure all partners have a place at the table and that overarching policies can be applied at the local scale. Finally, we must adapt to a changing climate by protecting the highest quality habitat to make sure sage-grouse not only persist, but thrive in the state of Oregon

## Section 1: Introduction

### Background

Greater sage-grouse (*Centrocercus urophasianus*; hereafter "sage-grouse") are the largest North American grouse species and depend on sagebrush (*Artemisia* spp.) habitats for cover and forage. Typically, sage-grouse habitat occurs in sagebrush communities at elevations of 1,220 to 2,438 m (4,000 to 8,000 ft) with annual precipitation of 25 to 38 cm (10 to 16 in) and rolling topography with slopes generally less than 30% (Call and Maser 1985).

In Oregon, sage-grouse were once found in most sagebrush habitats east of the Cascade Mountain range. European settlement and conversion of sagebrush steppe into agricultural production led to extirpation of the species in the Columbia Basin by the early 1900s (Batterson and Morse 1948). Sage-grouse currently occupy sagebrush habitats within Baker, Crook, Deschutes, Grant, Harney, Lake, Malheur, and Union counties of Oregon.

Within the extant range of sage-grouse in Oregon, spring population indices have demonstrated an overall decline since the 1940s. Analyses by Coates et al. (ver. 4.0, 2025) found sustained declines of sage-grouse populations in Oregon over the past 60 years, but declines varied among various spatial and temporal scales (1960–2023). Spring breeding population indices in Oregon have not exceeded the 2003 baseline since 2006, and have generally declined since the early 2000s, reaching a low point in 2019 (Prochazka et al. 2025).

In 2000, with concern for a potential Endangered Species Act (ESA) listing of greater sage-grouse increasing, the Oregon Department of Fish and Wildlife (ODFW) signed a Memorandum of Understanding (MOU) with the Western Association of Fish and Wildlife Agencies (WAFWA) committing the agency to develop a sage-grouse conservation strategy. A team of experts was convened, and the first version of the *Greater Sage-Grouse Conservation Assessment and Strategy for Oregon* (or "CAAS") was in place by August 2005, setting the statewide population objective at the 2003 population level, and the habitat objective at maintaining ≥70% of sagebrush habitat in advanced structural stages.

In March 2010, the U.S. Fish and Wildlife Service (USFWS) published a decision finding that range-wide, greater sage-grouse were warranted for federal listing under the ESA but precluded by higher listing priorities (U.S. Fish and Wildlife Service 2010). This decision prompted an unprecedented effort by collaborators to address the main concerns of the USFWS. Habitat loss and fragmentation, exacerbated by lack of regulatory mechanisms to protect sage-grouse and their habitats, were the primary justification for the 2010 "warranted but precluded" decision (U.S. Fish and Wildlife Service 2010). In response, the 2005 CAAS was revised and approved in April 2011, incorporating the concept of core and low-density sage-grouse habitats, and providing population and habitat objectives at both the statewide and BLM-district scale.

In 2012, the Oregon Sage-grouse Conservation Partnership (SageCon) was convened at the request of the Governor John Kitzhaber's office to formulate an "all lands, all threats" approach to sage-grouse conservation. The partnership was initially an Oregon-based collaborative effort jointly convened by the State of Oregon, the Bureau of Land Management (BLM), and the

Natural Resources Conservation Service (NRCS) with membership across the spectrum of conservation partners and land managers.

Acknowledging the need for a regulatory framework to protect sage-grouse habitat, the Oregon House Committee on Agriculture and Natural Resources introduced House Bill (HB) 3086 during the 2013 regular session. This bill allowed ODFW to develop and administer a mitigation policy for proposed development actions in sage-grouse habitat. The bill was signed into law in August 2013 and became Oregon Revised Statutes (ORS) 498.500 and 498.502. The SageCon Partnership's Mitigation Technical Team then completed the *State of Oregon Greater Sage-Grouse Habitat Mitigation Manual* in 2014, providing the basis for ODFW's mitigation rules (OAR 635-140-0025), which were adopted in July 2015.

Given the "warranted but precluded listing" in 2010, the USFWS resolved to revisit the listing determination for sage-grouse in 5 years. Leading up to the 2015 listing determination by USFWS, former Governor Kate Brown signed Executive Order 15-18, outlining Oregon's new regulatory approach and financial commitments, and adopted the SageCon Partnership's *Oregon Sage-grouse Action Plan* (Action Plan) as "the plan for sage-grouse conservation in Oregon". The 2015 Action Plan expanded on the 2011 CAAS, outlining a plan to address threats to sage-grouse and their habitats based on a framework that is adaptable to local conditions and priorities. The 2025 CAAS is considered a complementary document to the Action Plan, focusing on ODFW's specific responsibilities for managing Oregon's sage-grouse populations, and ODFW's role in cooperation and coordination under the Action Plan.

Commitments of state and federal agencies and private landowners improved the regulatory mechanisms surrounding sage-grouse conservation and contributed to the 2015 USFWS decision (U.S. Fish and Wildlife Service 2015) that greater sage-grouse were not warranted for ESA listing. However, Oregon's sage-grouse populations continued to decline as the quantity and quality of sagebrush habitats continued to be impaired by numerous ecosystem-wide threats. These threats to the sagebrush ecosystem have been driven by the interaction between anthropogenic and climatic factors. In Oregon, primary threats to sage-grouse populations and habitats are generally recognized, but not limited to, the following:

1. Landscape-scale wildfire, which converts sagebrush-steppe habitats to grasslands, frequently dominated by invasive annual grasses. Like most threats to the sagebrush ecosystem, this invasive annual grass-wildfire cycle is exacerbated by drought.
2. Invasive annual grass displacement of native sagebrush-steppe-associated bunch grasses and forbs with or without the aid of wildfire.
3. Conifer encroachment into sagebrush-steppe habitats.
4. Mesic habitat impairment related to historic land use practices, drought, and other factors that increase erosion and channel incision.
5. Habitat fragmentation due to human encroachment and development.

Rangeland managers recognized that a targeted approach to habitat conservation is required to address these widespread threats to the sagebrush ecosystem. The concept of 'Threat-Based Land Management' was developed, recommending land managers should first prioritize defending intact and functional core sagebrush habitats, and then focus on growing those habitats from the core outward (Johnson et al. 2019, Doherty et al. 2021, Renner et al. 2023, revised 2025). Advancements in technology, including remote-sensing and geographic information systems (GIS), have continued to improve the ability to evaluate rangeland conditions at larger geographic scales, facilitating landscape-scale prioritization of conservation and restoration actions.

In November 2021, the BLM published a notice of intent to amend Land Use Plans regarding sage-grouse conservation, including the revision of the 2015 priority and general habitat management areas. ODFW recognized this as a critical opportunity to coordinate state-level sage-grouse management planning with the BLM's Rangewide Sage-Grouse Resource Management Plan amendment, prompting the Department's 2023–25 revision of the sage-grouse habitat map and the CAAS.

**Purpose and Scope**

The 3rd edition of the CAAS represents a departure from the two previous editions, due to the adoption of *The Oregon Sage-Grouse Action Plan* in September 2015. The Action Plan incorporates and expands on concepts from the 2011 CAAS, particularly the sage-grouse core area approach, population and habitat objectives, and the convening of Local Implementation Teams (LITs). The Action Plan aligns commitments to action across state, federal, and local jurisdictions, as well as voluntary efforts by private landowners and non-government organizations. Importantly, it also defines the roles and responsibilities of coordinating agencies, including ODFW, specific to implementing the Action Plan (Figure 1).

> *ODFW is responsible for tracking and monitoring the greater sage-grouse populations in Oregon, including data collection, analysis, and reporting; advising on the impact of conservation measures and investments; monitoring habitat functions; and consulting on project proposal and/or approaches with local governments, project proponents, permitting entities, private landowners, BLM, NGOs, tribes, state agencies, and others. ODFW will collect and analyze data relevant to plan implementation and effectiveness in addressing sage-grouse population and habitat health, which along with information from other entities (i.e., BLM, NGOs), will be shared with the state coordinating council and the statewide technical team. In addition, ODFW will continue to engage in the advancement of on-the-ground conservation actions and research, both directly and through partners. Pursuant to its revised rules, ODFW is also responsible for implementation of mitigation rule provisions.*
>
> *–The Oregon Sage-Grouse Action Plan pp. 32-33.*

In this new version of the CAAS, we will describe the Department's approach to fulfilling the responsibilities described in the Action Plan, while seeking to avoid duplicative or contradictory information.

## Single Species Management and Ecosystem Conservation

The CAAS and supporting background information is intended to promote effective management of Oregon's sage-grouse populations and intact, functional sagebrush communities. The methods, objectives, and strategies herein are based on the life history of sage-grouse and are informed by the best available science. Although this document focuses on conservation of sage-grouse and their habitats, other sagebrush-associated species will benefit from responsible management of sagebrush-steppe habitats, acknowledging the role of sage-grouse as an umbrella species is not overarching (Wisdom et al. 2002, Rowland et al. 2006, Hanser and Knick 2011, Dinkins and Beck 2019, Runge et al. 2019). Promoting resilient sagebrush ecosystems is an overarching theme of the CAAS. Development of this plan considers potential implications to other species and aims to provide multi-species benefits where possible, while avoiding actions or recommendations known to negatively impact other species. While single-species management actions specific to sage-grouse do not benefit all neighborhood species, maintaining connectivity and reducing fragmentation of sagebrush habitats is necessary for the long-term persistence of sagebrush-associated species (Connelly et al. 2004, Hanser and Knick 2011). Oregon's sage-grouse populations and sagebrush habitats comprise nearly 20% of the North American range-wide distribution (Connelly et al. 2004), so management actions in Oregon have implications beyond the state's jurisdiction.

## Relationship of Document to Federal Endangered Species Act Listing Criteria

The population and habitat assessments and management strategies provided in this Plan are intended to address the listing criteria used by the U.S. Fish and Wildlife Service (USFWS). The following factors are used in the process of deciding whether or not a species warrants protection under the Act:

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range;

B. Over-utilization for commercial, recreational, scientific, or educational purposes;

C. Diseases or predation;

D. The inadequacy of existing regulatory mechanisms; or

E. Other natural or manmade factors affecting the species' survival.

The intent of this Plan is to address these criteria where possible and provide a framework for ODFW to guide the conservation and management of sage-grouse in a way that prevents a future listing under the ESA.

## An Adaptive Management Approach

The CAAS advocates for an adaptive management framework considering the best available science to make management decisions to benefit sage-grouse and their habitats. Adaptive resource management is a flexible and iterative learning process that produces improved understanding, enabling managers to evaluate the effectiveness of their management decisions, and researchers to gain information on system response to the treatment (Lancia et al. 1996, National Research Council 2004). The outcomes of management actions should be evaluated for effectiveness, and then adjusted, adopted, or discontinued. Effectiveness may be measured by improved sage-grouse demographic rates (e.g., production, survival, population growth), increased use by sage-grouse, and/or improved habitat quantity and quality. In the context of social cooperation in sage-grouse conservation, effectiveness can be measured by reduced tension among collaborators and whether actions help meet environmental, social, and economic goals (National Research Council 2004). Proposed actions should be implemented in an experimental context and evaluated under the framework of adaptive resource management, or "learning by doing" (Macnab 1983, Nudds 1999). The Department of the Interior's Adaptive Management Working Group (Williams et al. 2009) recommends a series of 9 steps to facilitate effective adaptive management:

1. Affected parties commit to adaptively manage the project/enterprise for the duration
2. Identify clear, measurable, and agreed-upon objectives
3. Identify a set of potential management actions for decision making
4. Develop models that characterize different management alternatives
5. Design and implement a monitoring plan
6. Select management actions
7. Monitor system responses
8. Compare predicted versus observed changes in resource status
9. Cycle back to Step 6 (iteration)

The CAAS advocates for applying this structure to habitat conservation projects, mitigation projects, management actions, policy development, research projects, and collaboration at all levels. While ODFW has the legal authority and responsibility for managing sage-grouse in Oregon (ORS 496.012), the department manages less than one percent of the land inhabited by sage-grouse in the state. Therefore, responsible, and effective sage-grouse management may only occur through collaboration among ODFW, private citizens, land management agencies, and other cooperating organizations using combined resources.

ODFW recognizes that land use planners and managers must consider these recommendations within the context of social-economic issues and decisions that fall under the jurisdiction of the respective governmental bodies. While most conservation actions regarding sage-grouse are voluntary, some land management decisions must be considered within a regulatory context, including state mitigation and land use statutes and rules, Federal Land Policy and Management Act, National Environmental Policy Act, Wild Free-Roaming Horses and Burros Act Of 1971, The General Mining Act of 1872, and the Endangered Species Act, among others.

The updated CAAS also carefully considers sage-grouse management decisions and approaches specific to ODFW. These approaches are guided by the mission of the Oregon Department of Fish and Wildlife: *to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations*. Examples of these management decisions include harvest guidelines, translocation protocols, captive rearing, trapping and marking, scientific collection permits, and dealing with sensitive sage-grouse data, such as lek locations. Policy and guidance from ODFW, the state of Oregon, WAFWA, and the Association of Fish and

Wildlife Agencies (AFWA), including best known science, formulate the approach to these difficult decisions. The CAAS provides clarity on ODFW's considerations of these management issues.

**How the Document will be Updated**

The CAAS may be updated at the direction of the Oregon Fish and Wildlife Commission, or by recommendation of the ODFW Sage-Grouse Conservation Coordinator after consultation with contributing partners and affected parties. The decision to update this document should be based on the availability of relevant new scientific data or research, or policy developments which affect the relevance and effectiveness of this document. Updates to the CAAS should be considered on a 5-year basis.

**Summary**

The decline of Oregon's sage-grouse populations and the loss of sagebrush habitats have been of significant conservation concern since the mid-20$^{th}$ century. Over the past 75 years, many regulatory and management actions have been enacted to address these concerning sage-grouse population trends and declines in habitat quantity and quality in Oregon. Conservation efforts were accelerated in 2005 with the establishment of ODFW's 1$^{st}$ edition of the *Greater Sage-Grouse Conservation Assessment and Strategy for Oregon* (CAAS) and again in 2011 with the updated 2$^{nd}$ edition of the CAAS. The scope of sage-grouse conservation in Oregon was broadened in 2015 with the publication of the *Oregon Sage-grouse Action Plan* (Action Plan), which was adopted by the Governor's Executive Order 15-18 as the overarching plan for Oregon, and specified the roles and responsibilities of conservation partners across Oregon's Sage-Grouse Conservation Partnership. The 3$^{rd}$ edition of the CAAS, this document, defines, clarifies, and updates how ODFW will meet our obligations under the Action Plan. The CAAS is not prescriptive but emphasizes the need for iterative adaptive management within a collaborative social context.

**Recommendations**

1. Consider objectives, actions, and reports in the context of proactively addressing USFWS ESA listing criteria.
2. Utilize an adaptive management framework (e.g., Williams et al. 2009) by incorporating iterative implementation and effectiveness monitoring for conservation actions and adjusting management actions as necessary.
3. Consider the effects of single-species management actions on other sagebrush obligate and sagebrush associated species.
4. Review the *Greater Sage-Grouse Conservation Assessment and Strategy for Oregon* on a 5-year basis and determine if an update to the document is necessary based on major changes to the status of sage-grouse populations or habitats in Oregon.

## Section 2: Leveraging Science to Address Threats to Sage-Grouse

Wesley Batterson and William Morse published *Oregon Sage Grouse* in 1948, the first publication to report the use of lek counts to monitor sage-grouse breeding populations. Over 75 years later, Oregon continues to utilize science to guide sage-grouse management in the state by investing in needed research and adapting management actions accordingly.

The potential of a federal ESA listing in 2010, and again in 2015 (USFWS 2010 and 2015), accelerated research investments across the range, refining our understanding of sage-grouse biology and the ecology of sagebrush systems. New population modeling, remote sensing, and monitoring tools emerged, and technical transfer experts developed techniques to improve adoption by managers (Olsen et al. 2024). Meanwhile, the quality and quantity of sage-grouse habitat continued to decline precipitously.

The scope of direct and indirect threats to sage-grouse and their habitats is vast and well documented throughout the sage-grouse literature. ODFW relies on the frequently updated USGS annotated bibliography to remain current with the latest relevant research (e.g., Teige et al. 2023). The primary threats are inter-related and rooted in degraded ecological integrity. Rather than summarizing all the new sage-grouse and sagebrush research since the publication of the 2011 CAAS, we will highlight the current understanding of primary threats to sage-grouse, outline important research and tools that will be used to inform Oregon's approach to management, and discuss knowledge gaps and research needs. Finally, we discuss approaches for prioritization of actions to address these issues given limited resources.

Beyond the scope of biology and ecology research, as managers we must also consider social and administrative conditions. The interdisciplinary science of human dimensions informs decision making by considering the complex interactions between humans and their environment. Effective conservation proactively identifies where ecology need, social acceptance, and favorable administrative conditions come together to create "conservation readiness" (Wollstein et al. 2024). In this section, we feature a prioritization framework that accounts for the social aspects of conservation to help narrow the scope of action for local planning and implementation.

### Wildfire, Invasive Annual Grasses, and Conifer Encroachment

The inter-related threats of wildfire, invasive annual grasses, and conifer encroachment are responsible for the majority of sage-grouse habitat conversion to lower quality ecological states and resulting ecosystem dysfunction (Doherty et al. 2022). The environmental stressors that contribute to the expansion of these threats are complex but are proximally linked to changes in fire regimes within the sagebrush ecosystem. Due to the large and growing spatial extent of these threats, it is critical to understand the effects of these large-scale changes on sage-grouse demographics and behavior. ODFW and our partners have invested in important research to better understand the interaction between sage-grouse and an environment altered by changing fire regimes.

*Wildfire*
Sagebrush vegetation and wildlife communities have evolved with wildfire, but over the past 40 years, the size and frequency of wildfire has increased in Oregon (Figure 2.1) and beyond (Crist 2023), contributing to a decline in sagebrush habitat quantity and quality, and sage-grouse populations (Brooks et al. 2015, Coates et al. 2016*b*). This altered fire regime is due largely to the expansive presence of flammable invasive annual grasses, an increase in human ignitions, and hotter and drier weather in a warming climate.

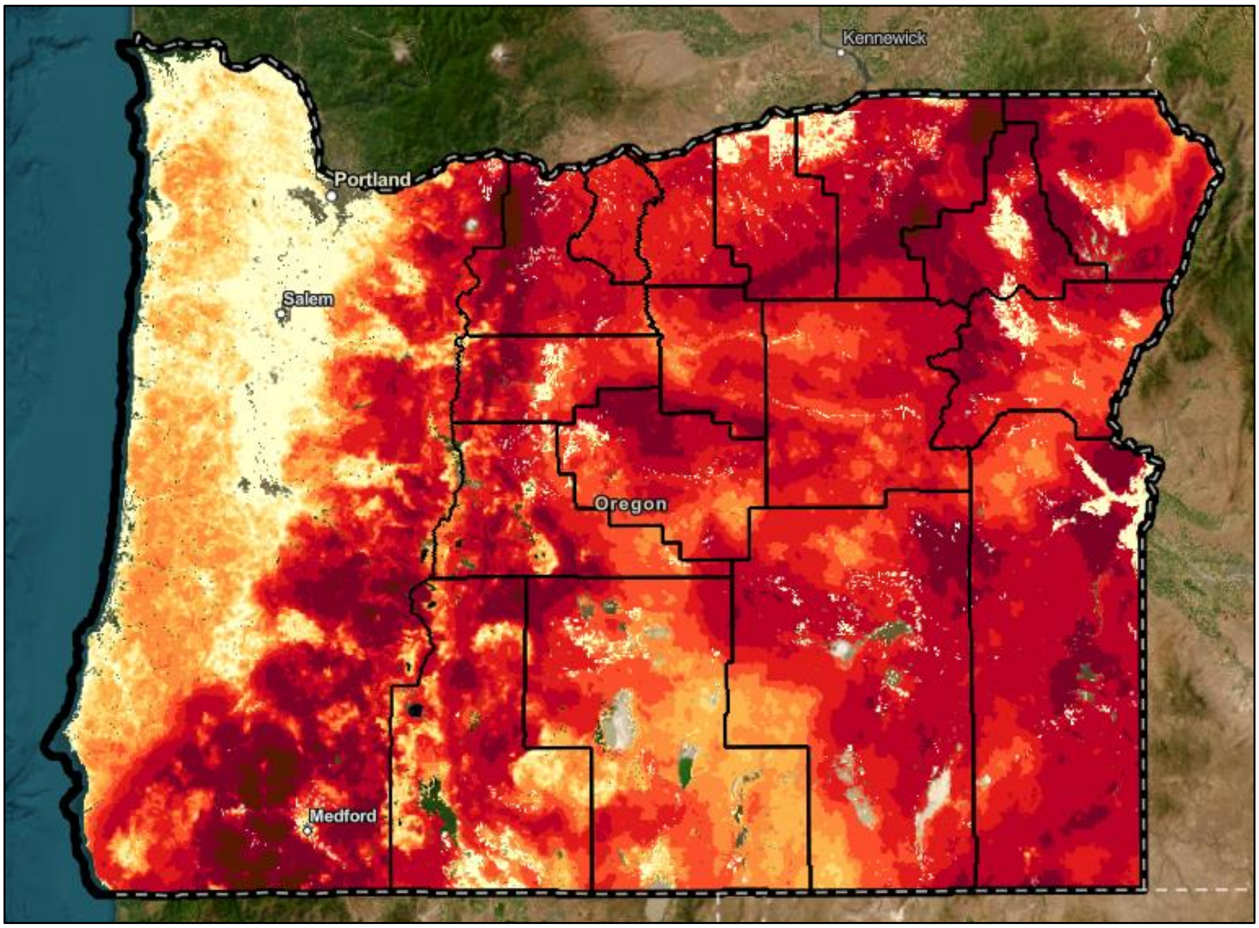


**Figure 2.1**. Wildfire likelihood (burn probability) in Oregon (2024) is an estimate of the average annual likelihood that a wildfire will occur at any given location. The map is from the SageCon Landscape Planning Tool, using the Pacific Northwest Wildfire Hazard Assessment. Values range from 0 (lightest) to 0.1 (darkest).

Sagebrush communities suffer high mortality following wildfire and their recovery is slow with minimal to no post-fire resprouting, depending on sagebrush species, particularly in lower elevations with drier conditions and often poorer soils. Recovery becomes more difficult due to post-fire conversion of sagebrush to habitats dominated by invasive annual grasses (IAGs). IAGs are intrinsically connected to the scope and scale of wildfires in the sagebrush biome. They create continuous beds of dry fuel after early summer desiccation, increasing the likelihood of ignition and rapid spread of wildfires. IAGs can quickly establish after disturbance, particularly in nutrient-rich post-fire habitat. IAG invasion of a site significantly reduces the natural fire return interval, often to periods insufficient to allow natural sagebrush recovery.

Sage-grouse demographic response to fires is strongly related to the reduction in sagebrush cover that occurs after a fire. The magnitude of the effect has been well studied in Oregon. Following the 2012 Holloway Fire that burned 99,148 ha (245,000 ac) through high-quality core sage-grouse habitat in the Trout Creek Mountains, researchers began a long-term study to examine the population response. These studies found strong negative effects of wildfire on critical sage-grouse vital rates. Nest success and chick and female survival were consistently lower than comparative published values (Foster et al. 2019, Anthony et al. 2021*a*). Female sage-grouse also exhibited high seasonal site fidelity to burned habitats, indicating a potential maladaptation to a landscape with more frequent disturbances (Foster 2016). Still, females selected nest microsites that provided some thermal refugia from the reduced cover, emphasizing the importance of vegetation remnants and post-fire restoration to sage-grouse persistence and recovery within wildfire burned areas (Anthony et al. 2021*b*). Similar impacts to vital rates were confirmed in a before-after comparison of sage-grouse exposed to two large wildfire events near the Nevada/California border, where adult survival was reduced by 50% and nest survival was reduced by 79% immediately post-fire (Tyrell et al. 2023).

Prevention, early detection, and rapid suppression of wildfire reduces the costs of fighting fire and post-fire restoration. Oregon's robust Rangeland Fire Protection Associations (RFPAs) play a vital role in providing rapid wildfire response in remote, fire-prone areas across the range of sage-grouse. These volunteer associations coordinate with Incident Management Teams in cooperation with the Oregon Department of Forestry (ODF), BLM, and USFS. The extreme wildfire year of 2024 demonstrated the importance of RFPAs when agency resources were insufficient to address multiple initial responses and attacks. RFPA actions likely prevented hundreds of thousands of additional acres of sage-grouse habitat and other rangelands from burning during the wildfire seasons of 2015–2023, and especially during the extreme wildfire season of 2024 (Figure 2.2). ODF supports RFPAs through administrative guidance, cost reimbursement, fire suppression training, facilitating access to federal grants, and providing surplus firefighting equipment. Support for equipment acquisition and maintenance, in addition to capacity for coordinating with Incident Management Teams is identified as critical to the continued success of RFPAs (Rural Fire Protection Associations 2024).

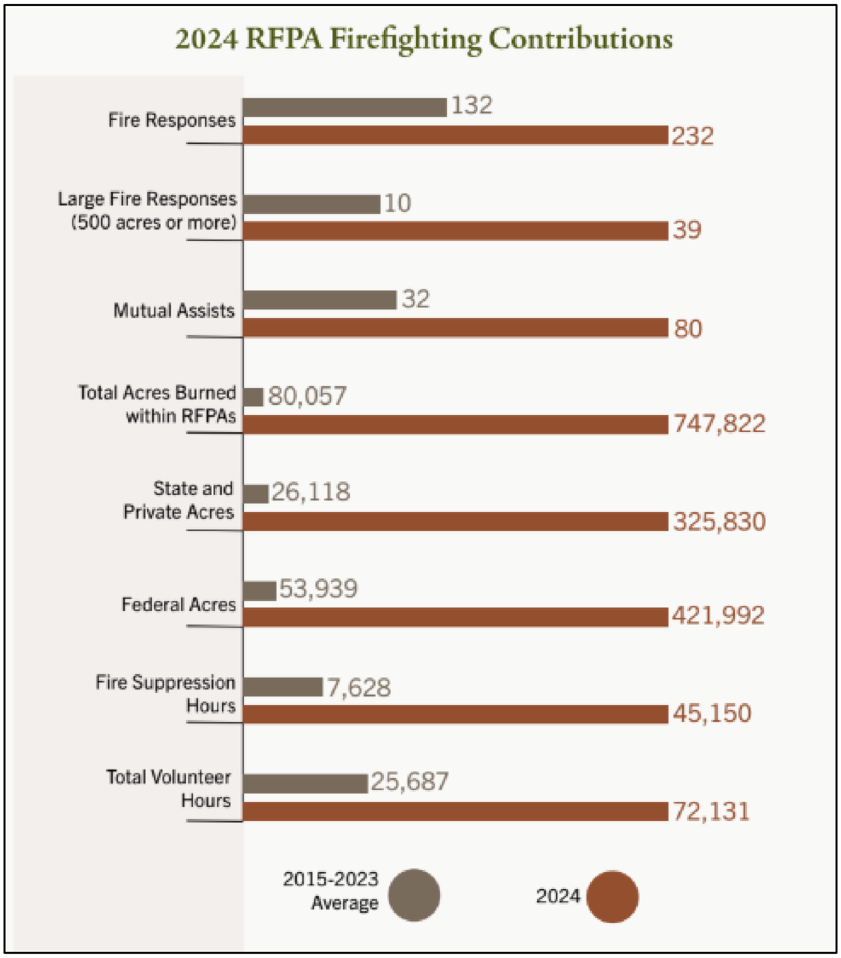


**Figure 2.2**. Rangeland Fire Protection Association average contributions (2015–2023) to annual fire response, compared with the extreme fire year of 2024 (Rural Fire Protection Associations 2024).

Unfortunately, fire suppression will not stop the spread of invasive annual grasses into unburned habitats (Smith et al. 2023); as the authors succinctly state, "Fire needs annual grasses more than annual grasses need fire". Annexation of native plant communities by IAGs progresses with or without fire in sagebrush ecosystems, but fire can accelerate the transition. Suppressing wildfire is still important to protecting sagebrush ecosystems but should not be considered a solution to the significant IAG threat.

*Invasive Annual Grasses*

In Oregon, the primary species of IAGs are cheatgrass (or downy brome) *(Bromus tectorum)*, medusahead *(Taeniatherum caput-medusae),* and ventenata *(Ventenata dubia)*, and each species is widespread throughout eastern Oregon (Figure 2.3). These species have high early season growth rates and seed production. In addition to aiding the expansion of wildfire, IAGs displace native perennial plant communities, impacting forage quality and quantity, and deteriorating cover for sagebrush-associated species, and reducing native plant abundance and diversity.

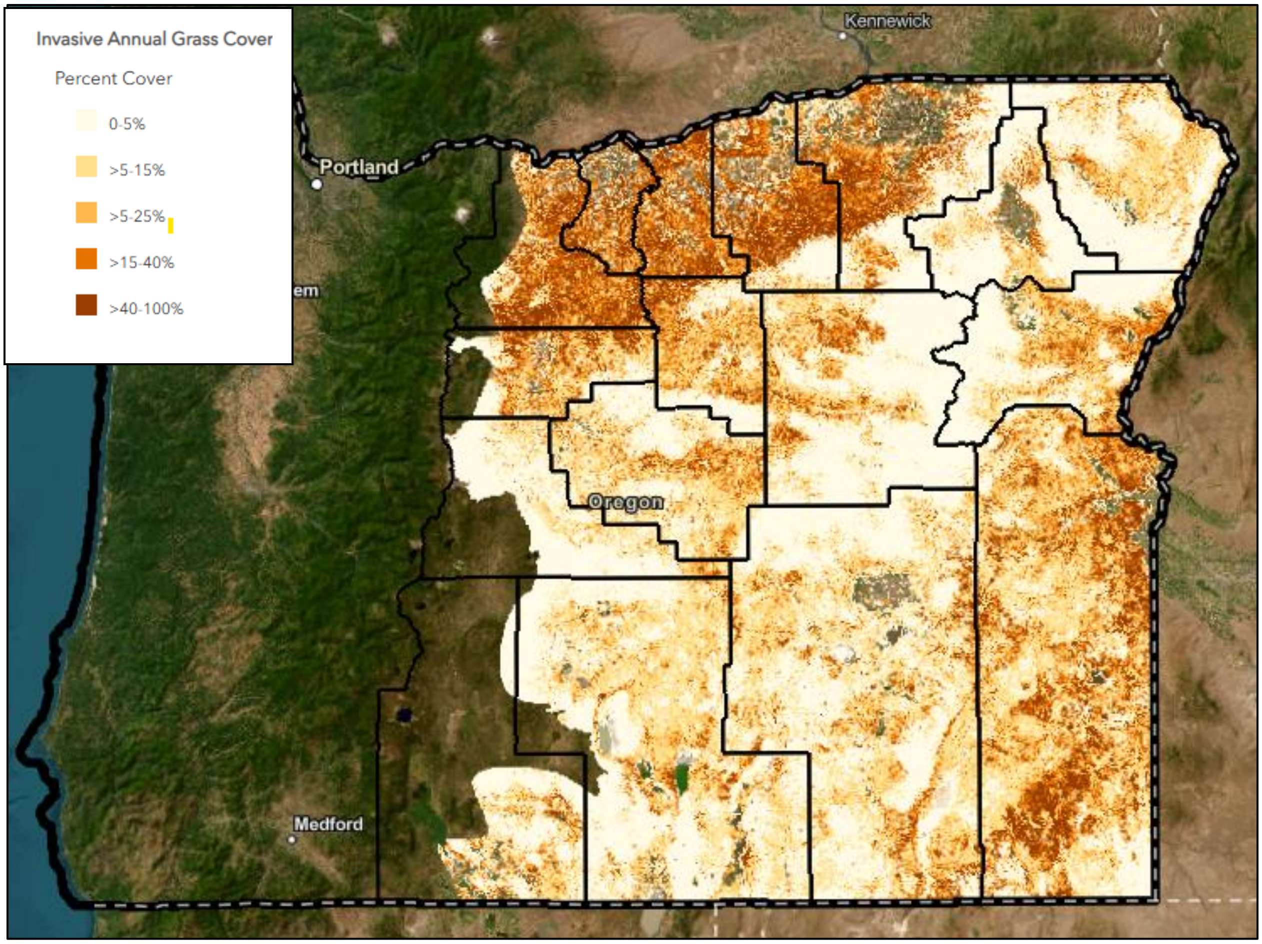


**Figure 2.3**. Invasive annual grass cover (2024) in eastern Oregon. The map is from the SageCon Landscape Planning Tool, using data from the Rangeland Analysis Platform.

While wildfire scope and scale are closely tied to IAG presence, other forms of disturbance such as weather-related erosion, heavy hoof action, or tread from machinery or vehicles also help proliferate IAGs, allowing incursion into previously unaffected areas such as cooler north slopes and higher elevations. Further, the disturbance of soil-biocrusts whether by hoof action or heavy equipment removes this natural suppressor of IAGs (Germino et al. 2022). Conifer encroachment also plays a role in the IAG feedback loop. Junipers compete with other vegetation for sunlight, nutrients, and water, increasing bare ground and creating opportunity for cheatgrass to invade. Western juniper steppe and juniper woodland habitats have a probability >69% of containing cheatgrass in central Oregon (Lovtang and Riegel 2012).

Many techniques have been used to attempt to control IAGs, including the use of various herbicides, prescribed grazing, biocontrol, and seeding, as well as other less successful practices (Ditomaso et al. 2017, Germino et al. 2021, Stephenson et al. 2023). The most successful method for suppressing IAGs long-term is the establishment of perennial grasses. Perennial bunchgrasses provide a barrier to IAG establishment and expansion due to their ability to outperform annual grasses in capturing resources (e.g., water, light, space). However, perennial bunchgrasses often fail to establish without initial annual grass control, are vulnerable to fire, and have lower seed production and fitness, particularly in environments with low resistance and resilience.

Pre- and post-emergent herbicides have shown promise in suppressing IAGs and allowing the establishment of perennial grasses. Two commercial products that limit the germination of IAG seeds include imazapic (Plateau; BASF Corporation, Research Triangle Park, NC) and indaziflam (Rejuvra, Envu, Cary, NC). Indaziflam/Rejuvra inhibits cellulose biosynthesis, a key component of plant cell walls, and can remain active in the soil for more than 3 years with little negative effect on established perennials. An experimental study in Colorado found that indaziflam will control cheatgrass for multiple years without impacts to perennial species richness or abundance (Clark et al. 2019). Imazipic inhibits the enzyme acetohydroxy acid synthase (AHAS), which is involved in the production of amino acids essential to plant growth and can provide control for approximately 1 year. Application of imazipic in Nevada reduced cheatgrass densities by >95% in fallow plots, and grass seed mixes performed more successfully in treated vs. untreated plots (Clements et al. 2022). Co-application of indaziflam and imazapic had a more rapid effect on cheatgrass control than indaziflam alone in a post-fire application study in Idaho, but the results were not uniform (Kluender et al. 2025).

After the herbicide residual has been depleted, treatments should be followed with beneficial seed mixes and seedling planting, particularly deep-rooted bunch grasses such as bluebunch wheatgrass *(Pseudoroegneria spicata)* and shallow-rooted cool season species, such as Sandberg bluegrass *(Poa secunda)*, during the period of reduced competition from IAGs (Anthony and Germino 2023, Kluender and Germino 2023, Kleunder et al. 2025)). Post-herbicide plantings of native seed mixes did not outperform a combination of native and introduced perennial grass seeds in outcompeting cheatgrass. The addition of crested wheatgrass *(Agropyron cristaum)* and Siberian wheatgrass *(Agropyron fragile)* to native grass seed mixes resulted in an additional 28–32% reduction in cheatgrass density (Clements et al. 2022). Until techniques to better establish native seedings are improved, these introduced perennial grasses can play an important role in outcompeting cheatgrass, particularly within arid, low elevation sites.

Experimental findings demonstrate the important adaptive learning framework required to find effective herbicide treatment of IAGs while minimizing the effects on native perennials, particularly with relatively new chemical products. The threat of IAGs has resulted in extensive restoration treatments that have been minimally effective. A framework of Early Detection Rapid Response (EDRR; United State Geological Survey 2024) in core habitats is a useful approach to defend high quality habitats from seemingly inevitable invasion, but appropriate site selection is critical given limited resources. A well-informed prioritization system, adaptive management, and learning, incorporating local knowledge, and repeated intervention over time will improve restoration success, as well as continued investments in research with practical management applications (Germino et al. 2021). The Oregon Rangeland Monitoring Program provides a standardized, repeatable, protocol for monitoring restoration treatments at multiple scales, and is based on best available science (www.sageconpartnership.com/ormp).

*Conifer Encroachment*

Western juniper *(Juniperus occidentalis)* has been expanding into sagebrush ecosystems over the past 140 years due to both anthropogenic and climatic factors (Figure 2.4.). These factors include fire suppression, often related to historic grazing practices which reduced fine fuel loads, episodic climate variation (wet periods and milder winters allowing juniper establishment ~120–140 years ago), and rising $CO_2$ levels (Miller et al. 2005).

The detrimental effects of the incursion of conifers, particularly western juniper, into Oregon's sagebrush shrublands have wide-ranging impacts on ecosystem vegetation composition, wildlife, water and nutrient cycles, carbon storage, resilience to fire, and resistance to cheatgrass. Conifer expansion is the second leading cause of decline of ecological integrity in the sagebrush biome (Doherty et al. 2022, Mozelewski et al. 2024).

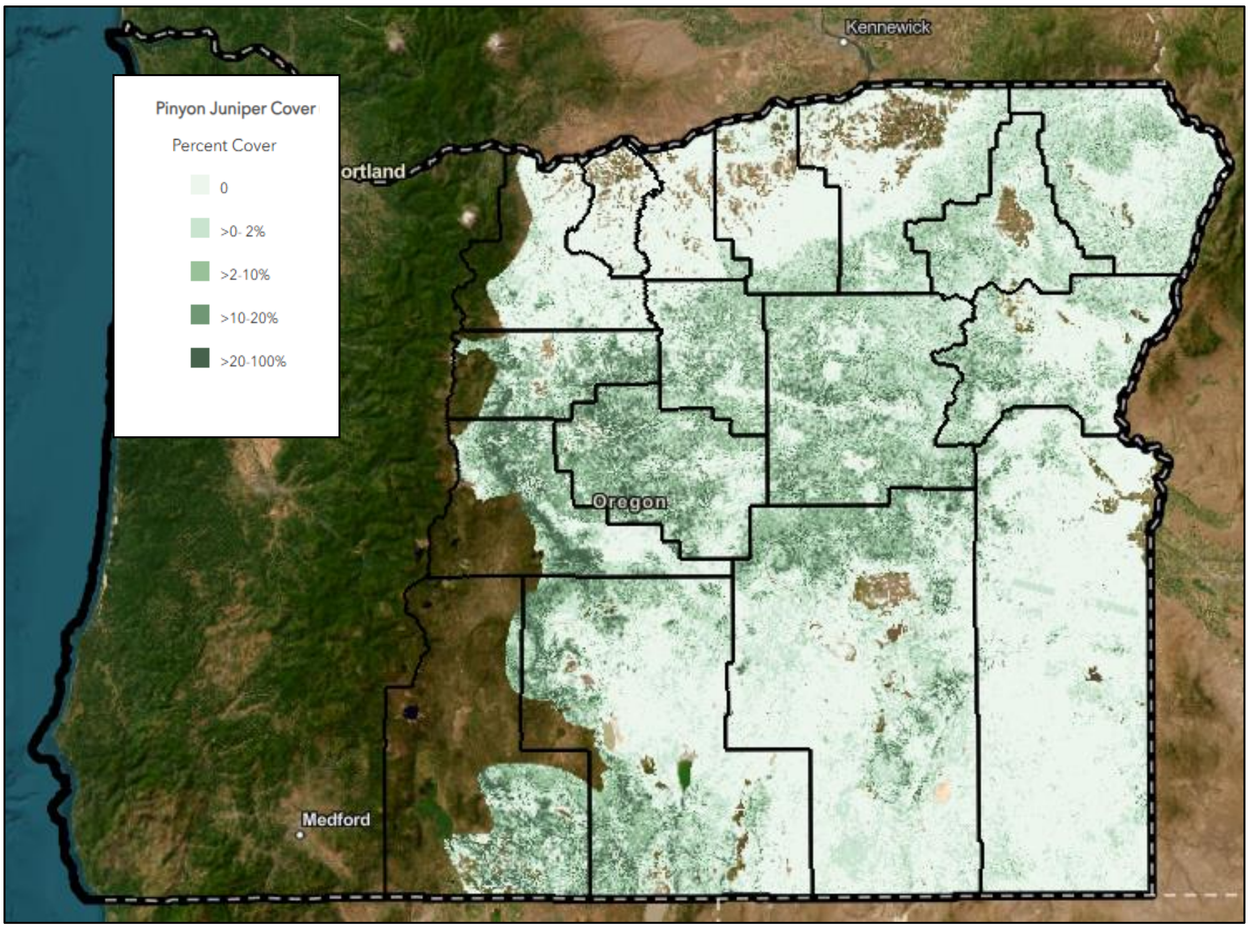


**Figure 2.4**. Pinyon-Juniper habitat cover (2024) in eastern Oregon. This map is from the SageCon Landscape Planning Tool using data from the Rangeland Analysis Platform.

Sage-grouse are particularly sensitive to tree encroachment but respond favorably to pinyon-juniper removal (Severson et al. 2017*b* and 2017*c*, Olsen 2019, Olsen et al. 2021, Coates et al. 2024). Female sage-grouse which selected nest and brooding sites closer to conifer removal areas experienced improved survival, and higher nest and brood success (Sandford et al. 2017, Severson et al. 2017*b*). Similarly, following a large-scale conifer removal project in Oregon, female sage-grouse shifted nests into conifer-cleared areas and were 43% more likely to nest within 1000 m of treatments (Severson et al. 2017*c*). Just one year post-treatment, relative sage-grouse population growth rates (λ) in the treated areas began to diverge from the control, and λ in treated areas increased by 11.2% by the end of the analysis period (2012–2017; Olsen 2019).

Conifer encroachment is also tied to lek extirpation (Baruch-Mordo et al. 2013). Sage-grouse avoidance of conifer habitats, even at low levels, is likely related to perching and nesting structure availability for avian predators. Probability of sage-grouse habitat use declines when juniper cover reaches 1.5–4% (Coates et al. 2017, Severson et al. 2017*a*).

While mechanical tree removal (e.g., hand felling and use of heavy machinery) may increase the risk of invasion by IAGs due to the associated surface disturbance, examinations of mechanical post-removal understory forage quality and quantity demonstrated positive effects, with measurable increases in total biomass, crude protein, herbaceous cover, perennial grass cover and height, and sagebrush height (Severson et al. 2017*a*, Haab et al. 2024). Several best management practices exist to minimize the risk of IAG invasion following juniper treatment. These BMPs include implementing the lowest-impact treatment methodology that is feasible (i.e., chainsaw cutting vs. heavy machinery), using machinery during periods when the ground is frozen, spraying and seeding post-treatment, including slash piles, and avoiding broadcast burning at lower elevations (e.g., Maestas et al. 2015). The presence of perennial bunchgrasses at treatment sites can reduce the likelihood of long-term annual grass dominance (Bates et al. 2005). The use of broadscale prescribed fire to remove juniper is more likely to result in sagebrush mortality, biocrust impairment, and IAG invasion (Miller et al. 2014).

While the major threats facing the sagebrush biome are daunting, not all sites are equally vulnerable. Sites with cooler soil temperature and higher moisture regimes show resistance to the spread of IAGs and resilience (recovery of perennial species) after a disturbance (Chambers et al. 2014, Chambers et al. 2017, Riginos et al. 2023). The resilience and resistance (R&R) framework has been mapped biome-wide to assist in prioritizing conservation investments and predicting outcomes (Maestas et al. 2016). An integrated strategy including wildland fire rapid response, postfire rehabilitation, fuels management, and informed prioritization of habitat restoration is necessary to, at minimum, retain existing sage-grouse habitat.

### Exacerbating Factors

Other forms of disturbance on the landscape also contribute to the impairment of sagebrush ecosystem function. Broadly, these disturbances include habitat degradation and associated stress from overgrazing by domestic livestock and free-roaming equids, anthropogenic disturbances from infrastructure, mineral and energy development, recreation, and climate change stressors. The effects can range from direct loss of habitat, avoidance of human presence, predator subsidies, noise disturbance, and direct mortality. These factors are covered in significant detail in the *Oregon Sage-grouse Action Plan*, but we will summarize current understanding and highlight new research findings since 2011 CAAS and the 2015 Action Plan.

*Climate Change and Weather Events*

While environmental conditions change throughout a species' evolutionary history, anthropogenic effects have resulted in environments changing at rates beyond which some species can adapt, particularly those with limited dispersal capabilities. For Oregon's sage-grouse, this change appears to take the form of more extreme temperature fluctuations, increased frequency of drought, and changes in dominant vegetation that ultimately increase the scale and severity of wildfire on the landscape.

An effort to predict climate change effects over the next century in southeastern Oregon evaluated four potential climate and management action scenarios (Creutzburg et al. 2015). Interestingly, all climate change scenarios projected expansion of moist shrub steppe and contraction of dry and xeric shrub steppe to varying degrees. Wildfire is predicted to increase 26% over the next century under the current climate scenario and doubled or quadrupled across more severe scenarios. Exotic grasses increased rapidly in all scenarios and the model predicted poor success in containment but did suggest that control of juniper expansion in priority treatment areas was possible (Creutzburg et al. 2015).

Weather events can also have a direct influence on survival of sage-grouse chicks and adults, as well as nest success (Bergerud 1988, Anthony and Willis 2009). At a longer temporal scale, shifts in climate conditions can result in changes to habitat that make portions of sage-grouse range unsuitable, resulting in decreased fitness or abandonment of the habitat.

Sage-grouse populations appear to track climate variability and are susceptible to increasing drought cycles and arid conditions expected to accompany climate change in the sagebrush biome. Sage-grouse population growth rates ($\lambda$) are positively associated with previous-year precipitation, whereas drought had a negative impact on nest survival but not adult survival (Lundblad et al. 2024*b*). Precipitation recharges mesic areas which are critical food sources for grouse broods. Dry weather patterns result in lower breeding rates for female sage-grouse (Behnke 2021). In southeast Idaho, Coates et al. (2016*b*) found precipitation within 10 km (~6.2 mi) of a lek during the previous spring, summer and fall positively influenced male sage-grouse lek attendance. Timing of precipitation matters when it comes to thermoregulatory effects on nesting and brood rearing. In southern Oregon and northern Nevada, females hatched smaller clutches in areas that received higher amounts of winter precipitation, and rain or snow during the early brood rearing period resulted in lower chick survival rates (Street 2020).

The western US, including Oregon, experienced a 22-year megadrought from 2000 to 2021 (Williams et al. 2022, O'Neil et al. 2023). A megadrought is a period of extreme dryness lasting for decades but including occasional years of wet conditions. It is not yet clear whether this drought has concluded. Conditions in this time period were drier than any other 22-year period in the past millennium as a result of below average precipitation and above average temperatures that increase evaporation, lead to early snowmelt, and lower surface and subsurface water availability (Figures 2.5 and 2.6; O'Neill et al. 2023). These conditions impact water supply, streamflow, water temperature, agriculture, wildfire propensity, and overall ecosystem health.

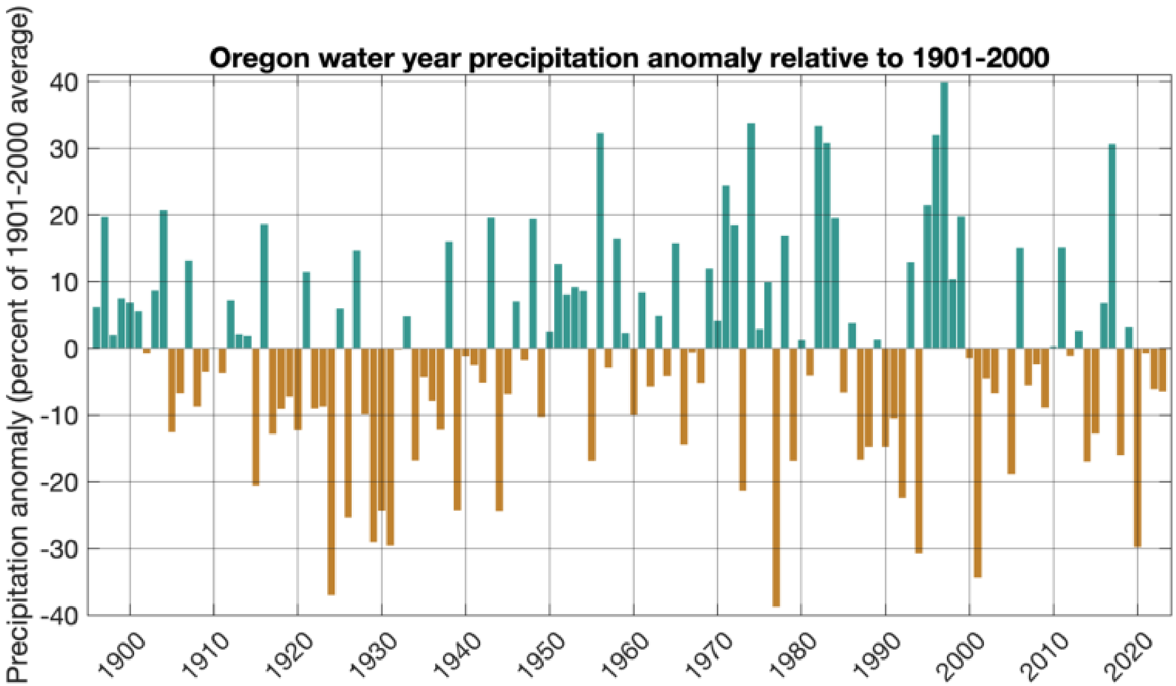


**Figure 2.5.** Total precipitation for the water years of 1896–2023 as a percentage of the 1901–2000 statewide average of 35.32”. Data from the PRISM Climate Group (O’Neill et al. 2023).

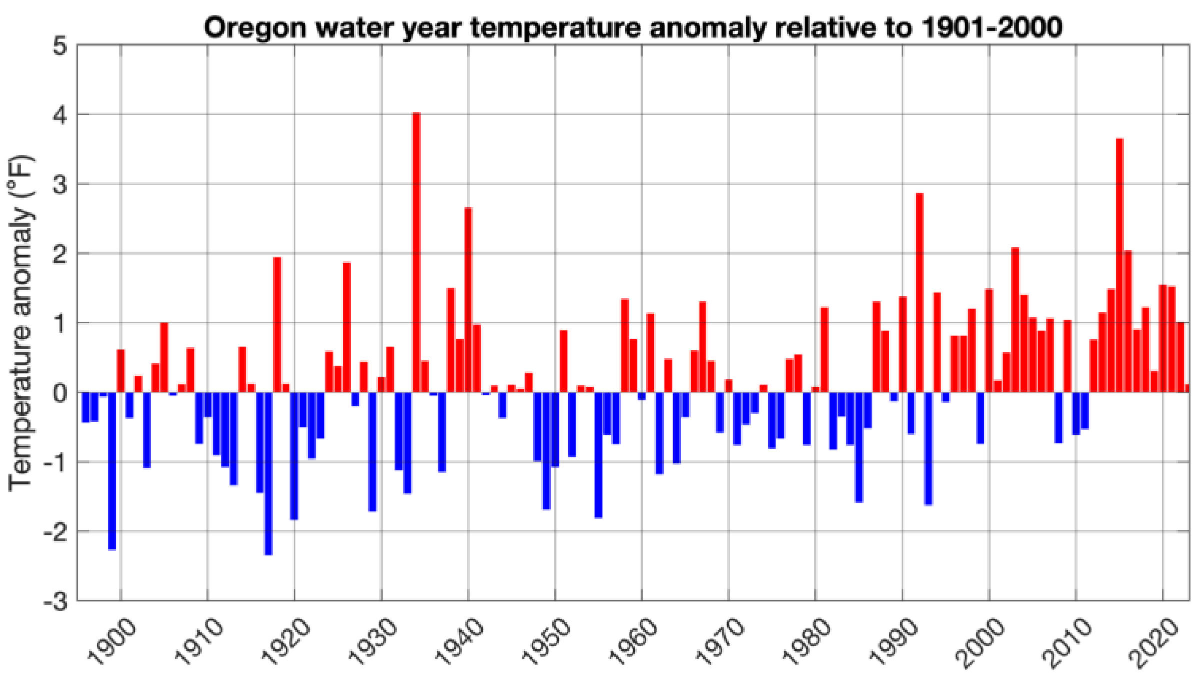


**Figure 2.6.** Temperature anomalies in Oregon during water years 1896–2023 relative to the average temperature from 1901–2000. Data from the PRISM Climate Group (O’Neill et al. 2023).

*Understory Degradation and Non-native Grazers*
Addressing understory degradation is one of the greatest challenges in the sagebrush biome as IAGs and native vegetation communities vie for dominance (Ielmini et al. 2021). Connelly et al. (2000*b*) recommended 15–25% sagebrush cover, and at least 15% perennial grass and 10% diverse forb understory cover (≥18 cm) for breeding, nesting, and early brood rearing habitats. Sage-grouse nest and brood success is linked to a dense herbaceous understory (Connelly et al. 1991, Gregg 1991). Sage-grouse chicks are particularly vulnerable to predation during their first 2 weeks of life. A healthy herbaceous understory provides concealment from predators, shelter from weather, and critical nutritional offerings in the pre-laying period and early brood-rearing periods. Greater forb and insect consumption has been positively correlated to chick survival (Barnett and Crawford 1994, Drut et al. 1994*a*, Drut et al. 1994*b*). Forbs and arthropods provide critical protein necessary for egg production and incubation tolerance in hens, and early growth needs for young chicks (Drut et al. 1994*a*, Drut et al. 1994*b*, Connelly et al. 2000*b*).

The combination of poorly managed grazing, fire, and mechanical and chemical treatments have a compounding detrimental effect on forb presence, particularly when combined with the stressors of drought and a warming climate (Pennington et al. 2016). Invasive broadleaf plants often categorized as "noxious weeds" also exclude native perennial forbs and grasses, such as various knapweeds, whitetop, Canada thistle, leafy spurge, and many others, and thrive in disturbed environments. These weeds are controlled with chemical herbicides that can have long-lasting effects on non-target native forbs. Biological controls, natural enemies of specific noxious weeds, can provide long-term, host-specific control when available (Dumroese et al. 2015). When outplanting forbs back into a system with a depleted seedbank, it is important to consider the Great Basin Native Plant Project's directive, "the right seed in the right place at the right time" (Dumroese et al. 2015). Managers should use propagules and seeds collected locally, seed or plant at the right time, and consider the appropriate microsite for best success. "Seed islands" can be used to increase forb establishment by focusing restoration within a project on sites with a high potential for success (Reever Morghan et al. 2005, Landeen et al. 2021).

Livestock grazing is the predominant land use across sage-grouse range, and often implicated and litigated as a factor in sage-grouse decline, particularly spring grazing on federal allotments. Historic grazing practices characterized by heavy stocking rates and repeated growing season use resulted in widespread degradation of rangelands (Davies et al. 2024). Improved oversight of grazing on public land and the maturation of rangeland science aided in better stewardship of grazed rangelands, but legacy effects of perennial plant replacement with invasive plants and increased erosion, particularly near water sources, impedes habitat recovery (Williamson et al. 2020, Davies et al. 2024).

Concerns about the interaction between grazing and sage-grouse are two-fold: direct effects on sage-grouse demographics, such as nest and brood survival, and long-term impacts to habitat quality and quantity. A robust study undertaken in Idaho over 10 years involving over 1,300 radio-marked sage-grouse hen and over 1,200 nests found no evidence that low to moderate spring grazing reduced nest survival (Conway et al. 2024). Researchers also found that grazed pastures resulted in a greater abundance of insects in the spring, a benefit for broods. In

Wyoming, sage-grouse populations responded positively to grazing after peak vegetation growth but declined with high grazing levels on cool-season grasses during peak growth (Monroe et al. 2017). In central Montana, a NRCS Sage Grouse Initiative (SGI) rotational grazing system did not have a measurable effect on nest success, and the study affirmed the importance of shrub cover and grass height to sage-grouse habitat selection (Helm 2023).

Poorly managed grazing can have serious impacts on understory, perennial grass cover, and palatability of forage (Forbey et al. 2013). Grazing can have the positive effect of reducing cheatgrass biomass when strategically applied, achieving a reduction in fine fuels (Davies et al. 2024). When comparing a gradient of grazing by both cattle and equids, Street (2020) found nest and brood sites had less cover of perennial grasses and forbs and more bare ground or cheatgrass as grazing increased. Cattle grazing on public land is managed with restrictions on timing and animal unit-months (AUMs), whereas public land equids provide a constant grazing pressure that increases with the size of the herd. Cheatgrass cover increased with increasing horse activity at both nest and brood sites, but not with cattle grazing, likely due to heavier hoof damage and the ability to graze closer to the ground, creating more disturbance and bare ground than cattle.

In recent years, free-roaming equid (horses and burros) populations have increased in sagebrush ecosystems due to both biological and social reasons. Horses have high growth rates, long reproductive lifespans, and a lack of natural predators. Meanwhile, wild horse advocacy groups use the legal system to delay the BLM from the process of legal removal. The BLM sets 'Appropriate Management Levels' (AML) to balance grazing needs of equids, domestic livestock, and wildlife. The number of free-roaming equids has increased to approximately three times AML for all 177 Herd Management Areas administered by the BLM across the West. Herds over AML negatively affect sage-grouse vital rates, particularly nest, brood, and juvenile survival (Beck et al. 2024). In Oregon, AML is 2,700 animals across 18 HMAs. Oregon herd numbers are estimated to increase 20% annually and were estimated around 5,000 animals as of 2025, though not all HMAs intersect sage-grouse range (Bureau of Land Management 2025).

Equids can alter habitat particularly during drought, disturb leks, increase bare ground, and reduce perennial grass height. Female sage-grouse initiated nests at lower rates, and expressed elevated levels of the stress hormone corticosterone, during drought years combined with the presence of abundant non-native grazers in northern Nevada and southern Oregon (Behnke 2021). When modeling sage-grouse population rate of change ($\lambda$) as a function of feral horse abundance, Coates et al. (2021*a*) found on average, for every 50% increase in horse abundance over maximum AML, sage-grouse populations declined 2.6% annually. In Wyoming, Beck et al. 2024 documented -8% nest survival and -18% brood (early and late) and juvenile survival when max AML was exceeded by 300%.

Livestock and free-roaming equids show a strong preference for mesic habitats such as riparian meadows, particularly after cooler season forage senesces. Overuse of these habitats can create the potential for erosion, deepening streambanks, and dewatering adjacent meadows (Hockett 2002). These mesic areas are critically important for late summer brood rearing but comprise less than 2% of the landscape (Chaney et al. 1990). Belsky et al. (1999) found historic livestock grazing has altered approximately 80% of stream and riparian ecosystems in the western states.

Livestock exclusion and repair of past damage provides critical benefits to late summer broods. Pioneering work by Bill Zeedyk introduced the concept of low-tech, hand-built rock structures to restore degraded wet meadows in sagebrush rangelands (Maestas et al. 2018). This idea evolved to include hand-built instream structures, such as beaver dam analogs, to raise incised channels and address headcuts, allowing rewatering of adjacent meadows (Wheaton et al. 2019).

*Mining and Energy*

Human population growth and associated technology has created an ever-increasing demand for energy and other raw materials. Extraction of these materials and concern with the volatility and long-term supply of fossil-fuels has led to a push for more renewable energy sources. Oregon has aggressive renewable energy goals to replace fossil fuel energy, often putting state mandates at odds with sage-grouse conservation. Oregon's "Renewable Portfolio Standard" requires large investor-owned utilities to obtain at least 27% of their energy from renewable resources by 2025, and at least 50% by 2040 (Oregon Senate Bill 1547). Small utilities must obtain at least 5% of their electricity from renewable resources starting in 2025.

Oregon does not have the correct geology to produce large extractable supplies of oil and gas, but it does have a wealth of wind, solar, geothermal and non-fuel extractable resources including crushed stone, sand and gravel, pumice/pumicite, cement, diatomite, and perlite (U.S. Geological Survey 2025). Oregon ranks 35$^{th}$ in the nation for the value of nonfuel mineral production, valued at $493M in 2024. Oregon also has reserves of valuable locatable minerals including cobalt and lithium, both of which are needed to produce lithium-ion batteries, and uranium, used as fuel in nuclear reactors to generate electricity.

The development of energy and mining infrastructure in the sagebrush biome comes at the cost of increased fragmentation from facilities, roads and transmission lines, perching structures and anthropogenic subsidies for avian predators, sound disturbance from operations, increased vehicle traffic, and soil disturbance leading to spread of invasive plants, permanent removal of habitat, and impacts to surface and groundwater.

*Lithium*

A Presidential determination on March 31, 2022, authorized the use of Defense Production Act (DPA) Title III authorities to strengthen the U.S. industrial base for large-capacity batteries and specifically to increase domestic mining and processing of critical materials such as cobalt, graphite, lithium, and nickel for the large-capacity battery supply chain (U.S. Geological Survey 2025). On January 20, 2025, the presidential executive order entitled, "Unleashing American Energy" directed "The Secretary of the Interior, Secretary of Agriculture, Administrator of the EPA (Environmental Protection Agency), Chairman of CEQ (Council on Environmental Quality), and the heads of any other relevant agencies, as appropriate, shall identify all agency actions that impose undue burdens on the domestic mining and processing of non-fuel minerals and undertake steps to revise or rescind such actions."

Along the Oregon/Nevada border, the McDermitt Caldera (Figure 2.7) has been identified as a potential lithium mining site which includes some of the most intact sage-grouse habitat in the state. One proposed plan by BLM mineral lessees would result in drilling at more the 260 sites across 2,914 ha (7,200 ac) of sage-grouse habitat. Proposals from other developers cover the greater portion of the caldera, including Nevada. The BLM and State of Oregon have mitigation regulations in place to address the impact of such disturbances (See Section 7). The scale of disturbance and associated mitigation requirements would be determined by the ODFW Sage-grouse Mitigation Program via the Habitat Quantification Tool (HQT). The impacts are expected to be significant, including the removal of habitat, avoidance due to noise and human presence, increased traffic, and the potential for direct mortality.

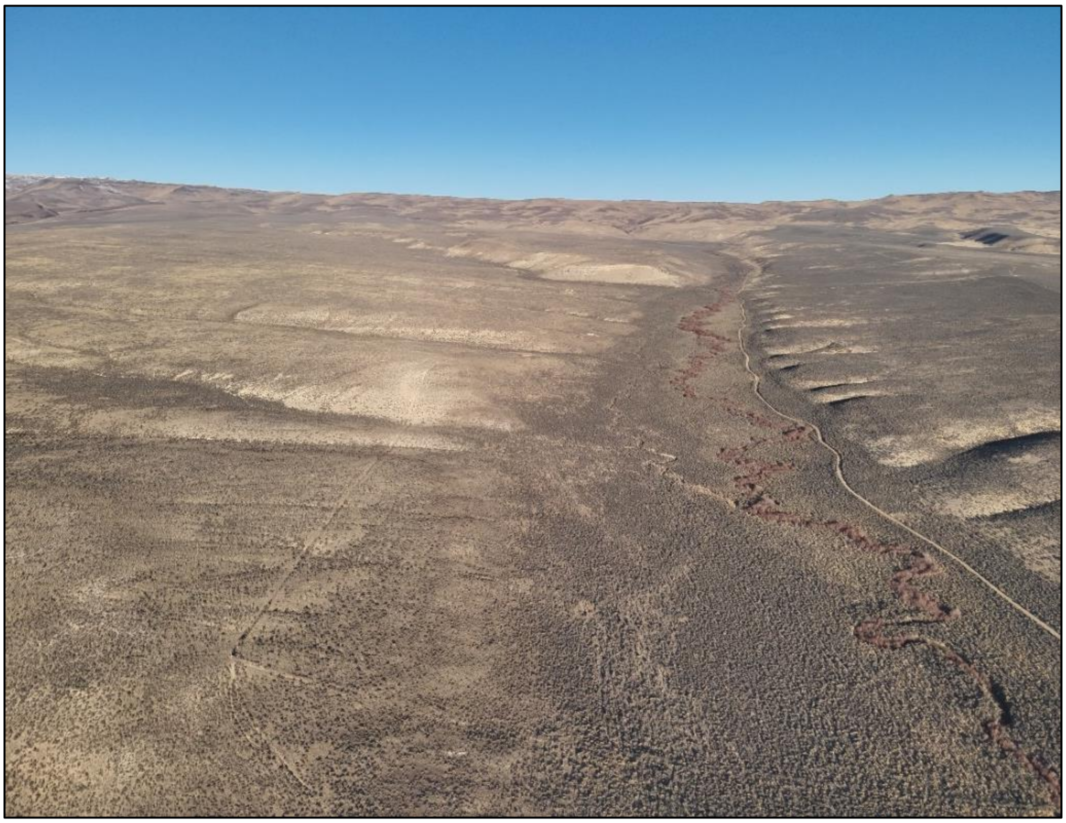

**Figure 2.7.** The McDermitt Caldera hosts one of the world's largest known accumulations of lithium minerals and contains core sage-grouse habitat (photo from ODFW).

*Wind Energy*

The construction of wind farms requires selecting and clearing sites with consistent wind resources, accompanied by road construction, buried electrical cables requiring additional surface disturbance, and associated transmission lines. Direct impacts from wind-facility development include mortality due to collisions with construction equipment and wind turbine blades. Raptor collisions have decreased with the tubular steel tower design and buried electrical lines, reducing perching opportunities, versus earlier designs, but bats are particularly susceptible to direct mortality. Indirect impacts specific to sage-grouse involve avoidance and decreased habitat available for use with proximity to infrastructure (LeBeau et al. 2014, LeBeau et al. 2017*b*). Decreases in lek counts (-56%) within 1.5 km (0.9 mi) of infrastructure were documented 3 years post-installation in Wyoming (LeBeau et al. 2017*a*).

Sage-grouse feed exclusively on sagebrush during winter months, and this habitat is limited by its availability above the snowpack. Windswept ridges that keep sagebrush exposed during the winter may be prime sites for wind energy development. Because sage-grouse are dependent on sagebrush for winter forage, loss of winter habitat can have severe impacts on survival and subsequent breeding population size (Swenson et al. 1987, Connelly et al. 2004). There is a need for additional information on impacts of wind facilities on sage-grouse behavior.

#### *Geothermal Energy*

Oregon has abundant potential geothermal energy that could be used to generate electricity with minimal carbon emissions but does not currently have active geothermal energy leases in sage-grouse core or low-density habitat. Geothermal developments would be expected to have similar impacts as other energy development facilities, including transmission lines, improved roads, fencing, and storage facilities. The primary concern is that the noise generated can be substantial and has the potential to mask sage-grouse vocalizations during lekking, increase stress, avoidance, and decrease lek attendance (Blickley et al. 2012*a*, Blickley et al. 2012*b*, Blickley and Patricelli 2012). In a before-after-control-impact (BACI) study in Nevada, predicted abundance declined ~24% within 5 km (3.1 mi) of geothermal sites, and lek absence rates increased by ~730% within 2 km (1.2 mi). The study also found decreased nest survival in proximity to geothermal infrastructure, and increased density of common ravens, a known predator of sage-grouse nests (Coates et al. 2023). Topography also plays a role in how far sound and light carry across a landscape and cause behavioral changes in sage-grouse (Coates et al. 2023).

#### *Solar*

Photovoltaic (PV) technology converts energy radiating from the sun into electricity. Utility-scale PV facilities over 20 megawatts (MW) involve a large field of solar collectors which generate electricity that is directed to the power grid. These systems typically require 4 ha (10 ac) to produce 1 MW. Solar facilities are accompanied by access roads and transmission lines. There are many solar projects operating or under development within the sagebrush ecosystem, including Oregon.

From 2012-2022, annual solar generation in Oregon increased from 95,100 to 2.2 million megawatt-hours (MWh), providing about 2.8% of Oregon electricity needs (Oregon Department of Energy 2024). ODFW provides recommendations on siting solar energy facilities to avoid and minimize impacts to fish and wildlife (Oregon Department of Fish and Wildlife 2024).

Impacts to sage-grouse from utility-scale PV facilities involve both fragmentation and complete removal of usable habitat resulting in displacement and reduced reproductive rates (LeBeau et al. 2017*a* and 2017*b*, Kirol et al. 2020). Fences and transmission lines provide perching subsidies for raptors and ravens that depredate sage-grouse nests. Maintenance roads provide travel corridors for predators, and potential food subsidies via roadkill.

### *Land Use and Development*

#### *Human Encroachment*

Human population centers are accompanied by habitat fragmentation, agriculture, predator subsidies, roads, vehicles, transmission lines, noise, and recreation among other disturbance factors. An examination of sage-grouse persistence and extirpation considering human-caused disturbance found extirpation of sage-grouse was most likely in areas having at least 4 persons per $km^2$ in 1950, 25% cultivated cropland in 2002, or the presence of three or more droughts per decade. Extirpation was more likely in areas near the periphery of sage-grouse range and when sagebrush cover was less than 25% within 30 km (18.6 mi) (Aldridge et al. 2008). The amount of agricultural tillage negatively affected the likelihood of large leks (>25 males) in northeastern Montana and southcentral Saskatchewan. Large leks were 4.5 times less likely to occur than small leks when fragmentation due to tillage exceeded 21% of land within 1.0 km (0.6 mi) of breeding sites (Tack 2009).

#### *Transmission and Telecommunication Infrastructure*

Transmission lines, communication towers, and other telecommunications infrastructure, can have direct and indirect effects on sage-grouse survival. Utility wires are known to cause mortality (Borell 1939), and collisions with power lines accounted for a low percentage of mortalities in two Idaho studies (Connelly et al. 2000*b*, Beck et al. 2006).

Transmission line corridors and telecommunication towers provide perching subsidies for common ravens and other avian predators. Perching on vertical structures increases the range of vision of raptors and corvids, allowing for greater speed and effectiveness in searching for and acquiring prey (Steenhof et al. 1993, Manville 2004). Increased abundance of raptors and corvids within occupied sage-grouse habitats may result in predation rates outside the range of natural variation (Lammers and Collopy 2007, Coates 2007). Proximity to power lines was related to decreased lek attendance, nest site selection, nest success, and brood success (Gibson et al. 2018, Kohl et al. 2019, LeBeau et al. 2019). In a 9-year study in central Nevada, the extent to which power lines influenced sage-grouse nest success and probability of lek growth was closely tied to common raven abundance (Gibson et al. 2018) The effects of the power lines on sage-grouse demographics extended 2.5–12.5 km (1.6–7.8 mi) (Gibson et al. 2018).

Transmission structures and communication towers may provide nesting sites for corvids and raptors in habitats with low vegetation and relatively flat terrain. Thus, these birds may preferentially seek out transmission structures in areas where natural perches and nesting sites are limited. For example, within one year of construction of a 372.5 mi transmission line in southern Idaho and Oregon, raptors and common ravens *(Corvus corax)* began nesting on the support structures, and within 10 years of construction 133 pairs of raptors and ravens were nesting on the transmission structures (Steenhof et al. 1993). Ravens are particularly adaptable to new structures on the landscape. In a Nevada study, raptor observations remained stable over a 5-year period after construction of a power line in Nevada, but common ravens increased >200% (Atamian and Sedinger 2007). A survey of over 1,000 communication sites across the range of greater sage-grouse found differences in avian predator occupancy based on landcover, structure type, and presence of microwave emissions, and decreased when other perching and nesting subsidies were available nearby (Szabo et al. 2024).

Golden eagle *(Aquila chrysaetos)* predation of sage-grouse increased from 26% to 73% (of the total predation) after a transmission line was constructed within 200 m (220 yd) of an occupied lek in northeastern Utah (Ellis 1984). The lek was extirpated, and Ellis (1984) concluded that the presence of the transmission line resulted in changes in sage-grouse dispersal patterns and fragmentation of the habitat. In Washington, 95% (19 of 20) of leks ≤4.7 mi (7.6 km) from 500 kV transmission lines are now unoccupied, while the unoccupied rate for leks >4.7 mi (7.6 km) is 59% (22 of 37 leks; Schroeder 2008). Leks within 0.25 mi (0.4 km) of new powerlines constructed for coalbed methane development in the Powder River Basin of Wyoming had significantly slower growth rates compared to leks further from these lines, which was presumed to be the result of increased raptor predation (Braun et al. 2002).

The presence of transmission lines may fragment sage-grouse habitats even if raptors and corvids are not present. Braun (1998) found that use of otherwise suitable habitat by sage-grouse near power lines increased as distance from the power line increased for up to 0.375 mi (0.5 km). The report also noted the presence of power lines may limit sage-grouse use within 0.6 mi (1 km) in otherwise suitable habitat. Similar avoidance behavior has been documented in closely related species such as greater and lesser prairie-chickens *(Tympanuchus cupido* and *T. pallidicinctus)*, where habitats within 1.6 km (1 mi) of power lines were avoided (Hagen et al. 2004, Pitman et al. 2005, Robel et al. 2005, Pruett et al. 2009).

Transmission lines and communication towers can be co-located with existing infrastructure to reduce effects, acknowledging that these amenities are critical to rural communities. However, when facilities are co-located, this adds more capacity to the system, leading to opportunities for more infrastructure, particularly solar farms, which are detrimental to sage-grouse. The ability to communicate via cell phone in rural areas is important to the local economy can be critical to the early detection and suppression of range fires by Rural Fire Protection Associations.

*Recreation*

The impacts of recreational activity on sage-grouse habitat have been poorly documented in the literature. However, displaying males or visiting female sage-grouse have been known to abandon lek sites frequented by birdwatchers and photographers who observe and photograph at distances not tolerated by the birds (Call 1979). Off highway vehicle (OHV) use also may be detrimental to sage-grouse breeding or nesting activities if the timing and intensity of the activity conflicts with sage-grouse use of those areas. Intensive off-trail OHV use may cause nest abandonment, if laying or incubating females are flushed from nesting locations. Previous work on sage-grouse indicates that it is one of the most sensitive grouse species with respect to abandoning a nest once disturbed (Patterson 1952).

### Direct mortality

*Disease and Parasites*

Christiansen and Tate (2011) list 36 diseases and internal and external parasites known to infect sage-grouse. The suppressive effect of these organisms is a particular concern for small, isolated populations where reduced fitness increases the likelihood of extirpation. While mortality events are uncommon, Batterson and Morse (1948) reported a sage-grouse population crash in Oregon in 1919–1920 when dead and dying grouse were common throughout the preferred portions of their range. Certain pathogens may be subject to amplification due to climate warming due to their responsiveness to moisture and temperature. Anthropogenic disturbance creates physiological stress in sage-grouse hosts, further increasing susceptibility to pathogens (Christiansen and Tate 2011).

In general, there has been little focus on monitoring and research of sage-grouse disease, until the emergence of West Nile Virus (Flaviviridae, *Flavivirus;* WNV). This mosquito-borne virus from Africa, was introduced to the U.S. in 1999 and has since become endemic. When WNV reached the western U.S. in 2002, sage-grouse were highly vulnerable, and populations were reduced by up to 25% in some areas (Naugle et al. 2004, Moynahan et al. 2006). Total mortality has been markedly reduced since 2003, but WNV is still a source of mortality in sage-grouse. Due to the connection between the mosquito host and standing water, sage-grouse may be more vulnerable during drought conditions when birds congregate near the remaining water sources, particularly at lower, warmer elevations (Naugle et al. 2004, Walker et al. 2007).

Oregon began monitoring live sage-grouse captured during research projects for WNV in 2004 in cooperation with the National Wildlife Health Center (NWHC). In 2006, a die-off of at least 60 sage-grouse was documented near Burns Junction, and two other sage-grouse deaths were confirmed from WNV near Crane and Jordan Valley. Monitoring expanded from 2006–2010 when the NWHC tested more than 1,800 blood samples from hunter- harvested birds in Oregon. The tests found a low prevalence of WNV antibodies (n = 19), and only one infected sage-grouse, a juvenile male harvested in northern Malheur County (Dusek et al. 2014). The lack of antibodies in the population is indicative of lack of resistance to the disease, however no other significant mortality events have been documented in Oregon since 2006.

*Predation*

Sage-grouse evolved with a suite of mammalian and avian predators and are adapted to coexist, assuming they have adequate escape and nesting cover and can produce enough chicks to replace turnover in the population. Issues arise when either a non-native predator enters the landscape, or a generalist predator population becomes artificially inflated due to human activity.

Survival of sage-grouse is typically high with more than approximately 60% of a cohort surviving from year to year. In Oregon, researchers found annual survival in the Trout Creek Mountains and Warner WMU (2015–2022) ranging from 41–71% (Titus et al. 2025 *in review*). Predation accounts for approximately 85% of reported non-hunting mortalities and 79–94% of nest failures (e.g., Bergerud 1988, Moynahan et al. 2007). Predation on nests and young chicks can be high and have population-level effects (Gregg et al. 1994, Aldridge and Brigham 2001, Schroeder and Baydack 2001, Coates 2007). In Idaho, predation was the most common cause of death for radio-marked sage-grouse (83% of males and 52% of females) in a hunted population (Connelly et al. 2000*a*). In Nevada, predation accounted for 90% of all mortalities, and adults were less vulnerable than subadults (Blomberg et al. 2013). The suite of predators on the landscape can vary with prey availability and habitat suitability (Hagen 2011*b*).

Predation rates may depend in part on the availability of alternative prey for predators, such as cottontail rabbits (*Silvlagus* spp.), jackrabbits (*Lepus* spp.) or other small mammals (Willis et al. 1993). Additionally, habitat quality may influence the rates of predation on sage-grouse (Schroeder and Baydack 2001). Predation on adult males is presumed to be most frequent during or shortly after the breeding season and on females during incubation and brood rearing (Hagen 2011*b*). In Nevada, predation risk on sage-grouse by mammals was higher than raptors in the fall, but more equivalent during the nesting season (Blomberg et al. 2013). A non-exhaustive list of observed sage-grouse predators is provided (Table 2.1), but most studies concur that coyotes *(Canus latrans)*, common ravens *(Corvus corax)*, golden eagles *(Aquila chrysaetos)*, and American badger *(Taxidae taxus)* represent most sage-grouse and sage-grouse nest predators (Conover and Roberts 2017).

**Table 2.1** Summary of observed predators of adult, sub-adult and juvenile sage-grouse, and sage-grouse nests (Hagen 2011*b*, Conover and Roberts 2017, Taylor et al. 2017).

| Predator | Adult | Juvenile/Sub-Adult | Nests |
|---|---|---|---|
| **Mammals** | | | |
| Coyote *(Canis latrans)* | X | X | X |
| Red Fox *(Vulpes vulpes)* | X | X | X |
| American Badger *(Taxidae taxus)* | X | X | X |
| Bobcat *(Lynx rufus)* | X | | X |
| American mink *(Neovison vison)* | X | | |
| Weasel *(Mustela* spp.) | | X | X |
| Striped Skunk *(Mephitis mephitis)* | | | X |
| Ground Squirrel *(Spermophilus* spp.) | | | X |
| Elk *(Cervus canadensis)* | | | X |
| Pronghorn *(Antilocapra americana)* | | | X |
| Raccoon *(Procyon Lotor)* | | | X |
| **Birds** | | | |
| Golden Eagle *(Aquila chrysaetos)* | X | X | |
| Bald Eagle *(Haliaeetus leucocephalus)* | X | X | |
| Prairie Falcon *(Falco mexicanus)* | X | X | |
| Gyrfalcon *(Falco rusticolus)* | X | X | |
| Northern Goshawk *(Accipiter gentilis)* | X | X | |
| Coopers Hawk *(Accipiter gentilis)* | X | X | |
| Ferruginous Hawk *(Buteo regalis)* | | X | |
| Red-tailed Hawk *(Buteo jamaicensis)* | | X | |
| American Kestrel *(Falco sparverius)* | | X | |
| Merlin *(Falco columbarius)* | | X | |
| Northern Harrier *(Circus cyaneus)* | | X | |
| Great-horned Owl *(Bufo virginianus)* | X | | |
| Snowy Owl *(Bubo scandiacus)* | X | | |
| Common Raven *(Corvus corax)* | | X | X |
| Black-billed Magpie *(Pica hudsonia)* | | | X |
| **Snakes** | | | |
| Western Rattlesnake *(Crotalus oreganus)* | | | X |
| Western Gopher Snake *(Pituophis catenifer)* | | X | X |

Controlling predators is controversial and generally not sustainable at large spatial or temporal scales. Experimental removal of coyotes in Wyoming actually resulted in decreased sage-grouse nest success, likely due to mesopredator release, whereas raven removal can increase nest success (Dinkins et al. 2016). Counts of male sage-grouse on leks increased the years following raven removal, indicating population-level effects (Peebles et al. 2017).

Common ravens (ravens) are a generalist predator that have increased in resource-limited arid environments due to anthropogenic subsidies providing food and nesting structures. Raven numbers have increased over 3-fold in the western U.S. and 2-fold in Oregon between 1980-2022 (Ziolkowski et al. 2023) and have much higher abundance (+204%) within the range of sage-grouse than outside (Harju et al. 2021). Human subsidies increase the densities and growth rate of ravens and increase the landscape carrying capacity for ravens (Coates et al. 2016*a*, Dinkins et al. 2021*c*, Revekant 2021). Subsidization of ravens is illustrated by the strong positive relationship between raven and road density, although high raven densities have also been found in recently burned habitats (O'Neil et al. 2018, Dinkins et al. 2021*c*, Owens 2023, Perry 2023). Landfills are a significant subsidy, hosting more ravens than all other resources in the western Mojave Desert of California (Boarman et al. 1995). Raven impacts to sage-grouse are typically associated with nest predation (Coates and Delehanty 2004), although ravens have been shown to disrupt male lekking behavior (Atkinson et al. 2021). Raven density has been linked to sage-grouse nest failure, particularly in areas of low shrub canopy cover (Coates and Delehanty 2010). Where raven densities exceed 0.40 ravens/ $km^2$ (0.15 $mi^2$) significant reductions in sage-grouse nest survival have been found (Coates et al. 2020). The foraging patterns of transient, resident, and resident-nesting ravens and their relative impacts on sage-grouse nests are not well understood. Ravens provisioning nests and defending a territory are more likely to forage in closer proximity to their nest, which can lead to increased likelihood of sage-grouse nest discovery by nesting ravens (Bui et al. 2010, Dinkins et al. 2016).

*An Oregon Case Study in Raven Control*

The USFWS authorized ODFW to initially remove raven nests and then lethally remove adult ravens in the vicinity of nesting habitat within Oregon's Baker PAC starting in 2021. This population of sage-grouse has declined nearly 82% since 1985 (see Section 3). The density of ravens in the Baker PAC is estimated at 0.52 ravens/$km^2$ (0.2 $mi^2$), exceeding the threshold determined by Coates et al. (2020). In cooperation with Oregon State University, this study includes raven habitat use and density monitoring, sage-grouse space use, sage-grouse hen demographics and movement monitoring, experimental removal of anthropogenic subsidies (e.g., roadkill), and a nutritional analysis of raven fecal samples to determine the extent to which ravens consume sage-grouse eggs in this declining PAC (Owens 2023, Perry 2023. Dinkins 2024, Rich et al. 2024). Reference study sites include the Bully Creek, Cow Lakes, Crowley (2017–2019) and Soldier Creek PACs. The results of this study will inform ODFW's approach to raven management for the conservation of severely imperiled populations of sage-grouse. Initial results from this research indicate that both lethal and non-lethal control of ravens lowered raven densities within treatment areas and had positive effects on local sage-grouse nest survival (Rich 2025).

*Harvest*
Hunter harvest has the potential to impact sage-grouse populations when harvest exceeds the natural mortality rate. To avoid duplication, a complete science review is provided in Section 8 (Harvest Management). Recreational hunting was determined not to be a threat to sage-grouse populations in the 2010 and 2015 USFWS ESA listing decisions as state and provincial agencies adopted increasingly conservative approaches to regulated hunting. (U.S. Fish and Wildlife Service 2010 and 2015). Range-wide sage-grouse management guidelines recommend a harvest rate of 10% or less (Connelly et al. 2000*b*). Oregon's policy has been for harvest not to exceed 5% of the fall population and in practice harvest has been estimated at <3% of the fall population in the hunted areas (e.g., Vold 2024). Also, sage-grouse are not hunted range-wide in Oregon. Oregon's sage-grouse harvest strategy is held as an example of adaptive harvest management likely to ensure population persistence, though the strategy could benefit from an explicit feedback loop (population simulation) to link harvest to next-year populations (Dahlgren et al. 2021). At some level of harvest, sage-grouse hunting mortality is likely to become additive without an adaptive, conservative, and controlled recreational harvest management strategy.

*Pesticides*
Insecticides are used by USDA's Animal and Plant Health Inspection Service (APHIS), in cooperation with the Oregon Department of Agriculture (ODA), to suppress grasshopper and Mormon cricket outbreaks in eastern Oregon on federal, state, and private lands. In Oregon, only liquid diflubenzuron (Dimilin), for immature insects, or solid bait carbaryl, for mature grasshoppers, are considered for use. There is low potential that these insecticides would be toxic to sage-grouse either by direct exposure or through consuming treated insects. The primary concerns with these treatments are reduced availability of insect prey by juvenile sage-grouse. The 2019 APHIS Environmental Assessment (EA) includes additional conservation measures for application of grasshopper and Mormon cricket control to minimize impacts and disturbance to sage-grouse. A revised EA was initiated in 2025 and will not be complete prior to the publication of this document.

Organophosphorus insecticides which inhibit acetylcholinesterase, an enzyme essential for central nervous system function have been found to be directly responsible for death of sage-grouse in proximity to agriculture fields in southeastern Idaho (Blus et al. 1989). Sage-grouse can be attracted to the green vegetation and insects associated with irrigated crops, particularly alfalfa, during the late summer brood rearing period (Hagen et al. 2007, Connelly et al. 2011). The registration of organophosphorus insecticides methamidophos and disulfoton in the U.S. was voluntarily suspended in 2009 (Environmental Protection Agency 2009), but dimethoate is still widely used on agricultural crops.

*Vehicle and Fence Collisions*
Roads can cause direct mortalities via collisions in addition to increasing noise disturbance, fragmentation of habitat, and increased presence of avian predators, all affecting the fitness of sage-grouse populations (Manier et al. 2014). Juvenile sage-grouse are most susceptible to collisions with vehicles (Wallestad 1975, Aldridge and Boyce 2007). Mortalities from vehicle collisions were more frequent than collisions with wires and fences in Montana (Wallestad

1975). Vehicles accounted for 4–6% of mortalities among radio-marked females in Idaho and Montana (Connelly et al. 2000*a*, Sika 2006). Avoidance of roads, particularly by nesting sage-grouse hens, may be related to selecting habitats with lower avian predator densities (Dinkins et al. 2014).

Barbed wire fences are ubiquitous across the western landscape and a cause of direct mortality in sage-grouse, particularly in the vicinity of large leks. A barbed wire fence in winter habitat killed at least 36 sage-grouse the first winter after installation (Call and Maser 1985), and 21 mortalities were reported along a similar fence in Wyoming (Connelly et al. 2004). Fence marking with reflective markers hung from the top strands of fences has proven to reduce collisions (Stevens et al. 2012). In Wyoming, 11.36 and 4.55 sage-grouse strikes/mi (1.6 km) were detected along an unmarked and marked fence, respectively, in a 1.5 year time period (T. Christiansen, WGFD, 2009, unpublished report). In Idaho, 3.5 versus 0.6 sage-grouse strikes/km (0.6 mi) were documented along unmarked and marked fences, respectively, an 83% reduction in collisions (Stevens et al. 2012). Long-term monitoring of fences in southwestern Wyoming detected over 1,000 collisions of which 60% occurred on marked fences, and observed increased collisions near locations where sage-grouse congregate regardless of the time of year (Woolwine et al. 2024).

## A Framework for Addressing Threats

Understanding the causes related to sage-grouse population decline has been the source of much investment. The scope and scale of the issues are daunting, and resources to address these problems are limited. In this section, we explore progress in the concepts around prioritizing conservation actions that will have meaningful effects on sage-grouse populations and their habitats. The complexity of land ownerships, various land use plans (e.g., BLM, USFS) in operation, the need for rural economy viability, coupled with the escalating decline of sagebrush ecosystem integrity, makes clear that prioritizing this work is not as simple as espousing a motto. Adoption of a prioritization framework needs to come from all levels of the partnership pyramid, from leadership to implementation (see Figure 6.1).

### *Defend the Core*

A proactive and preventative conservation approach for sage-grouse and sagebrush habitats was first articulated by the NRCS Working Lands for Wildlife program (NRCS 2020, Maestas 2022): “Defend the Core, Grow the Core, Mitigate Impacts”. This concept was accompanied by a much-used graphic equating preserving intact core habitat with the preventative care you might receive at the doctor, while degraded habitats were categorized as reactive emergency care, which is expensive and has a lower chance of success (Figure 2.8). Successful actions will involve identifying the most important and intact sage-grouse habitats that overlap with landowners willing to take conservation actions.

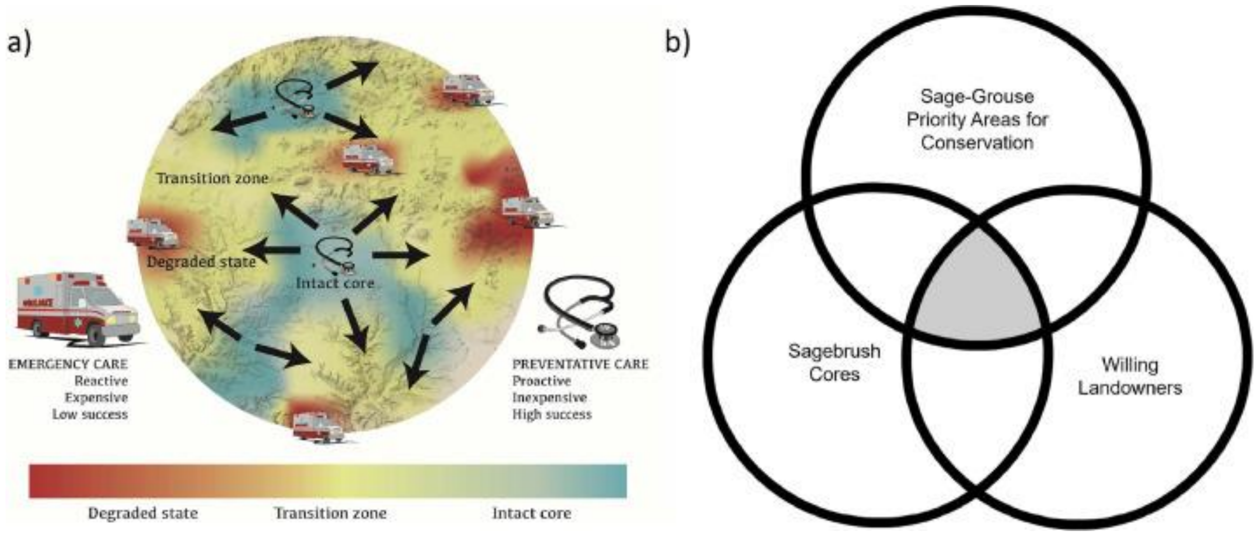


**Figure 2.8.** 'Defend the Core, Grow the Core' strategy (as modified from Maestas et al. 2022) developed to help guide threat reduction in the NRCS Framework for Conservation Action in the Sagebrush Biome (Panel a) (NRCS 2021). The Framework builds on SGI's history of delivering targeted conservation assistance to willing landowners for sage-grouse while encouraging the incorporation of ecosystem conditions (i.e., Core) into decision making (Panel b) (Naugle et al. 2024).

*Prioritizing Habitat for Conservation*

Spanning the disciplines of habitat modeling, sage-grouse biology, and human dimensions is the pursuit of identifying which habitats to prioritize for conservation in the sagebrush ecosystem. One important range-wide habitat model is the Sagebrush Conservation Design (SCD; Doherty et al. 2022), developed by a working group of diverse experts to support and inform WAFWA's Sagebrush Conservation Strategy Part II (Remington et al. 2024). The SCD leverages remotely sensed landcover to model sagebrush ecological integrity and divides the biome into:

1) Core Sagebrush Areas (CSAs),
2) Growth Opportunity Areas (GOAs), and
3) Other Rangeland Areas (ORAs).

This concept prioritizes first protecting intact, functioning sagebrush ecosystems, then expanding outward from the core, rather than first focusing on the most degraded habitat, following the direction of the "Defend the Core" philosophy. The SCD provides a prioritization framework for a proactive conservation approach, but in Oregon it does not scale down to practical applications. The SCD was one of the layers that informs the creation of the updated Oregon core and low-density habitat maps (Section 4). When relating the SCD sagebrush ecological integrity index to sage-grouse population trends, authors found growth rates of populations were stable to positive in core areas and negative to strongly negative outside the core areas (Doherty et al. 2022). These new core and low-density map boundaries are an important first step in prioritizing habitat, identifying those habitats that support 90% of Oregon's sage-grouse population.

An important takeaway from the SCD is that 87% of habitat losses in CSAs range-wide were due to increases in two threats: invasive annual grasses and conifers, whereas 4% of loss was attributed to perennial grass decline, and 3% of loss was directly caused by human modification. The SCD also showed that range-wide 0.53 M ha (1.3 M ac) of intact sagebrush is lost on average each year. This analysis brings into sharp relief that Oregon must prioritize the crisis of invasive annual grass conversion and conifer encroachment into sagebrush ecosystems, and intertwined wildfire interactions, utilizing a framework that conserves the most important intact habitat.

*An Oregon-based Strategy*

Moving from the low-resolution framework of the SCD, experts from Oregon's Sage-Steppe Habitat Response (Sage-SHARE) working group created a strategy intended to be effective at more relevant scales, dubbed "Threat-Based Strategic Conservation". Using the concepts of the SCD and Threat-Based Land Management (Johnson et al. 2019), this exercise in prioritization demonstrates how to transfer the "Defend the Core" concept to management-relevant scales utilizing Threat-based Ecostate Maps (Institute for Natural Resources 2023) and a set of five general principles (Figure 2.9; Sage-SHARE 2022).

**Five Principles of Threat-Based Strategic Conservation**

1. Prioritize defending and growing the core from primary ecosystem-level threats.
2. Find the relevant scale and people for your area.
3. Let your WHY guide your WHERE and WHAT.
4. Beware of both action bias and action paralysis.
5. Remember that conservation is empowered by relationships.

**Figure 2.99.** Guiding principles of threat-based strategic conservation (Sage-SHARE 2022)

Threat-based ecostate maps (ecostates) consist of a set of maps representing 3-year averages of rangeland ecosystem condition starting from 1989-1991 to present, allowing managers to track the change in ecological state over time. The percent cover data comes from the Rangeland Analysis Platform, developed by the USDA and University of Montana using remote sensing combined with ground-truthing and machine learning technology to map vegetation (RAP; Version 3). There are 8 threat-based ecostates that describe current vegetation composition combined with a level of threat from invasive annual grasses, wildfire, and juniper encroachment severity. These maps represent a critical tool in Oregon's ability to monitor sagebrush ecosystem condition.

*Next Steps*

The next logical tier in this process is the creation of an Oregon statewide spatial strategy to inform and prioritize sage-grouse habitat conservation at the implementation level. This spatial decision support tool would assist cooperative efforts in determining the appropriate action to take in conservation efforts, considering both sage-grouse demographic information and habitat condition. Decision support resources are emerging to assist with this effort, e.g., the USGS PReSET (Prioritizing Restoration of Sagebrush Ecosystems Tool; Aldridge et al. 2024). This decision-support tool generates maps of prioritized sites for restoration and conservation actions, based on customized management objectives such as restoring habitat connectivity or preserving sagebrush habitat resilient to drought.

An important example of the application of Threat-based Strategic Conservation is the framework proposed by Boyd et al. (2024) to address the threat of IAGs. This framework involves both proactive maintenance of intact habitat and restoration of adjacent impacted sites, before addressing the most impacted sites. This model builds on the Sagebrush Conservation Design (Doherty et al. 2022) to provide specific guidance for managers addressing the threat of IAGs. Priority maps designate management recommendations under the framework of MAINTAIN, IMPROVE, and CONTAIN (Figure 2.10). Similar approaches can be applied to other threats under this framework, such as conifer encroachment and wildfire risk.

**Categories of IAG Management Priorities**

MAINTAIN: Places with high ecological integrity at high risk of future invasion.
*Management: Early detection and rapid response; enhance resistance, manage propagule pressure.*

IMPROVE: Places that are currently impacted by invasive annual grasses, but could be restored to high ecological integrity with active intervention.
*Management: Actively suppress invasive annual grasses and restore competitive, climate-appropriate perennials.*

CONTAIN: Places severely impacted by invasive annual grasses, where abiotic conditions make restoration success unlikely.
*Management: Manage as annuals-dominated system. Prioritize fire prevention and fuels management; prevent spread.*

**Figure 2.1010.** A framework for addressing the threat of invasive annual grasses, as informed by Threat-Based Strategic Conservation and the Sagebrush Conservation Design (Boyd et al. 2024).

**Summary**

Landscape-scale impacts of wildfire, invasive annual grasses and weeds, and conifer encroachment in the context of a highly human-influenced landscape and changing climate, have lowered the demographic rates of sage-grouse and caused local extirpation of the species from large areas of its historic range in Oregon. Many additional factors can contribute to depressed rates of sage-grouse adult, nest, brood, and juvenile survival, including disease, parasites, predation, harvest, pesticides, and collisions. The scale of threats is daunting, but the best available science shows that it is critical to grow the remaining high quality intact sagebrush habitats while protecting these high-quality habitats from incursion by landscape altering threats. Prioritization frameworks are emerging to provide tools to managers and Sage-Grouse Local Implementation Teams to maximize the effectiveness of conservation actions in the sagebrush ecosystem.

**Recommendations**

1. Prioritize addressing the primary, landscape-scale threats of wildfire, invasive annual grasses, and conifer encroachment.
2. Focus conservation actions to increase the overall sage-grouse carrying capacity of the landscape, specifically to improve adult female, nest, and brood survival.
3. Engage in cooperative planning to develop a sage-grouse habitat spatial strategy based on both sage-grouse demographic information and habitat conditions.
4. Utilize prioritization frameworks, such as Threat Based Strategic Conservation, to strategically identify the most valuable investments in habitat restoration and uplift within Oregon's sage-grouse range.
5. Support research to quantify the demographic impact of IAG invasion on sage-grouse populations, including experimental techniques to improve understory habitat conditions.
6. Support research to evaluate climate-driven effects on sage-grouse populations, including the effects of site-specific resistance and resilience on Oregon's sage-grouse population strongholds.
7. Improve ODFW's understanding of the effects of large-scale development, particularly mining and renewable energy, on sage-grouse habitat use and demographic impacts.
8. Continue to investigate the impacts of high-density raven populations on local sage-grouse productivity and habitat use.
9. Support the development of a model evaluating sage-grouse fence collision risk using sage-grouse GPS location data. This model would be used to prioritize fence marking or fence removal efforts.
10. Engage in discussions regarding wildfire and fuel break designs and management, supporting those actions which have no impact to sage-grouse habitats while effectively reducing the risk of wildfire spread within sage-grouse habitats.

## Section 3: Monitoring and Assessment of Oregon's Sage-grouse Populations

Coordinating the annual monitoring of Oregon's sage-grouse populations and reporting sage-grouse population trends are two primary responsibilities of ODFW's Game Bird Program. Each spring, male sage-grouse attend leks, or strutting grounds, to display for and breed with female sage-grouse. Counting the number of males attending leks is the primary method of monitoring sage-grouse populations in Oregon, and across the range of the species in western North America. Recorded monitoring of sage-grouse leks in Oregon began as early as 1940, with lek survey effort increasing consistently since 1980 (Figure 3.1).

### Recent History of Monitoring Efforts

Sage-grouse lek monitoring effort in Oregon increased significantly in the 2010s following the USFWS 'warranted but precluded' ESA listing decision for greater sage-grouse and leading up to the 2015 species review. More recently, lek survey effort increased again in 2015, following the establishment of the BLM's Adaptive Management Strategy within the BLM 2015 Greater Sage-Grouse Approved Resource Management Plan (US DOI BLM OR/WA 2015). Larger sample sizes of lek data were necessary to inform the annual population trigger analysis under the BLM's 2015 Adaptive Management Strategy. To support this analysis, Oregon BLM and ODFW established a cooperative financial assistance agreement (2015–2019) to support lek monitoring, increasing the quantity and quality of Oregon's spring lek count data and ensuring each sage-grouse Priority Area for Conservation (PAC) was adequately surveyed. The cooperative agreement provided financial support for ODFW to hire 4–6 temporary employees to survey leks each spring, focusing on remote areas of Harney, Lake, and Malheur counties, which would otherwise receive relatively low survey effort. The agreement also provided financial support for ODFW to reimburse volunteers with the Adopt-a-Lek (AAL) Program for their mileage and modest per diem. Finally, the cooperative agreement supports aerial lek searches by helicopter and aerial infrared lek counts. Based on ODFW's aerial survey effort to date, systematic searches of core and low-density sage-grouse habitat by helicopter are the most effective way to locate new or previously unknown lekking locations and aerial infrared lek counts are the most effective way to obtain counts of males at known leks which are inaccessible on the ground. ODFW's cooperative lek monitoring agreement with BLM was renewed in 2020 with the same goals as the original agreement to ensure adequate sampling of sage-grouse leks; the current agreement expires in September 2025. Pending funding availability and Oregon BLM State Office priorities, ODFW intends to establish a new cooperative lek monitoring agreement with the BLM for 2026–2030 to maintain adequate survey effort in each PAC and inform the Adaptive Management Strategy of the 2025 BLM Sage-Grouse RMP Amendment (US DOI BLM 2025).

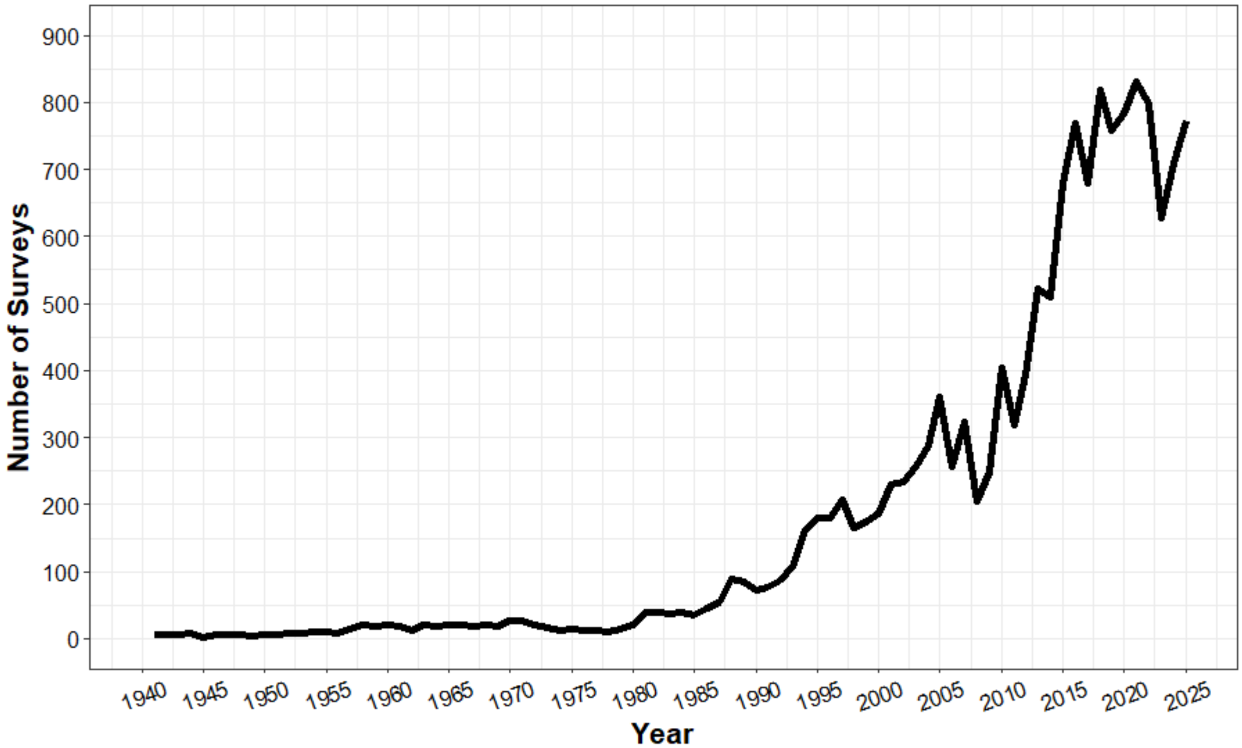


**Figure 3.1**.Sage-grouse lek survey effort in Oregon, 1941–2025.

**Lek Monitoring Protocol**

ODFW's sage-grouse lek monitoring guidelines were updated in this version of the CAAS, based on the Western Association of Fish and Wildlife Agencies (WAFWA) published 'Standards for Collection and Reporting Greater Sage-Grouse Lek Count Data' (hereafter, WAFWA Guidelines; Cook et al. 2022). ODFW's lek monitoring guidelines differ slightly from the published WAFWA Guidelines but some of the language within this section is taken directly from these guidelines where it is applicable to Oregon.

Individual leks are those locations where two or more male sage-grouse congregate to perform their strutting display during at least two breeding seasons within a 10-year period. Potential lek sites must meet this requirement to be added to Oregon's centralized sage-grouse lek database. Once a lek location has been confirmed with two or more displaying males for two years, Oregon requires only one or more displaying males present at the lek location within a 10-year period for the lek to be considered 'Occupied'. In addition to individual lek locations, Oregon identifies lek complexes as those situations where two or more individual leks are closely associated (e.g., majority of males may display at any of the known lek locations within a complex during a given breeding season or across multiple breeding seasons). This association of multiple individual leks can be identified in the field by lek observers, using data from GPS-marked males, or assumed based on geographic proximity. Typically, if two or more individual leks are within 1.6 km (1 mi) of the next closest known lek, these leks are grouped and considered a single lek complex.

Oregon's definition of 'lek complex' is similar to the WAFWA Guidelines definition of 'lek'. Oregon does not use the term lek to describe the collective individual lek locations within lek complexes because ODFW and other Oregon sage-grouse conservation partners are interested in tracking the attendance and spatial distribution of individual leks within lek complexes annually. Importantly, all individual leks within a lek complex must be surveyed on the same morning to avoid biases associated with the intra-season movements of males within a complex. Identifying the individual leks within a lek complex also acts as a more effective communication tool among lek observers to ensure all the closely associated leks within a lek complex are surveyed on the same morning.

Lek counts are used to assess sage-grouse population size and trends; the following protocol must be followed to ensure unbiased estimates:

- Male sage-grouse begin attending leks in early March and often continue through early May. Lek counts should be conducted only between 15 March–30 April each year to coincide with peak female attendance.
- Lek counts must be conducted only from 30 minutes before sunrise to 2 hours after sunrise. Lek counts conducted outside of this window are not included in the data analyses to estimate Oregon's annual sage-grouse abundance (Appendix 2.). Detection probability of males declines significantly beyond 45 minutes post-sunrise, so whenever possible, lek surveys should be completed during this timeframe.
- Lek counts should be conducted during mornings with clear to partly cloudy skies, little to no wind, and no precipitation. Lek counts should not be conducted if weather conditions (i.e., wind gusts >15 mph (24 km/h), rainy or snowy conditions) or disturbance (i.e., humans, livestock, predators, other wildlife, etc.) precludes normal display activities.
- For unbiased estimates of population size and trends, a minimum of 50% of the 'Occupied' or 'Occupied-Pending' lek complexes (see below for definitions) within a geographic scale of interest (i.e., PAC, WMU, BLM District, statewide, etc.) should be counted at least 2 times, annually. Lek complexes should be counted at 7–14-day intervals. If a geographic scale of interest contains <10 active or active pending leks, a minimum of 80% of these leks should be counted at least once annually.
- All known 'Occupied' or 'Occupied-Pending' lek complexes on accessible public or private lands should be surveyed a minimum of every 3 years.
- All known 'Unoccupied' or 'Unoccupied-Pending' lek complexes on accessible public or private lands should be surveyed a minimum of every 6 years, ideally during the peak of a population cycle not during the trough of a population cycle.

*Ground Surveys*

Sage-grouse lek counts should primarily be conducted from the ground when the lek location is accessible. Ground surveys should be conducted by a trained observer viewing the lek through a spotting scope or binoculars from a concealed location, generally >200 m (>656 ft) from the lek to avoid disturbing the sage-grouse. The observer should record survey information (i.e., lek identifier and name, date, time, weather conditions) at the beginning of the survey; data may be recorded electronically or on paper datasheets in the field. The observer should count the sage-grouse on the lek from right to left, or left to right, recording the number of males, females, and sage-grouse of unknown sex, and report each separately. The observer should survey each lek until the maximum male count recorded has remained the same for two or more consecutive counts, and for a minimum of 15 minutes.

*Presence-Absence Checks*
Presence-absence sage-grouse lek checks report lek activity when a lek count cannot be obtained, documenting the lek status as active/detected or not detected during a given breeding season. For example, if an observer visits a known lek location outside of the dawn lek count timeframe or when weather conditions preclude a lek count and the observer detects male sage-grouse at the lek, this lek may be active during the given breeding season and an observer should return on a subsequent morning to conduct a lek count. Additional signs of activity include documentation of fresh sage-grouse droppings, feathers, or tracks. Importantly, if sage-grouse or sage-grouse sign are not observed at a known lek when the lek is visited outside of the lek count timeframe or viewed under conditions that preclude a lek count, the lek should not be reported as 'inactive' during the given breeding season. Rather, the observer should report neither sage-grouse nor sage-grouse sign were detected during the presence-absence lek check.

Although presence-absence checks for activity at sage-grouse leks may provide some useful information (e.g., prioritization for subsequent lek count), the structure of Oregon's centralized sage-grouse lek database precludes the utility of presence-absence checks. Oregon tracks annual lek activity status based on lek counts and does not incorporate presence-absence checks into annual reporting of population status or trend at any geographic scale. Presence-absence lek checks should be collected opportunistically and reported but should not be prioritized over lek counts.

*Aerial Lek Searches*
Systematic aerial sage-grouse lek surveys have been conducted in Oregon since the 1990's, and the majority of known lek locations in Oregon were discovered during these aerial surveys. Aerial lek searches are important for locating previously unknown lek locations and for documenting lek location shifts over time. Aerial lek searches by helicopters (nine seasons) and fixed-wing aircraft equipped with infrared camera technology (one season) were conducted consistently during each sage-grouse breeding season from 2016 through 2025, supported by a cooperative financial assistance agreement between ODFW and BLM. ODFW assessed the utility of aerial infrared lek searches compared to helicopter lek searches and determined lek detection probabilities of the aerial infrared methodology were lower than helicopter surveys. Pending funding availability, helicopter surveys should continue to be used annually to document spatial distribution of sage-grouse leks in Oregon, and supplement data collection on the ground when necessary due to access challenges. Aerial lek searches by helicopter should be prioritized in sage-grouse core habitat/PACs and adjacent low-density habitat based on sage-grouse population trends and status, time since the last aerial lek search of an area, and in response to emerging needs (e.g., survey an area prior to proposed large-scale development or to assess population responses to wildfires).

Aerial lek searches should be conducted between March 25–April 15 to coincide with peak female attendance at leks. Like lek counts, aerial lek searches should be conducted only from 30 minutes before sunrise to 2 hours after sunrise, and only during mornings with clear to partly cloudy skies, little to no wind, and no precipitation. Aerial lek searches should not be conducted if weather conditions preclude normal display activities.

Helicopters should generally fly transects at 0.4 km (0.25 mi) intervals, oriented in a north to south direction, to maximize detection probability of displaying male sage-grouse under optimal early-morning light conditions. Helicopters should maintain speeds around 50 mph and stay 15–30 m (50–100 ft) above ground level while conducting lek searches. When displaying male sage-grouse are spotted from the helicopter, observers should obtain a male count by hovering far from the lek to avoid flushing the birds. If the birds flush prior to detection or during the aerial count, observers should record the maximum number of males identified and the total number of sage-grouse counted as the birds flush. Observers should record whether male sage-grouse were initially observed displaying or if the birds were only observed after they were flushed. Observers should obtain and record an accurate GPS location of any sage-grouse discovered during the aerial lek search, and these locations should be subsequently surveyed on the ground for verification of any potential new leks.

*Aerial Lek Counts*
Aerial sage-grouse lek counts are infrequently necessary to supplement ground counts when survey effort goals are not being met within a given geographic scale of interest (e.g., PAC-scale). Several PACs contain areas with significant access challenges, such as remote terrain with poor road conditions [i.e., Louse Canyon PAC] or a high proportion of private lands preventing access [i.e., Cow Valley PAC], and may require occasional aerial survey effort to meet lek survey goals. Aerial lek counts may be conducted using helicopters, or fixed-wing aircraft equipped with infrared imaging and high-definition camera technology. Although aerial lek counts have lower detection probabilities than ground lek counts, aerial counts are often able to record the number of displaying males at a given lek location under ideal conditions when following established survey protocols. Counts of displaying males may be recorded in the database while counts of flushed birds from the aircraft should only be used document the lek status as active/detected during a given breeding season.

Aerial lek counts should be conducted between 15 March–30 April. Like ground lek counts, aerial lek counts should only be conducted from 30 minutes before sunrise to 2 hours after sunrise, and only during mornings with clear to partly cloudy skies, little to no wind, and no precipitation. Aerial lek counts should not be conducted if weather conditions preclude normal display activities. Due to the lower detection probabilities of aerial lek counts, a minimum of 2 visits to each lek monitored using this method should be required to enter these count data into the lek database.

Use of aerial drone technology for conducting wildlife surveys is expected to increase during the next decade. As noted in the WAFWA Guidelines, drones have not been widely used for counting sage-grouse leks to date, and there is currently limited research evaluating the efficacy of drones for conducting lek surveys or evaluating the potential disturbances of drones to breeding sage-grouse at leks. ODFW may utilize drones for conducting aerial lek counts in the future, depending on the cost and effectiveness of this method. Refer to the WAFWA Guidelines Drone Protocol for specific details on the recommended methodology for use of drones to conduct sage-grouse lek surveys.

**Oregon's Centralized Lek Database**

ODFW is responsible for managing and maintaining Oregon's centralized sage-grouse lek database, which contains all known lek locations and associated lek surveys from 1941–present. Oregon's sage-grouse lek complexes are uniquely named and identified by a 6-character code, where the first 2 characters reflect the county where the lek complex is located, and the last 4 digits represent the unique lek complex number. For example, MA0100 identifies lek complex number 100 in Malheur County. Similarly, individual leks within lek complexes are uniquely named and identified. For example, MA0100-02, named Wilson Creek #2, is the second of four individual leks within the MA0100 lek complex. Each individual lek has a unique name and alpha-numeric identifier, even if there is only one individual lek within a lek complex. For example, lek HA0050-01, named Steens South Loop, is the only individual lek within the HA0050 lek complex. Lek locations are spatially identified as the GPS location of the activity center of the individual lek. Lek locations can shift over time as the activity center shifts. Generally, the GPS location is updated in the database when a shift in the activity center is > 0.1 mi (0.16 km). To avoid confusion among leks with a similar name (e.g., "Dry Creek"), observers should record and reference the alpha-numeric identifier when referring to leks and reporting results from lek surveys.

Following each sage-grouse lek survey season, lek counts are entered into the database by the ODFW Districts in sage-grouse habitat, and by the ODFW Sage-Grouse Conservation Coordinator. The ODFW Upland Gamebird Coordinator and Sage-Grouse Conservation Coordinator are responsible for QA/QC of annual lek survey data, where each lek survey record is reviewed and must be approved before being added into the database. This level of review is necessary to prevent data entry errors and potentially erroneous counts which could bias annual population estimates.

**Lek Conservation Status Definitions**

State wildlife agencies typically refer to sage-grouse leks by 'activity status' or 'conservation status' based on the number of males observed during lek surveys over a given period of time. In Oregon, sage-grouse leks and lek complexes are referred to by their 'conservation status' and classified as occupied, occupied-pending, unoccupied-pending, unoccupied, or historic (Table 3.1). This classification system is used to guide sage-grouse lek monitoring (see Appendix 1), where accessible occupied and occupied-pending leks must be surveyed at least every 3 years, unoccupied and unoccupied-pending leks must be surveyed at least once every 6 years, and historic leks are not prioritized for recurring survey effort. Sage-grouse habitat management is often guided by lek conservation statuses, where performing habitat restoration and uplift treatments in closer proximity to occupied or occupied-pending leks is encouraged for the greatest benefit to local sage-grouse breeding populations. Additionally, BLM's 2025 Oregon Approved Sage-Grouse Resource Management Plan (RMP) Amendment frequently refers to lek activity (conservation) statuses to guide Management Objectives and Direction throughout the RMP (US DOI BLM 2025). Lastly, lek conservation statuses are used by ODFW's Greater Sage-Grouse Habitat Mitigation Program (see Section 7) and are referenced in Oregon Administrative Rule 660-023-0115, which is specific to Greater Sage-Grouse as a Goal 5 Resource per Oregon's Department of Land Conservation and Development (DLCD).

Previous versions of the CAAS (Hagen 2011*a*) defined conservation statuses for leks based on the number of displaying males observed at a given lek and the survey history of the lek over a 7-year period. The WAFWA Guidelines (Cook et al. 2022) define a range-wide standard for lek conservation, or activity, statuses. In this version of the CAAS, ODFW updated Oregon's lek conservation status definitions to be in close alignment with the published WAFWA range-wide standard definitions. However, a significant portion of Oregon leks (317 leks, ~25% at the time of assessment), did not fall within an activity status category under the WAFWA definitions. Therefore, ODFW updated the lek conservation status definitions to include all possible lek situations, regardless of survey history. ODFW's updated lek conservation status definitions are described and provided in a table, below.

<u>Occupied lek</u>**:**
A lek with one or more males counted during two or more years within the last 10 years.

<u>Occupied-Pending lek</u>**:**
A lek with one or more males counted during one year within the last 10 years, ***or***
A lek with no surveys within the last 10 years but with one or more males counted during the most recent lek survey conducted prior to the most recent 10-year period.

<u>Unoccupied-Pending lek</u>**:**
A lek with only one survey within the last 10 years where the survey recorded no males and the lek had at least one male recorded during a survey between 11 to 20 years ago, ***or***
A lek with no surveys within the last 10 years but with at least one male recorded during a survey between 11 to 20 years ago, ***or***
A lek with no surveys within the last 20 years but with at least one male recorded during a survey between 21 to 30 years ago.

<u>Unoccupied lek</u>**:**
A lek with at least two surveys within the last 10 years where all surveys have recorded no males, and which had at least one male recorded during a survey between 11 to 20 years ago.

<u>Historic lek</u>**:**
A lek with at least one survey within the last 20 years where all surveys have recorded 0 males, ***or***
A lek at which no males have been recorded within the last 30 years regardless of survey status.

**Table 3.1**. Definitions of Oregon’s Sage-Grouse Lek Conservation Statuses, 2025.

<table>
<tr><th>Lek Status</th><th>10-year survey period</th><th>11–20-year period</th><th>21–30-year period</th></tr>
<tr><td>Occupied</td><td>1+ males counted during 2+ surveys</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Occupied-Pending</td><td>1+ males counted during 1 survey</td><td colspan="2"></td></tr>
<tr><td>No surveys conducted</td><td colspan="2">1+ males counted during the most recent survey</td></tr>
<tr><td rowspan="3">Unoccupied-Pending</td><td>Only 1 survey with 0 males observed</td><td>And 1+ males counted during 1+ surveys</td><td></td></tr>
<tr><td>No surveys conducted</td><td>And 1+ males counted during 1+ surveys</td><td></td></tr>
<tr><td>No surveys conducted</td><td>And no surveys conducted</td><td>And 1+ males counted during 1+ surveys</td></tr>
<tr><td>Unoccupied</td><td>0 males counted during 2+ surveys</td><td>And 1+ males counted during 1+ surveys</td><td></td></tr>
<tr><td rowspan="2">Historic</td><td colspan="2">0 males counted during 1+ surveys</td><td></td></tr>
<tr><td colspan="3">0 males recorded within the last 30 years</td></tr>
</table>

### Sharing Sage-Grouse Data

Sage-grouse are designated as a sensitive species under OAR 635-100-0040. Oregon’s sage-grouse data are classified as Level 2B ‘Limited’ (specific); therefore, these data are not publicly available. Under House Bill 2841 (2019), ODFW may refuse to disclose or may disclose with a Data-Sharing and Non-Disclosure Agreement (DSNDA) certain biological data, including habitat, location, or population information of threatened and endangered (T&E) species, species being considered for T&E listing, and species designated as sensitive under OAR 635-100-0040. When ODFW receives a Public Records Request for sage-grouse data, the Department may provide the requested data by establishing a DSNDA with the requesting entity, after first consulting with the Wildlife Division Administrator to ensure the data request is appropriate and data sharing is warranted. DSNDAs are generally less than two years in length but may be amended to accommodate longer time periods, given the entity met all terms and conditions of the DSNDA during the initial phase of the agreement. In addition to DSNDAs, ODFW has longstanding MOUs in place with partnering federal agencies (BLM and USFWS) which fund and assist with lek monitoring in Oregon, and updated lek data are provided to these two federal partners, annually.

### Adopt-a-Lek Volunteer Program

ODFW does not provide the public with sage-grouse lek locations, as these data are considered classified and are not publicly available. However, the Department provides an opportunity for the public to view sage-grouse leks and participate in the annual lek monitoring effort through ODFW's Adopt-a-Lek (AAL) Volunteer Program. The AAL Program was established in 2006 to increase lek survey effort in remote areas of Malheur County. Citizen scientists enrolled in the AAL Program are trained and coordinated by the Adopt-a-Lek Program Coordinator, a short-term contracted position which has been grant-funded by the National Fish and Wildlife Foundation, the USFWS, and the Oregon Wildlife Foundation. The AAL Program Coordinator works closely with the ODFW Sage-Grouse Conservation Coordinator prior to and during the lek season to ensure the volunteer-collected lek data is of high-quality and meets the standard to be added to Oregon's statewide lek database. The AAL Program Coordinator is the primary point of contact for AAL Volunteers and is responsible for developing the annual AAL Volunteer lek survey schedule, training volunteers on the lek survey protocol, corresponding with volunteers on their lek assignments, and providing maps and information on lek access in these remote areas. Additionally, the AAL Program Coordinator collects and collates all the volunteer survey data, travel reimbursement forms, and volunteer hours, and develops a final report at the end of the survey season. The AAL Program has grown in popularity during recent years, enrolling nearly 50 volunteers annually, including volunteers from Oregon, Idaho, and Washington. During 2014–2025, volunteers with the AAL Program surveyed 46–121 (mean = 83) individual leks and conducted 67–295 (mean = 182) lek surveys, annually. The AAL Program contributes over 20% of Oregon's annual lek survey effort.

**Oregon Sage-Grouse Population Assessment**

*Historical Conditions*

Sage-grouse once occupied most sagebrush habitats east of the Cascade Mountains in Oregon (Figure 3.2). European settlement and conversion of sagebrush steppe habitats into agricultural production led to extirpation of sage-grouse from the Columbia Basin by the early 1900s (Batterson and Morse 1948). Monitoring of sage-grouse populations did not begin until after this early range contraction, so estimates of sage-grouse abundance at the time of European settlement are unavailable. However, there is strong evidence Oregon's sage-grouse populations have declined since the early 1900s (Crawford and Lutz 1985, Willis et al. 1993, Connelly and Braun 1997, Connelly et al. 2004), although the magnitude of this decline between 1900–1980 is not possible to estimate with certainty. Considering the various anthropogenic influences on sage-grouse populations in Oregon during the early to mid-1900s and the lack of reliable sage-grouse population data before 1980, sage-grouse population estimates prior to 1980 should be interpreted with caution.

Historically, several anthropogenically-driven factors likely affected Oregon's sage-grouse populations both locally and statewide during the early to mid-20$^{th}$ century (Hagen 2005, 2011*a*). Intensive predator control programs of the mid-1900s may have artificially increased gamebird populations, including sage-grouse, as these programs culled an estimated 10,000 coyotes annually in Oregon, with approximately 60% of annual take from counties within sage-grouse range (Hagen 2011*a*). Additionally, widespread use of Compound 1080 (synthesized sodium fluoroacetate) and strychnine by private and governmental predator control programs likely contributed to the mortality of a significant number of predators both directly and indirectly in the mid-1900s (Connolly et al. 2004). However, there were several factors which likely had a negative impact on sage-grouse populations during this timeframe as well. Historic overgrazing and landscape-scale sagebrush eradication programs (e.g., Vale Project; Willis et al. 1993) impacted large areas of intact sage-grouse habitat and likely had lasting indirect impacts on local sage-grouse populations beyond the direct impacts of habitat destruction and degradation. Additionally, estimated sage-grouse harvest was >5,000 birds during several hunting seasons between 1951–1974, which likely had an additive effect on mortality, despite larger population sizes (Hagen 2011*a*). Lastly, populations of avian predators, specifically common ravens, were much lower in the Great Basin in the early to mid-20th century compared to present-day populations (Coates et al. 2020). Common ravens are heavily subsidized by humans for food resources and nesting structures, resulting in artificial population increases during the past 80 years, and likely impacting sage-grouse reproductive success in these areas where raven populations are significantly higher than historical levels (Coates et al. 2020, 2021*c*).

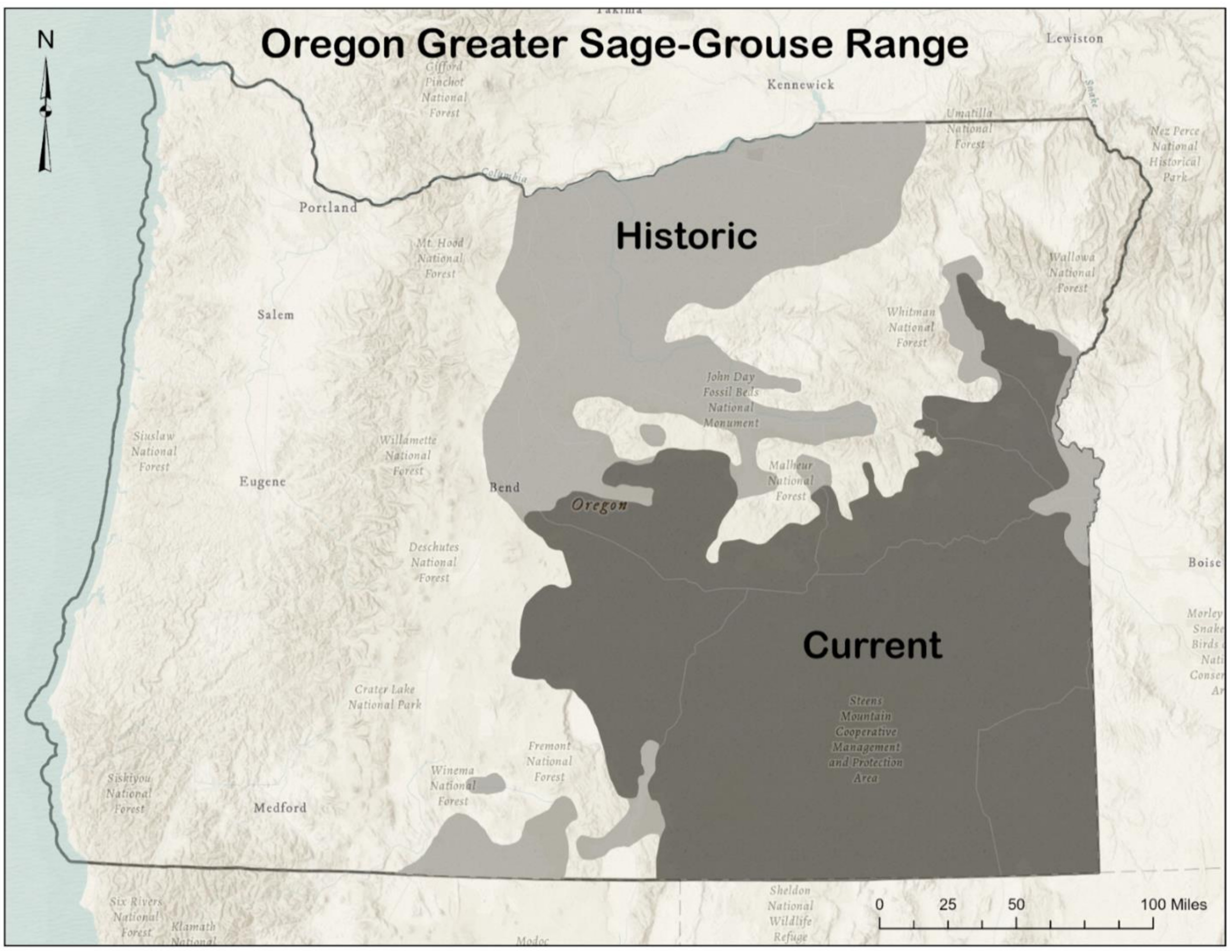


**Figure 3.2.** Historic and current range of greater sage-grouse in Oregon, 2025. The historic range is derived from Schroeder et al. (2004), and the current range is derived from the Oregon sage-grouse core and low-density habitat map (updated 2023) developed by ODFW in cooperation with local, state, and federal partners.

*Current Population Assessment*

Five subpopulations of sage-grouse were previously defined in the state of Oregon, the Central Oregon, Western Great Basin, Northern Great Basin, Klamath, and Baker subpopulations (Hagen 2011*a*, Garton et al. 2011). Oregon's Klamath subpopulation has been considered extirpated since the late-20th century. Recent range-wide analyses of greater sage-grouse genetic structure have provided new data to suggest Oregon's extant sage-grouse subpopulations are more well-connected than previously assumed (Oyler-McCance et al. 2022). These analyses identified two unique greater sage-grouse populations range-wide, an eastern and a western population, split approximately along the Continental Divide (Figure 3.3). Oregon's sage-grouse populations are characterized as the Great Basin subpopulation of the western population, and Oregon's populations are genetically similar the sage-grouse populations of southwestern Idaho and northern and central Nevada. However, these analyses also revealed further genetic differentiation of the Central Oregon subpopulation from the larger Great Basin subpopulation (Figure 3.3). The genetic analyses of Oyler-McCance et al. 2022 support dispersal and movement data gathered from GPS-marked sage-grouse in Oregon over the past 15 years, emphasizing the importance of maintaining connectivity among Oregon's core sage-grouse habitats to continue facilitating connectivity among these sage-grouse populations.

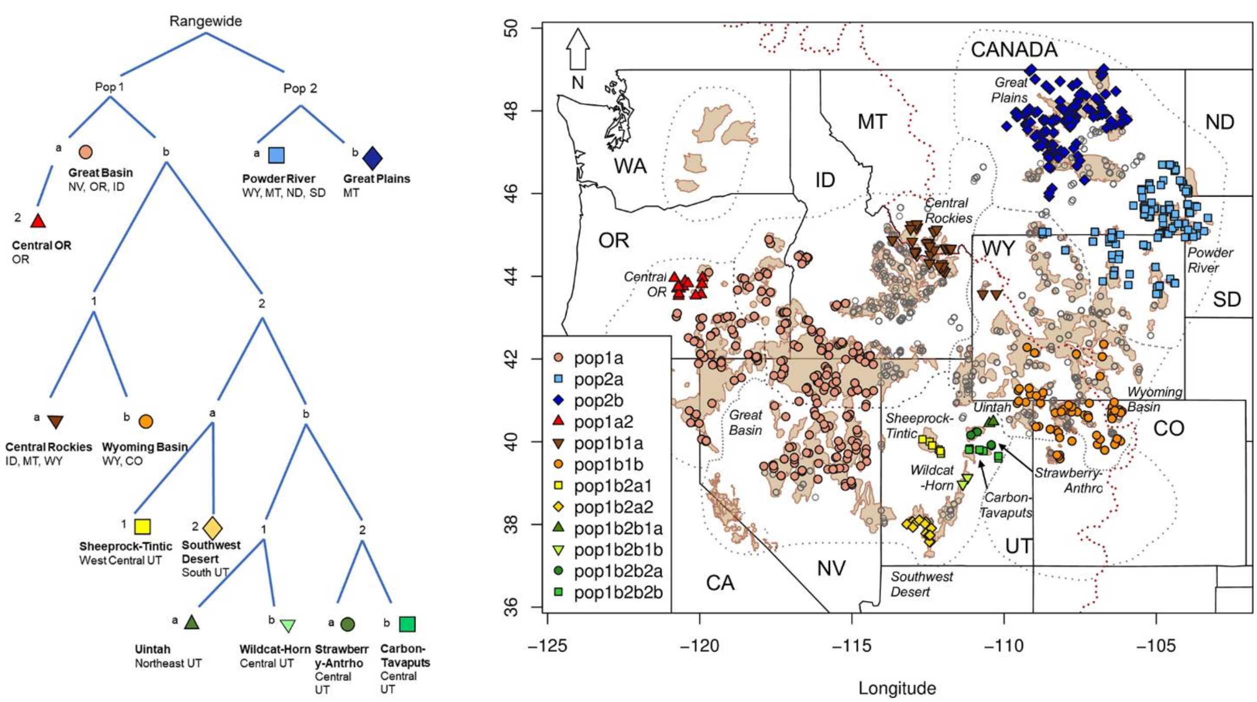


**Figure 3.3.** Geographic subdivisions of greater sage-grouse populations in the western United States, based on the range wide analysis of genetic structure conducted by Oyler-McCance et al. 2022.

The most recent range-wide sage-grouse population assessment analyzed and reported population rates of change (λ) at multiple spatial and temporal scales and found sage-grouse populations in the Great Basin have experienced -78.6%, -61.4%, and -46.4% declines in abundance during 1967–2021, 1985–2021, and 2002–2021, respectively (Coates et al. 2021*b*). Within the current extant range of sage-grouse in Oregon, spring population indices based on lek monitoring show a significant decline in sage-grouse abundance during the past 50 years (Hagen 2005, Hagen 2011*a*, Vold 2024), which matches the overall population trend in the Great Basin during this timeframe. Oregon's sage-grouse populations have oscillated on 6–12-year cycles, driven largely by annual precipitation patterns. Despite periods of oscillation, both the peaks and nadirs (troughs) of these population cycles have continued to decline since Oregon's earliest sage-grouse population estimate (1980), with the overall lowest statewide population estimate recorded in 2019 (Figure 3.4).

Statewide monitoring of Oregon's sage-grouse leks began to improve in the 1980s, resulting in increased sample sizes of annual lek attendance data within most of Oregon's sage-grouse range. ODFW's standardized lek monitoring protocol was established in 1996, improving the quality and quantity of lek survey data and ensuring data consistency across the range. This plan considers 1980–present as the relevant timeframe to assess sage-grouse populations in Oregon. Data collected during 1980–2003 were used to set ODFW's original sage-grouse population and habitat objectives for Oregon (Hagen 2005), establishing 2003 as the baseline year which Oregon's sage-grouse population and habitat metrics should be assessed. Previous versions of the CAAS estimated Oregon sage-grouse population sizes using the best available methodologies at these times, as described in Hagen (2005, 2011*a*). The more recent estimation methodology of Hagen (2011*a*) was used to estimate Oregon's sage-grouse breeding and post-breeding population sizes during 2011–2024 (Vold 2024). Oregon sage-grouse population summary reports were published by ODFW annually from 2016–2024 and are archived on ODFW's sage-grouse webpage.

During 2024–25, ODFW contracted with USGS to develop an updated sage-grouse population model for Oregon, which is detailed in Appendix 2. The updated model accounts for imperfect detection of male sage-grouse attending leks and provides unbiased estimates of sage-grouse abundance at large (Oregon range-wide) and small (PAC) spatial scales. Although the sage-grouse population trend estimates from the two models are similar, point estimates of population size are different. Three key differences between the previous and new population models explain these discrepancies:

1) Oregon's previous population model did not account for the specific variables influencing detection of sage-grouse during a given survey (i.e., time since sunrise), within a survey season (i.e., Julian date), or the interannual variation in detection probability among years, each of which the new model estimates and incorporates. Without accounting for variability in detection probability of males attending known leks, the old model functioned as an index of minimum population size, where the new model estimates true abundance of sage-grouse.

2) The new population model incorporates variability in male attendance to leks within a breeding season to account for the 'non-lek mating' cohort, which the previous population model

did not consider. Within the new model, the age-weighted average male lek attendance rate was defined as 0.58 (95% CI = 0.46–0.71; Wann et al. 2019).

3) The new model adjusts for presently unknown leks on the landscape by considering those previously unknown leks added to the database annually, 1940–2024.

The new model requires repeated counts (e.g., multiple surveys per season) to provide unbiased estimates of sage-grouse abundance, and the years from 2017–present have a sufficient sample size of repeat surveys to run the model. To estimate the statewide sage-grouse population abundance during the period from 1980–2016, we fit a general linear model using the 2017–present population estimates from the new model and the previous model [New Model Estimates ~ 1 + Previous Model Estimates; p = 0.0456, r-sq. = 0.513]. We used the results of this general linear model to predict the updated statewide population abundance during 1980–2016 from the population estimates of the previous model during this timeframe (Figure 3.4).

In 2024, Oregon's statewide population estimate was 41,875 sage-grouse (95% CI = 38,980–54,634), which was down from an estimated 50,869 sage-grouse (95% CI = 41,794–66,238) in 2017, the most recent peak in the population cycle, and down -20.7% from the 2003 baseline population. The most recent population nadir (trough) was evident in 2019 when the statewide population was estimated at 30,644 sage-grouse, the lowest statewide estimate during the 45-year period from 1980–2024. Population trends (i.e., changes in population size) should be interpreted from complete population cycles using the population nadirs (Coates et al. 2021*b*). During the 1980–2024 timeframe, five nadirs exist in Oregon's statewide sage-grouse population cycles, in years 1985, 1996, 2008, 2013, and 2019. Comparing trends for each of these four previous population nadirs to the most recent nadir, Oregon's sage-grouse populations, statewide, have declined by -36.2% (1985–2019), -21.0% (1996–2019), -10.7% (2008–2019), and -13.2% (2013–2019).

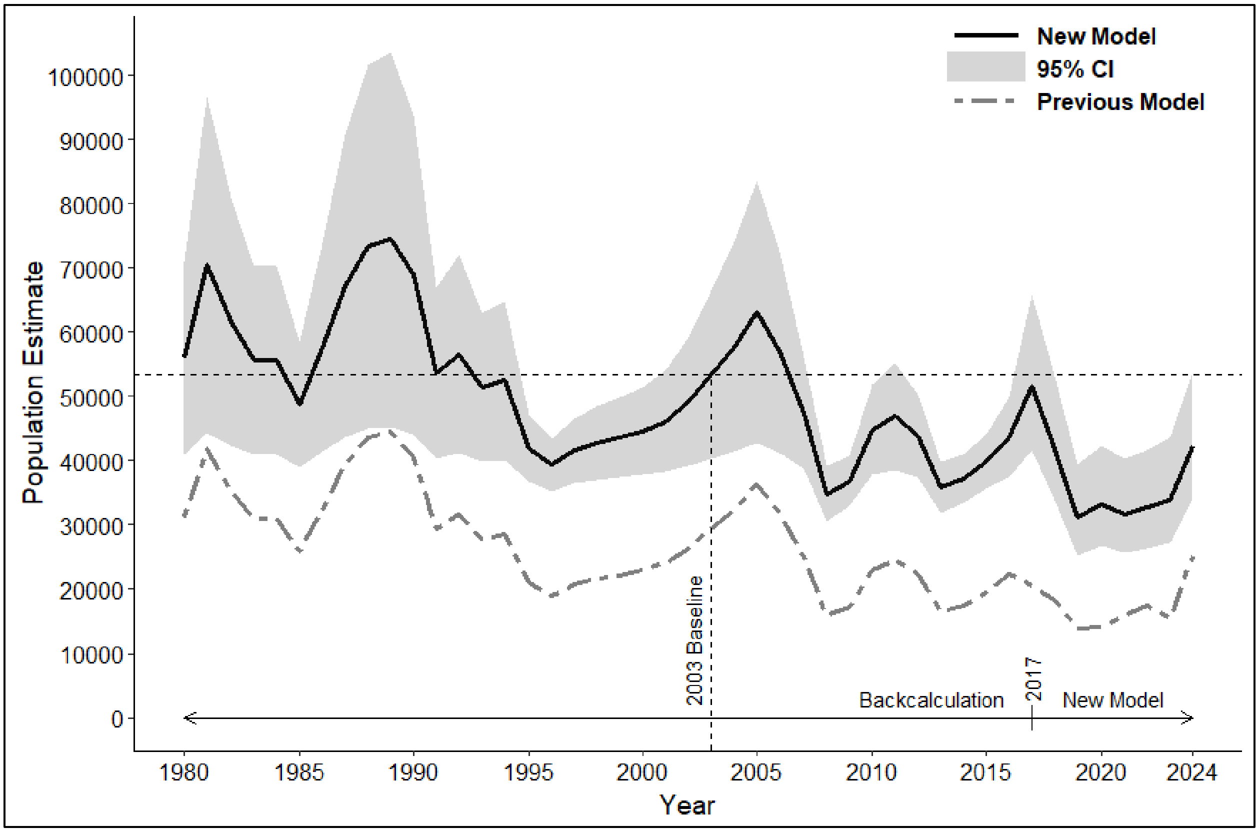


**Figure 3.4.** Oregon sage-grouse statewide population estimates, 1980–2024. The solid black line represents the population estimates from the new model, and the dashed gray line represents the population estimates from the previous model. The population goal is set at the 2003 level, representing the baseline for Oregon's statewide sage-grouse population size.

### Population Goal and Management Objectives

Like other managed game species (e.g., mule deer), ODFW has little or no ability to increase sage-grouse population sizes at large or small scales in Oregon, as sage-grouse demographic performance and resulting population abundances are directly related to climactic and habitat conditions which are beyond the purview of ODFW. However, as the state agency responsible for managing sage-grouse populations, ODFW maintains population management objectives for the species. In accordance with the Wildlife Policy (ORS 496.012), the Department's primary population management goal is to restore, maintain, and enhance populations of greater sage-grouse such that multiple uses of populations and their habitats can continue. In previous versions of the CAAS (Hagen 2005, 2011*a*), ODFW set an overall statewide population goal (i.e., abundance) and population goals for each BLM District with sage-grouse habitat, using 2003 as the baseline reference year. Previously, the statewide population goal was approximately 30,000 birds. Considering sage-grouse populations in Oregon generally oscillate over 6–12-year cycles, the Department will continue to manage sage-grouse to maintain or enhance their statewide distribution and abundance oscillating around the 2003 spring breeding population level, approximately 53,000 birds, over the next 50 years. Additionally, recent research has changed the paradigm for monitoring trends of sage-grouse populations, where these populations should be considered at the scale of full population cycles (Coates et al. 2021*b*). As such, ODFW's management objectives for Oregon's sage-grouse populations should be based upon the nadir-to-nadir population trends. Therefore, the Department's management objectives for Oregon's sage-grouse populations are to maintain stable or increasing population trends statewide and at the PAC-scale, where trends are assessed between nadirs (troughs) of the population cycles.

**PAC-Scale Trend Analysis**

Maintaining a statewide population goal is important to help assess the overall status of Oregon's sage-grouse populations compared to their status in the recent past. However, habitat management for sage-grouse occurs at much finer scales, often at the PAC-scale or smaller (Figure 3.5). In Oregon, PACs are 'core' sage-grouse habitats which have been geographically divided to represent biologically significant management units for Oregon's sage-grouse populations (see Section 4). Note, the 2011 CAAS referred to these biologically significant units as 'core areas'. While the updated CAAS uses and discusses core sage-grouse habitats, PACs are used in place of the term 'core areas' when referring to Oregon's sage-grouse management units.

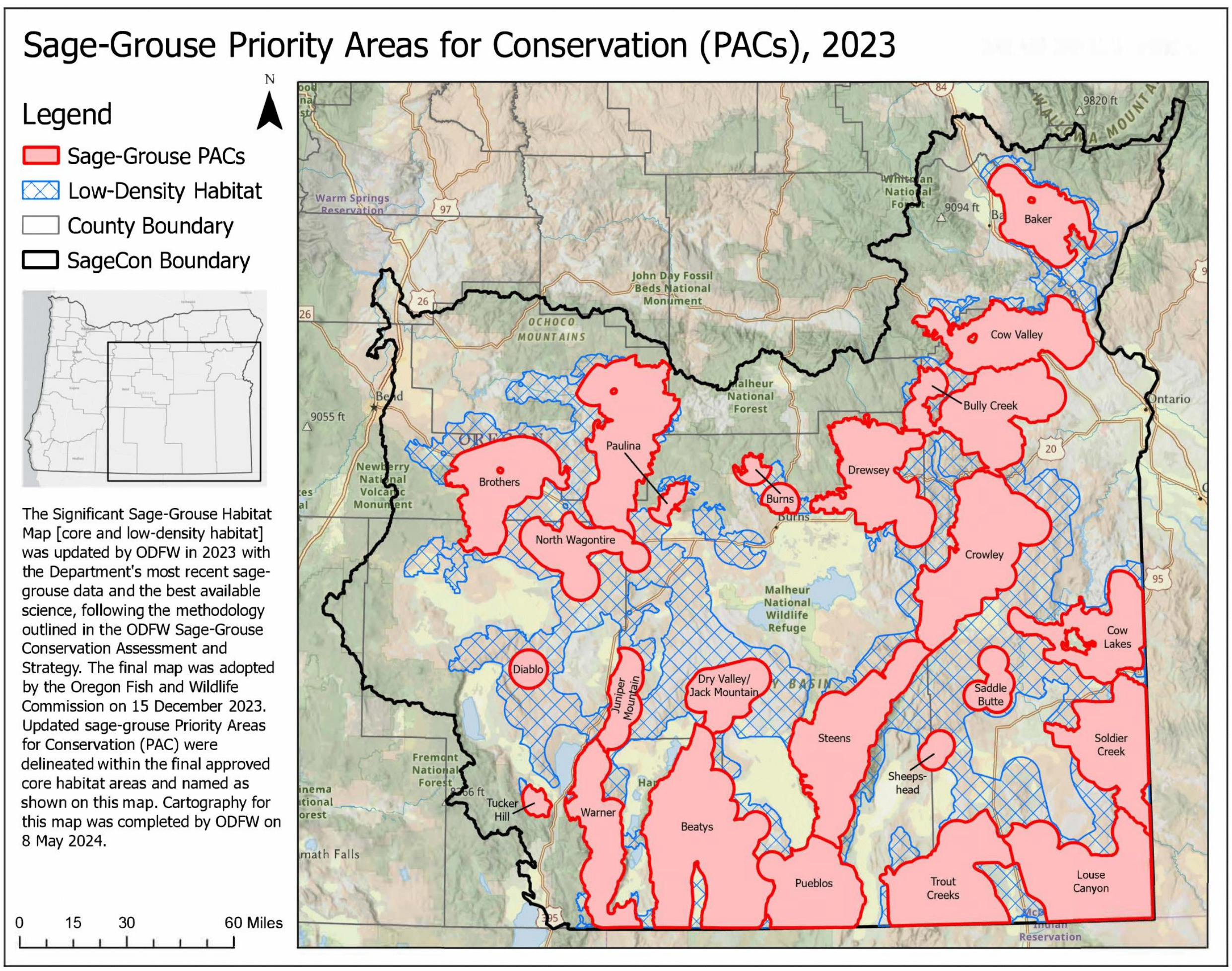


**Figure 3.5.** Oregon Sage-Grouse Priority Areas for Conservation (PACs), 2023.

In Oregon, sage-grouse population estimates prior to 2017 are unavailable at these finer scales but estimates of relative sage-grouse abundance are available through the USGS Rangewide Population Monitoring Framework (Ver. 4, Coates et al. 2025). Nadir-to-nadir sage-grouse population trends were calculated for each PAC during three time periods, short-term, mid-term, and long-term, using sage-grouse abundance data from Coates et al. 2025 (Ver. 4). Within PACs, the estimated Abundance Indexes for all leks were summed each year, 1980–2024. The short-term trend is defined as the most recent single oscillation of Oregon's sage-grouse population cycle, the mid-term trend is defined as the most recent 2 or 3 oscillations of the population cycle, and the long-term trend is defined as the most recent 4 or 5 oscillations of Oregon's sage-grouse population cycle. The specific time periods for population cycle oscillations of each PAC are described below and are viewable in the associated figures, below.

**Table 3.2.** Sage-grouse population trends within each of Oregon's Sage-Grouse Priority Areas for Conservation (PACs), 1980–2024.

| | Trend | | |
|---|---|---|---|
| **Priority Area for Conservation (PAC)** | **Short-term[1]** (1 oscillation, ~2012–2020) | **Mid-term[2]** (2 or 3 oscillations, ~2000–2020) | **Long-term[3]** (4 or 5 oscillations, ~1985–2020) |
| Baker | -22.8% | -79.6% | -81.5% |
| Beatys | -17.4% | -72.7% | -76.5% |
| Brothers | -58.7% | -53.5% | -80.9% |
| Bully Creek | -31.1% | -35.8% | -20.9% |
| Burns | -32.7% | -49.8% | -66.9% |
| Cow Lakes | -29.6% | -68.7% | -85.4% |
| Cow Valley | +1.9% | -21.8% | -3.3% |
| Crowley | -16.9% | -38.1% | -55.5% |
| Diablo | -42.6% | -60.2% | -71.8% |
| Drewsey | -31.3% | -43.7% | -73.3% |
| Dry Valley – Jack Mountain | 0.0% | -72.2% | -85.7% |
| Juniper Mountain | +10.1% | +16.6% | -32.4% |
| Louse Canyon | -21.2% | -25.0% | -56.8% |
| North Wagontire | -33.7% | -49.5% | -73.7% |
| Paulina | -15.4% | -51.7% | -60.3% |
| Pueblos | -5.8% | -34.1% | -53.2% |
| Saddle Butte | +55.5% | +40.5% | 0.0% |
| Sheepshead | -24.2% | -48.2% | -65.4% |
| Soldier Creek | -37.9% | -52.2% | -68.3% |
| Steens | -10.2% | -10.4% | -45.4% |
| Trout Creeks | +7.1% | -18.4% | -49.3% |
| Tucker Hill | -8.4% | +3.6% | +61.1% |
| Warner | -14.4% | -46.2% | -65.5% |
| Areas outside of PACs | -63.1% | -75.6% | -87.1% |

[1] The short-term trend is defined as the most recent single oscillation of Oregon's sage-grouse population cycle. Generally, the short-term trend considers the 2012–2020 time period. The trend is calculated among nadirs of the population cycle for each PAC independently, so some variability exists in the defined time periods. Refer to the section below for the specific population nadirs and associated time period oscillations for each PAC.
[2] The mid-term trend is defined as the most recent 2 or 3 oscillations of Oregon's sage-grouse population cycle. Generally, the mid-term trend considers the 2000–2020 time period.
[3] The long-term trend is defined as the most recent 4 or 5 oscillations of Oregon's sage-grouse population cycle. Generally, the long-term trend considers the 1985–2020 time period.

*Baker PAC*

The Baker PAC is an area of approximately 115,262 ha (284,815 ac), located mostly within Baker County; a small portion of the PAC falls within Union County. Sixty-two leks are known to exist in the Baker PAC. As of 2024, the conservation statuses of these leks were: 16 Occupied, 5 Occupied-Pending, 3 Unoccupied-Pending, 17 Unoccupied, and 21 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1993, 2001, 2014, and 2023 (Figure 3.6A). The Baker PAC experienced an increasing population trend during the period of 1993–2001, and declining trends during all other periods (Figure 3.6B). The short-term population trend (1 oscillation) was -22.8% during 2014–2023, the mid-term population trend (2 oscillations) was -79.6% during 2001–2023, and the long-term population trend (4 oscillations) was -81.5% during 1985–2023 (Table 3.2).

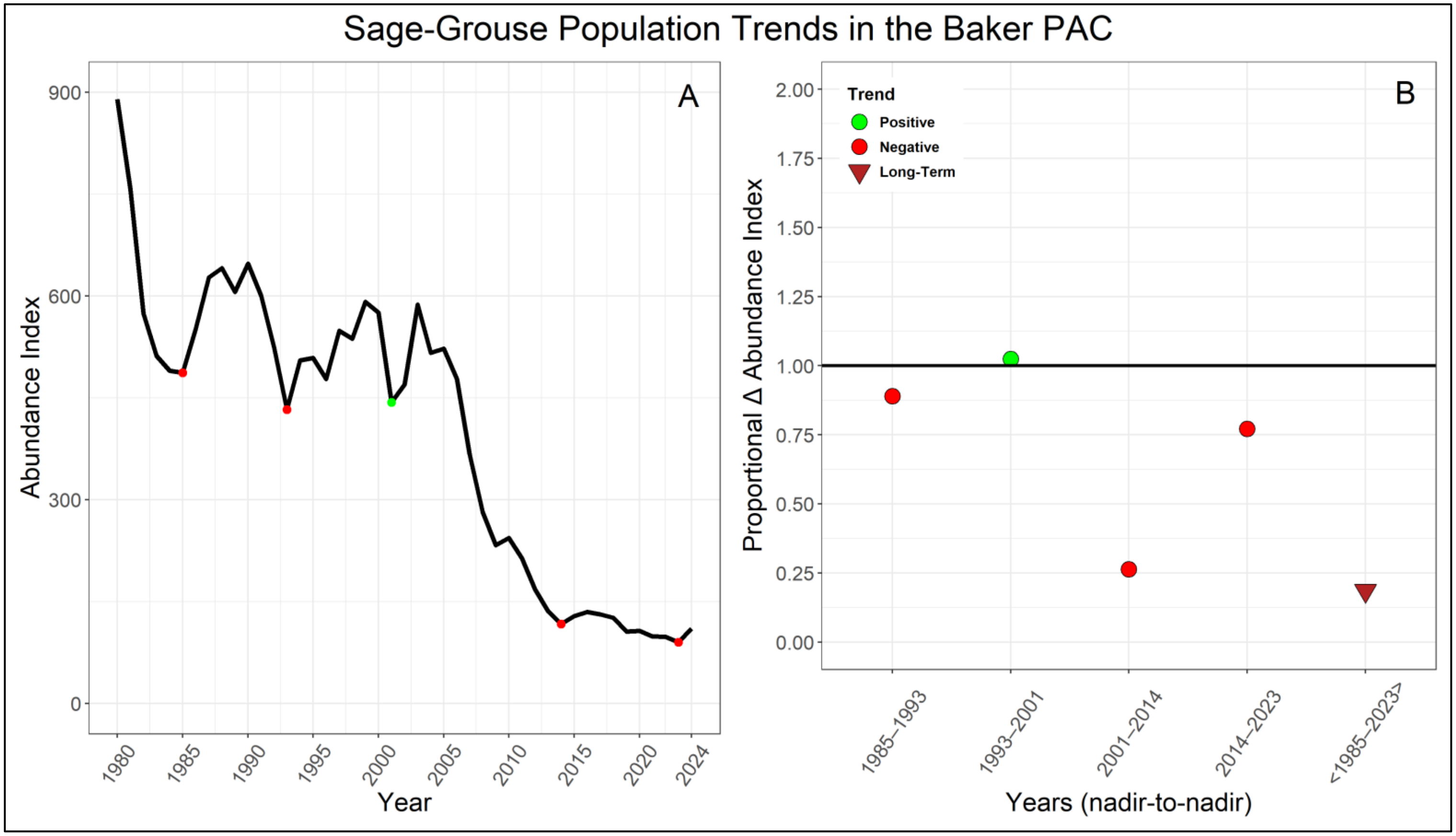


**Figure 3.6.** Sage-grouse population trends in the Baker PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Beatys PAC*

The Beatys PAC is an area of approximately 337,541 ha (834,073 ac), located within Lake County and Harney County, and contains 165 known leks. As of 2024, the conservation statuses of these leks were: 81 Occupied, 25 Occupied-Pending, 18 Unoccupied, and 41 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2013, and 2019 (Figure 3.7A). The Beatys PAC experienced an increasing population trend during the period of 1996–2002, and declining trends during all other periods (Figure 3.7B). The short-term population trend (1 oscillation) was -17.4% during 2013–2019, the mid-term population trend (2 oscillations) was -72.7% during 2002–2019, and the long-term population trend (4 oscillations) was -76.5% during 1985–2019 (Table 3.2).

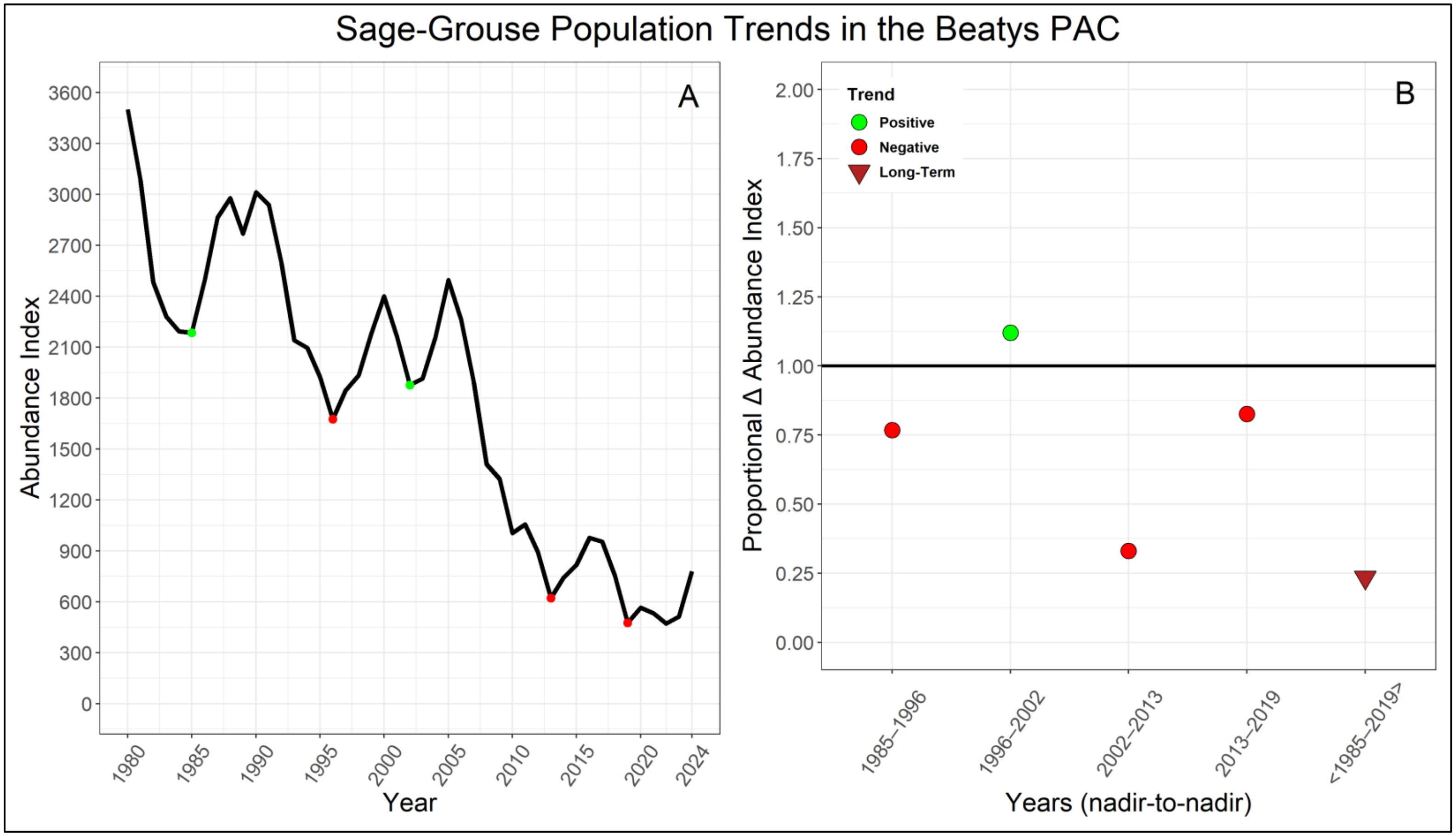


**Figure 3.7.** Sage-grouse population trends in the Beatys PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Brothers PAC*

The Brothers PAC is an area of approximately 156,589 ha (386,936 ac), located mostly within Deschutes County; a portion of the PAC falls within Crook County and Lake County. Fifty leks are known to exist in the Brothers PAC. As of 2024, the conservation statuses of these leks were: 30 Occupied, 2 Occupied-Pending, 9 Unoccupied, and 9 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2003, 2009, and 2019 (Figure 3.8A). The Brothers PAC experienced an increasing population trend during the period of 2003–2009, and declining trends during all other periods (Figure 3.8B). The short-term population trend (1 oscillation) was -58.7% during 2009–2019, the mid-term population trend (2 oscillations) was -53.5% during 2003–2019, and the long-term population trend (4 oscillations) was -80.9% during 1985–2019 (Table 3.2).

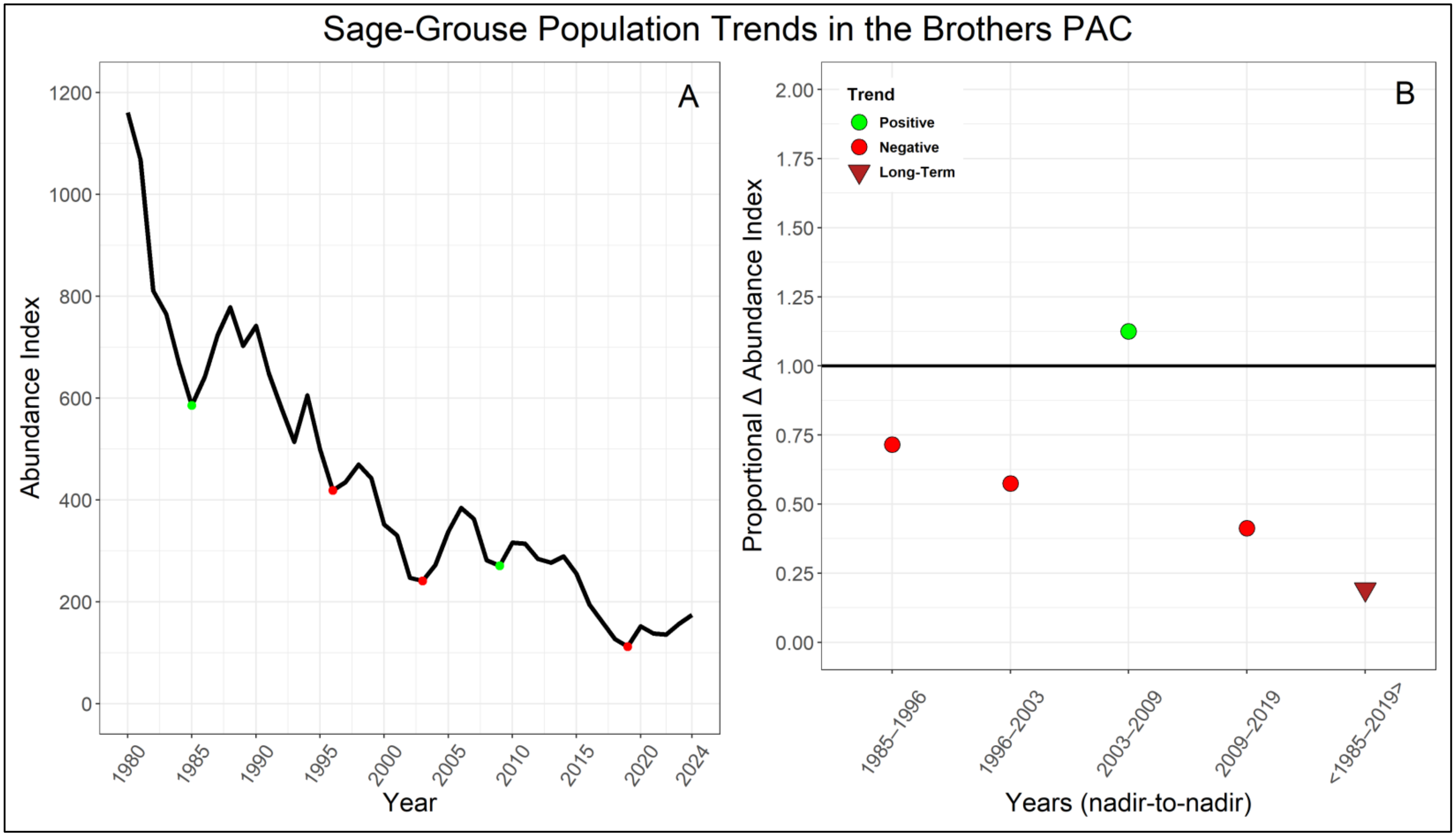


**Figure 3.8.** Sage-grouse population trends in the Brothers PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Bully Creek PAC*

The Bully Creek PAC is an area of approximately 201,538 ha (498,006 ac), located mostly within Malheur County; small portions of the PAC fall within Grant County and Harney County. Fifty-six leks are known to exist in the Bully Creek PAC. As of 2024, the conservation statuses of these leks were: 36 Occupied, 4 Occupied-Pending, 6 Unoccupied, and 10 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1993, 2001, 2008, 2014, and 2020 (Figure 3.9A). The Bully Creek PAC experienced an increasing population trend during the periods of 1993–2001 and 2001–2009, and declining trends during all other periods (Figure 3.9B). The short-term population trend (1 oscillation) was -31.1% during 2014–2020, the mid-term population trend (3 oscillations) was -35.8% during 2001–2020, and the long-term population trend (5 oscillations) was -20.9% during 1985–2020 (Table 3.2).

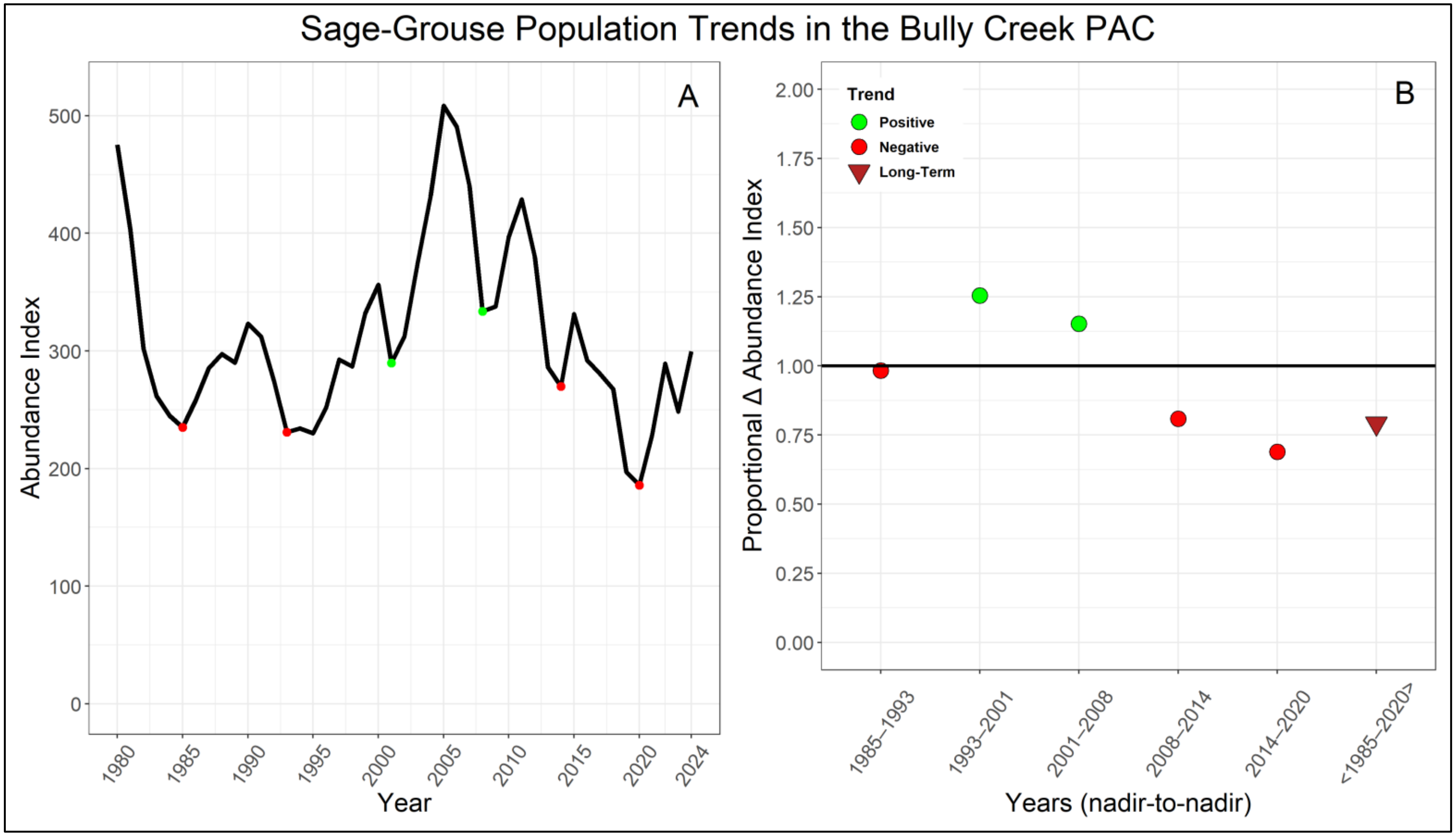


**Figure 3.9.** Sage-grouse population trends in the Bully Creek PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Burns PAC*

The Burns PAC is an area of approximately 31,098 ha (76,845 ac), located within Harney County, and contains 5 known leks. As of 2024, the conservation statuses of these leks were: 3 Occupied and 2 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2009, 2014, and 2020 (Figure 3.10A). The Burns PAC experienced an increasing population trend during the period of 1996–2002, and declining trends during all other periods (Figure 3.10B). The short-term population trend (1 oscillation) was -32.7% during 2014–2020, the mid-term population trend (3 oscillations) was -49.8% during 2002–2020, and the long-term population trend (5 oscillations) was -66.9% during 1985–2020 (Table 3.2).

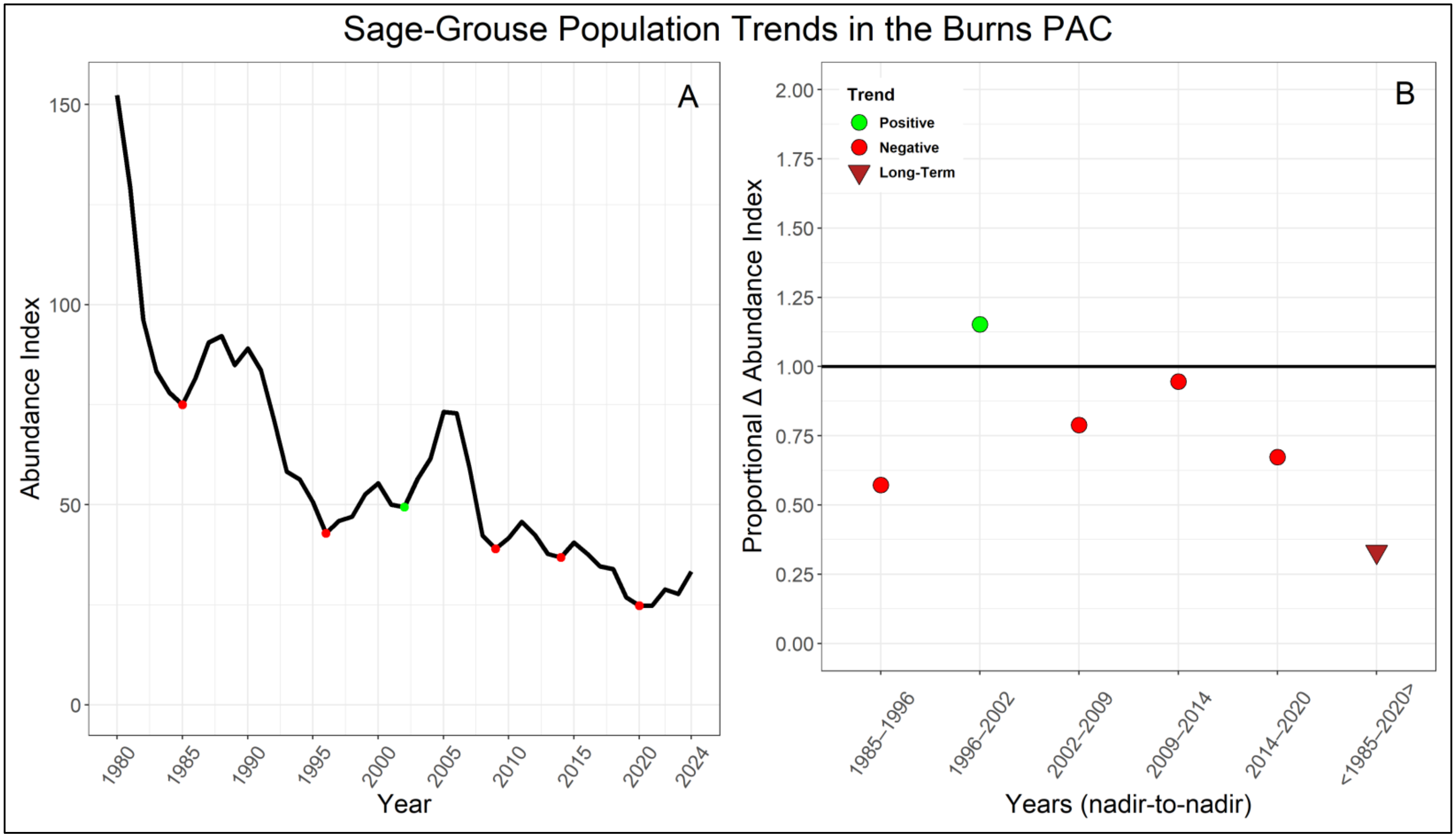


**Figure 3.10.** Sage-grouse population trends in the Burns PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Cow Lakes PAC*

The Cow Lakes PAC is an area of approximately 141,890 ha (350,613 ac), located within Malheur County, and contains 63 known leks. As of 2024, the conservation statuses of these leks were: 26 Occupied, 7 Occupied-Pending, 15 Unoccupied, and 15 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1995, 2001, 2008, 2013, and 2022 (Figure 3.11A). The Cow Lakes PAC experienced an increasing population trend during the period of 1995–2001, and declining trends during all other periods (Figure 3.11B). The short-term population trend (1 oscillation) was -29.6% during 2013–2022, the mid-term population trend (3 oscillations) was -68.7% during 2001–2022, and the long-term population trend (5 oscillations) was -85.4% during 1985–2022 (Table 3.2).

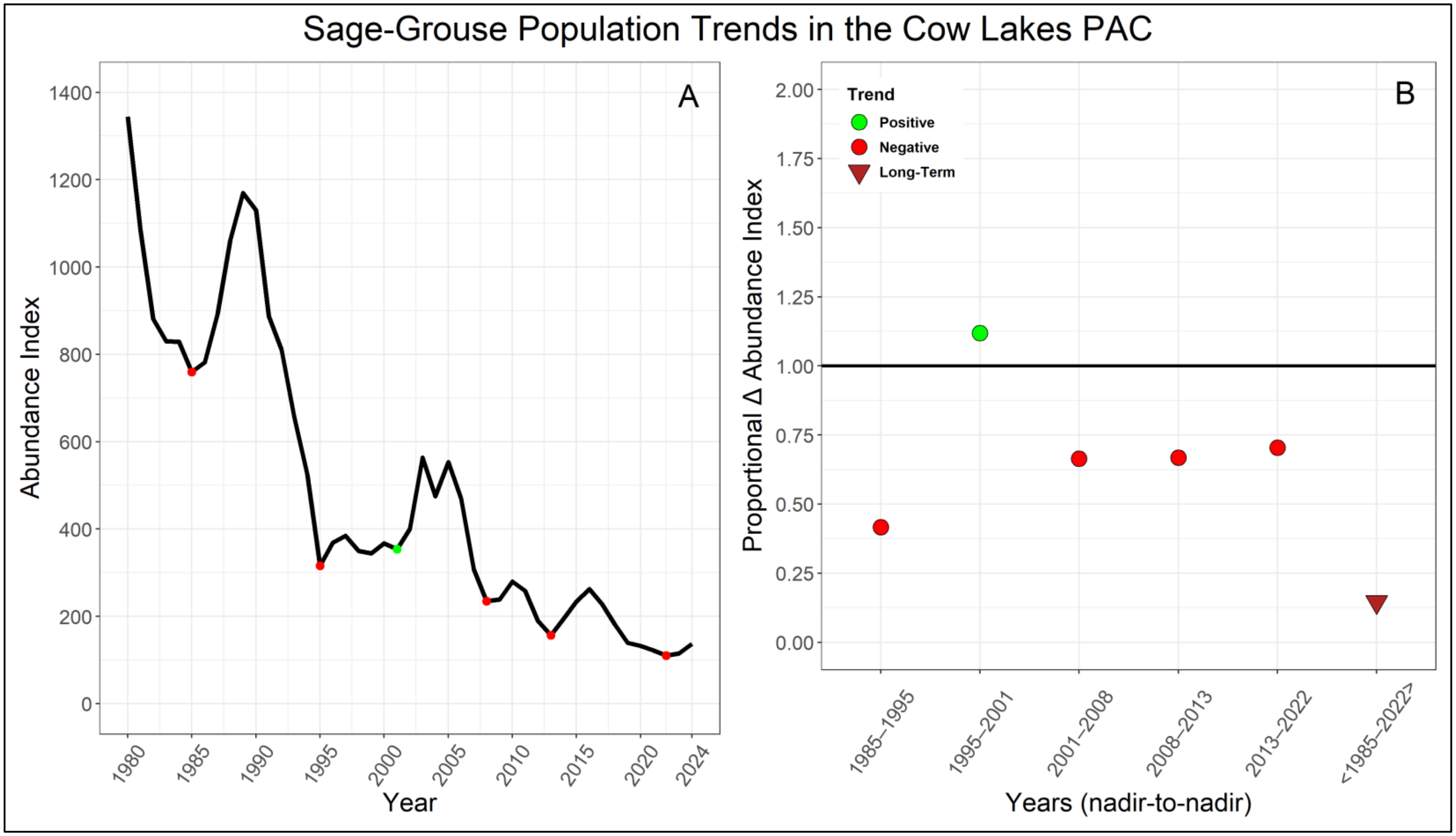


**Figure 3.11.** Sage-grouse population trends in the Cow Lakes PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Cow Valley PAC*

The Cow Valley PAC is an area of approximately 164,097 ha (405,489 ac), located within northern Malheur County and southern Baker County, and contains 59 known leks. As of 2024, the conservation statuses of these leks were: 35 Occupied, 7 Occupied-Pending, 2 Unoccupied, and 15 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2001, 2008, 2014, and 2019 (Figure 3.12A). The Cow Valley PAC experienced an increasing population trend during the periods of 1996–2001, 2001–2008, and 2014–2019, and declining trends during all other periods (Figure 3.12B). The short-term population trend (1 oscillation) was +1.9% during 2014–2019, the mid-term population trend (3 oscillations) was -21.8% during 2001–2019, and the long-term population trend (5 oscillations) was -3.3% during 1985–2019 (Table 3.2).

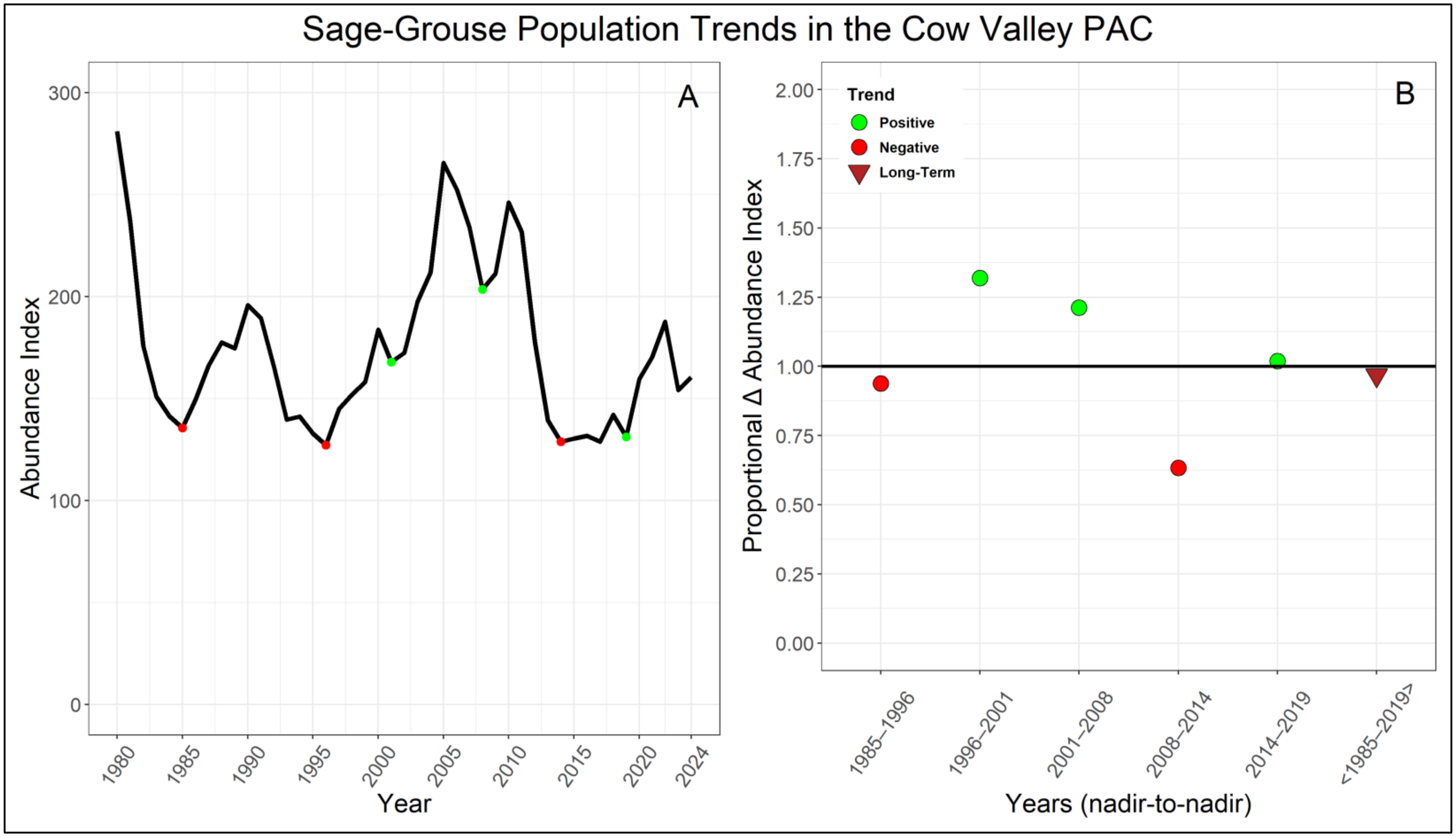


**Figure 3.12.** Sage-grouse population trends in the Cow Valley PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Crowley PAC*

The Crowley PAC is an area of approximately 238,168 ha (588,519 ac), located mostly within Malheur County; a small portion of the PAC falls within Harney County. Fifty-three leks are known to exist in the Crowley PAC. As of 2024, the conservation statuses of these leks were: 32 Occupied, 4 Occupied-Pending, 5 Unoccupied, and 12 Historic leks. Nadirs of the population cycle occurred during the years 1984, 1996, 2002, 2008, 2013, and 2021 (Figure 3.13A). The Crowley PAC experienced an increasing population trend during the period of 2008–2013, and declining trends during all other periods (Figure 3.13B). The short-term population trend (1 oscillation) was -16.9% during 2013–2021, the mid-term population trend (3 oscillations) was -38.1% during 2002–2021, and the long-term population trend (5 oscillations) was -55.5% during 1984–2021 (Table 3.2).

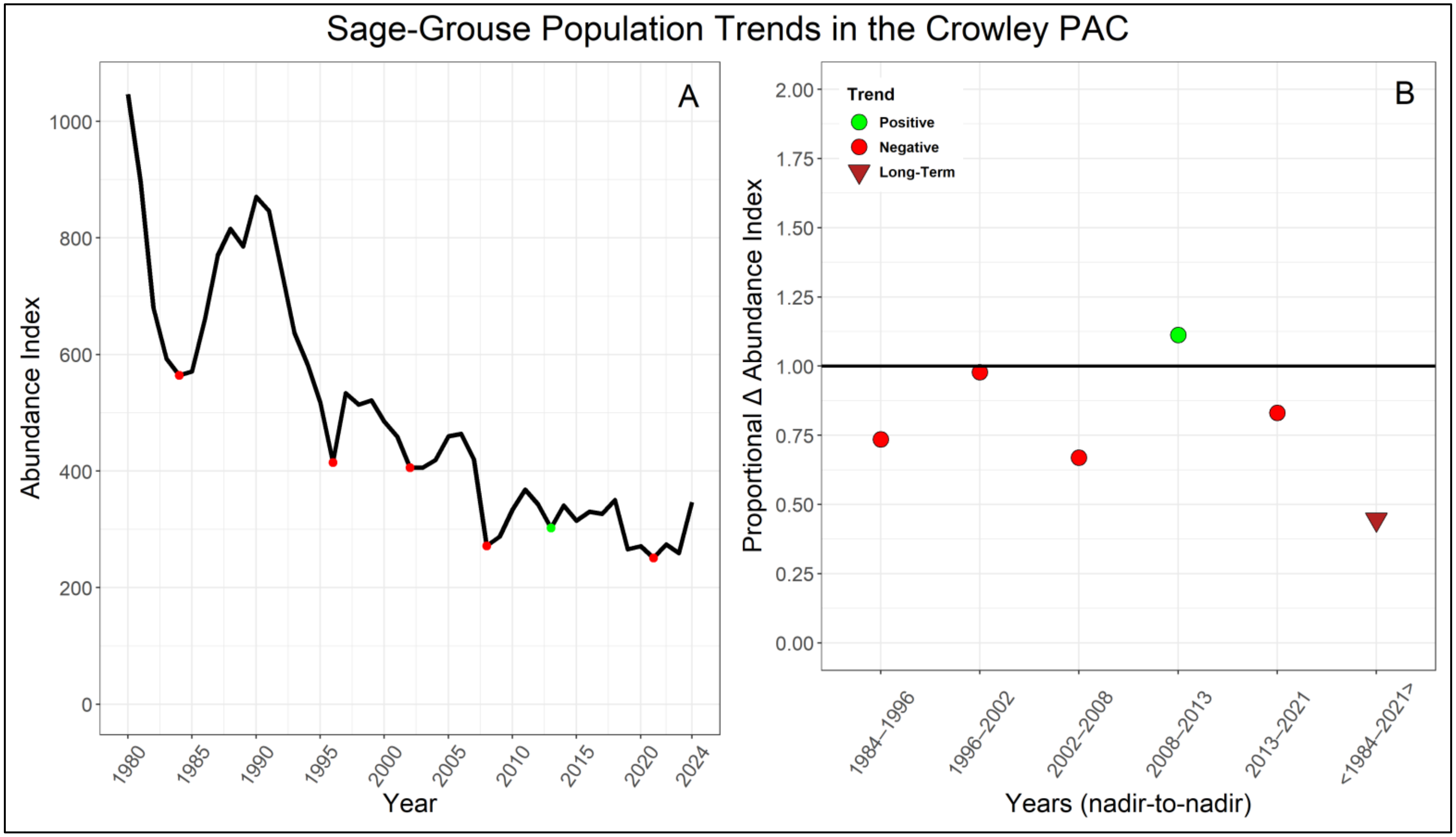


**Figure 3.13**.Sage-grouse population trends in the Crowley PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Diablo PAC*

The Diablo PAC is an area of approximately 22,852 (56,469 ac), located within Lake County, and contains 3 known leks. As of 2024, the conservation statuses of these leks were: 1 Occupied and 2 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2009, 2013, and 2021 (Figure 3.14A). The Diablo PAC experienced an increasing population trend during the period of 1996–2002, and declining trends during all other periods (Figure 3.14B). The short-term population trend (1 oscillation) was -42.6% during 2013–2021, the mid-term population trend (3 oscillations) was -60.2% during 2002–2021, and the long-term population trend (5 oscillations) was -71.8% during 1985–2021 (Table 3.2).

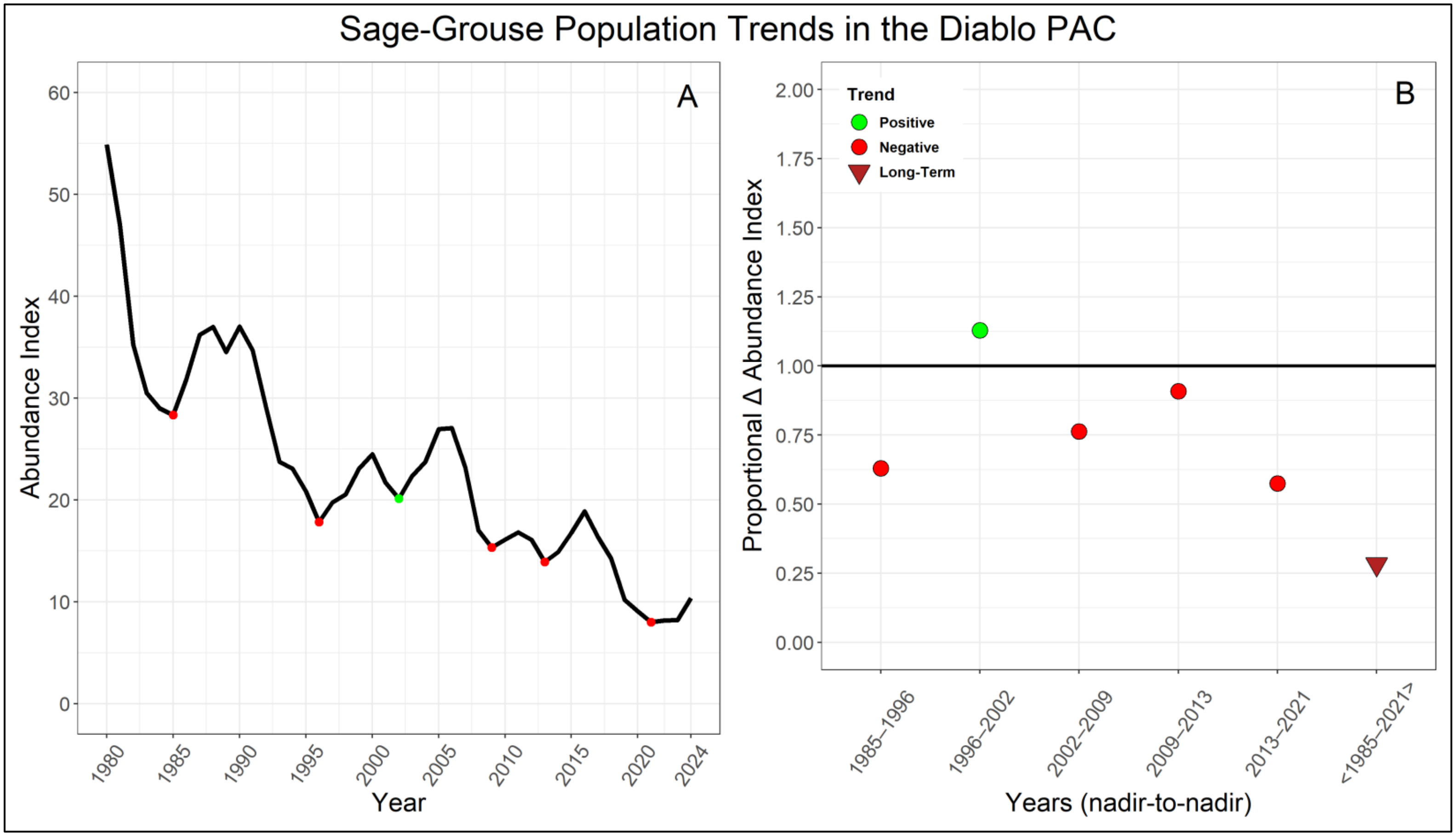


**Figure 3.14.** Sage-grouse population trends in the Diablo PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Drewsey PAC*

The Drewsey PAC is an area of approximately 178,879 ha (442,015 ac), located mostly within Harney County; a small portion of the PAC falls within Malheur County. Fifty-one leks are known to exist in the Drewsey PAC. As of 2024, the conservation statuses of these leks were: 36 Occupied, 3 Occupied-Pending, 4 Unoccupied, and 8 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2009, 2013, and 2019 (Figure 3.15A). The Drewsey PAC experienced an increasing population trend during the period of 2002–2009, and declining trends during all other periods (Figure 13.15B). The short-term population trend (1 oscillation) was -31.3% during 2013–2019, the mid-term population trend (3 oscillations) was -43.7% during 2002–2019, and the long-term population trend (5 oscillations) was -73.3% during 1985–2019 (Table 3.2).

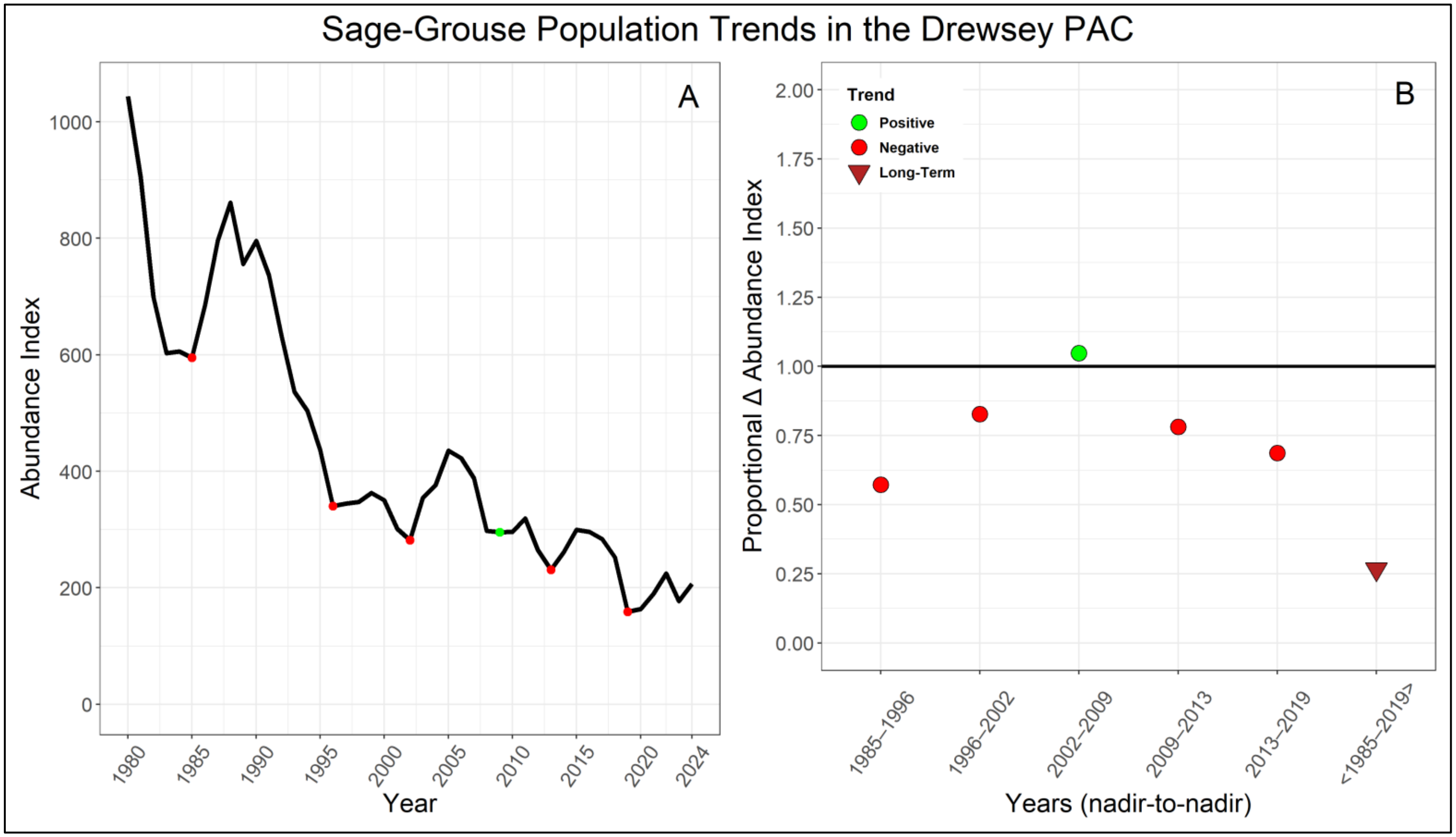


**Figure 3.15.** Sage-grouse population trends in the Drewsey PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Dry Valley – Jack Mountain PAC*

The Dry Valley – Jack Mountain PAC is an area of approximately 80,749 ha (199,532 ac), located within Harney County, and contains 12 known leks. As of 2024, the conservation statuses of these leks were: 5 Occupied, 1 Occupied-Pending, 1 Unoccupied, and 5 Historic leks. Nadirs of the population cycle occurred during years 1966, 1974, 1984, 1996, 2002, 2009, 2015, and 2019 (Figure 3.16A). The Dry Valley – Jack Mountain PAC experienced an increasing population trend during the period of 1996–2002, and declining trends during all other periods (Figure 3.16B). The short-term population trend (1 oscillation) was stable (0.0%) during 2015–2019, the mid-term population trend (3 oscillations) was -71.2% during 2002–2019, and the long-term population trend (5 oscillations) was -85.7% during 1984–2019 (Table 3.2).

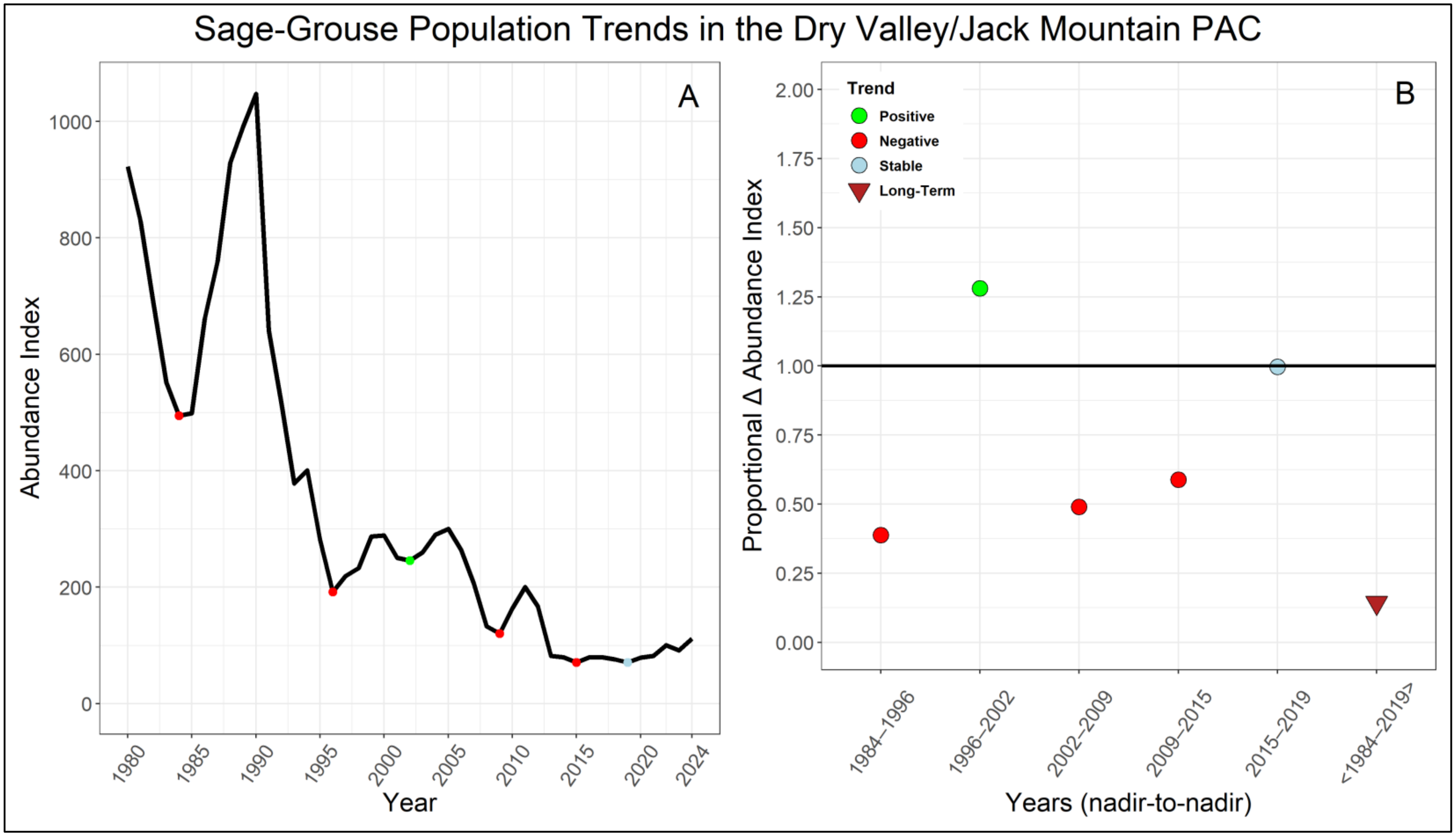


**Figure 3.16.** Sage-grouse population trends in the Dry Valley – Jack Mountain PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Juniper Mountain PAC*

The Juniper Mountain PAC is an area of approximately 55,493 ha (137,125 ac), located within Harney County and Lake County, and contains 11 known leks. As of 2024, the conservation statuses of these leks were: 4 Occupied, 1 Occupied-Pending, and 6 Historic leks. Nadirs of the population cycle occurred during the years 1984, 1996, 2009, 2013, and 2019 (Figure 3.17A). The Juniper Mountain PAC experienced an increasing population trend during the periods of 1996–2009 and 2013–2019, and declining trends during all other periods (Figure 3.17B). The short-term population trend (1 oscillation) was +10.1% during 2013–2019, the mid-term population trend (3 oscillations) was +16.6% during 1996–2019, and the long-term population trend (4 oscillations) was -32.4% during 1984–2019 (Table 3.2).

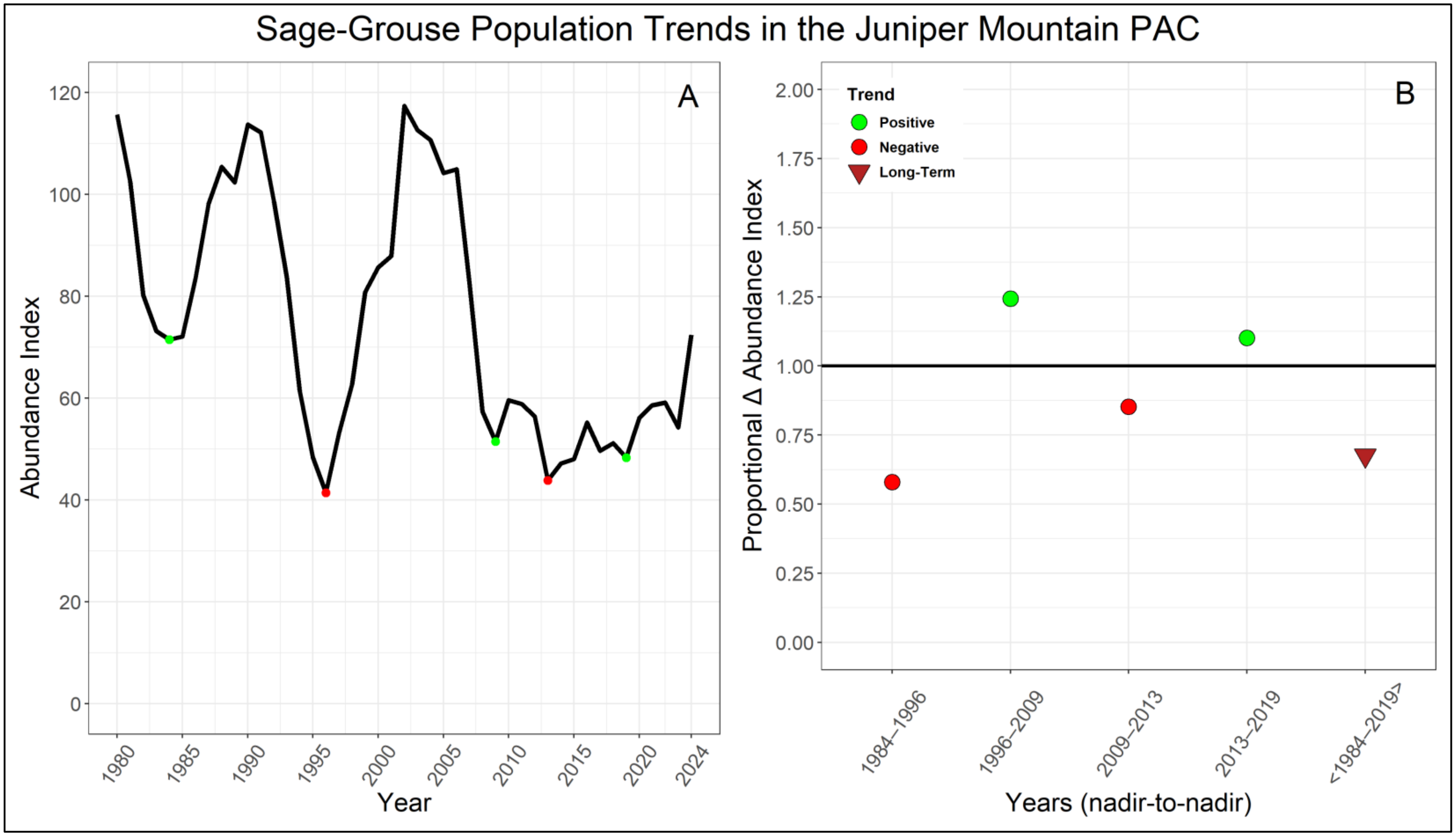


**Figure 3.17.** Sage-grouse population trends in the Juniper Mountain PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Louse Canyon PAC*

The Louse Canyon PAC is an area of approximately 222,584 ha (550,012 ac), located within Malheur County, and contains 61 known leks. As of 2024, the conservation statuses of these leks were: 25 Occupied, 15 Occupied-Pending, 10 Unoccupied, and 11 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2014, and 2019 (Figure 3.18A). The Louse Canyon PAC experienced declining trends during all time periods (Figure 3.18B). The short-term population trend (1 oscillation) was -21.2% during 2014–2019, the mid-term population trend (2 oscillations) was -25.0% during 1996–2019, and the long-term population trend (3 oscillations) was -56.8% during 1985–2019 (Table 3.2). Note, unlike most PACs, the abundance data do not suggest the Louse Canyon PAC experienced a population nadir during the 2000–2010 period.

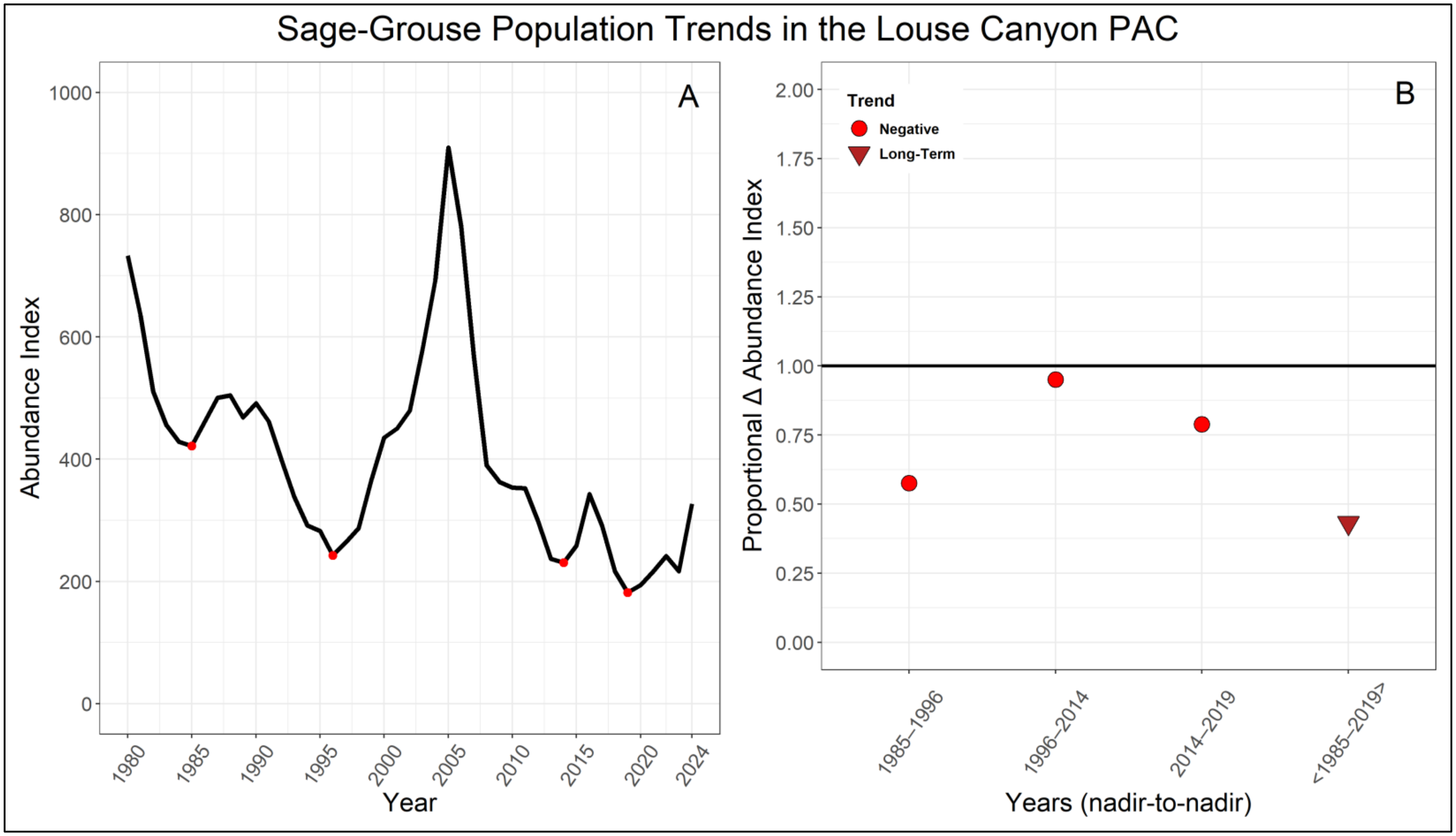


**Figure 3.18.** Sage-grouse population trends in the Louse Canyon PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*North Wagontire PAC*

The North Wagontire PAC is an area of approximately 110,676 ha (273,484 ac), located mostly within Lake County; a portion of the PAC falls within Deschutes County and Harney County. Nineteen leks are known to exist in the North Wagontire PAC. As of 2024, the conservation statuses of these leks were: 10 Occupied, 1 Occupied-Pending, 1 Unoccupied, and 7 Historic leks. Nadirs of the population cycle occurred during the years 1993, 2002, 2013, and 2023 (Figure 3.19A). The North Wagontire PAC experienced declining population trends during all time periods (Figure 3.19B). The short-term population trend (1 oscillation) was -33.7% during 2013–2023, the mid-term population trend (2 oscillations) was -49.5% during 2002–2023, and the long-term population trend (4 oscillations) was -73.7% during 1985–2023 (Table 3.2).

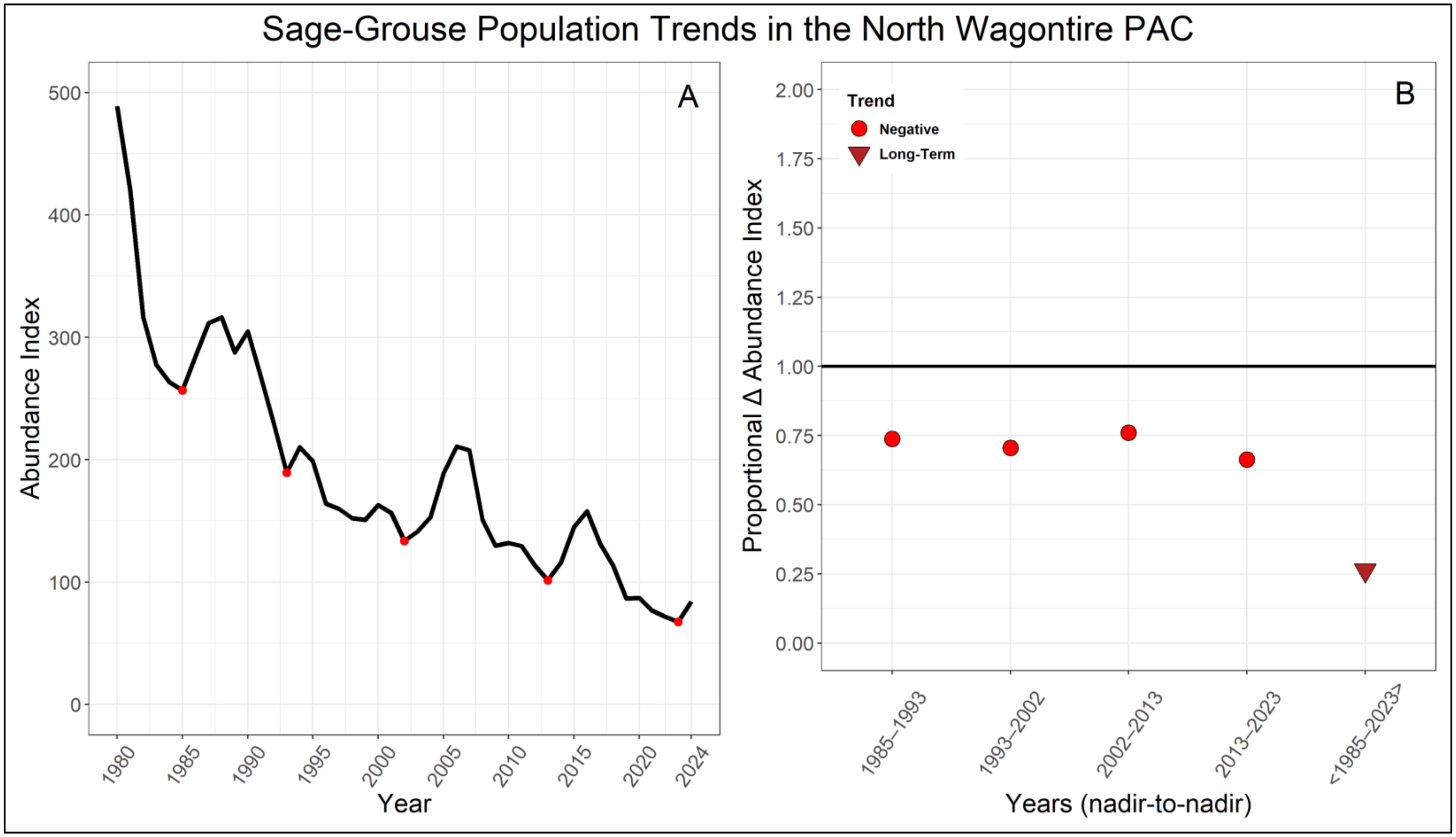


**Figure 3.19.** Sage-grouse population trends in the North Wagontire PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Paulina PAC*

The Paulina PAC is an area of approximately 225,290 ha (556,698 ac), located mostly within Crook County; a portion of the PAC falls within Deschutes County, Harney County, and Lake County. Sixty-seven leks are known to exist in the Paulina PAC. As of 2024, the conservation statuses of these leks were: 35 Occupied, 11 Occupied-Pending, 5 Unoccupied-Pending, 8 Unoccupied, and 8 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2009, 2013, and 2023 (Figure 3.20A). The Paulina PAC experienced an increasing population trend during the period of 2009–2013, and declining population trends during all time periods (Figure 3.20B). The short-term population trend (1 oscillation) was -15.4% during 2013–2023, the mid-term population trend (3 oscillations) was -51.7% during 2002–2023, and the long-term population trend (5 oscillations) was -60.3% during 1985–2023 (Table 3.2).

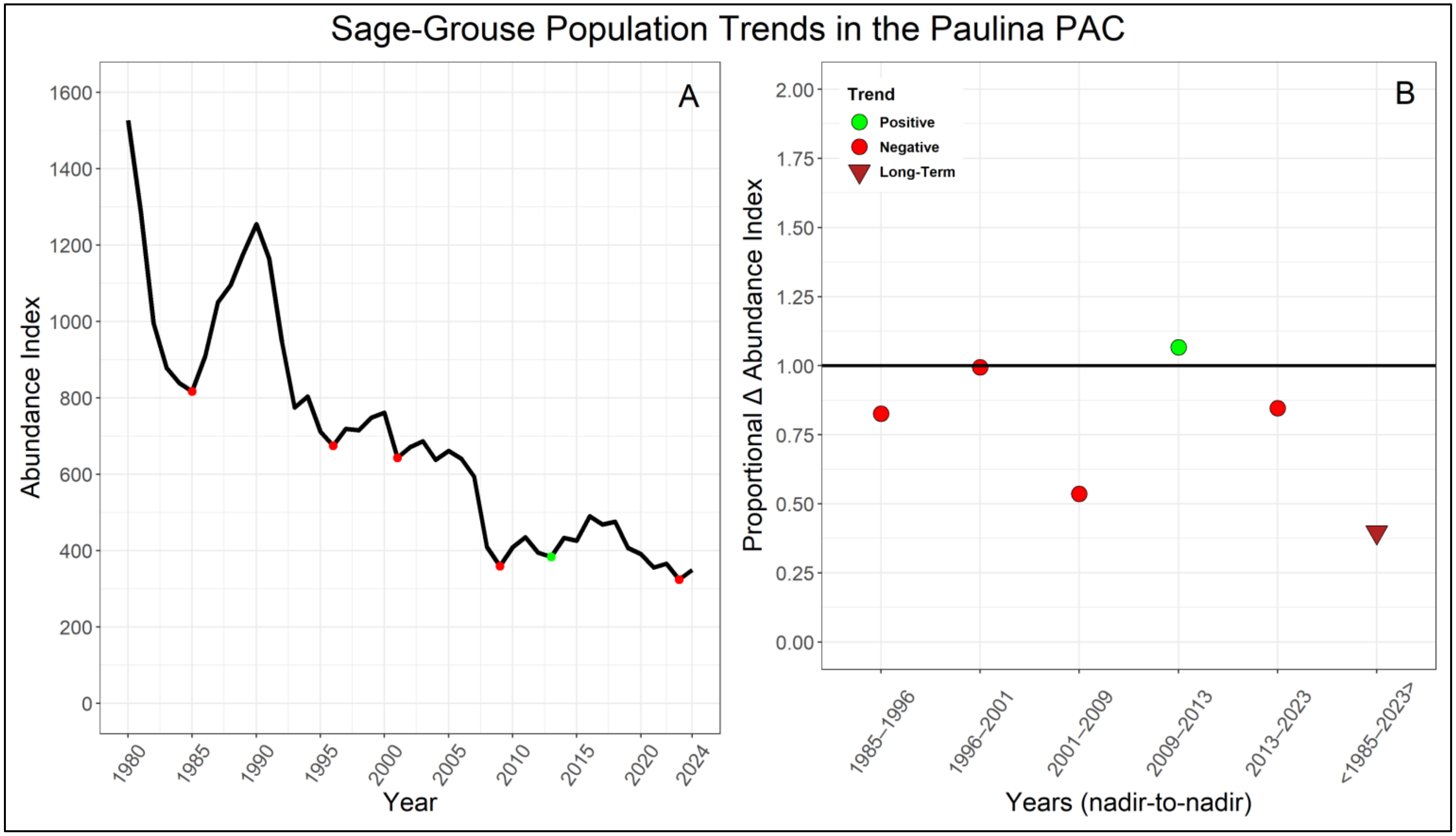


**Figure 3.20**.Sage-grouse population trends in the Paulina PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Pueblos PAC*

The Pueblos PAC is an area of approximately 143,527 ha (354,659 ac), located within Harney County, and contains 46 known leks. As of 2024, the conservation statuses of these leks were: 25 Occupied, 5 Occupied-Pending, 10 Unoccupied, and 6 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2009, 2013, 2019, and 2022 (Figure 3.21A). The Pueblos PAC experienced an increasing population trend during the period of 1996–2009, and declining trends during all other periods (Figure 3.21B). The short-term population trend was -5.8% during 2019–2022 (1 oscillation) and -31.8% during 2013–2022 (2 oscillations). The mid-term population trend (3 oscillations) was -31.4% during 2009–2022, and the long-term population trend (5 oscillations) was -53.2% during 1985–2022 (Table 3.2).

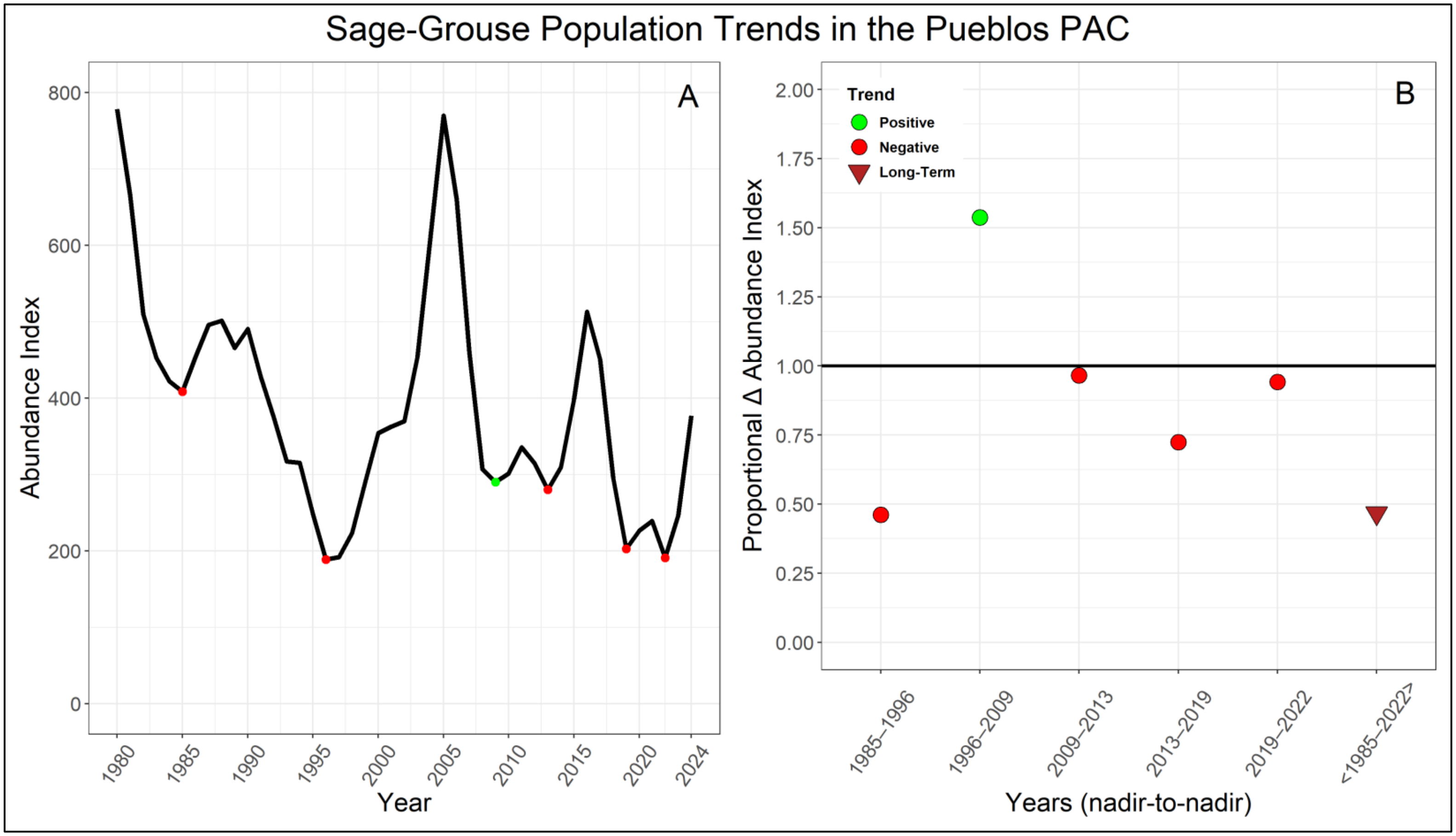


**Figure 3.21.** Sage-grouse population trends in the Pueblos PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Saddle Butte PAC*

The Saddle Butte PAC is an area of approximately 43,189 ha (106,722 ac), located in Malheur County, and contains 5 known leks. As of 2024, the conservation statuses of these leks were: 3 Occupied, and 2 Occupied-Pending leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2009, 2013, and 2020 (Figure 3.22A). The Saddle Butte PAC experienced an increasing population trend during the periods of 1996–2002 and 2013–2020, and declining trends during all other periods (Figure 3.22B). The short-term population trend (1 oscillation) was +55.5% during 2013–2020, the mid-term population trend (3 oscillations) was +40.5% during 2002–2020, and the long-term population trend (5 oscillations) was stable (+0.0%) during 1985–2020 (Table 3.2).

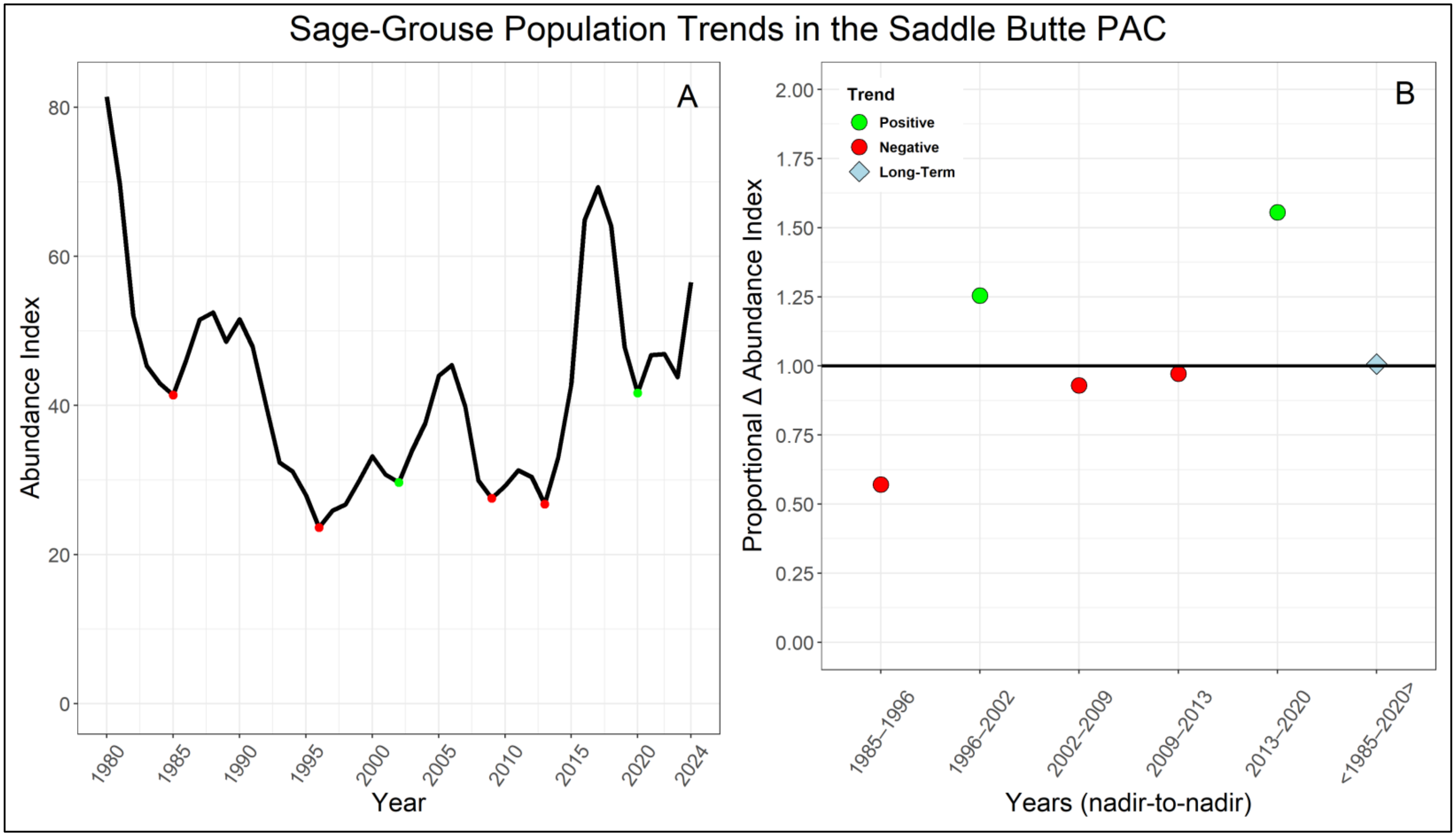


**Figure 3.22.** Sage-grouse population trends in the Saddle Butte PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Sheepshead PAC*

The Sheepshead PAC is an area of approximately 20,084 ha (49,627 ac), located within Harney County and Malheur County, and contains 4 known leks. As of 2024, the conservation statuses of these leks were: 2 Occupied, 1 Unoccupied, and 1 Historic lek. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2009, 2013, and 2021 (Figure 3.23A). The Sheepshead PAC experienced an increasing population trend during the period of 1996–2002, and declining trends during all other periods (Figure 3.23B). The short-term population trend (1 oscillation) was -24.2% during 2013–2021, the mid-term population trend (3 oscillations) was -48.2% during 2002–2021, and the long-term population trend (5 oscillations) was -65.4% during 1985–2021 (Table 3.2).

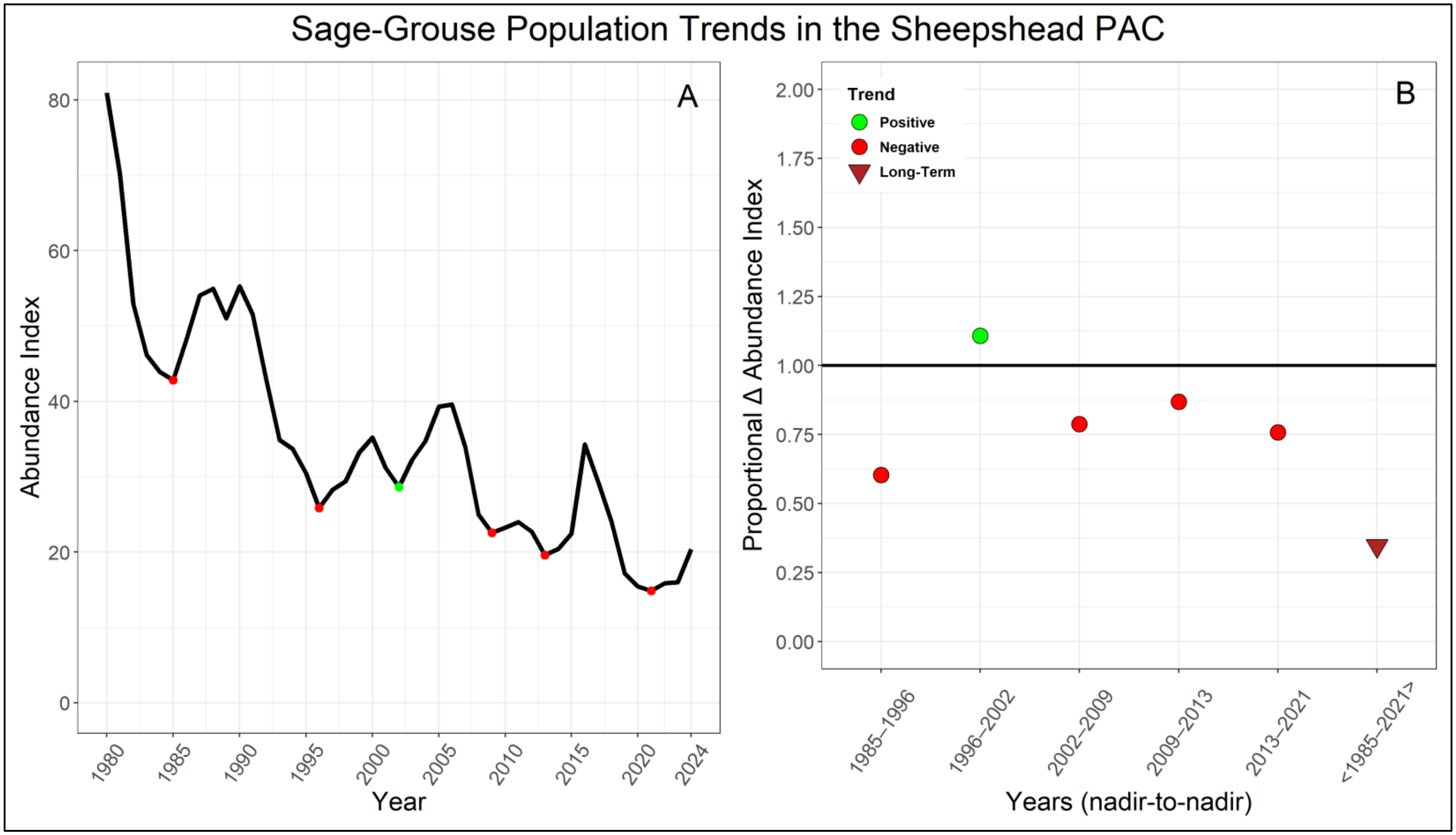


**Figure 3.23.** Sage-grouse population trends in the Sheepshead PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Soldier Creek PAC*

The Soldier Creek PAC is an area of approximately 163,915 ha (405,039 ac), located in Malheur County, and contains 67 known leks. As of 2024, the conservation statuses of these leks were: 38 Occupied, 5 Occupied-Pending, 9 Unoccupied, and 15 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2008, 2013, and 2020 (Figure 3.24A). The Soldier Creek PAC experienced declining population trends during all time periods (Figure 3.24B). The short-term population trend (1 oscillation) was -37.9% during 2013–2020, the mid-term population trend (3 oscillations) was -52.2% during 1996–2020, and the long-term population trend (4 oscillations) was -75.2% during 1985–2020 (Table 3.2).

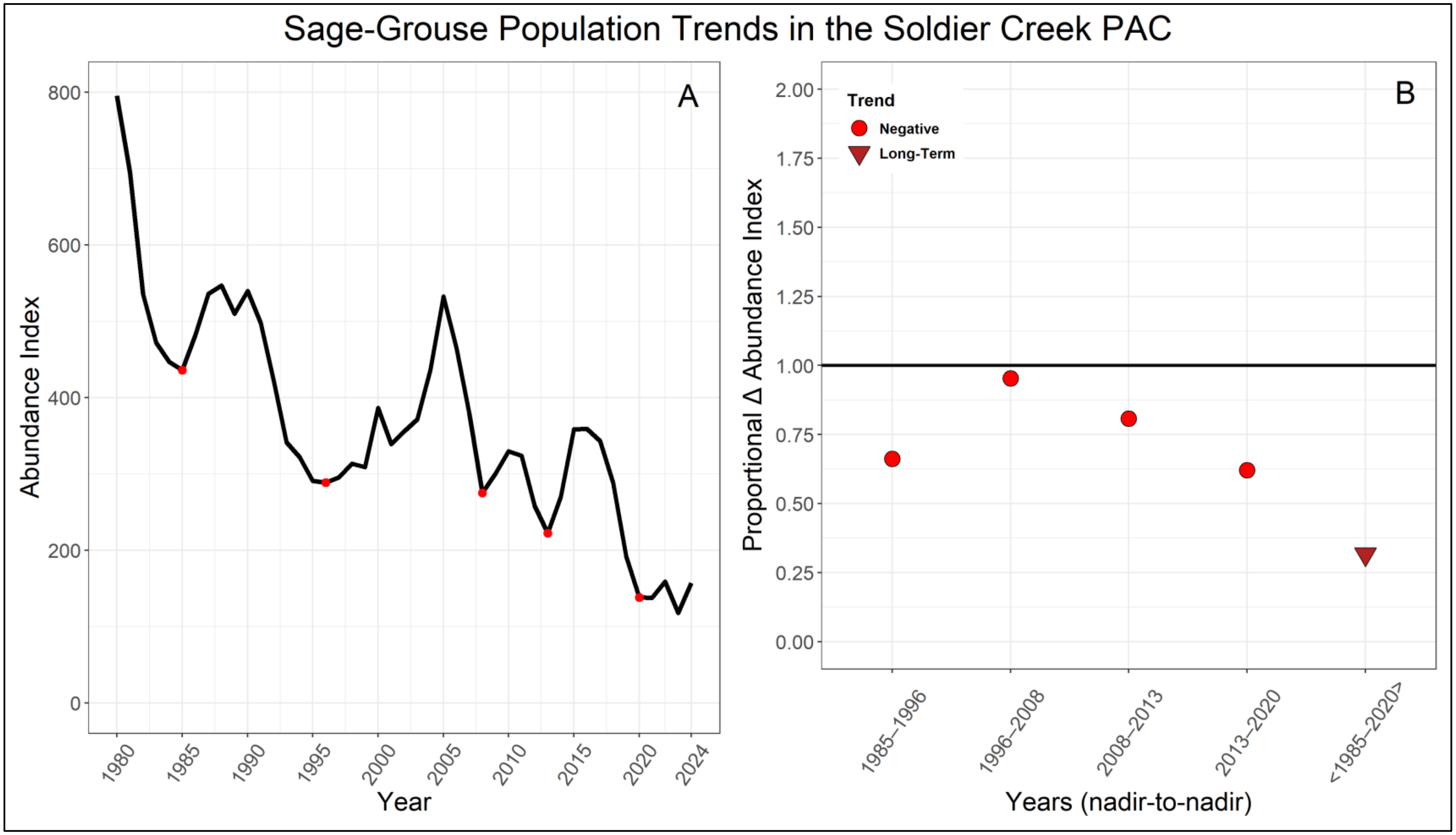


**Figure 3.24.** Sage-grouse population trends in the Soldier Creek PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Steens PAC*

The Steens PAC is an area of approximately 222,216 ha (549,101 ac), located mostly within Harney County; a small portion of the PAC falls within Malheur County. Forty-seven leks are known to exist in the Steens PAC. As of 2024, the conservation statuses of these leks were: 24 Occupied, 10 Occupied-Pending, 3 Unoccupied, and 10 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2008, 2013, and 2020 (Figure 3.25A). The Steens PAC experienced an increasing population trend during the period of 1996–2008, and declining trends during all other periods (Figure 3.25B). The short-term population trend (1 oscillation) was -10.2% during 2013–2020, the mid-term population trend (3 oscillations) was -10.4% during 1996–2020, and the long-term population trend (4 oscillations) was -45.4% during 1985–2020 (Table 3.2).

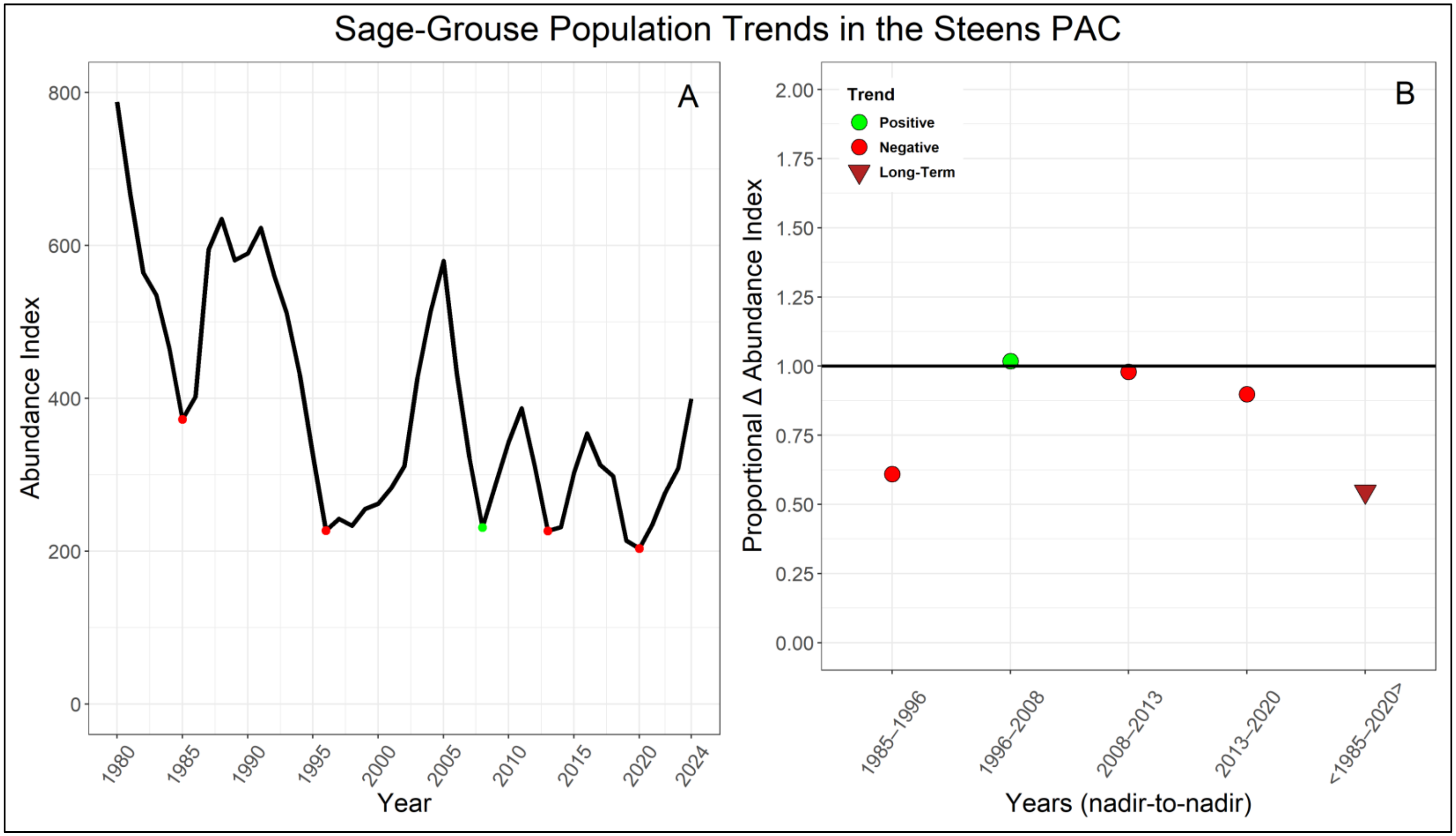


**Figure 3.25.** Sage-grouse population trends in the Steens PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Trout Creeks PAC*

The Trout Creeks PAC is an area of approximately 193,032 ha (476,988 ac), located within Harney County and Malheur County, and contains 103 known leks. As of 2024, the conservation statuses of these leks were: 52 Occupied, 16 Occupied-Pending, 19 Unoccupied, and 16 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2008, 2013, and 2021 (Figure 3.26A). The Trout Creeks PAC experienced an increasing population trend during the period of 1996–2002 and 2013–2021, and declining trends during all other periods (Figure 3.26B). The short-term population trend (1 oscillation) was +7.1% during 2013–2021, the mid-term population trend (3 oscillations) was -18.4% during 2002–2021, and the long-term population trend (5 oscillations) was -49.3% during 1985–2021 (Table 3.2).

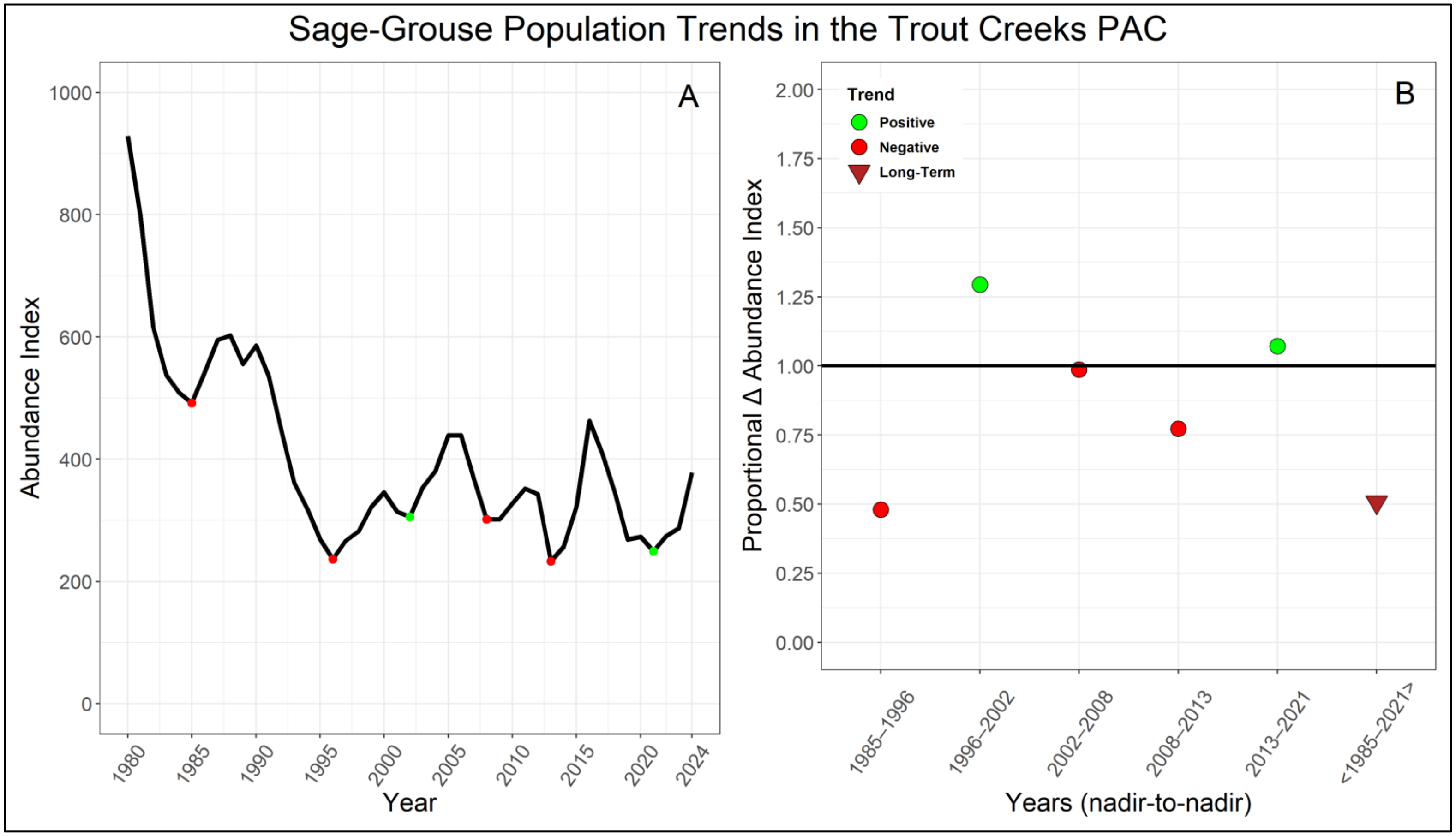


**Figure 3.26**.Sage-grouse population trends in the Trout Creeks PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Tucker Hill PAC*

The Tucker Hill PAC is an area of approximately 12,482 ha (30,844 ac), located within Lake County, and contains 6 known leks. As of 2024, the conservation statuses of these leks were: 4 Occupied and 2 Historic leks. Nadirs of the population cycle occurred during the years 1984, 1997, 2001, 2009, 2013, and 2023 (Figure 3.27A). The Tucker Hill PAC experienced an increasing population trend during the periods of 1984–1997 and 2001–2009, and declining trends during all other periods (Figure 3.27B). The short-term population trend (1 oscillation) was -8.4% during 2013–2023, the mid-term population trend (3 oscillations) was +3.6% during 2001–2023, and the long-term population trend (5 oscillations) was +61.1% during 1985–2023 (Table 3.2).

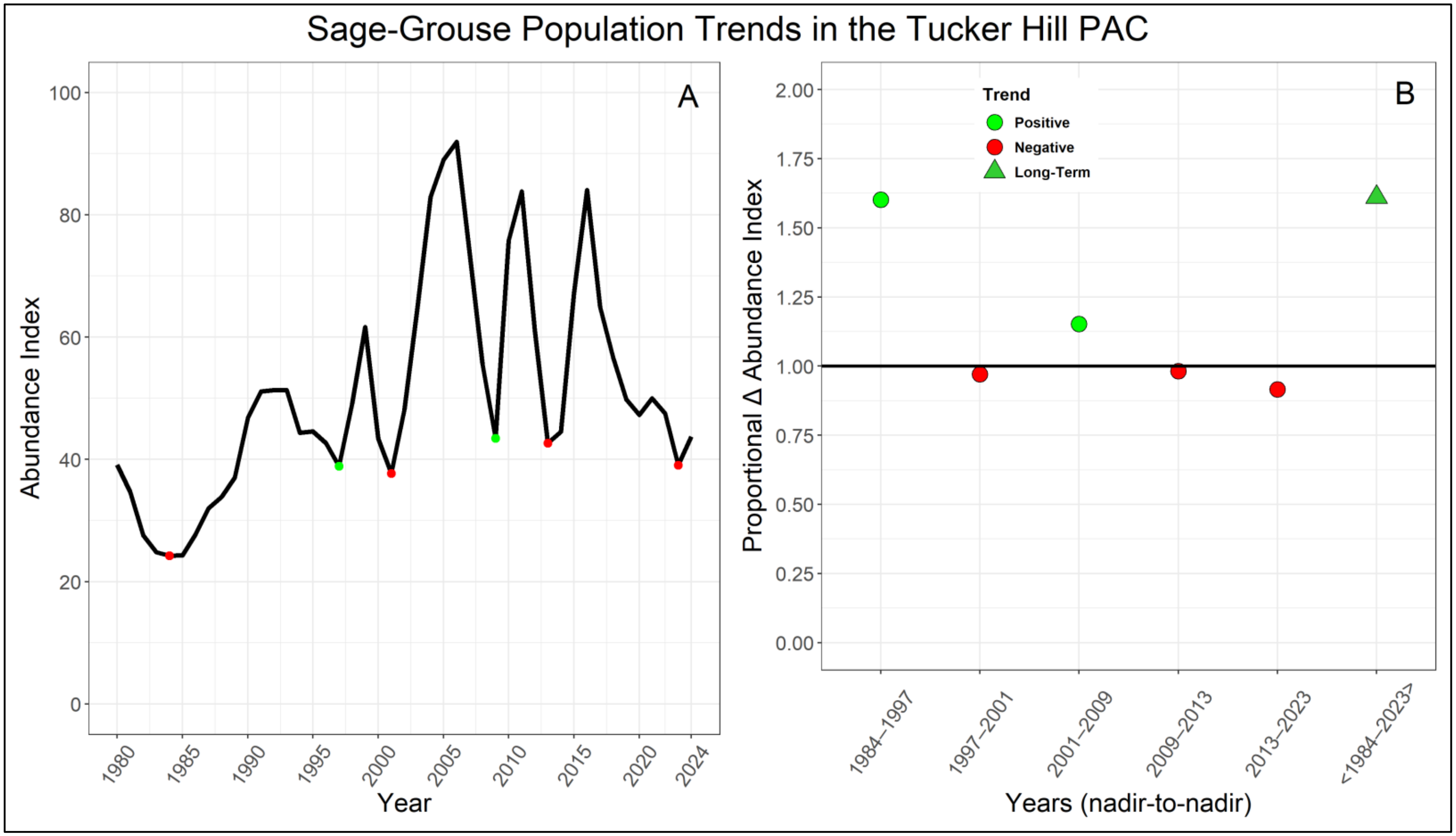


**Figure 3.27.** Sage-grouse population trends in the Tucker Hill PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Warner PAC*

The Warner PAC is an area of approximately 135,531 ha (334,901 ac), located within Lake County, and contains 62 known leks. As of 2024, the conservation statuses of these leks were: 33 Occupied, 5 Occupied-Pending, 9 Unoccupied, and 15 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2009, 2014, and 2019 (Figure 3.28A). The Warner PAC experienced declining population trends during all time periods (Figure 3.28B). The short-term population trend (1 oscillation) was -14.4% during 2014–2019, the mid-term population trend (3 oscillations) was -46.2% during 1996–2019, and the long-term population trend (4 oscillations) was -65.5% during 1985–2019 (Table 3.2).

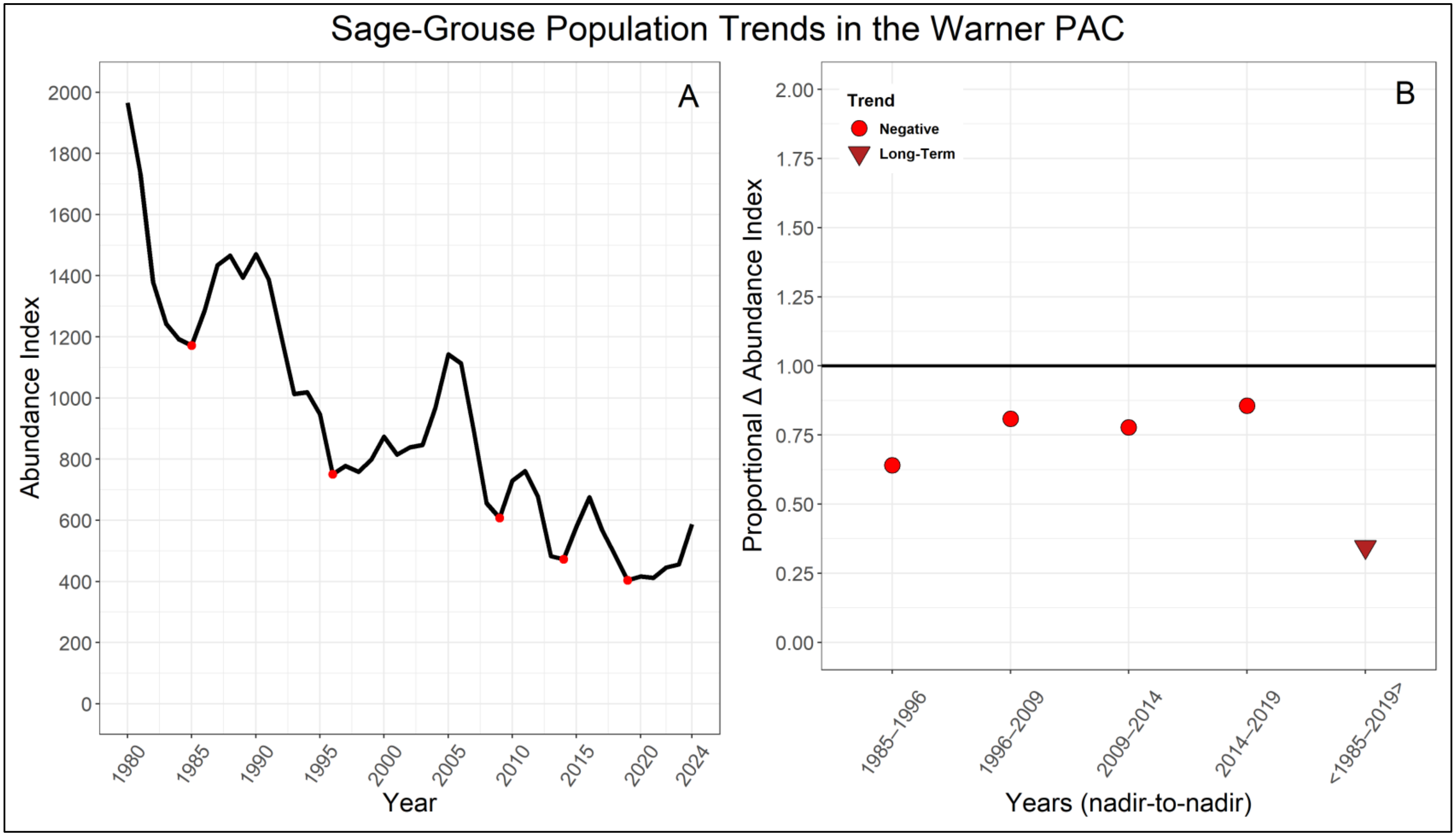


**Figure 3.28.** Sage-grouse population trends in the Warner PAC. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

*Areas outside of PACs*

There are 40 known leks located in areas outside of Oregon's PACs. As of 2024, the conservation statuses of these leks were: 1 Occupied-Pending, 2 Unoccupied-Pending, 5 Unoccupied, and 32 Historic leks. Nadirs of the population cycle occurred during the years 1985, 1996, 2002, 2009, and 2019 (Figure 3.29A). Areas outside of Oregon's PACs experienced declining population trends during all time periods (Figure 3.29B). The short-term population trend (1 oscillation) was -63.1% during 2014–2019, the mid-term population trend (2 oscillations) was -75.6% during 2002–2019, and the long-term population trend (4 oscillations) was -87.1% during 1985–2019 (Table 3.2). Notably, those areas outside of PACs have realized greater declines in population trend in both the short-term and long-term than areas within PACs.

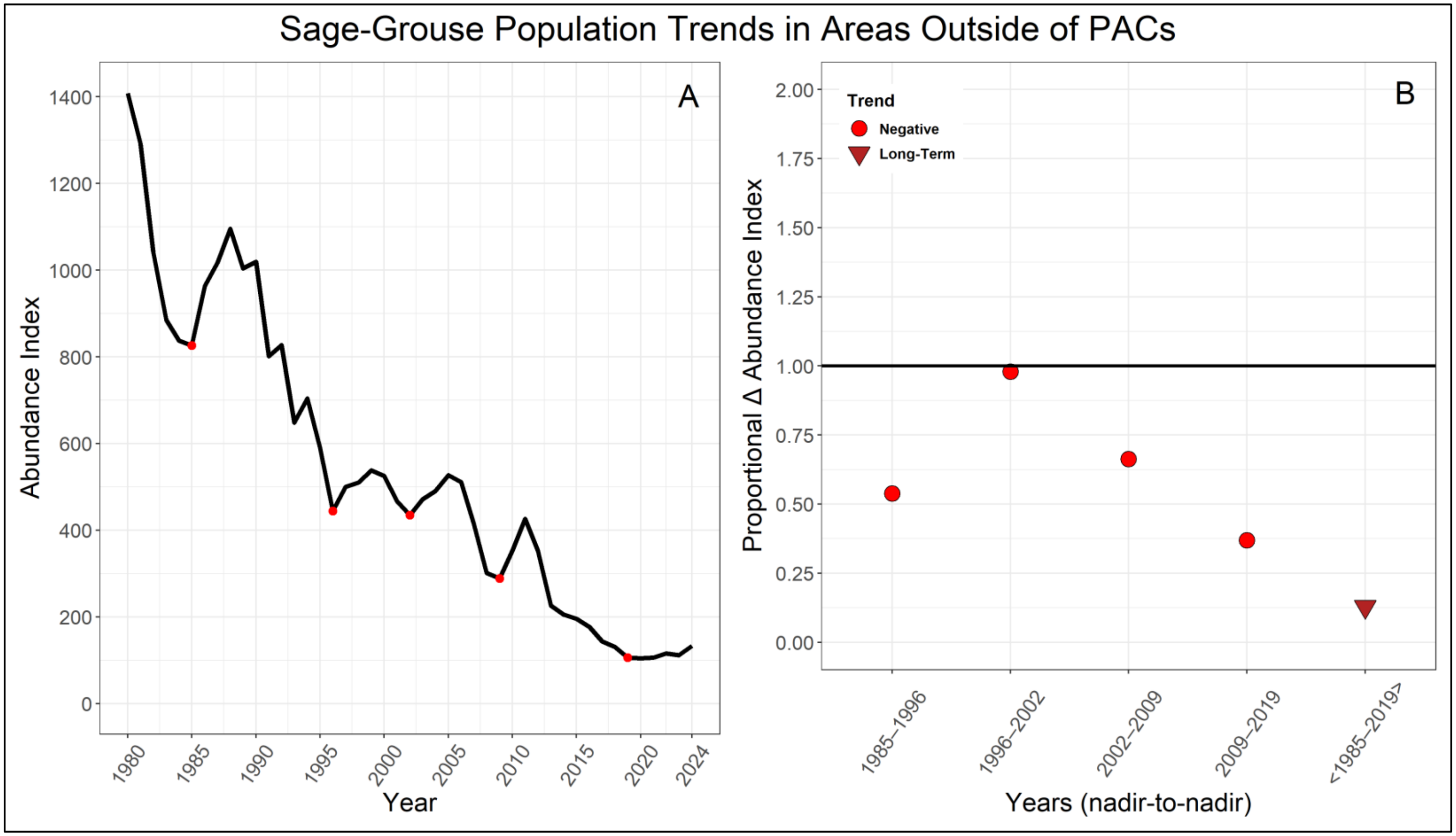


**Figure 3.29**.Sage-grouse population trends in areas outside of Oregon's PACs. Panel A shows the index of sage-grouse abundance through time, 1980–2024. Panel B shows the proportional change in the index of sage-grouse abundance from nadir-to-nadir, where 1.0 indicates a stable population trend during the time period, values < 1.0 indicates a negative population trend during the time period, and values >1.0 indicates a positive population trend during the time period.

**Monitoring Sage-Grouse Production**

Production is a critical stage in the life history of sage-grouse. Multiple years of above average productivity at local or regional scales can drive increases in sage-grouse population abundance, whereas several years of below average productivity often results in noticeable population declines. Annual sage-grouse productivity corresponds directly to the amount, timing, and intensity of precipitation, and mean temperatures in the spring and summer (Blomberg et al., 2012; Lundblad et al. 2022). In addition to annual precipitation and temperatures in April and August, Lundblad et al. (2022) reported a positive effect of mesic habitat availability during the late brood-rearing period on sage-grouse productivity, where productivity increased significantly when the proportion of mesic habitat in a management unit rose above 20%. Additionally, the study found a negative effect of annual herbaceous vegetation (≥30% cover) on sage-grouse productivity, where productivity decreased significantly when the proportion of annual herbaceous vegetation (i.e., invasive annual grasses) rose above 0%. Lastly, the study reported a negative effect of conifer cover (≥3%) on sage-grouse productivity, where productivity decreased significantly when the proportion of conifer cover rose above 0%.

ODFW monitors trends in annual sage-grouse production using hunter-harvested wings, which are returned to the Department following the September hunting season. Sage-grouse hunting in Oregon is controlled by permit-only, with a daily and seasonal bag limit of two birds during the nine-day hunting season. Permits are allocated in 10 Wildlife Management Units or sub-units (WMUs or sub-WMUs) with robust populations of sage-grouse. The average number of wings received during the most recent 10-year period (2015–2024) was 240.1 wings, which is lower than the average number of wings received during the previous two decades (1995–2004: 601.5 wings; 2005–2014: 464.3 wings) due to reductions in the number of controlled hunt permits authorized. Demographic information collected from hunter-harvested and returned sage-grouse wings directly informs ODFW's sage-grouse harvest management framework (see Section 8).

The sex of harvested birds is determined based on the length of the outer two primary wing feathers (P9 and P10), and the age of harvested birds is determined using characteristics of the outer primary feathers (P7–P10), first secondary feather, tertial feathers, and wing coverts (Braun and Schroeder 2015). Wings are classified into three age groups, juvenile (hatch year), yearling (second year), and adult (after hatch year). After hatch year birds are classified as adults unless they can be definitively identified as yearlings by the presence of juvenile P9 and/or P10 feathers (Braun et al. 2015). In Oregon, most breeding occurs in March and early April, so few yearling males are identifiable in the harvest due to molt progression. Additionally, if non-nesting or early nesting yearling females complete their wing molt before harvest, there is no reliable way to differentiate these birds from after second year adult females (Braun and Schroeder 2015). ODFW reports the results from hunter-harvested wing analyses annually, as an appendix within the Annual Population Monitoring Report. These reports are archived and available on ODFW's sage-grouse webpage.

Two main indices of sage-grouse production are assessed using hunter-harvested wings: 1) the number of juveniles per adult or yearling female (i.e., chicks per hen; *R*) and 2) the proportion of juveniles in the harvested cohort. In Oregon, the long-term (1993–2024) average chick per hen ratio is 1.53 (95% C.I.=1.36–1.70; range: 0.60–2.48) and the long-term average proportion of juveniles in the harvest is 47.7% (95% C.I.=44.7–50.7; range: 28.0–61.0). Annual mean productivity of sage-grouse populations in Oregon was similar to other regions of the Great Basin over the past ~30 years, where average sage-grouse productivity in Idaho (1996–2020) was 1.63 chicks per hen, and average productivity in Nevada (1995–2020) was 1.50 chicks per hen (Lundblad et al. 2022). Connelly et al. (2000*b*) suggests a chick per hen ratio > 2.25 indicates a healthy, stable or increasing population. However, sage-grouse production is generally lower in the Great Basin, so the level of production necessary to maintain sage-grouse populations in this region may be lower than $R$ = 2.25 (Braun 2012).

Annual sage-grouse productivity in Oregon is largely driven by large-scale mechanisms related to annual weather patterns, including seasonal precipitation, seasonal mean temperatures, and the interactions between precipitation and temperature. However, there are also several key habitat variables which influence sage-grouse production, as detailed above. Therefore, habitat management actions focused on increasing mesic habitat availability and decreasing cover of invasive annual grasses and conifers within sage-grouse brood-rearing habitats should improve sage-grouse production in these areas.

**Summary**

Spring lek surveying is the primary method ODFW uses to monitor sage-grouse populations. Section 3 provides a systematic methodology for conducting lek surveys, including ground and aerial surveys. This section outlines the process of sharing sensitive sage-grouse data. An updated and comprehensive list of lek conservation statuses is provided to include all possible lek situations, regardless of survey history. These definitions exceed the categories in the previous CAAS and those used by WAFWA. In cooperation with the USGS, ODFW developed an updated population model which accounts for imperfect detection, variable rates of lek attendance, and presently unknown leks. The updated model improved Oregon's sage-grouse population estimates using current modeling methodologies, informed by the best available data. PAC-scale population trends (1980–present) are also presented, providing context to population changes at smaller scales. Methods for monitoring sage-grouse production are also provided and are now based on hunter-harvested wing collections rather than driving brood routes. Based on the new population model and considering sage-grouse populations in Oregon oscillate over 6–12-year cycles, we recommend revising ODFW's population goal to manage sage-grouse statewide to maintain or enhance their distribution and abundance oscillating around the 2003 spring breeding population level, approximately 53,000 birds, over the next 50 years. Additionally, we recommend revising ODFW's sage-grouse population objectives to manage Oregon's sage-grouse populations to maintain stable or increasing population trends statewide and at the PAC-scale. We recommend assessing population trends between nadirs (troughs) of the population cycles at the statewide and PAC-scales.

**Recommendations**

1. Utilize improved scientific models to track sage-grouse populations at the statewide and PAC-scale.
2. Using the updated population model, set a goal to manage sage-grouse statewide to maintain or enhance their distribution and abundance oscillating around the 2003 spring breeding population level, approximately 53,000 birds, over the next 50 years.
3. Set objectives to manage Oregon's sage-grouse populations to maintain stable or increasing population trends statewide and at the PAC-scale. Population trends should be assessed between nadirs (troughs) of the population cycles at the statewide scale and PAC-scale.
4. Utilize hunter-returned wings to contribute to Oregon sage-grouse demographic knowledge and inform ODFW's harvest management framework.
5. Update lek conservation status definitions to include all leks, regardless of survey history.
6. Invest in research to maximize the efficiency of ODFW's annual lek monitoring effort.

## Section 4: Mapping Oregon’s Sage-grouse Range

### Core area approach

Under OAR 635-140-0015, ODFW is directed to implement a 'Core Area Approach to Conservation' of Oregon’s sage-grouse habitats, which was established in 2015 to address sage-grouse management from a conservation biology perspective and ensure long-term viability of Oregon’s sage-grouse populations. The Department’s core area approach identifies Oregon’s most productive sage-grouse populations and those associated habitats which meet all life history needs of these populations. ODFW defines three types of sage-grouse habitat in Oregon, core, low-density, and general habitats, and maintains maps delineating geographic areas of these habitat types. Core habitats are defined as those areas necessary to conserve 90% of Oregon’s sage-grouse populations, including important breeding, wintering, and migratory or connectivity areas, with an emphasis on those populations of highest breeding density. Low-density habitats are defined as those areas which provide additional breeding, summer, and migratory habitats, covering those populations of lower breeding density and the connectivity corridors among core habitats. General habitats are those areas outside of designated core and low-density habitats which are occupied by sage-grouse seasonally or year-round. The first version of Oregon’s significant sage-grouse habitat map delineating core and low-density habitats was developed in 2011; the significant habitat map was updated in 2023 using the Department’s best available data, including over 100 previously unknown lek locations and additional location data from GPS-marked sage-grouse.

### Framework Overview

ODFW’s framework for delineating core and low-density habitats was established in the 2011 version of this Plan and has been updated here to reflect four main steps: 1) the model, 2) internal boundary refinement, 3) review by tribal entities and partnering state and federal agencies, and 4) review by County-elected officials, Sage-Grouse Local Implementation Teams, private landowners and allotment holders, and the public.

Step 1 of the framework, the model, is based on the Doherty et al. (2011) landscape-scale ‘core area’ classification of sage-grouse breeding habitats using relative abundance from lek data. In addition to delineating ‘core areas’ using the method outlined by Doherty et al. (2011), ODFW’s model incorporates ‘local’ and ‘seasonal’ connectivity corridors, or migratory habitats, among core areas. Lastly, known winter concentration areas are incorporated into the model using location data from individually marked sage-grouse. Once core and low-density habitats have been defined by the model in Step 1, these habitat boundaries are refined by ODFW Wildlife Division and Habitat Division staff in Step 2 of the framework, using location data from marked sage-grouse (spring, summer, and fall seasons), local knowledge, aerial imagery, and additional spatial habitat data (e.g., Ecostate data, Digital Elevation Model data, existing human development, etc.).

Completion of steps 1 and 2 of this framework concludes the internal process, and a draft map of sage-grouse core and low-density habitats is presented to tribal entities and natural resource specialists within partnering agencies (i.e., BLM, USFWS, USFS, NRCS, DSL) in Step 3. The

Department considers all input received during Step 3 and further refines these habitat boundaries before publishing a draft map for review by elected County officials and County Planning departments, Sage-Grouse LITs, private landowners and allotment holder, and the public in Step 4. Again, the Department considers all input received during Step 4 and further refines these habitat boundaries before publishing a final draft map for review by the Oregon Fish and Wildlife Commission.

**Step 1: The Model, 2023 Habitat Map Update**

*Lek strata* – Using the Doherty et al. (2011) approach, average maximum counts of male sage-grouse at known lek sites were used to identify breeding densities within Oregon's sage-grouse range. Leks included in the analysis (n=664) were those with ≥ 1 male recorded as the maximum count during an 8-year period (2015–2022). For those leks not surveyed within the 8-year timeframe but which had males present during the most recent survey, the percent change in males from the year of the last survey compared to 2022 was used to estimate lek size in 2022 (Hagen 2011*a*). These lek locations and count data were the two inputs for a kernel density analysis (Worton 1989), which populated a grid of 1-km$^2$ (0.39-mi$^2$) raster cells within sage-grouse breeding habitat (within 6.4 km [4.0 mi] of leks, see below), where each cell represented the expected count of male sage-grouse as a function of the number and proximity of surrounding leks. Once the grid was attributed with male counts, each lek was classified from largest to smallest based on expected abundance values and then grouped into 1 of 4 lek strata: 1) very high-density, 2) high-density, 3) moderate-density, 4) low-density, containing the top 25%, 50%, 75%, and 100% (i.e., percentiles) of the known breeding population, respectively. Leks classified as very high-density or high-density stratum (25% and 50%, respectively) were buffered by 6.4 km (4.0 mi) and leks classified as moderate-density or low-density stratum (75% and 100%, respectively) were buffered by 8.5 km (5.3 mi) to delineate the potential nesting areas associated with each lek stratum. The 6.4 km radius was used to define the extent of breeding habitat for the high-density strata because female sage-grouse distribute their nest spatially in relation to lek locations, where >80% of nests are located within a 6.4 km radius of leks in Oregon (ODFW 2009). The larger radius (8.5 km) was used to define the extent of breeding habitat for the moderate- and low-density strata as the spatial requirements to support breeding populations in low-abundance areas or fragmented landscapes are greater (Doherty et al. 2011; Hagen 2011*a*).

*Connectivity* – In addition to the lek density strata, connectivity corridors among leks were delineated using a similar kernel density analysis, but where the search radius was increased to 16 km (9.9 mi) to approximate the average maximum extent of movement between breeding areas and other seasonal habitats (i.e., brood-rearing, summering, wintering; Hagen 2011*a*). Two types of connectivity corridors were mapped, local corridors and seasonal corridors, using 75% and 90% kernel density utilization distributions, respectively. Polygons of both local and seasonal connectivity corridors were clipped to 'occupied habitat', which was identified using the best-available sage-grouse habitat data layer (Doherty et al. 2016). The clipped edges were smoothed to 2 km (1.2 mi) to account for fringe habitats (Hagen 2011*a*).

*Winter habitat* – Sage-grouse show high fidelity to wintering areas, and their overwinter survival depends upon the availability of palatable sagebrush plants. Sage-grouse winter habitat use has been monitored in several areas of their range in southeastern Oregon, including within the Baker, Beatys, Brothers, Bully Creek, Cow Lakes, Cow Valley, Crowley, Paulina, Soldier Creek, Trout Creeks, and Warner PACs. Using sage-grouse GPS and VHF location data collected during November–February from 1997–2022, 90% kernel density utilization distributions of sage-grouse winter use were delineated within each PAC.

*Core area mapping* – Core areas are defined as those sagebrush or other habitat types which support sage-grouse within: A) areas of very high-, high-, and moderate-density lek strata; B) areas where low-density lek strata overlap local connectivity corridors; or C) areas where winter habitat use kernel density polygons overlap with low-density lek strata, local or seasonal connectivity corridors, or occupied habitat.

*Low-density area mapping* – Low-density areas are defined as those sagebrush or other habitat types which support sage-grouse within: A) areas of low-density lek strata within seasonal connectivity corridors; B) areas of low-density lek strata outside of connectivity corridors; C) areas where local connectivity corridors occur outside of the lek density strata, or D) areas where seasonal connectivity corridors occur outside of the lek density strata.

*General habitat areas* – General sage-grouse habitats are those areas which are occupied by sage-grouse but fall outside of core or low-density habitat areas. Note, general habitats are not specifically defined in the modeling process (Step 1) but may be incorporated within the significant sage-grouse habitat map during the boundary refinement process (Steps 2–4). For example, if an area has known sage-grouse use but does not have adequate sage-grouse use data to support designating the area as 'low-density', it may be designated as 'general' sage-grouse habitat.

The modeling methodology used in Step 1 is detailed further in Appendix 3.

**Steps 2–4: Boundary Refinement, 2023 Habitat Map Update**

Once the large-scale modeling of core and low-density habitats was completed in Step 1, these modeled boundaries were manually refined, using location data from marked sage-grouse (spring, summer, and fall seasons), local knowledge, aerial imagery, and additional spatial habitat data (e.g., Ecostate vegetation data, Digital Elevation Model data, existing human development, etc.) to make fine-scale boundary adjustments. Much of the initial boundary refinement occurred internally during Step 2, where each modification to the modeled boundary was biologically justified and documented.

Criteria used during the boundary refinement process were:

1) Exclusion of existing municipalities. Cities and towns were buffered to 0.8 km (0.5 mi) and excluded from the core and low-density habitat map.
2) Adjustments were made only to the modeled boundaries (i.e., no 'donut holes'). The one exception to this rule made during the 2023 map revision process was removing the Jordan Craters volcanic field in the Cow Lakes PAC from the sage-grouse habitat map.

Although surrounded by core habitat, the volcanic field has no vegetation to support sage-grouse and the GPS location data from marked sage-grouse in the area confirmed the birds do not use this area.

3) Each boundary modification required a biologically relevant justification.
4) Adjustments were made at a 1:4,000 or finer resolution.

After the internal draft of the updated habitat map was completed in Step 2, additional adjustments to the mapped habitats occurred during Steps 3 and 4 to capture input from external partners, including tribal entities, private landowners and ranch managers, partnering state and federal agencies, sage-grouse LITs, and the public. Like in Step 2, boundary adjustments made during Steps 3 and 4 reflected fine-scale habitat use of sage-grouse, where each adjustment cited a valid biological justification. In addition to meeting with tribal entities, private landowners and ranch managers, state and federal agencies, and each Sage-Grouse LIT, ODFW met with willing elected officials and planning departments in each county with significant sage-grouse habitat (i.e., Baker, Crook, Deschutes, Harney, Malheur, Lake) and hosted at least one public meeting per county, offering interested parties as much opportunity to provide input as possible.

**Map Adoption, 2023 Habitat Map Update**

Upon completion of Steps 1–4, ODFW published a final draft of the updated core and low-density habitat map (Figure 4.1) >2 months in advance of the scheduled review by the Oregon Fish and Wildlife Commission (Commission). The core sage-grouse habitat was geographically divided into PACs to represent biologically relevant management units for Oregon's sage-grouse populations (Figure 3.5). Note, the 2011 CAAS referred to these biologically relevant units as 'core areas' (e.g., Baker core area). In the updated CAAS, the term PAC replaces the term 'core area' when referring to Oregon's sage-grouse management units (e.g., Baker PAC).

In December 2023, the updated core and low-density sage-grouse habitat map was adopted by the Commission into Oregon Administrative Rule (OAR). Following adoption by the Commission, ODFW coordinated with the Oregon Department of Land Conservation and Development (DLCD) to update the maps in DLCD's Goal 5 Sage-Grouse Rule, OAR 660-023-0115. In January 2025, the Land Conservation and Development Commission (LCDC) adopted the updated sage-grouse significant habitat map into Exhibits A, B, and C of OAR 660-023-0115, replacing the deprecated maps.

**Future Updates**

As ODFW and its conservation partners continue to monitor Oregon's sage-grouse populations and collect data through annual lek surveys, aerial lek searches, and research projects, the Department will obtain new information regarding sage-grouse breeding densities, seasonal habitat use and distribution, and migratory corridors. Sage-grouse populations respond to changes in their habitat conditions, and sagebrush habitats are generally slow to recover from disturbances, even following restoration efforts. Additionally, sage-grouse populations in Oregon oscillate on 6–12-year cycles, driven largely by interannual precipitation patterns. As such, ODFW should review the best available information and consider updating Oregon's significant sage-grouse habitat map on a 10-year basis.

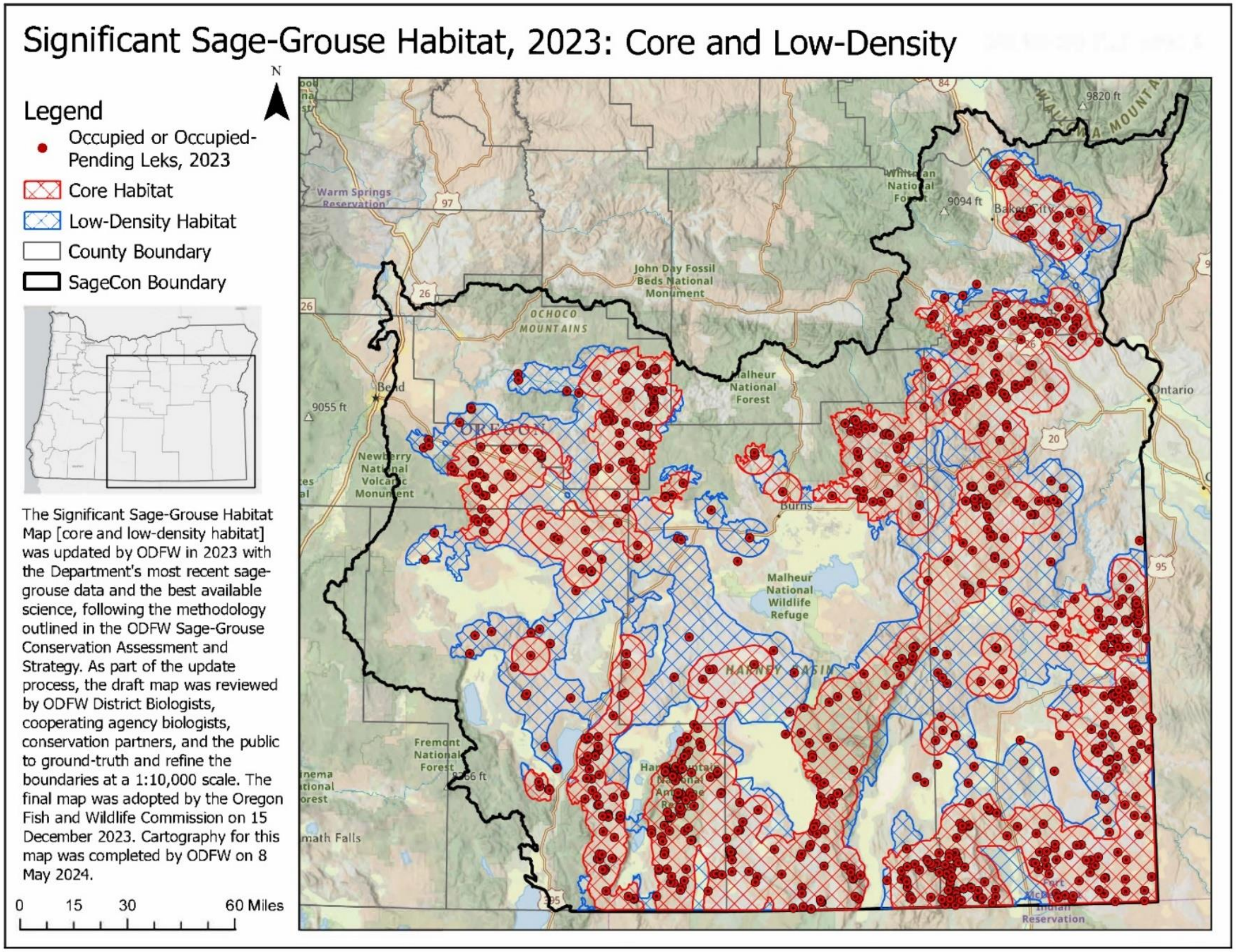


**Figure 4.1**. Map of Oregon’s significant sage-grouse habitats, 2023.

**Summary**

Oregon utilizes a core-area approach to sage-grouse conservation, which involves identifying the most important habitats necessary to conserve 90% of Oregon's sage-grouse populations. Section 4 details the methodology used to model and then refine ODFW's sage-grouse core and low-density habitat map, which was most recently updated in December of 2023. The updated core habitat was geographically divided into biologically relevant sage-grouse management units, referred to as Sage-Grouse Priority Areas for Conservation (PACs). In the 2011 CAAS, these biologically relevant management units were referred to as 'core areas', where in the 2025 CAAS, the terminology was updated to 'PACs'. The updated sage-grouse habitat map is used by the ODFW Greater Sage-Grouse Habitat Mitigation Program to mitigate impacts of large-scale development to significant sage-grouse habitat, and by DLCD as a Goal 5 resource, of which land use rules are applied. Oregon's significant sage-grouse habitat map is also used to help land managers (e.g., private landowners, BLM, DSL, and others) prioritize habitat restoration and uplift efforts to benefit local sage-grouse populations.

**Recommendations**

1. Maintain a map of sage-grouse core, low-density, and general habitat that is formally reviewed on a minimum 10-year basis and, if needed, recommended for update.
2. Include a robust partner and public review process for habitat map updates.
3. Coordinate closely with DLCD on future map updates, public input, and adoption.
4. Support research to GPS-mark sage-grouse in PACs where ODFW has little or no information on habitat or space use, especially to inform connectivity corridors among seasonal habitats.

## Section 5: Monitoring Oregon's Sage-grouse Habitat

The sagebrush biome has less than 60% of its historical range intact (Miller et al. 2011) and is considered one of the most imperiled ecosystems in the West (Noss and Peters 1995). Oregon is not exempt from this loss, despite a strong regulatory framework to protect habitat from development (see Section 7). In this section, we will discuss the historical and current composition of Oregon's sage-grouse range, assess previous habitat objectives, and provide context for an updated approach to monitoring and conserving sage-grouse habitat.

### Historical Distribution of Sage-grouse Habitat

Habitat for sage-grouse in Oregon prior to Euro-American settlement encompassed 7.2 M ha (17.7 M ac) of sagebrush throughout eastern Oregon (Figure 5.1). The conversion of sagebrush-steppe to agricultural land in the Columbia Basin of Oregon was responsible for an estimated loss of 600,000 ha (1.5 M ac) of sage-grouse habitat, nearly all of which is currently in private ownership. The current range, approximately 6 M ha (14.7 M ac), varies in suitability for sage-grouse. Although approximately 69,200 ha (171,000 ac) of potential habitat still exists in the Klamath Basin region, there have been no confirmed observations of sage-grouse in that region since 1993.

Numerous activities have impacted and potentially continue to impact the distribution and quality of sage-grouse habitat including land use conversion, fragmentation, resource extraction, historical grazing practices, conifer expansion, invasive annual grasses, and wildfire (Doherty et al. 2022).

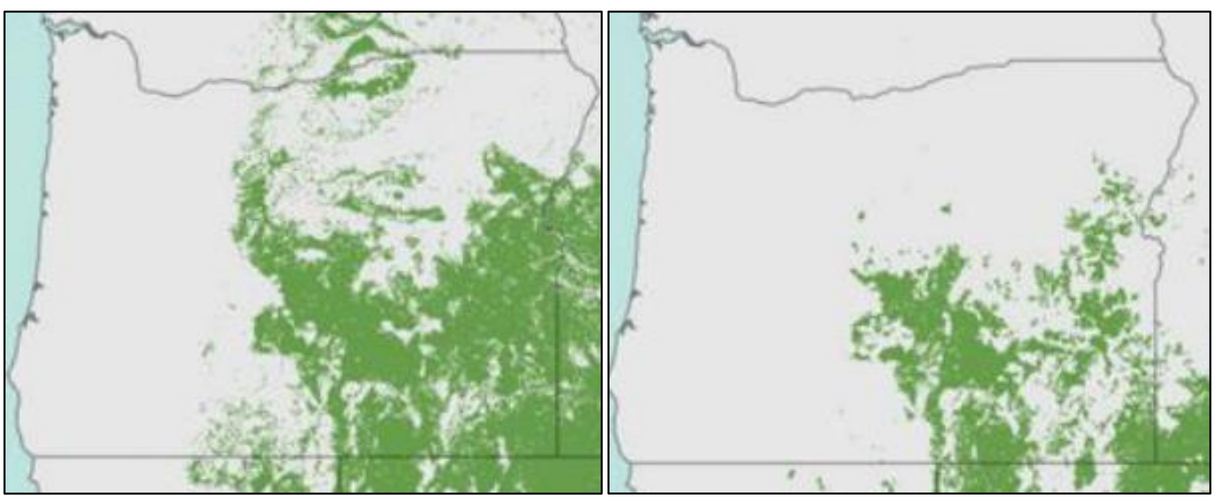

**Figure 5.1.** Historic (pre-settlement) sagebrush ecosystem distribution in Oregon (left) compared to current distribution (right). These maps are from The Nature Conservancy.

*Agricultural Conversion*
Permanent conversion of sagebrush to agricultural lands was the single greatest cause of decline in sagebrush-steppe habitat in the Columbia Basin (Quigley and Arbelbide 1997). In the northern half of eastern Oregon, large areas of sagebrush-steppe habitat have been converted to agricultural production (Wisdom et al. 2002). In southeastern Oregon, most conversion occurred in the late 1800s to early 1900s, reached a threshold in the mid-1950s and has remained

relatively unchanged since. Sage-grouse will occasionally use agricultural lands (e.g., alfalfa) as late summer and late brood-rearing habitat, but row crops and dryland cereal grains are generally not beneficial habitat (Swensen et al. 1987, Blus et al. 1989). In Washington, where sage-steppe habitat is severely imperiled, Conservation Reserve Program (CRP) fields planted to perennial vegetation provide important year-round habitat when intermixed with remnant sagebrush-steppe vegetation (Shirk et al. 2017).

Total acreage of land used for agriculture has declined in the past 30+ years based on the USDA Census of Agriculture (Figure 5.2). In those Oregon counties predominantly overlapping sage-grouse range, there has been a nearly universal decline in cropland and irrigated acres, while pastureland acreage is steady to increasing. Maintenance of pastureland is important to the persistence of sage-grouse in these counties, where responsible grazing can have minimal impacts on sage-grouse populations and forestall detrimental development.

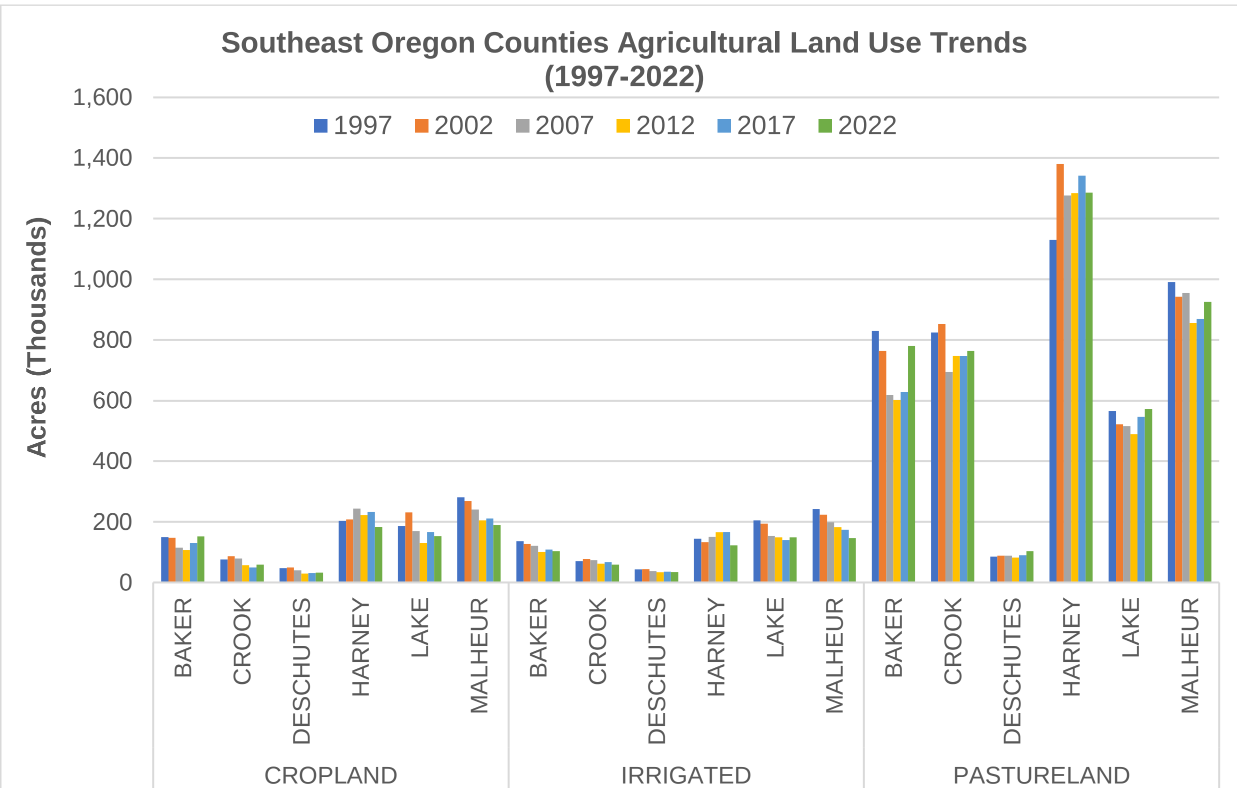


**Figure 5.2.** Trends in agricultural land use (acres) in 6 eastern Oregon counties coincident with sage-grouse range from 1997-2022 from USDA Census of Agriculture data.

*Sagebrush Removal*

Prior to the 1980s, herbicide treatment of large tracts of land (primarily using 2,4-D) was a common method of reducing sagebrush (Braun 1987). In addition to the loss of sagebrush, the use of 2,4-D resulted in the decline of forbs (Miller and Eddelman 2001). In many cases, broad scale herbicide treatment may have contributed to declines in sage-grouse breeding populations (Enyeart 1956, Higby 1969, Peterson 1970, Wallestad 1975). A Utah study suggests this adverse impact on sage-grouse was compounded if the area was subsequently reseeded to crested wheatgrass (*Agropyron cristatum*) (Enyeart 1956). In Malheur County, for example, the Vale

Project resulted in approximately 202,000 ha (500,000 ac) of sagebrush eradication projects for the benefit of livestock grazing (Willis et al. 1993). Approximately 50% of the treated area was reseeded with crested wheatgrass and various other grass mixes. Most of these treatments occurred on mild slopes in areas of moderately deep to deep soils which, based on current knowledge of sage-grouse, would have likely impacted breeding and winter habitats. While near monocultures of crested wheatgrass may be detrimental to sage-grouse habitat use in the short term, it can be highly effective in stabilizing an area and reducing the risk of invasive annuals (e.g., cheatgrass). Moreover, sagebrush has been documented to re-colonize some of these seedings and return to usable sage-grouse habitat over the past 30 years (Kindschy 1991).

Reduced application rates of some herbicides (e.g., tebuthiuron) may increase forb and perennial grass cover while retaining some sagebrush cover (Olson and Whitson 2002, Dahlgren et al. 2006). However, such applications of tebuthiuron have been documented to benefit sage-grouse in only one study (Dahlgren et al. 2006). Smith et al. (2018) found that tebuthiuron treatments of Wyoming big sagebrush communities with intended benefit to sage-grouse may not improve diet quality significantly enough to make up for the decreases in reduced cover associated with treatments. An increase in cheatgrass has been found up to 11 years following the use of tebuthiuron in dense stands of Wyoming big sagebrush (Blumenthal et al. 2006). Most recently, Smith et al. (2023) published results of a 9-year study which assessed greater sage-grouse response to both mowing and tebuthiuron treatments in Wyoming big sagebrush. Nest survival, brood survival, and female survival rates did not increase following treatment. The authors concluded that maintenance of large, undisturbed tracts of sagebrush will best facilitate sage-grouse persistence on the landscape. Today, land managers rarely design sagebrush removal projects for the sole purpose of increasing livestock forage. However, even sagebrush removal for the purposes of enhancing sage-grouse habitat is discouraged given the scope and scale of sagebrush loss from wildfire.

Mechanical treatments (mowing, plowing, chaining) of sagebrush have generally been more “local” or small in nature, but these too, have been known to adversely impact sage-grouse habitat if done on a broad scale (Swensen et al. 1987). Even small-scale projects to reduce sagebrush can be damaging if in the wrong location, for example, in winter habitat. However, mechanical treatments may enhance brood rearing habitats where such habitats have been degraded (Dahlgren et al. 2006).

*Fire and Fuel Breaks*

Far exceeding the scale of mechanical and herbicidal removal of sagebrush is the escalated scope and scale of modern range fires. Wildfire has contributed to conversion of sagebrush communities into marginal or non-habitat. From 1980-2024, over 1.8M ha (4.4M ac) of sage-grouse range were affected by wildfire, averaging nearly 40,500 ha (100,000 ac) per year. The largest fire year on record was 2012, the year after the previous CAAS was approved, with ~362,000 ha (~894,000 ac) burned, including 181,000 ha (477,483 ac) in core habitat in Oregon. In 2024, over 269,500 ha (666,000 ac) of sage-grouse range burned, over 5% of sage-grouse habitat in Oregon, including 207,500 ha (512,606 ac) in core habitat, the second largest year on record after 2012 (Figures 5.3 and 5.4). With increasing frequency and scale, wildfire is outpacing the sagebrush biome’s natural capacity to recover.

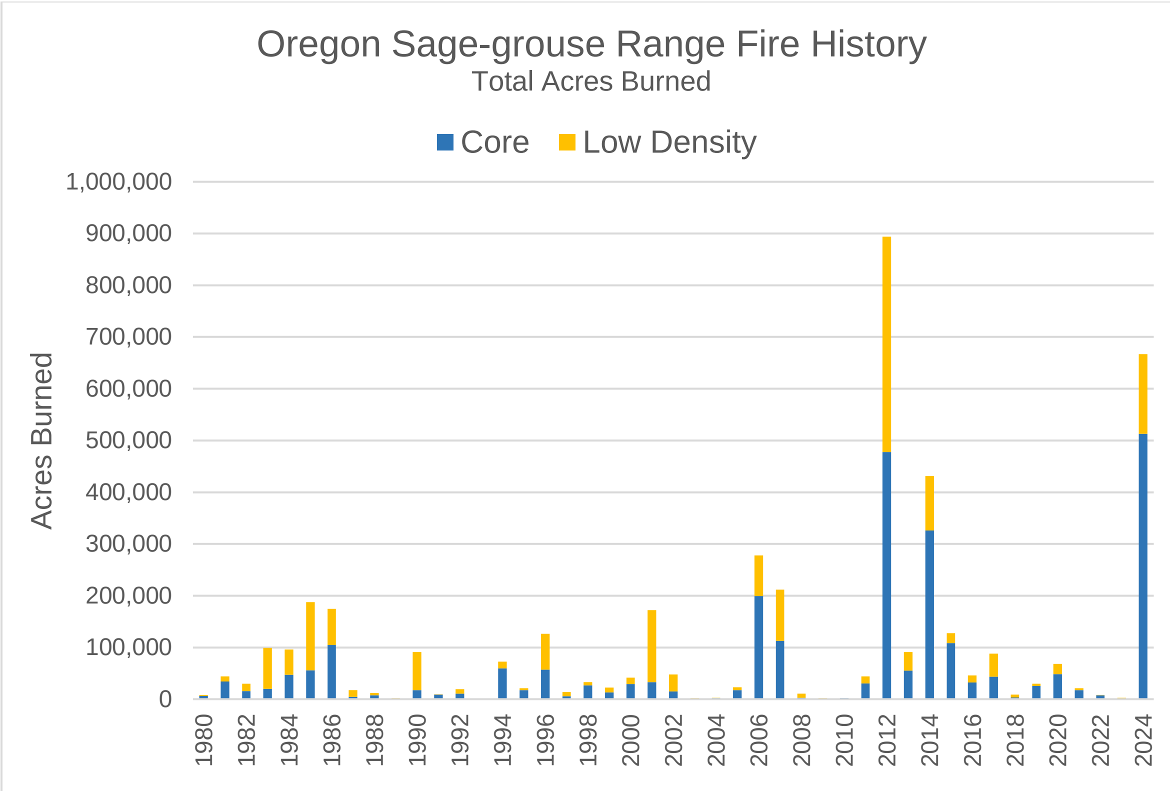


**Figure 5.3**. Total acres of range burned in sage-grouse core and low density habitat (1980-2024).

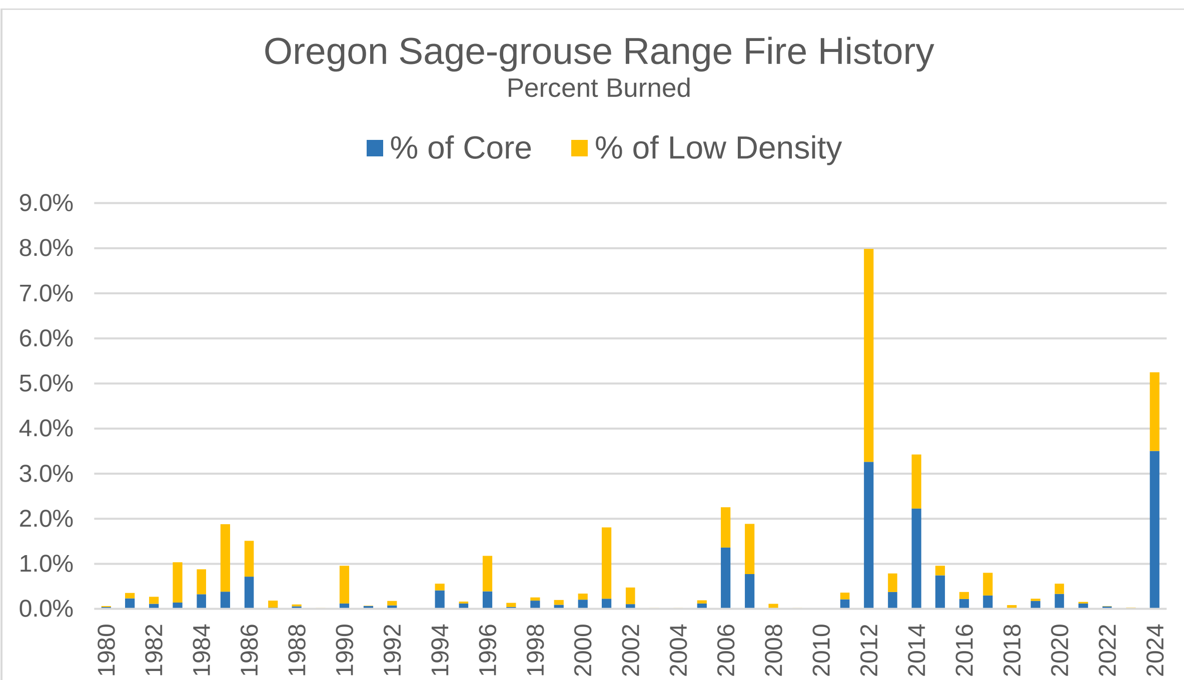


**Figure 5.4**. Percent of sage-grouse core and low density habitat burned in range fires (1980-2024).

Fuel breaks to control the spread of range fires are increasingly being implemented, though the large-scale impact of this practice comes with concerns for increasing fragmentation and removal of late-stage structural classes of sagebrush. Fuel breaks help facilitate fire suppression by modifying fuels and allowing safe access points for firefighters and is an increasing management tool of the BLM. A meta-analysis of fuel break performance from 1985-2018 in the western U.S. found fuel breaks were less successful in areas with low resistance to disturbance and low resilience after disturbance, in areas with more woody fuels, and in high temperature/low precipitation conditions (Weise et al. 2023). Fuel breaks were more effective in areas dominated by fine fuels and when they were more accessible to maintenance and fire crews. Maintenance frequency and fuel break type were also related to performance. There is a need for improved knowledge on the optimum design of fuel breaks to minimize impacts to wildlife while providing an important function in limiting the spread of range fires (Shinneman et al. 2018).

Targeted spring grazing can be used to maintain fuel breaks by reducing fine fuels with minimal ecosystem impacts when compared to controls (Clark et al. 2023). Reduction of fine fuels has been directly correlated with reducing shrub combustion (Davies et al. 2015 and 2016). A promising new technology is the advent of virtual fencing (VF) for cattle. This technology allows cattle grazing to be focused within a predetermined, unfenced boundary by incorporating auditory and electrical cues from collars to keep the herd within the fuel break boundary. Forage utilization trials support the efficacy of VF technology in focusing grazing within a virtual boundary (Boyd et al. 2023). Fine tuning grazing applications with fencing, VF, and adjustments to timing, duration, and intensity of grazing, in order to reduce fine fuels with minimal impacts to ecosystem integrity is an opportunity to elevate the coexistence of ranching and sage-grouse in an increasingly fire prone environment.

Potential wildland fire operational delineations (PODs) are spatial tools to assist in pre-planning for fire. PODs identify fire containment operations such as roads, ridgetops, and fuel transitions to identify spatial units where fire can be contained (Caggiano et al. 2020). The process engages land managers, fire staff, and partners to make informed fire response decisions prior to active incidents. While the strategy was originally designed for the USFS, proactively identifying and utilizing the PODs approach in sage-grouse habitat is a tactic that has the potential to improve fire suppression response and ultimately reduce the scope and scale of range fires.

**Sage-grouse Habitat Needs**

Habitat needs for sage-grouse vary by annual life history activities, but sagebrush is the most crucial. The leaves of sagebrush are eaten throughout the year and comprise 99% of the sage-grouse winter diet. Ideal spring nesting and brood rearing habitats include taller sagebrush (40–80 cm) with canopy coverage of 15–25%, and tall native perennial bunchgrass cover (≥18 cm), and abundant native forbs of at least 15% coverage (Crawford et al. 2004, Braun et al. 2005). Lekking sites are small open areas from 0.04–4.0 ha (0.10 to 10 ac) in size but located in the vicinity of denser escape cover (to aid in predator avoidance) (Dalke et al. 1963). Summer use areas include important mesic areas abundant with forbs and invertebrates and tall sagebrush with 10-25% canopy cover. Fall habitats are similar to late summer habitats, but birds may move up in elevation to take advantage of the remaining broadleaf forage before switching primarily to sagebrush leaves. During the winter months, sage-grouse forage nearly exclusively on sagebrush leaves, so relatively dense stands of highly palatable sagebrush plants are required. Sage-grouse are typically to be found on south-facing slopes and protected draws in winter where tall sagebrush still provide coverage and protection over the snow (Braun et al. 2005).

In Oregon, the dominant overstory structure is comprised of Wyoming big sagebrush (*Artemesia tridentata wyomingensis*), low sagebrush (*A. arbuscula*), stiff sagebrush (*A. rigida*), and a small proportion of mountain big sagebrush (*A. t. vaseyana*) at higher elevations. Native understory vegetation consists of common forbs such as *Lupinus, Crepis,* and *Lomatium* spp. and native bunchgrasses including bluebunch wheatgrass (*Pseudoroegneria spicata*), giant wildrye (*Leymus cinereus*), Idaho fescue (*Festuca idahoensis*), and Sandberg's bluegrass (*Poa secunda*).

Landscape composition and configuration are essential considerations that can impact sage-grouse movement and space use. More homogeneous sagebrush interspersed with complimentary habitats (e.g., mesic, perennial forbs, perennial grassland) confer a lower energetic cost to achieving daily requirements. Sage-grouse are more likely to occupy large patches of sagebrush compared to small or isolated patches (Shirk et al. 2017). A study of spring habitat use by female sage-grouse in Baker and Malheur counties, Oregon found sage-grouse survival and neighborhood size decreased as the proportion of anthropogenic footprint increased, indicating that anthropogenic presence was causing avoidance behaviors and limiting utilization of the landscape (Owens et al. 2024). The same study found decreased female survival with increasing juniper cover. Both interspersion of anthropogenic disturbance and the presence of juniper increase the risk of predation by providing linear travel corridors for mammalian predators, and perches for avian predators (Owens et al. 2024).

Aldridge et al. (2008) modeled habitat factors explaining sage-grouse extirpation and found 25% sagebrush cover (within mean home range size) was necessary for minimum probability population persistence (55%) and increased to over 90% probability of persistence at 70% sagebrush cover (Figure 5.5).

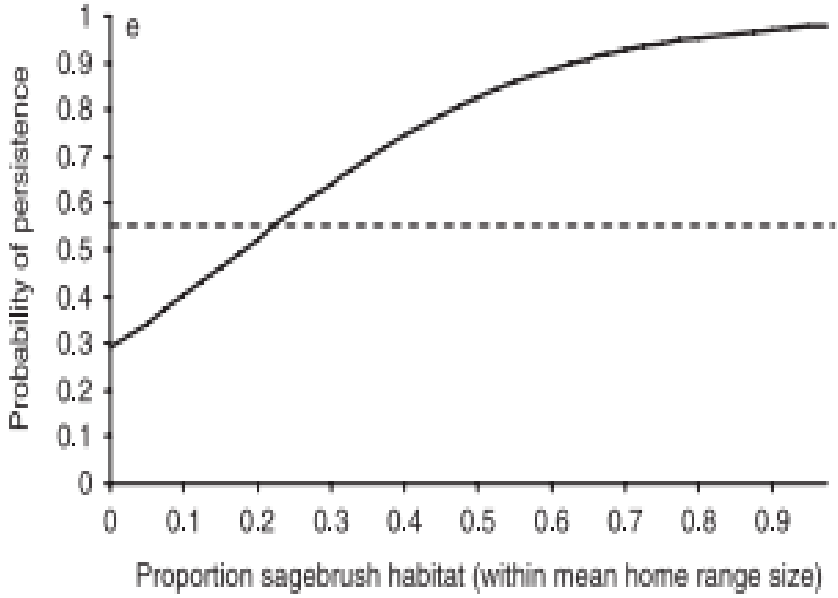


**Figure 5.5**. Threshold response curve for persistence of greater sage-grouse based on proportion of sagebrush habitat within mean home range size (30.77 km [19.12 mi] radius). Dashed lines indicate optimal threshold cut-off probability (0.5524) while holding other model parameters at their mean value. Persistence is predicted above the threshold, and extirpation is predicted below the threshold (Aldridge et al. 2008).

**Habitat Goal Status**

In the 2011 CAAS, Oregon's sage-grouse habitat goal was set maintain at least 70% of the sage-grouse range as sagebrush habitat in advanced structural stages. Oregon is not currently meeting the habitat goal, though this metric has proven difficult to measure and fails to address overall habitat quality, including understory. In 2011, sage-grouse habitat in Oregon was comprised of approximately 70% sagebrush and 30% potential habitat, which was believed sufficient to support the previous 30 years of sage-grouse populations. This ratio was recommended as a reasonable minimum threshold in the 2001 BLM Proposed Southeastern Oregon Resource Management Plan – Final Environmental Impact Statement (EIS) (Bureau of Land Management 2001; Karl and Sadowski 2005). It was also acknowledged that later stage structural classes of sagebrush should be retained for the cover benefits to multiple wildlife species. The findings of Aldridge et al. (2008; Figure 5.5) support the original habitat objectives from the 2011 CAAS, particularly at mid-scales (within 30 km [19 mi]).

The development of remote-sensing platforms, particularly the USDA Rangeland Analysis Platform (RAP; Version 3), have allowed improved analysis tools, particularly the Sagebrush Conservation Design and Threat-based Ecostate Maps (see discussion in Section 2). The ecostate maps provide a snapshot of vegetation conditions across Oregon rangelands at 30$m^2$ pixels, incorporating the threats of invasive annual grasses, juniper encroachment, and wildfire from 1990 to present, allowing for finer-scale scrutiny of habitat. The categories are described in Table 5.1.

**Table 5.1.** Summary of threat-based ecostate categories (Institute for Natural Resources 2023).

| Ecostate | Description | Shrub Cover | Herbaceous Cover | Tree Cover |
|---|---|---|---|---|
| **A** | Good Condition Shrubland | >12% | Perennials exceed annuals by 3:1 | <5% |
| **A-C** | Intermediate Condition Shrubland | >12% | Perennials dominant over annuals between 1:1 and 3:1 | <5% |
| **C** | Poor Condition Shrubland | >12% | Annuals dominant | <5% |
| **B** | Good Condition Grassland | <12% | Perennials exceed annuals by 3:1 | <5% |
| **B-D** | Intermediate Condition Grassland | <12% | Perennials dominant over annuals between 1:1 and 3:1 | <5% |
| **D** | Poor Condition Grassland | <12% | Annuals dominant | <5% |
| **Tree** | Low-mid Cover | N/A | N/A | 5-20% |
| **Tree** | High Cover | N/A | N/A | ≧ 21% |

Based on the most recent rangeland vegetation maps (2023), sagebrush habitat across all categories (good, intermediate, and poor) covers an estimated 67% of the core sage-grouse habitat and 66% of low-density habitat for a total of 67% (ecostates A, A-C, and C; Tables 5.2, 5.3, and 5.4), falling short of the 2011 objective of 70%. An estimated 12% of the habitat (core and low density) that meets the goal for sagebrush cover is heavily compromised by invasive grasses (Ecostate C: Poor condition shrubland) and at risk of complete habitat loss following wildfire. An additional 35% of areas with adequate sagebrush cover have levels of annual grass invasion that are of concern (Ecostates A-C: Intermediate condition shrubland) if invasion increases. Cumulatively, the percentage of sagebrush habitat along with the widespread distribution of invasive species across the range warrants a high level of concern about the condition of Oregon's sage-grouse habitat.

Classifying structure and cover provided by sagebrush is a useful approximation of sage-grouse habitat needs, but a more refined approach would consider the quality of the understory and threats associated with invasive vegetation, all relevant to overall ecosystem function. An improved objective sets higher quality habitats (Ecostates A, A-C, and B) at the 70% objective, currently 60% in core habitat, 50% in low density, and 57% total (Tables 5.2, 5.3, and 5.4).

Under the "Defend the Core, Grow the Core" approach, the remaining high-quality ecostates in core areas must first be protected before we can expect growth of the best habitats. Ecostate A habitats in Oregon sage-grouse range have declined substantially between 1990 and 2023 from 64% to 24% in core habitats, 55% to 13% in low density habitat, and 61% to 20% overall while other poorer quality habitats gained acreage (Tables 5.2, 5.3, and 5.4). This loss can be attributed to the increased frequency and scale of wildfire and subsequent conversion to lower quality categories, the steady invasion of conifers, and the conversion of understory to invasive annual grasses with or without the aid of fire. Wildfires have cumulatively burned approximately 676,000 ha (1.67 M ac) of core sage-grouse habitat in Oregon between 1990-2023 and 457,000 ha (1.13 M ac) of low density habitat (Table 5.6, Figure 5.12), which only partially accounts for the 2.35 M ha (5.81M ac) of Ecostate A lost since 1990 in core, and 1.4M ha (3.57 M ac) lost in low density habitats. Tree cover has increased in both habitats by approximately 272,000 ha (672,000 ac) in the same time period. Conversion to poor condition shrubland and poor condition grassland accounts for ~2 M ha (5.0 M ac) of higher quality habitat lost since 1990, overshadowing other threats. This loss can be largely attributed to invasive annual grass incursion, with or without the aid of wildfire, and exacerbated by long-term drought conditions.

The recovery of habitats from disturbance during the 22-year period from 2000-2021 was exacerbated by the driest period on record for Oregon in the past 1,200 years (O'Neill et al. 2023). Impacts from this megadrought resulted in drying of groundwater supplies, soils, surface-water bodies without normal recharge, dried vegetation susceptible to fire, and stressed wildlife. This megadrought would likely have affected the recovery of even the most resilient habitats from disturbance and made otherwise stable sites less resistant in the face of disturbance. A visual comparison of the distribution of ecostate change shows the entire range is impacted to various degrees, with more severe changes seen within recent fire scars (Figures 5.6–5.11). The impact of a 22-year megadrought on the state of vegetation across sage-grouse range is apparent when looking at the scale of change. Some habitats exhibit more resistance and resilience than others when withstanding and recovering from external disturbances. These habitats tend to be those with deeper, cooler soils and better moisture conditions, often found in higher elevation shrub-steppe. Examining the distribution of ecostates at the PAC-level shows those PACs that are most severely impacted and those that are at or near the objective of 70% Ecostates A, A-C, and B (Table 5.5).

**Table 5.2.** Comparison of threat-based ecostate composition within Oregon sage-grouse core habitats (2023 map) during 3 time periods: 1990, 2003, and 2023 (Institute for Natural Resources 2023, updated 2025).

| Core Habitat Ecostate | Acreage | | | % of Total Acreage | | | Acreage Change | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2003 | 2023 | 1990 | 2003 | 2023 | 1990–2003 | 2003–2023 | 1990–2023 |
| **A**: Good condition shrubland | 4,953,686 | 2,927,818 | 1,853,885 | 64.3 | 38.3 | 24.4 | (2,025,868) | (1,073,933) | (3,099,801) |
| **A-C**: Intermediate condition shrubland | 1,225,985 | 2,425,596 | 2,612,892 | 15.9 | 31.7 | 34.4 | 1,199,611 | 187,296 | 1,386,907 |
| **C**: Poor condition shrubland | 29,111 | 332,999 | 676,647 | 0.4 | 4.4 | 8.9 | 303,888 | 343,648 | 647,536 |
| **B**: Good condition grassland | 326,687 | 332,717 | 115,951 | 4.2 | 4.3 | 1.5 | 6,030 | (216,766) | (210,736) |
| **B-D**: Intermediate condition grassland | 425,622 | 769,887 | 728,454 | 5.5 | 10.1 | 9.6 | 344,265 | (41,433) | 302,832 |
| **D**: Poor condition grassland | 32,417 | 258,465 | 771,110 | 0.4 | 3.4 | 10.2 | 226,048 | 512,645 | 738,693 |
| **Tree**: low-mid cover | 705,638 | 605,612 | 832,930 | 9.2 | 7.9 | 11.0 | (100,026) | 227,318 | 127,292 |
| **Tree**: high cover | 94,372 | 139,616 | 201,182 | 3.3 | 2.9 | 3.4 | 45,244 | 61,566 | 106,810 |

**Table 5.3.** Comparison of threat-based ecostate composition within Oregon sage-grouse low-density habitats (2023 map) during 3 time periods: 1990, 2003, and 2023 (Institute for Natural Resources 2023, updated 2025).

| Low-Density Ecostate | Acreage | | | % of Total Acreage | | | Acreage Change | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2003 | 2023 | 1990 | 2003 | 2023 | 1990–2003 | 2003–2023 | 1990–2023 |
| **A**: Good condition shrubland | 2,509,107 | 1,366,997 | 610,540 | 54.5 | 29.8 | 13.4 | (1,142,110) | (756,457) | (1,898,567) |
| **A-C**: Intermediate condition shrubland | 1,148,923 | 1,570,458 | 1,629,517 | 24.9 | 34.3 | 35.9 | 421,535 | 59,059 | 480,594 |
| **C**: Poor condition shrubland | 38,628 | 383,246 | 770,009 | 0.8 | 8.4 | 17.0 | 344,618 | 386,763 | 731,381 |
| **B**: Good condition grassland | 125,037 | 162,285 | 49,537 | 2.7 | 3.5 | 1.1 | 37,248 | (112,748) | (75,500) |
| **B-D**: Intermediate condition grassland | 273,300 | 419,410 | 352,367 | 5.9 | 9.1 | 7.8 | 146,110 | (67,043) | 79,067 |
| **D**: Poor condition grassland | 44,543 | 282,924 | 605,432 | 1.0 | 6.2 | 13.3 | 238,381 | 322,508 | 560,889 |
| **Tree**: low-mid cover | 466,622 | 399,724 | 524,070 | 10.1 | 8.7 | 11.5 | (66,898) | 124,346 | 57,448 |
| **Tree**: high cover | 71,117 | 91,718 | 134,729 | 3.3 | 2.8 | 3.3 | 20,601 | 43,011 | 63,612 |

**Table 5.4.** Comparison of threat-based ecostate composition within all Oregon sage-grouse habitats (core and low-density habitats; 2023 map) during 3 time periods: 1990, 2003, and 2023 (Institute for Natural Resources 2023, updated 2025).

| Total Habitat Ecostate | Acreage | | | % of Total Acreage | | | Acreage Change | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2003 | 2023 | 1990 | 2003 | 2023 | 1990–2003 | 2003–2023 | 1990–2023 |
| **A**: Good condition shrubland | 7,462,793 | 4,294,815 | 2,464,425 | 60.6 | 35.1 | 20.3 | (3,167,978) | (1,830,390) | (4,998,368) |
| **A-C**: Intermediate condition shrubland | 2,374,908 | 3,996,054 | 4,242,409 | 19.3 | 32.7 | 35.0 | 1,621,146 | 246,355 | 1,867,501 |
| **C**: Poor condition shrubland | 67,739 | 716,245 | 1,446,656 | 0.6 | 5.9 | 11.9 | 648,506 | 730,411 | 1,378,917 |
| **B**: Good condition grassland | 451,724 | 495,002 | 165,488 | 3.7 | 4.0 | 1.4 | 43,278 | (329,514) | (286,236) |
| **B-D**: Intermediate condition grassland | 698,922 | 1,189,297 | 1,080,821 | 5.7 | 9.7 | 8.9 | 490,375 | (108,476) | 381,899 |
| **D**: Poor condition grassland | 76,960 | 541,389 | 1,376,542 | 0.6 | 4.4 | 11.3 | 464,429 | 835,153 | 1,299,582 |
| **Tree**: low-mid cover | 1,172,260 | 1,005,336 | 1,357,000 | 9.5 | 8.2 | 11.2 | (166,924) | 351,664 | 184,740 |
| **Tree**: high cover | 165,489 | 231,334 | 335,911 | 60.6 | 35.1 | 20.3 | (67,168) | (104,797) | (171,965) |

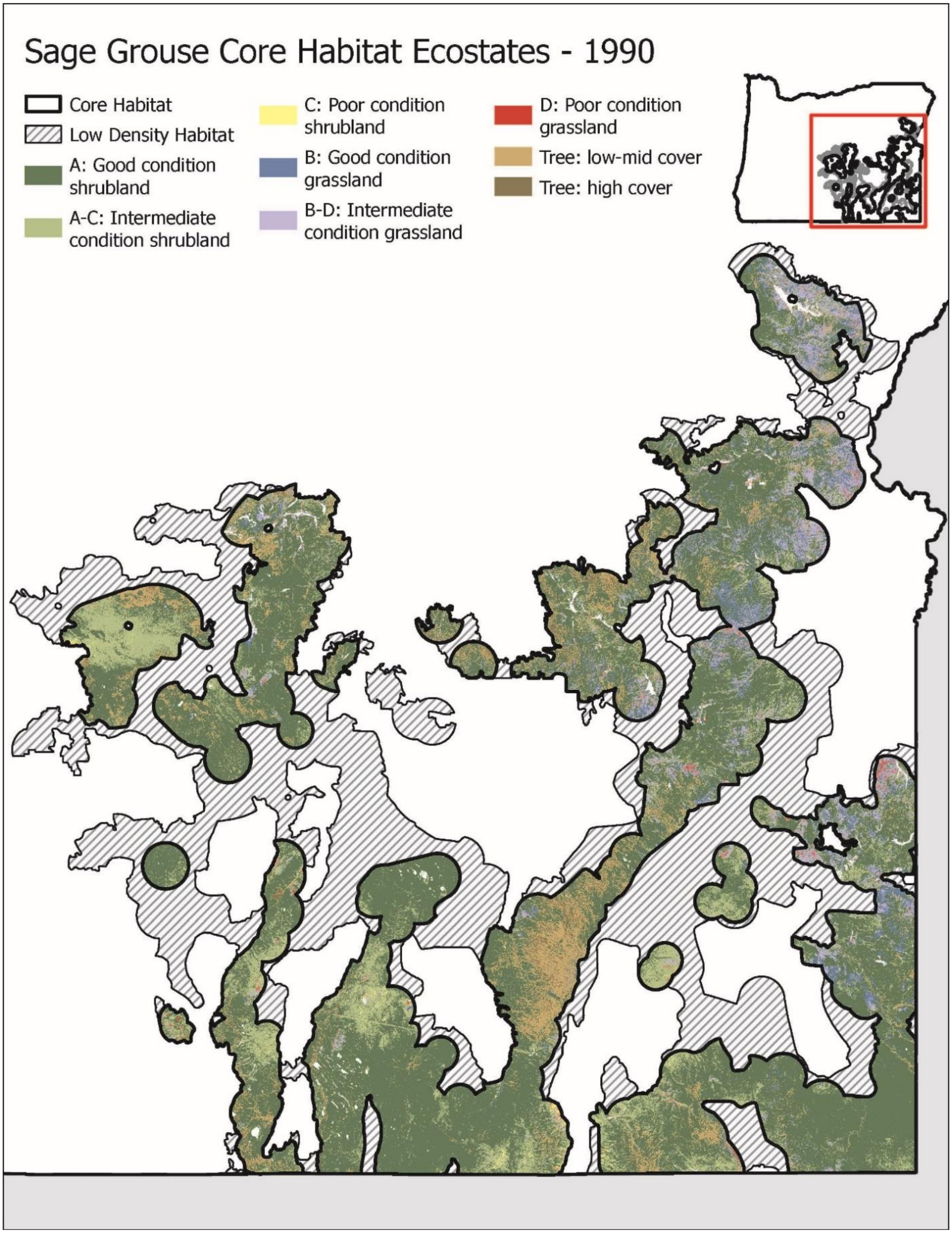


**Figure 5.6**. Distribution of Ecostate categories in 1990 within sage-grouse core habitat (Institute for Natural Resources 2023, updated 2025).

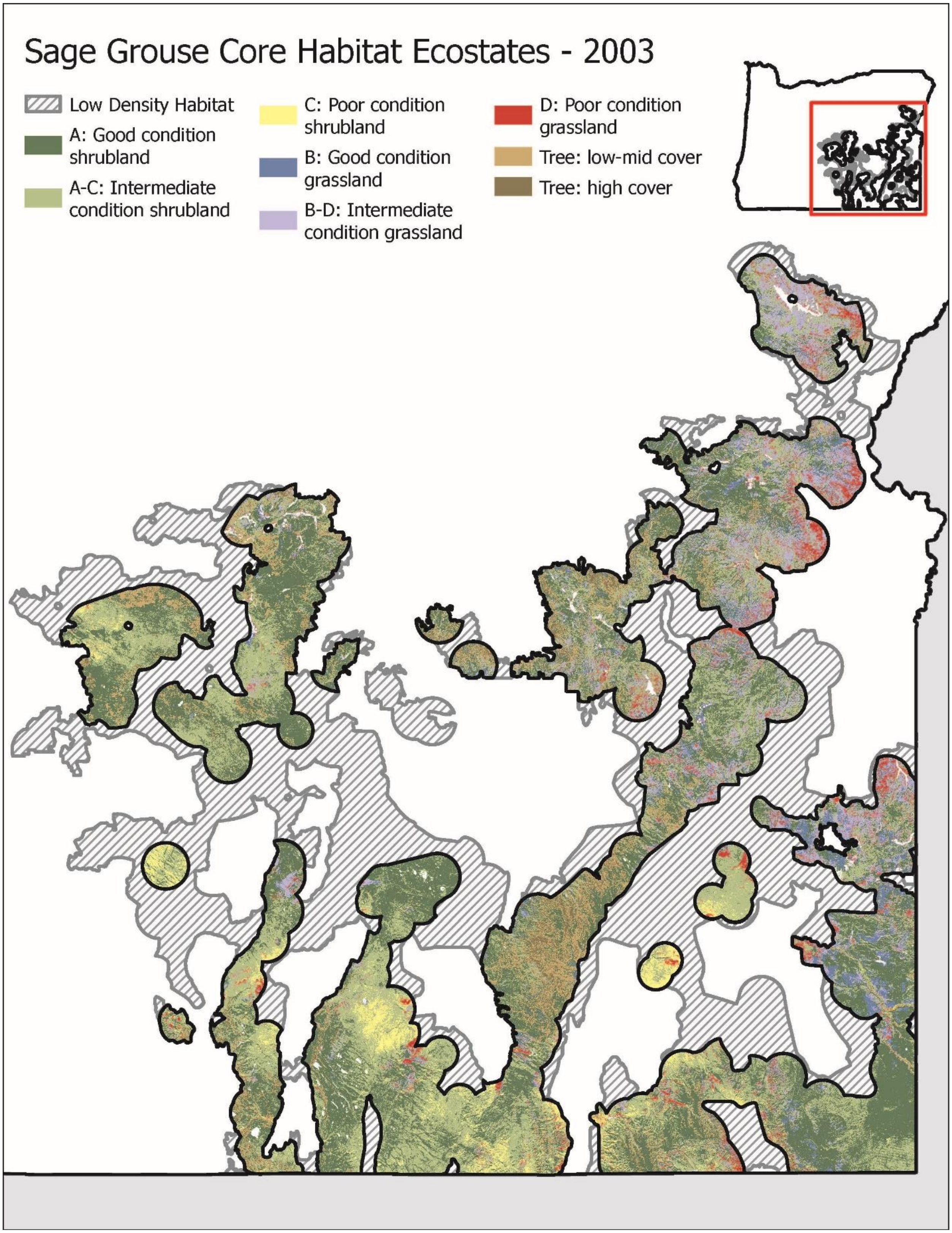


**Figure 5.7**. Distribution of Ecostate categories in 2003 within sage-grouse core habitat (Institute for Natural Resources 2023, updated 2025).

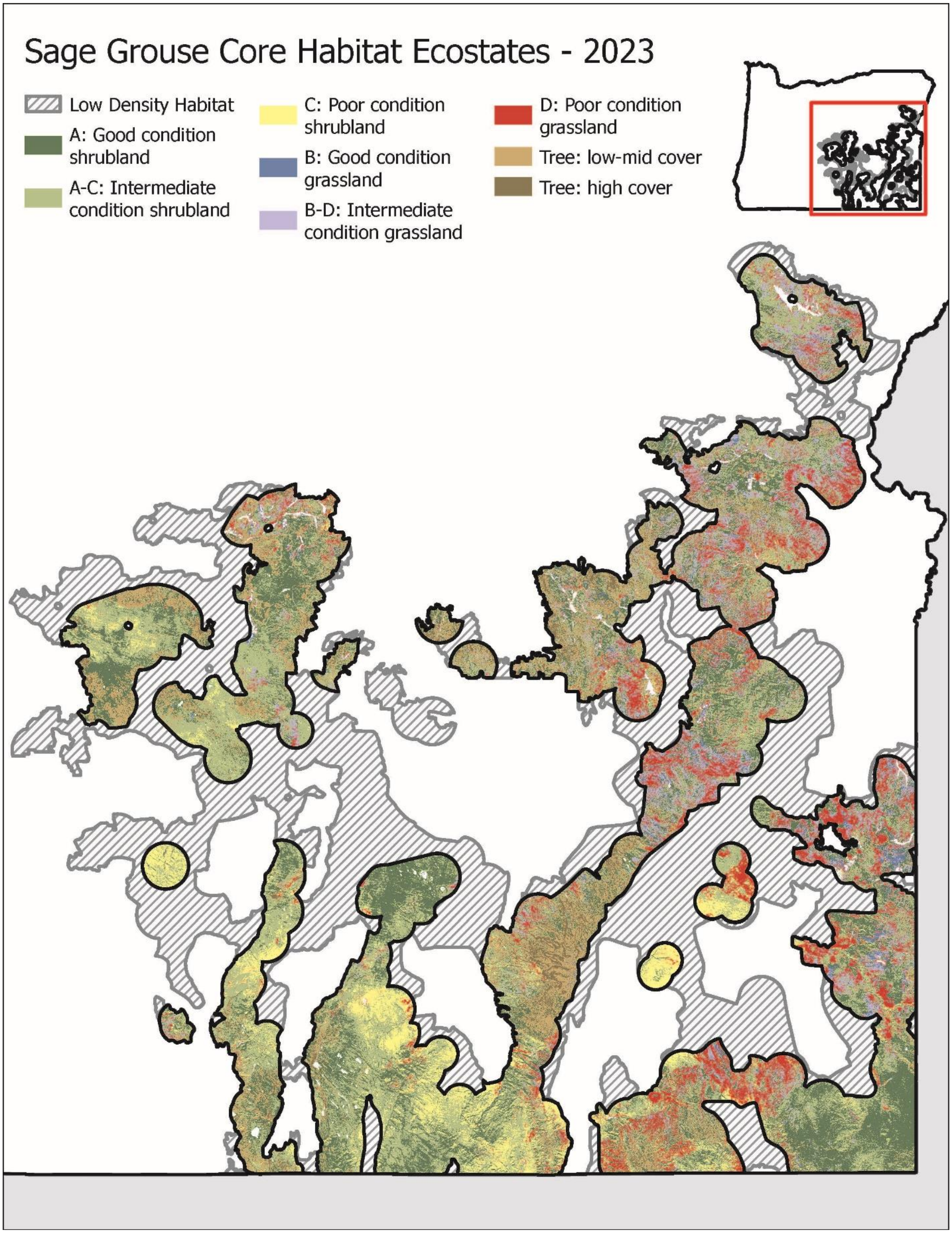


**Figure 5.8**. Distribution of Ecostate categories in 2023 within sage-grouse core habitat (Institute for Natural Resources 2023, updated 2025).

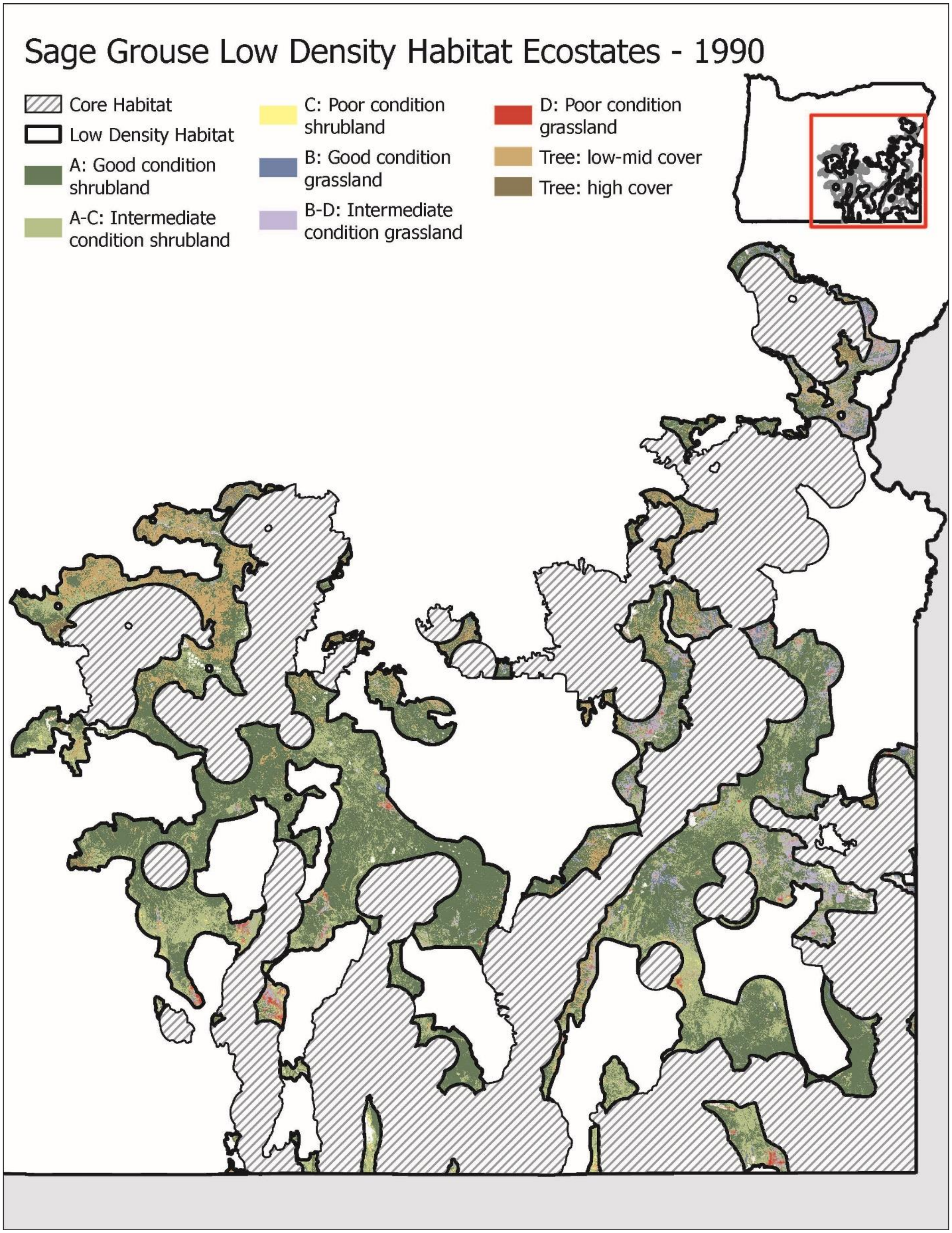


**Figure 5.9**. Distribution of Ecostate categories in 1990 within sage-grouse low density habitat (Institute for Natural Resources 2023, updated 2025).

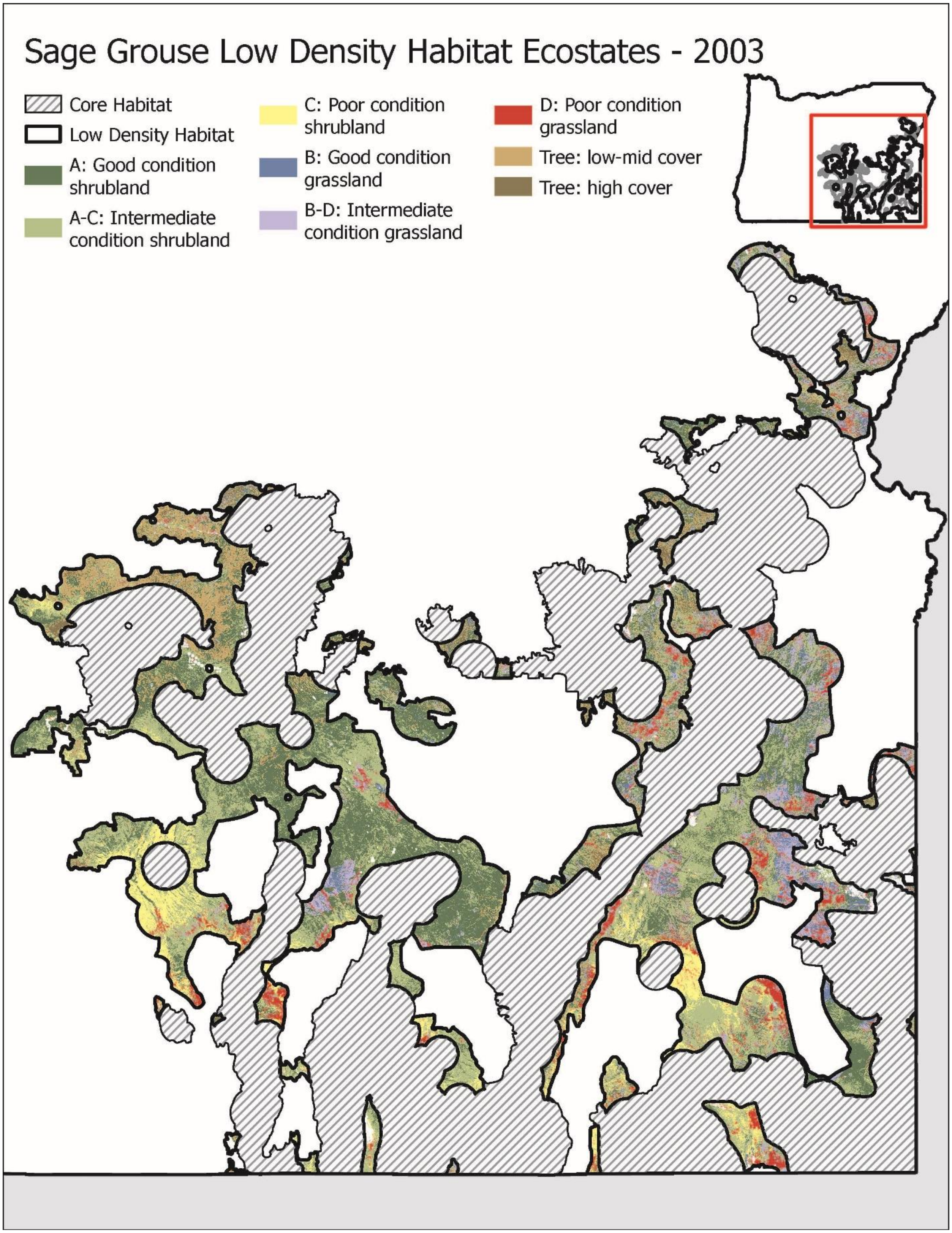


**Figure 5.10.** Distribution of Ecostate categories in 2003 within sage-grouse low density habitat (Institute for Natural Resources 2023, updated 2025).

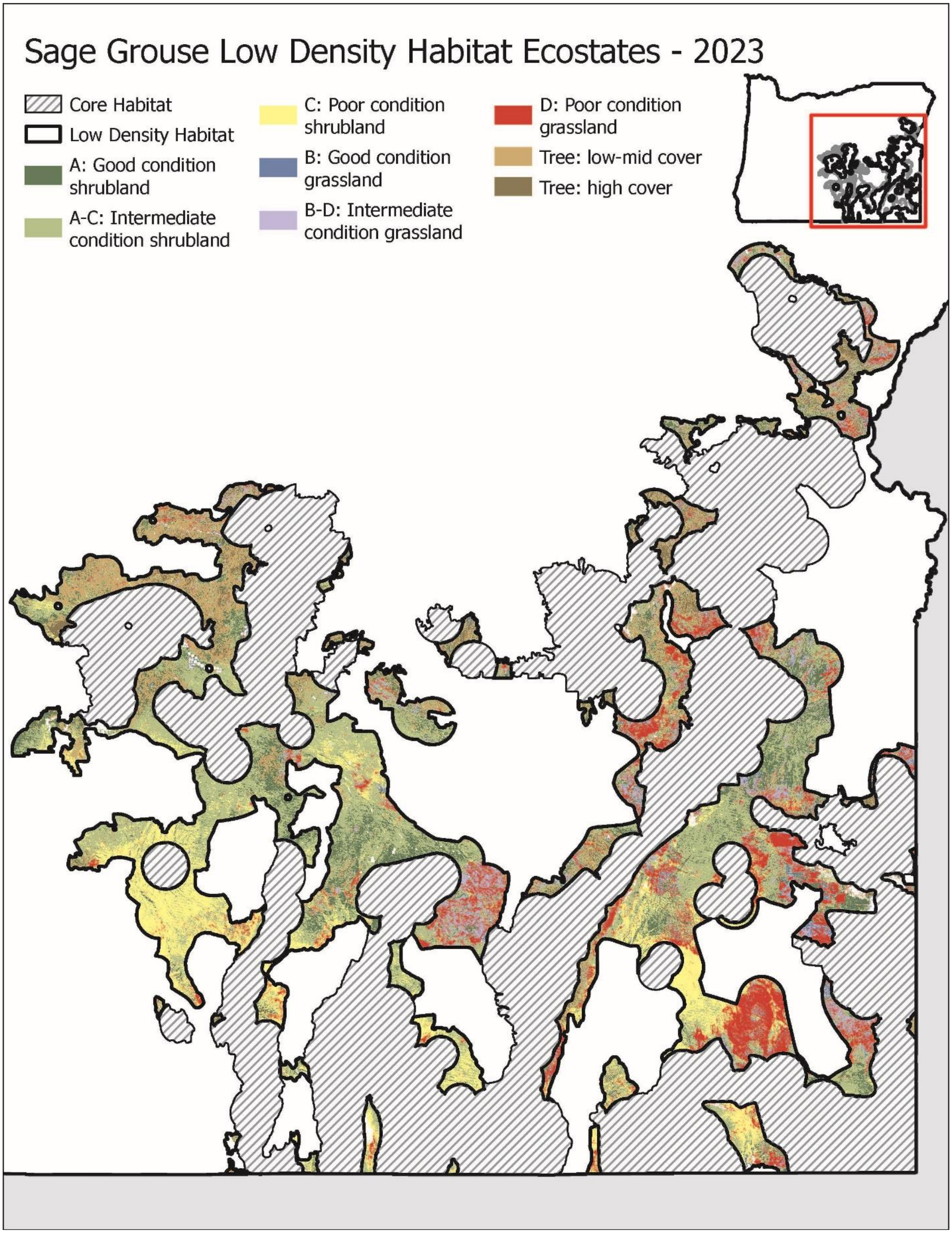


**Figure 5.11**. Distribution of Ecostate categories in 2023 within sage-grouse low density habitat (Institute for Natural Resources 2023, updated 2025).

**Table 5.5.** Threat-based Ecostate composition (acres) of Oregon sage-grouse PACs, 2023 (Institute for Natural Resources 2023, updated 2025). **Bold** indicates PACs that are meeting or exceeding the habitat objective (70% Ecostates A, A-C, and B).

| Priority Area for Conservation (PAC) | A: Good condition shrubland | A-C: Intermediate condition shrubland | C: Poor condition shrubland | B: Good condition grassland | B-D: Intermediate condition grassland | D: Poor condition grassland | Tree: low-mid cover | Tree: high cover | Proportion of A, A-C, and B |
|---|---|---|---|---|---|---|---|---|---|
| Baker | 35,601 | 106,339 | 4,959 | 6,066 | 67,425 | 34,749 | 11,500 | 557 | 0.55 |
| **Beatys** | 220,855 | 388,536 | 154,649 | 474 | 3,921 | 10,937 | 31,821 | 6,104 | **0.75** |
| Brothers | 116,441 | 136,723 | 21,332 | 94 | 1,053 | 1,648 | 95,229 | 11,055 | 0.66 |
| Bully Creek | 65,502 | 134,754 | 10,971 | 12,802 | 114,343 | 88,235 | 54,538 | 9,399 | 0.43 |
| Burns | 13,727 | 16,141 | 618 | 597 | 4,306 | 1,414 | 27,201 | 10,528 | 0.41 |
| Cow Lakes | 70,023 | 68,253 | 3,323 | 21,481 | 79,267 | 82,676 | 9,087 | 252 | 0.48 |
| Cow Valley | 83,594 | 111,692 | 3,265 | 8,762 | 91,185 | 60,624 | 29,501 | 3,859 | 0.52 |
| Crowley | 141,257 | 173,136 | 9,200 | 24,637 | 118,273 | 96,037 | 18,176 | 3,021 | 0.58 |
| Diablo | 1,781 | 18,395 | 35,586 | 38 | 25 | 20 | 357 | - | 0.36 |
| Drewsey | 80,351 | 109,253 | 9,272 | 7,793 | 45,195 | 43,627 | 94,619 | 37,005 | 0.46 |
| **Dry Valley/ Jack Mountain** | 121,037 | 62,563 | 5,506 | 100 | 2,728 | 2,301 | 135 | - | **0.95** |
| **Juniper Mountain** | 26,032 | 76,648 | 26,421 | 56 | 494 | 3,375 | 1,875 | 1,185 | **0.75** |
| **Louse Canyon** | 279,266 | 164,917 | 19,986 | 3,323 | 25,430 | 44,700 | 10,898 | 316 | **0.82** |
| **North Wagontire** | 38,767 | 159,477 | 16,149 | 680 | 8,244 | 3,577 | 41,315 | 1,752 | **0.74** |
| Paulina | 147,048 | 196,359 | 11,607 | 3,873 | 35,558 | 31,399 | 88,148 | 16,269 | 0.65 |
| Pueblos | 62,856 | 138,854 | 118,785 | 1,126 | 4,481 | 15,082 | 11,564 | 631 | 0.57 |

Table 5.5, continued

| PAC | A: Good condition shrubland | A-C: Intermediate condition shrubland | C: Poor condition shrubland | B: Good condition grassland | B-D: Intermediate condition grassland | D: Poor condition grassland | Tree: low-mid cover | Tree: high cover | Proportion of A, A-C, and B |
|---|---|---|---|---|---|---|---|---|---|
| Saddle Butte | 1,938 | 38,951 | 36,149 | 85 | 2,202 | 27,056 | 6 | - | 0.39 |
| Sheepshead | 1,056 | 6,478 | 40,991 | 9 | 12 | 820 | 71 | - | 0.15 |
| Soldier Creek | 97,757 | 116,962 | 14,530 | 14,717 | 64,141 | 76,098 | 14,863 | 1,682 | 0.57 |
| Steens | 90,673 | 108,345 | 25,409 | 4,569 | 24,640 | 32,308 | 183,256 | 75,269 | 0.37 |
| Trout Creeks | 85,431 | 129,631 | 65,293 | 4,334 | 31,734 | 108,893 | 41,542 | 6,892 | 0.46 |
| Tucker Hill | 5,199 | 12,821 | 2,107 | 155 | 2,788 | 2,329 | 3,277 | 1,333 | 0.61 |
| Warner | 67,220 | 136,812 | 40,177 | 128 | 731 | 2,844 | 63,296 | 13,801 | 0.63 |

**Table 5.6.** Cumulative and percent acres burned within core and low-density sage-grouse habitat in Oregon during the periods of 1990–2003, 2003–2023, and 1990–2023.

| | 1990–2003 ac burned | 2003–2023 ac burned | 1990–2023 ac. burned | 1990–2003 % burned | 2003–2023 % burned | 1990–2023 % burned |
|---|---|---|---|---|---|---|
| **Core Habitat** | 327,865 | 797,480 | 1,125,345 | 1.9% | 9.5% | 11.4% |
| **Low-Density** | 280,845 | 1,392,390 | 1,673,235 | 1.9% | 4.5% | 6.4% |
| **Total** | 608,710 | 2,189,870 | 2,798,580 | 2.6% | 9.5% | 12.3% |

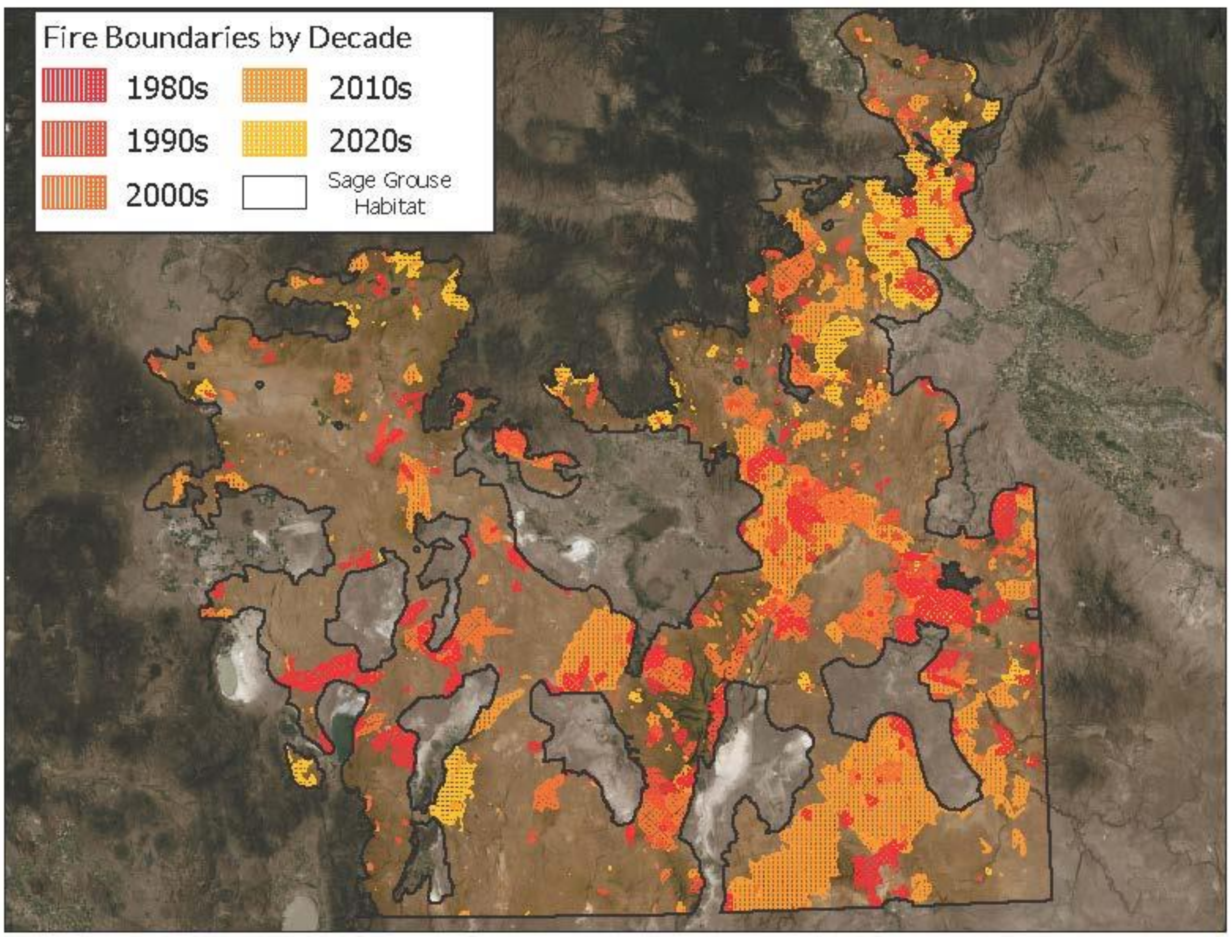


**Figure 5.12**. Fire boundaries within sage-grouse habitat (all categories) by decade (1980s – 2020s).

While ODFW is responsible for the management of the state's sage-grouse population, the department manages very little of the actual habitat (~0.02%). The vast majority of Oregon's sage-grouse range is owned and managed by the BLM (72%) and private landowners (20.5%), and less so by the Oregon Department of State Lands, U.S. Fish and Wildlife Service, and U.S. Forest Service (Table 5.7). This situation emphasizes the importance of cooperation and collaboration among land managers and highlights the need to monitor the quality and quantity of habitat across the range of ownership boundaries.

**Table 5.7.** Approximate distribution of land management in Oregon sage-grouse core, low-density, and total range.

| Land Manager | Core Acres *(% of Core)* | Low Density Acres *(% of Low Density)* | Total Acres *(% of Total)* |
|---|---|---|---|
| **BLM** | 5,558,884 *(69.9%)* | 3,616,460 *(75.3%)* | 9,175,344 *(72.0%)* |
| **Private** | 1,780,647 *(22.4%)* | 837,489 *(17.4%)* | 2,618,136 *(20.5%)* |
| **ODSL** | 266,205 *(3.3%)* | 229,070 *(4.8%)* | 495,275 *(3.9%)* |
| **USFWS** | 247,183 *(3.1%)* | 15,541 *(0.3%)* | 262,724 *(2.1%)* |
| **USFS** | 53,112 *(0.7%)* | 65,939 *(1.4%)* | 119,051 *(0.9%)* |
| **All Others** | 42,471 *(0.5%)* | 36,955 *(0.8%)* | 79,427 *(0.6%)* |

## Summary

To facilitate their annual survival and production, sage-grouse require high quality sagebrush habitats, consisting of overhead canopy cover of sagebrush and a healthy understory of forbs and perennial grasses. Since the mid-20$^{th}$ century, Oregon's sagebrush ecosystem has suffered conversion to other habitats and has declined in both quantity and quality. A minimum of 70% sagebrush cover in high to intermediate ecostates is necessary to maximize sage-grouse population persistence. Oregon is not currently achieving this objective primarily due to the loss of sagebrush following large wildfires and subsequent conversion to poor quality ecostates, in addition to historic sagebrush removal and conversion. Prioritizing the protection of existing high quality habitats from conversion to poorer quality ecostates is critical to stabilize sage-grouse populations in Oregon.

**Recommendations**

1. Adopt "Threat-Based Ecostates" as a tool for monitoring habitat quality and quantity.
2. Habitat Objective 1: Manage a minimum of 70% of greater sage-grouse range for sagebrush habitat in ecostates A (good condition shrubland), B (good condition grassland) and A-C (intermediate condition shrubland) and prioritize the protection and growth of these areas.
3. Habitat Objective 2: Manage sagebrush habitats to achieve a net conservation gain of intact sagebrush communities (ecostate A) and maintain stable or increasing amounts of sagebrush and perennial grassland habitats in ecostates A, B, and A-C, at the statewide and PAC-scale.
4. Engage with BLM and other land managers to design fuel breaks that optimize function while minimizing direct and indirect impacts to wildlife habitats.
5. Encourage federal land managers to prevent populations of free-roaming equids from exceeding AML in herd ranges overlapping sage-grouse core or low-density habitats.
6. Engage with cooperating land managers to provide advice and expertise on the best practices to improve sagebrush habitat conditions.
7. Support efforts to improve remote sensing techniques and data which inform Threat Based Ecostates geospatial layers.

## Section 6: Cooperation and Collaboration

Sage-grouse range is extensive and spans a wide variety of land ownerships and management paradigms. The best conservation outcomes for sage-grouse and their habitats will be achieved by cooperation among partners at range-wide, regional, and local scales (Figure 6.1). In this section, we describe the role of the department within this cooperative structure, affirm the role of Local Implementation Teams, and highlight some important partnerships. An extensive description of partnerships and roles is described in the Oregon Sage-grouse Action Plan and should be considered the guiding document for cooperation and collaboration.

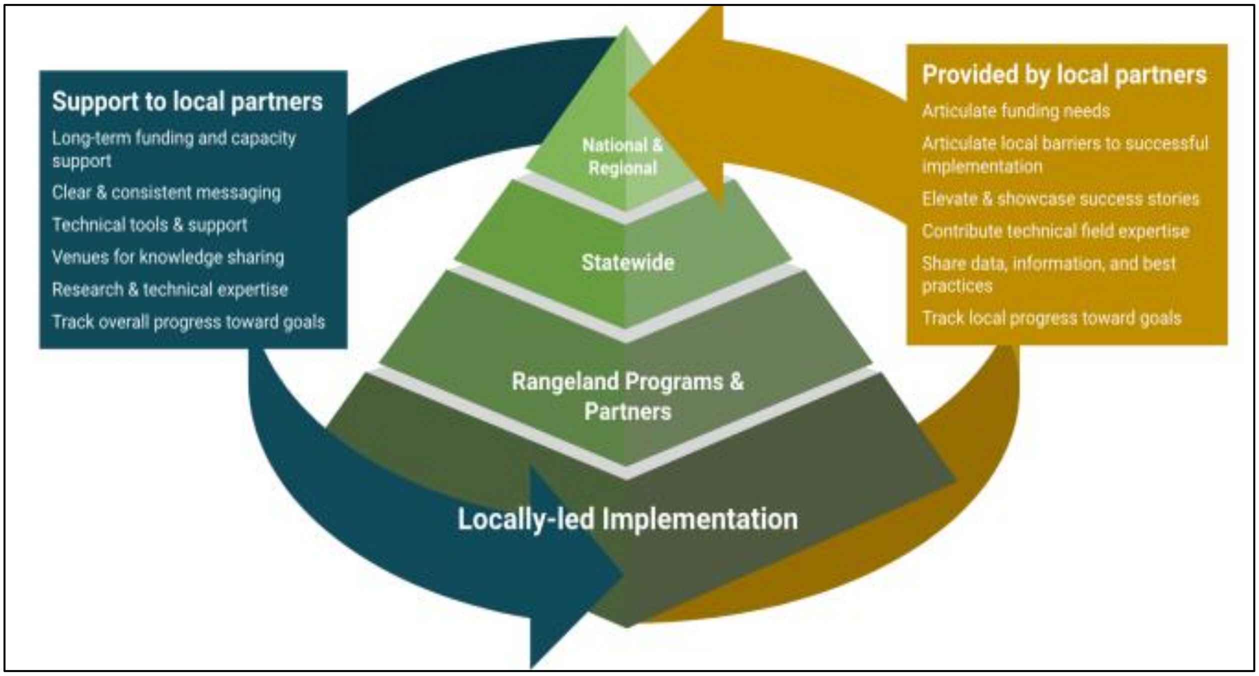


**Figure 6.1.** SageCon Partnership model for achieving coordinated and supported implementation of strategic conservation actions on-the-ground (The SageCon Partnership 2022).

### National and Regional Partners

*U.S. Fish and Wildlife Service*

The U.S. Fish and Wildlife Service (USFWS) plays a key role in sage-grouse conservation from the national to the local level. The agency oversees the Endangered Species Act listing process by reviewing the status of species and making listing decisions. The USFWS administers voluntary conservation agreements (see Rangeland Programs and Partners below), actively collaborates with partners, including the SageCon Partnership in Oregon, works to support land use planning efforts of other federal agencies such as the BLM and USFS, provides technical expertise, and reviews proposed actions and developments. The agency both initiates and supports sage-grouse research, conservation, and habitat restoration, including overseeing state-level Pittman-Robertson funding requests, and providing funding through the USFWS Partners for Fish and Wildlife Program, and legislatively allocated funds, such as the 2021 Bipartisan Infrastructure Law funds. The USFWS is also a land management agency, managing the Sheldon-Hart National Wildlife Refuge in the core of Oregon's sage-grouse range. ODFW interacts with USFWS through multiple levels of partnership, funding and project coordination, annual lek monitoring, and conservation planning efforts.

*Bureau of Land Management*
The Bureau of Land Management (BLM) manages approximately 70% of the sage-grouse range in Oregon and is a critical partner in Oregon sage-grouse conservation. The management of these lands is guided by Resource Management Plans. The Record of Decision for the *Approved Resource Management Plan Amendments for Greater Sage-grouse Rangewide Planning* in Oregon was signed on January 15, 2025. These amendments to the 2015 and 2019 planning efforts enhance sage-grouse conservation while allowing for continued multiple use on BLM-managed lands. ODFW serves as a cooperating agency for these processes and submits formal recommendations.

The BLM collaborates with various partners to implement coordinated conservation strategies and contributes both capacity and financial assistance to ODFW's lek monitoring efforts. The agency has also provided financial support to sage-grouse research projects in Oregon designed to provide specific management recommendations. The State of Oregon, acting through ODFW, and the BLM Oregon/Washington State Office have a Memorandum of Agreement outlining ODFW's role as a cooperating agency when the BLM is planning for operations or development that overlap sage-grouse habitat. The agreement outlines how BLM OR/WA will conform to Oregon's mitigation standards when authorizing uses on BLM-administered lands.

*Natural Resources Conservation Service*
The Natural Resources Conservation Service (NRCS) is a USDA agency that is a primary partner in sage-grouse conservation while supporting sustainable agricultural operations. The agency collaborates with state, local, and federal agencies, non-governmental organizations, and other interested parties to implement conservation actions through technical expertise and leveraging Farm Bill programs including Working Lands for Wildlife (see Rangeland Programs and Partners below), Environmental Quality Incentives Program (EQIP), Agricultural Conservation Easement Program (ACEP), among others. In Oregon, conservation practices offered under these programs include invasive conifer removal, invasive annual grass remediation, improvements to wet meadows and riparian habitat, improvements to overall rangeland health, and addressing resource concerns including wildlife habitat, irrigation efficiency, water quality/quantity, wildfire risk reduction, and more. ODFW interacts with the NRCS in a partnership capacity, referring private land contacts to the agency.

*U.S. Forest Service*
The U.S. Forest Service (USFS) manages approximately 8% of the remaining greater sage-grouse habitat range-wide and is responsible for helping to ensure that greater sage-grouse populations persist. The conservation measures in five Forest Service land management plan amendments protect the greater sage-grouse by monitoring, maintaining, and restoring the sagebrush steppe ecosystem. ODFW cooperates with the USFS in offering technical expertise and sharing sage-grouse population data, coordinating mitigation for impacts, as well as interacting in the larger context of the SageCon Partnership.

*Western Association of Fish and Wildlife Agencies*
The Western Association of Fish and Wildlife Agencies (WAFWA) coordinates efforts among western state agencies with additional technical expertise provided by federal partners including the USFWS, USGS, USFS, and BLM. WAFWA facilitates collaboration, shares new information, provides technical assistance, and develops conservation strategies. The WAFWA Sage and Sharp-tailed Grouse Technical Committee meets monthly and hosts a biannual workshop to share research and management advancements. The committee's primary responsibility is to provide technical assistance to the Sagebrush Initiative Committee (formerly the Sagebrush Executive Oversight Committee). The technical committee has produced guidance documents such as the *Greater Sage-grouse Range-wide Population Monitoring Guidelines* (Parts A & B) and white papers on translocation guidelines, captive rearing, hunting, and predator control. The WAFWA Sagebrush Conservation Initiative was formed to identify and fill high priority knowledge gaps to effectively conserve sagebrush habitats and the species within. The group published the *Sagebrush Conservation Strategy Parts I and II* (Remington et al. 2021 and 2024) as a guide to these efforts.

**Statewide**

*SageCon Partnership*
Collaboration among Oregon's partners in sage-grouse conservation is convened by the Oregon Sage-grouse Conservation Partnership (SageCon). Under the call to action of the Oregon Sage-grouse Action Plan, SageCon provides a forum for partner communication, provides technical support tools for implementation, monitors progress, helps partners define priorities and objectives, and works to direct funding and policy actions that support the Action Plan. The partnership emphasizes effective, strategic, and coordinated restoration efforts, shared strategic priorities, clear and measurable objectives, and communicating progress. SageCon hosts an annual summit to help partners network, access resources, and learn new information.

*ODFW Wildlife and Habitat Programs*
ODFW employs professional wildlife and habitat biologists who interact with private landowners regularly. In the context of sage-grouse, these biologists work to develop and maintain relationships with landowners in sage-grouse habitat, provide expert advice, and work with other entities and agencies to identify resources to assist with conservation projects. The department can encourage landowners to participate in LITs as their on-the-ground knowledge is an asset for guiding, prioritizing, and implementing habitat projects. There is occasionally funding available through these programs, as well as the ODFW Access & Habitat program.

*Oregon Watershed Enhancement Board*
The Oregon Watershed Enhancement Board (OWEB) provides critical funding to support the implementation of the Oregon Sage-grouse Action Plan. Executive Order 15-18 directs OWEB to work with NRCS, ODFW, and the Governor's Natural Resources Office to direct funding commitments to reflect the priorities of the Action Plan and evaluate the effectiveness of these investments. OWEB committed to investing at least $10M in projects between 2015 and 2025, and far surpassed this goal by reaching $18.4M in investments by April 2025.

*Department of Land Conservation and Development*
DLCD administers the Sage-grouse Conservation Rules (OAR 660-023-0115) adopted to implement LCDC Goal 5 (Significant Natural Resources). ODFW and DLCD coordinate to maintain consistency between the LCDC rules and the ODFW Sage-grouse Mitigation Rules. Other state agencies that carry out, fund, or permit actions within sage-grouse habitat are also required to maintain rules, coordination plans, and agreements consistent with the DLCD OARs. DLCD is required to maintain a central registry of development on all lands within sage-grouse habitat, in coordination with BLM and counties. The ODFW Sage-grouse Mitigation Program works with DLCD to maintain consistency between the registry of development and the mitigation database.

*Department of State Lands*
The Oregon Department of State Lands (DSL) mission is to ensure a legacy for Oregonians and their public schools through sound stewardship of lands, wetlands, waterways, unclaimed property, estates, and the Common School Fund. DSL has ~255,000 ha (630,000 ac) of sage-grouse habitat on its properties and has a 247,263 ha (611,000 ac) Candidate Conservation Agreement with Assurances (CCAA) to guide future conservation management and action. ODFW works with DSL to provide technical expertise as needed.

*Oregon Department of Forestry*
The Oregon Department of Forestry (ODF) provides technical and financial support to RFPAs to improve their capacity and effectiveness in fighting range fires on both federal and non-federal land. ODFW affirms the importance of support for RFPAs as a key need in suppressing large-scale wildfires that eliminate sage-grouse habitat.

**Rangeland Programs & Partners**

Rural economies that overlap sage-grouse range rely on agricultural working lands (see Appendix 4). The concept of "working lands conservation" refers to a system that conserves critical ecosystem services and biodiversity while sustainably providing goods and services for human inhabitants over the long term (Kremen and Merenlender 2018). Working lands can connect and protected areas and buffer them from threats. Maintaining healthy, sustainable economies in these rural landscapes is critical to the delivery of working lands conservation. Here we highlight a few major programs that support wildlife and habitat conservation on private lands.

*NRCS Working Lands for Wildlife*
Many of Oregon's sage-grouse conservation partners work to assist private landowners with resources to improve the health of rangelands. The USDA Natural Resources Conservation Service (NRCS) works directly with private landowners to conserve at-risk wildlife and western rangelands through the framework of the Sage Grouse Initiative (SGI) which is now part of the Working Lands for Wildlife (WLFW) program. This program directs Farm Bill resources to help producers make improvements on their land and reduce threats facing working rangelands. As the world's largest source of conservation funding, Farm Bill programs have the potential to reverse the decline rangeland ecosystem health. Policies that support and fund WLFW programs are critical to supporting private lands conservation of sage-grouse and their habitats.

*Candidate Conservation Agreements*
The USFWS currently has permits with the Department of State Lands, four Soil and Water Conservation Districts (SWCDs), and the Powder Basin Watershed Councils for the enhancement of sage-grouse survival through the Candidate Conservation Agreements with Assurances (CCAAs) program. These agreements prescribe actions that maintain and improve sagebrush ecosystem health with an overall benefit to rangeland health while improving sustainability of ranching operations. Participants voluntarily commit to 30-year agreements to maintain and enhance habitat and infrastructure through prescribed conservation actions to promote rangeland health and sage-grouse populations. In exchange, enrollees are prioritized for funding assistance and are provided regulatory protections in case of an ESA listing of sage-grouse. Agreements are monitored and adapted as needed to ensure durability of conservation actions over the life of the plan. Candidate Conservation Agreements (CCAs) are similar agreements administered by the USFWS, but lack the assurances of regulatory protection, primarily utilized on federally managed land.

Between 2015 and August 2025, ~330,905 ha (817,684 ac) of sage-grouse habitat on private lands were enrolled in CCAAs in Crook, Deschutes, Lake, Harney, Malheur, Baker, and Union counties, involving 67 landowners. More than 100 additional landowners have committed to enroll, with the promise of adding over ~414,654 ha (1,024,633 ac) to this total. Development, implementation, and monitoring of CCAAs represents a significant workload for and limited staff capacity is a barrier to enrollment. The department supports the use of conservation funding to support positions that develop and monitor CCAAs in Oregon.

*USFWS Partners for Fish and Wildlife Program*
The Partners for Fish and Wildlife Program ("Partners Program" administered by the USFWS helps landowners restore and enhance wildlife habitat through technical and financial assistance. The Partners Program also coordinates with the USDA to provide technical assistance developing, implementing, and evaluating Farm Bill Conservation program and initiatives, including Working Lands for Wildlife. Financial and technical resources from the Partners Program can be paired with other resources to expand the scope and scale of private land conservation assistance.

*Rangeland Research Partners*
ODFW collaborates with numerous organizations to design, fund, and implement research in the sagebrush biome. Oregon State University (OSU) is a primary collaborator on projects involving sage-grouse biology, demographics, and treatment response. Both the Department of Fisheries, Wildlife and Conservation Science, and the Department of Animal and Rangeland Science actively collaborate with ODFW on identifying and implementing research priorities. The research group at the Eastern Oregon Agricultural Research Center (EOARC), affiliated with OSU, and the OSU Extension Service provide important contributions to rangeland science, human dimensions in sagebrush biome restoration, and technical transfer of science to management. ODFW directly benefits from these research findings by synthesizing findings to inform documents such as the CAAS.

The USGS Western Ecological Research Center (WERC) and Forest Rangeland Ecosystem Science Center (FRESC) contribute abundant and valuable research that includes, but is not limited to, Oregon. ODFW has contracted with USGS to provide expertise for sage-grouse research and management needs, most recently the new population model for sage-grouse (see Section 3). The Nature Conservancy (TNC) occupies a unique niche providing applied sagebrush ecosystem research and conservation.

ODFW's research is largely funded by USFWS Pittman-Robertson funds ("P-R funds") from excise taxes on firearms, archery equipment, and ammunition. Another source of funding is from the dedicated Upland Game Bird Account from sales of upland game bird validations to upland bird hunters. Oregon State University contributes in-kind match or donated overhead to leverage the P-R funds. ODFW has also received in-kind and direct financial support from the BLM, NRCS, OWEB, SWCDs, Oregon Wildlife Foundation, the Nevada Chukar Foundation, and volunteerism from individuals, among other funding sources.

**Local Partnerships**

*Sage-grouse Local Implementation Teams*

Local Implementation Teams are local collaboration groups charged with prioritizing, facilitating funding, and coordinating implementation of on-the-ground sage-grouse conservation actions at a local level as identified in the CAAS and The Oregon Sage-grouse Action Plan. Local Implementation Teams (LITs) were first identified in the original 2005 CAAS as critical to on-the-ground prioritization and implementation of actions. The Action Plan adopted this idea and expanded the definition to include not just land managers but other interested parties. The LITs are divided by BLM District (Vale, Lakeview, Burns, and Prineville), or Field Office boundaries (formerly Resource Area), in the case of the Baker LIT. These teams are most effective with a full-time coordinator, but do not need to be mutually exclusive from existing collaborative teams that can fulfill the LIT mission. In the initial year of inception (2011–2016), LIT teams experienced attrition due to time commitments, lack of progress, or high turnover rates in coordination due to funding shortfalls.

ODFW acknowledges the importance of inclusive LITs and the role of SageCon in organizing these teams under the Action Plan. The department will continue to provide expertise and support for LITs through staff expertise and presence at meetings and contributions toward funding and oversight for LIT coordinators as needed.

*Counties*

Counties in eastern Oregon play an important role in making land use and development decisions that may intersect sage-grouse habitat. ODFW habitat and district biologists provide input on county level projects and permits that have the potential to impact sage-grouse habitat, including mitigation requirements (see Section 7). Executive Order 15-18 requires ODFW to ensure "early, efficient and constructive" staff participation in local permit review of projects subject to OAR 660 Division 30. The counties provide input in the development of the Oregon sage-grouse core and low-density habitat maps and are subject to the mitigation rules of the state.

*Northern Paiute Tribes*
The Northern Paiute Tribes have former reservation lands and aboriginal territories that are situated within sage-grouse range in Oregon. The Burns Paiute Tribe has been engaged in habitat restoration along the Malheur River. Their wildlife biologist is a member the SageCon Advisory Council and a participant in the Burns LIT representing the interests of their tribe. The Fort McDermitt Paiute Shoshone Tribe is located near the McDermitt Caldera, and members are engaged with the issues around mining and its impacts on natural resources. Both tribes are challenged with limited natural resource staff, and this can be a barrier to participation. ODFW does direct outreach to engage with these tribes on data sharing, lek monitoring, and identification of resources for habitat projects.

*Watershed Councils and Soil and Water Conservation Districts*
Oregon's Soil and Water Conservation Districts (SWCDs) are government-adjacent districts that work with land managers, agencies, and other partners to conserve the renewable natural resources of the state. SWCDs are governed by an independently elected board of directors.

Watershed Councils are voluntarily formed by local governments to "restore and enhance the waters and lands for native species, and for people". The councils assess and monitor environmental conditions and conduct voluntary conservation projects to achieve their mission. They are led by experts and guided by boards made of local community members.

In Oregon, SWCDs and Watershed Councils play an important role in delivering sage-grouse and sagebrush conservation through voluntary programs and partnerships, particularly by holding CCAAs with the USFWS (see *CCAAs* above) and delivering the OWEB funding to conserve sagebrush habitat across the state. SWCDs and Watershed Councils are active members and supporters of LITs and help host LIT Coordinator positions in some districts. ODFW interacts with SWCDs and Watershed Councils via the LITs and by offering expertise and capacity for projects when needed.

*Non-Governmental Organizations*
Oregon has numerous non-governmental organizations (NGOs) that provide input to the SageCon Partnership through the Advisory Council and the LITs. These entities include conservation organizations like The Nature Conservancy, Oregon Natural Desert Association, East Cascades Bird Alliance, Oregon Desert Land Trust, and the Theodore Roosevelt Conservation Partnership, among others. There are other collaborative groups that contribute to the goals of Action Plan and often overlap with LIT membership, including the High Desert Partnership, Harney County Wildfire Collaborative, Tri-Corner Community Collaborative, and Cooperative Weed Management Areas, and others. Additionally, there are organizations representing the interests of private landowners, such as the Oregon Cattlemen's Association. ODFW interacts with these groups in a variety of formats, including participation in the LITs and other collaborative groups, responding to comments and concerns with sage-grouse management strategies, and collaborating on research projects.

**Summary**

We provide a brief overview of the major partners and partnerships operating in Oregon's sagebrush biome and discuss how ODFW coordinates and collaborates with these entities. Given the scope and scale of the issues facing sage-grouse in Oregon, these partnerships are critical to the recovery of the species, which will depend upon our ability to improve the overall health of Oregon's sagebrush ecosystem. Project implementation occurs on the local scale and is ideally driven by Local Implementation Teams. LITs can refer to Oregon's sage-grouse conservation and management documents (e.g., Oregon Sage-grouse Action Plan and CAAS) for guidance and to help prioritize projects which are likely to provide the greatest benefit to sage-grouse populations. ODFW provides local expertise, capacity support, and funding for these partnerships.

**Recommendations**

1. Continue to engage as a significant partner within the Oregon SageCon Partnership.
2. Provide guidance, expertise, participation, and funding, when available, to support the Sage-grouse Local Implementation Teams. LITs need not be stand-alone entities but could be associated with other existing collaboration groups.
3. Provide guidance, expertise, and funding, when available, to support conservation planning, actions, and research on private and public lands.
4. Consult with BLM, counties, DLCD, tribes, watershed councils, SWCDs, and other administrative entities which operate within sage-grouse habitat.
5. Consult with non-governmental organizations that are invested in sage-grouse conservation by addressing concerns, providing expertise and input on proposed actions, and contributing funding and capacity when available.

## Section 7: Sage-grouse Regulatory Mechanisms

ODFW is a non-regulatory agency tasked with providing recommendations to permitting agencies when fish and wildlife species or their habitats are impacted. In Oregon, permitting agencies in sage-grouse habitat are the BLM, USFS, Oregon Department of State Lands (DSL), counties, and the Energy Facility Siting Council (EFSC). Anthropogenic development and fragmentation of sage-grouse habitat are a threat to the persistence of the species in much of its current range. This section will explain the regulatory assurances in place to protect and conserve sage-grouse habitat from human development in Oregon.

### Background

In 1973, the Oregon Legislature passed Senate Bill 100 establishing protections for 'Goal 5 Resources', which include natural resources such as wildlife and wetland habitats. Senate Bill 100 also established the Oregon Department of Land Conservation and Development (DLCD), a state agency responsible for assisting the counties with land use planning. Initial Goal 5 Resource inventories by ODFW included primarily deer and elk winter ranges and raptor nesting sites.

In 1991, ODFW adopted the Fish and Wildlife Habitat Mitigation Policy (Chapter 635 – Division 415), which directs ODFW to require or recommend mitigation for impacts to fish and wildlife habitat caused by land and water development actions. The policy established the mitigation hierarchy (avoid, minimize, mitigate) and classified habitats into six categories based on relative importance to fish and wildlife species (Table 7.1). Habitat Category 1 was classified as the most important habitat, which are considered essential and irreplaceable, while Habitat Category 6 was classified as least important habitats with low potential to become essential or important habitat for fish or wildlife species. Prior to the development of Oregon's sage-grouse mitigation program in 2015, areas within 3.2 km (2 mi) of an active sage-grouse lek were considered Category 1 habitat, where ODFW recommended complete avoidance of impacts.

**Table 7.1.** Oregon's Fish and Wildlife Habitat Mitigation Policy classifies habitats as one of six categories, depending upon the functions and values of the habitat to a specific species, population, or unique assemblage of fish or wildlife species, and establishes mitigation goals for each category of habitat.

| Habitat | Definition | Goal for Mitigation | Mitigation Strategy |
|---|---|---|---|
| Category 1 | Essential, limited, and irreplaceable habitat | No loss of habitat quantity or quality | Avoidance |
| Category 2 | Essential and limited habitat | No net loss of habitat quantity or quality and to provide a net benefit of habitat quantity and quality | In-kind, in-proximity mitigation |

Table 7.1., continued

| Habitat | Definition | Goal for Mitigation | Mitigation Strategy |
|---|---|---|---|
| Category 3 | Essential habitat or important and limited habitat | No net loss of habitat quantity or quality | In-kind or out-of-kind, in-proximity or off-proximity mitigation |
| Category 4 | Important habitat | No net loss of habitat quantity or quality | In-kind or out-of-kind, in-proximity or off-proximity mitigation |
| Category 5 | Habitat having high potential to become either essential or important habitat | Net benefit in habitat quantity or quality | Actions that improve habitat conditions |
| Category 6 | Habitat that has low potential to become essential or important habitat | Minimize impacts | Minimize direct habitat loss and avoid off-site impacts |

The USFWS 2010 status review determined sage-grouse were "warranted but precluded" for listing under the ESA, prompting the western states within sage-grouse range to address protections for sage-grouse populations and their habitats. In Oregon, the finding led to the development of sage-grouse planning documents by both ODFW and the BLM, as well as mitigation guidance for large-scale development projects in sage-grouse habitats. In 2012, the Department published *Implementing Habitat Mitigation for Greater Sage-Grouse Under the Core Area Approach*, a white paper providing interim guidance for renewable energy and other industrial-commercial development projects in sage-grouse habitat. The policy guidance considered core sage-grouse habitats, or those habitats which contained 90% of the breeding population) as Category 1 (essential and irreplaceable) and specified core habitats be avoided for land developments.

This interim guidance was in place while the state of Oregon and its conservation partners gathered empirical data to quantify the effects of certain development actions on sage-grouse populations and worked on the comprehensive plan for mitigation in sage-grouse habitats. The process was convened by the Oregon Governor's Office and was organized and governed by the SageCon Partnership. In 2014, SageCon's mitigation technical team drafted the first *State of Oregon Greater Sage-Grouse Mitigation Manual Version 1.1*. This document outlined a shared approach to the mitigation of impacts to sage-grouse across public and private lands and had three distinct goals:

1. Provide a net conservation benefit for sage-grouse and sage-grouse habitat at both the individual project scale and across the entire mitigation program.
2. Support responsible economic development and the long-term social and economic vitality of rural communities and rangeland health.

3. Provide an approach to permitting and mitigation decision-making that is:
    a. Coordinated across public and private land ownerships and permitting processes.
    b. Predictable, transparent, equitable, and science based.

These goals and objectives have been carried forward through the development and refinement of Oregon's sage-grouse habitat mitigation program.

On September 16, 2015, Oregon Governor Kate Brown signed Executive Order 15-18, which directed state agencies to fully implement the Oregon Sage-Grouse State Action Plan, providing direction for agencies which fund, operate, or permit actions within sage-grouse habitat. Executive Order 15-18 also aligned and linked Oregon Administrative Rules (OARs) which had been approved by both the Oregon Fish and Wildlife Commission and the Oregon Land Conservation and Development Commission (LCDC). These rules guiding development permitting in sage-grouse habitat are LCDC's OAR 660-023-0115 and ODFW's OAR 635-0140-0000–0025. The sage-grouse conservation and mitigation OARs operate together to ensure any large-scale development projects proposed and permitted at the county level in sage-grouse habitat will follow Oregon's sage-grouse mitigation requirements. Large-scale development is defined as "uses that are over 50 feet in height, have a direct impact in excess of five acres, generate more than 50 vehicle trips per day, or create noise levels of at least 70 dB at zero meters for sustained periods of time." Examples of large-scale developments include commercial developments, mineral and aggregate mines, and transportation and utility infrastructure. In 2019, ODFW and BLM signed a Memorandum of Agreement to further strengthen and define the roles and responsibilities for a coordinated approach to mitigation across Oregon's sage-grouse habitat, including both private and federally managed lands.

**ODFW's Mitigation Program**

*Quantifying Mitigation Requirements*

ODFW is responsible for administering the sage-grouse mitigation program and coordinating with BLM, USFWS, county governments, and other partners. The goal of the program is to site large-scale development outside of core and low-density sage-grouse habitats and encourage development siting within or adjacent to existing developments, other human disturbances, or low-quality/degraded habitats (e.g., Category 6). The Habitat Quantification Tool (HQT) was developed to assess project level impacts at multiple scales while accounting for the quality of the impacted habitats, as well as existing anthropogenic disturbances on the landscape. This science-based tool provides a quantitative assessment of functional acres lost (debits) due to a large-scale development project, or functional acres gained (credits) for a mitigation bank or mitigation property. Functional acres quantify the usefulness of a land acre as sage-grouse habitat, where Category 1 or Ecostate A habitats represent the greatest usefulness as sage-grouse habitat and Category 6 or Ecostate D habitats represent the lowest usefulness as sage-grouse habitat. ODFW's mitigation program and the HQT are fully described within the following publications:

- *Greater Sage-grouse Habitat Operations and Administrative Manual* (October 2019)
- *Oregon Sage-grouse HQT Scientific Rationale* (October 2019, version 2.2)
- *Oregon Sage-grouse HQT User Guide* (October 2019, version 2.2)

*Credit Projects*

Three methods to offset impacts to sage-grouse habitat have been established. Developers can choose to 1) perform the mitigation themselves as permittee-responsible mitigation (PRM), 2) contribute to the In Lieu Fee (ILF) fund, or 3) buy credits through an approved mitigation bank. Although the developer can select the type of credit project implemented, each project must be reviewed and approved by the Sage-Grouse Mitigation Program Administrator to verify credit projects comply with the operations and administration manual (ODFW 2019). Specifically, credit projects must be durable, provide a net conservation benefit, contribute uplift actions to the habitat, and ensure long-term maintenance and monitoring of the property. Success criteria and measures to quantify mitigation successfulness are also a key component of each credit project. Mitigation credits for a project must be generated within the service area which the debit or development project occurred (Figure 7.1).

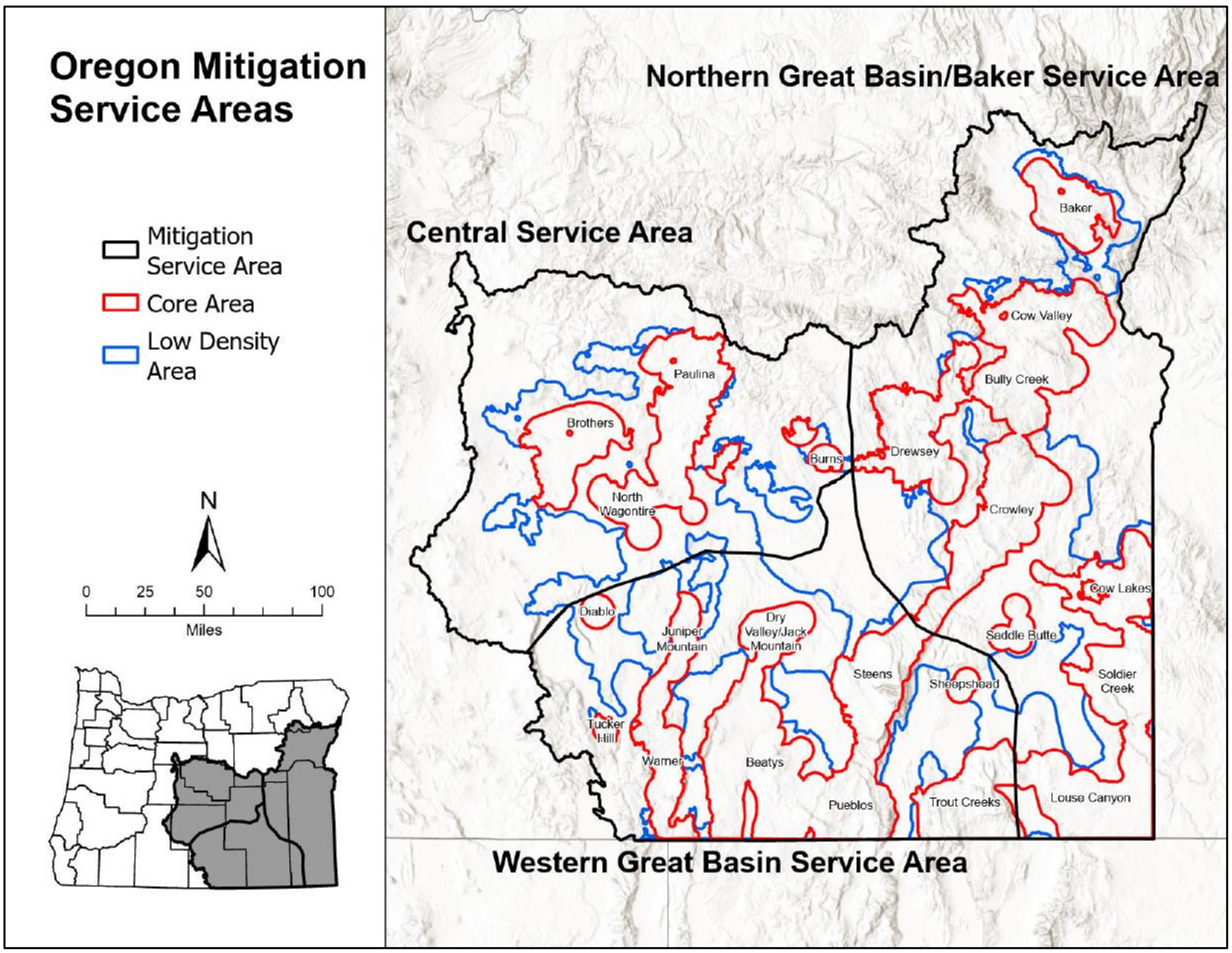


**Figure 7.1.** Oregon sage-grouse mitigation service areas, overlaid on core and low-density sage-grouse habitats. Impacts of large-scale development to these habitats must be mitigated within the same service area of occurrence.

*Permittee Responsible Mitigation (PRM)*

To utilize the PRM option, the proponent must present ODFW with the details of the credit generation project. The steps for this process entail submitting a project pre-proposal, followed by a full proposal to ODFW for approval. The proposal must ensure long term stewardship and durability of the mitigation site is secure. Credit project proposals will be reviewed by ODFW during the pre-proposal period and must be accepted as a viable option to move forward with development into a full proposal. The full proposal must contain all the criteria needed to ensure that the project will result in a net benefit for sage-grouse habitat (Figure 7.2.).

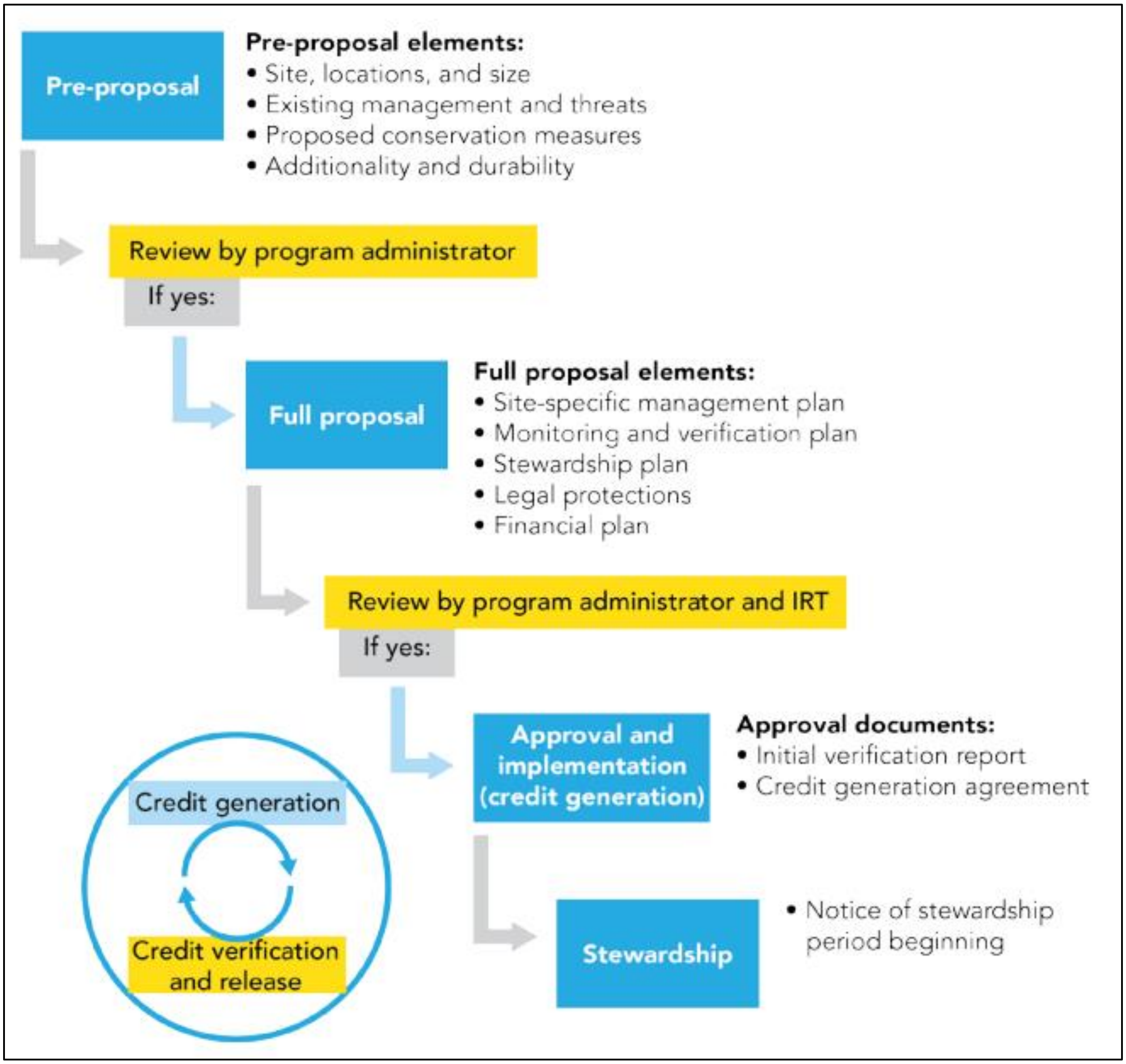


**Figure 7.2.** Basic steps for credit generation mitigation projects (State of Oregon 2019).

*In Lieu Fee*

ODFW and SageCon partners established the In-Lieu Fee (ILF) fund to allow for targeted and strategic investment in sage-grouse habitat restoration and uplift. The ILF provides developers with the option to invest in a mitigation fund managed by ODFW. Once sufficient funds have been invested into the ILF fund, ODFW sends out a Request for Proposals (RFP) to solicit bids for habitat restoration and uplift projects which meet the mitigation policy; these projects are funded by the ILF investment. The Sage-Grouse Mitigation Program Administrator uses "full cost accounting" methodology to set ILF fund credit rates. The formula accounts for land acquisition, lease, or easements, conservation measures, maintenance and monitoring, program administration, and long-term stewardship. To date, the ILF fund has not yet been utilized.

*Mitigation Banks*

Mitigation banks are an option to achieve compensatory mitigation for impacts to sage-grouse habitats. The owner of the mitigation bank generates credits and releases them for sale to developers when specific habitat uplift milestones on the enrolled mitigation property are achieved. The credits generated by the mitigation bank are specific to map units, of which both uplift actions to improve the condition sage-grouse habitat, as well as long term preservation of the habitat are quantified. The crediting process is similar to the wetland mitigation banks used by the Army Corps of Engineers and the species-specific mitigation banks required for USFWS listed species. However, Oregon's sage-grouse mitigation banks are not required to be accepted and enrolled into the Regulatory In-Lieu Fee & Bank Info Tracking System (RIBBITS) federal database. ODFW recently approved Oregon's first sage-grouse mitigation bank within the Northern Great Basin service area and there are two pending mitigation banks within the remaining two service areas.

**Regulatory Agencies**

*DLCD*

The Oregon Department of Land Conservation and Development (DLCD) is responsible for implementing Oregon's land use rules, including OAR 660-023-0115, also known as "The Sage-Grouse Rule". The DLCD Sage-Grouse Rule works with ODFW's sage-grouse mitigation rule, OAR 635-0140-0000–0025. Using these rules, DLCD and ODFW coordinate with county governments to help site large-scale developments outside of significant sage-grouse habitats. The DLCD Sage-Grouse Rule is triggered when a large-scale development action is considered for permitting by a county and falls within sage-grouse core, low-density, or general habitat. Development actions considered as conflicting uses with sage-grouse conservation include large-scale development and other activities within a certain distance from leks, but do not include farm use activities (see OAR 660-023-0115). The rule also sets forth metering and disturbance thresholds for large-scale development within sage-grouse habitat, where direct level impacts in any PAC may not exceed "any amount greater than 1.0% of the total area of the PAC in any 10-year period". Additionally, overall direct level impacts may not exceed 3.0% of the total area in any PAC. DLCD is responsible for maintaining a central registry of baseline and new disturbances within sage-grouse PACs.

*USFWS*

The USFWS is a federal regulatory agency that administers the Endangered Species Act (ESA), first enacted in 1973. The authority includes utilizing scientific evidence to decide if it is necessary to list a species as threatened or endangered, designating critical habitats, and developing recovery plans for listed species. The five possible ESA listing factors are:

> Factor A) The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range.

Factor B) Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.

Factor C) Disease and Predation.

Factor D) Inadequacy of Existing Regulatory Mechanisms.

Factor E) Other Natural or Manmade Factors Affecting the Species' Continued Existence.

If a species is listed under the ESA, agencies must cooperate with USFWS to avoid take of the species, permit otherwise prohibited activities, and apply the Convention on Internal Trade in Endangered Species of Wild Flora and Fauna (CITES) to the newly listed species. The purpose of the ESA is to prevent the extinction of the nation's imperiled species and use the best available science to allow for the recovery of the species.

*BLM*
The BLM manages public lands and subsurface estate under the jurisdiction of the Federal Land Policy and Management Act (FLPMA), which became law in 1976. This law directs the BLM to manage their public lands under the principles of multiple use and sustained yield, in accordance with land use plans developed under the authority of FLPMA. In 2021, the BLM initiated a significant effort to amend Greater Sage-grouse Land Use Plans in 77 resource management plans across ten western states. These land use plans built on the 2015 and 2019 efforts. After significant coordination with ODFW and other partners, the Record of Decision for the Approved RMP Amendments for Greater Sage-grouse Rangewide Planning in Oregon was signed on January 15, 2025 (Federal Register Vol. 90, No. 11), elevating the standard for sage-grouse conservation on BLM lands in Oregon.

*USFS*
The USDA Forest Service is also under the jurisdiction of FLPMA and is directed to manage their public land for multiple use and sustained yield. The Forest Service worked closely with the BLM in 2015 to develop a joint National Greater Sage-Grouse Planning Strategy. The Forest Service has 21 Land Management Plans (LMPs) in the range of greater sage-grouse.

*Other State Regulatory Agencies*
The Oregon Department of Geology and Mineral Industries (DOGAMI) and the Oregon Department of Energy (ODOE) work with the Department of the Interior BLM, state, and counties to regulate mining and energy development in Oregon. For example, before a large energy facility is built in Oregon, a developer must apply for a site certificate from the Energy Facility Siting Council under ODOE.

**Summary**

While most conservation actions are voluntary or incentivized, there are regulations in place to protect sage-grouse at the state and federal level, addressing one of the major concerns of the USFWS when considering the listing of sage-grouse, the inadequacy of regulatory mechanisms. ODFW's Sage-Grouse Mitigation Program was not yet in effect when the 2011 CAAS was approved. Oregon Administrative Rules guiding large-scale development in sage-grouse habitat were adopted in 2015 and are administered by both ODFW and DLCD. The goal of ODFW's mitigation program is to first avoid, then minimize, impacts to sage-grouse habitat before pursuing mitigation in the form of credit projects. There are limits on the pace and scale of mitigation that can occur in sage-grouse habitat, and the sage-grouse OARs have been largely successful in limiting fragmentation and disturbance caused by large-scale development. Since the implementation of these rules, there have been few large developments in Oregon's sage-grouse PACs, as reported by DLCD. Federal agencies (USFWS, BLM, and USFS) also have regulatory authority (e.g., ESA, FLPMA) related to sage-grouse populations or habitats.

**Recommendations**

1. Utilize the best available science to inform mitigation values through ODFW's Habitat Quantification Tool.
2. Cooperate with all permitting agencies to follow the mitigation hierarchy of "avoid, minimize, mitigate".
3. Develop accurate and clear communication resources to help developers, landowners, and regulatory agencies understand the relationship between sage-grouse regulatory mechanisms and land use permitting.
4. Coordinate with those mitigation banks in Oregon which supply mitigation credits as an agreed-upon solution for offsetting large-scale development in sage-grouse habitat.
5. Monitor the effectiveness of mitigation measures via sage-grouse demographic responses.

## Section 8: Sage-grouse Management Protocols

Special management challenges and opportunities are frequently encountered by ODFW's sage-grouse managers. Here we outline our strategies and protocols, as directed by the Oregon Legislature's mandate (Figure 8.1) and informed by the best available science. We provide an outline of ODFW's harvest management strategy for sage-grouse, recommend protocols for sage-grouse translocation, offer a position statement on captive rearing, and describe best management practices for trapping and marking.

**Oregon Revised Statute 496.012**

It is the policy of the State of Oregon that wildlife shall be managed to prevent serious depletion of any indigenous species and to provide the optimum recreational and aesthetic benefits for present and future generations of the citizens of this state. In furtherance of this policy, the State Fish and Wildlife Commission shall represent the public interest of the State of Oregon and implement the following coequal goals of wildlife management:

**(1)** To maintain all species of wildlife at optimum levels.

**(2)** To develop and manage the lands and waters of this state in a manner that will enhance the production and public enjoyment of wildlife.

**(3)** To permit an orderly and equitable utilization of available wildlife.

**(4)** To develop and maintain public access to the lands and waters of the state and the wildlife resources thereon.

**(5)** To regulate wildlife populations and the public enjoyment of wildlife in a manner that is compatible with primary uses of the lands and waters of the state.

**(6)** To provide optimum recreational benefits.

**(7)** To make decisions that affect wildlife resources of the state for the benefit of the wildlife resources and to make decisions that allow for the best social, economic and recreational utilization of wildlife resources by all user groups.

**Figure 8.1**. Title 41 Chapter 496.012 of the Oregon Revised Statutes was first adopted in 1973 and outlines the foundation for how wildlife is managed in Oregon.

### Harvest Management

Sage-grouse are defined as a game bird under ORS 496.007. Under the mandate of ORS 496.012 (Figure 8.1), the state is required to both maintain wildlife at optimum levels and permit an orderly and equitable utilization of available wildlife. These coequal goals are compatible specific to sage-grouse with strict harvest management protocols enacted by the department. Sage-grouse benefit from their status as a game bird in Oregon with a dedicated funding for research and management coming from the required upland game bird hunting validation.

Oregon currently operates under a 9-day controlled hunt season structure with a 2-bird season bag limit. The harvest policy includes not hunting isolated populations or those populations with fewer than 100 males detected at leks in 2 consecutive years. Permits are adjusted annually to ensure a harvest rate of <5% of the projected fall population for each hunt unit. Oregon has been utilizing restrictive harvest management for sage-grouse conservation since the 1930s (Crawford 1982). This approach is appropriate for sage-grouse life history considering their somewhat longer lifespan and lower annual production than other Galliformes, as well as periods of vulnerability, for example during dry years when they may congregate at water.

The USFWS found that harvest was not a significant threat to sage-grouse populations under existing frameworks when considering the greater sage-grouse for listing in both 2010 and 2015, stating, "In 2010, we concluded that hunting was not a threat to the species and based on current information about harvest rates, it continues to not have substantial impacts to sage-grouse. To date, changes in the management of sage-grouse hunting have resulted in a substantial reduction in sage-grouse hunting mortality rangewide" (USFWS 2010, 2015).

*Science Review*

The effect of hunting and harvest on sage-grouse populations has been examined many times via band return studies, non-hunted vs. hunted (at various levels) comparisons, and retrospective population models incorporating hunting regulations (Braun 1980, Crawford 1982, Braun and Beck 1985, Connelly et al. 2003*a*, Dinkins et al. 2021*a* and *b*). A harvest management structure that maintains harvest rates within the natural mortality rate (compensatory mortality) should have no effect on populations the following spring. This standard is difficult to assess due to the confounding effects and evolving understanding of density dependence in sage-grouse.

Crawford's analysis of Oregon hunting seasons with fluctuating regulations from 1949–1975 found that harvest was a function of population size and number of hunters, finding no relationship between the magnitude of harvest and subsequent spring populations, indicating harvest was compensatory (Crawford 1982). Above a certain level of harvest, hunting mortality is likely to become additive, requiring the implementation of a conservative, controlled, and adaptive recreational harvest management strategy (Dahlgren et al. 2021). Crawford (1982) also suggested that controlling the number of hunters could be achieved either by adjusting the area open for sage-grouse hunters or utilizing a tag or quota system, both of which techniques are utilized in ODFW's current sage-grouse harvest management.

Similarly, Braun (1980) found that a 16-day season with a 3-bird daily bag limit had no measurable effect on spring sage-grouse populations in Colorado. Connelly et al. (2003*a*) suggested that rates of population growth were less in hunted than non-hunted populations in Idaho, but these results were confounded by population growth rate differences in mountain valley compared to xeric lowland areas. Braun and Beck (1985) analyzed banded birds, harvest levels, and lek counts and concluded that the harvest rate of 7–11% in Colorado had no measurable effect on sage-grouse densities in spring. Similarly, a band-recovery study in Colorado and Nevada sage-grouse concluded that harvest rates <11% appear to be compensatory in nature (Sedinger et al. 2010).

Because sage-grouse do not fit the 'high productivity-short life span' life history model common to other game bird species, the assumption that harvest mortality replaces birds that would have died of other causes during the year (i.e., compensatory mortality) has been questioned (e.g., Johnson and Braun 1999, Gibson et al. 2011). Connelly et al. (2000*a*, 2003*a*) suggested that hunting losses are likely in addition to winter mortality for adult females (i.e., additive mortality). Johnson and Braun (1999) modeled population dynamics for sage-grouse in North Park, Colorado, and concluded that hunting mortality can be additive to other sources of mortality, especially in years of poor recruitment. Gibson (et al. 2011) found mortality from harvest was compensatory in a small, isolated population of sage-grouse in California. However, work from Colorado and Nevada indicates that harvest rates <11% appear to be compensatory in nature (Sedinger et al. 2010). This conclusion is similar to the rangewide sage-grouse management guidelines that recommend a harvest rate of 10% or less (Connelly et al. 2000*a*).

The compensatory mortality concept assumes there is density-dependent survival operating in the population. Experimental studies have found difficulty in decoupling the confounding effects of density-dependence, harvest, and population size (Sedinger and Rotella 2005). Connelly et al. (2003*a*) demonstrated that rates of population growth were less in hunted than unhunted populations in Idaho but did not account for density-dependence. Coates et al. (2016*b*) found a significant density dependent effect when modeling three decades of sage-grouse lek counts in the context of chronic wildfire impacts. Incorporating density dependence, particularly Gompertz-Ricker-type growth models (Garton et al. 2011), into population models improved fit and demonstrated some population suppression under high harvest pressure (30-day season length vs. 0 or 7 days; Dinkins et al. 2021*b*). Dinkins et al. (2021*a*) also summarized range-wide harvest management from the 1870s–2019 and concluded agency responsiveness to conservation concerns was reducing the potential for additive mortality.

The closure of sage-grouse hunting in 2013 and subsequent reinstatement in 2019 in the Trout Creek Mountains of Oregon offered the opportunity to directly estimate harvest probability and the effects of harvest on sage-grouse movement and survival. Using the Warner Wildlife Management Unit (WMU) as a reference unit and a dataset of 1,062 marked sage-grouse, researchers found monthly and annual survival was relatively high and did not vary significantly during harvest closure or reopening. The study also confirmed the likelihood of harvest was between 2.4–4.0% on the Trout Creeks and Warner WMUs, respectively (Hagen and Titus 2024, Titus et al. *in review*).

The best available science supports the conclusion that sage-grouse hunting can be conducted in a manner that has minimal to no impact on the population. However, managers should take a cautious approach by adjusting seasons adaptively depending on the population performance and consider additional stressors in the environment that may contribute non-hunting mortality beyond expected ranges.

*Oregon's Harvest Management Approach*

Oregon's policy specifies sage-grouse harvest must not exceed 5% of the estimated fall population. In practice, harvest is typically less than 3% of the fall population in each of the wildlife management units (WMUs) open to harvest. Sage-grouse are not hunted range-wide in Oregon; regulated hunting is currently permitted in 12 of 21 WMUs where sage-grouse occur.

Each summer, the estimated fall sage-grouse population sizes within each WMU are calculated based on the abundance estimates from the annual spring breeding population model, which is detailed in Section 3 and Appendix 2. Conservative rates of survival and production are applied to the estimated spring breeding population abundance within each WMU to derive the estimated fall population. First, a conservative rate of adult survival from spring to fall (S=0.7) is applied to the estimated spring breeding population, yielding the number of adult male and female sage-grouse surviving until fall. Next, the long-term (1993–2024) weighted-average sex ratio obtained from hunter harvested wings (1 male: 1.82 females) is applied, yielding the estimated number of females in the fall population. Lastly, a conservative rate of production (*R*=0.6 chicks per hen) is applied, yielding the number of juveniles in the fall population. Note, the long-term (1993–2024) average number of chicks per hen is *R*=1.5, while the lowest estimate of production recorded during this timeframe is *R*=0.6. The estimated fall population is calculated as the total number of surviving adult males and females, in addition to the number of juveniles. As each of these rates (e.g., survival and production) are conservative, this estimate represents the minimum fall population.

Using average hunter success and participation rates, the maximum number of permits allowable within each WMU is then calculated (i.e., the number of permits to keep harvest below 5% of the estimated fall population for each WMU). Next, extenuating circumstances which may uniquely impact populations within each WMU are considered, relying on local knowledge from ODFW District biologists. Considerations for adjusting permit recommendations or opening or closing a hunt unit include:

1. Recent wildfire or other major disturbance.
2. Poor past hunter success rates.
3. Isolated populations.
4. Populations with less than 100 males over a 2-year period.
5. Concern with genetic bottlenecks.
6. Vulnerability of subpopulations due to accessibility (e.g., near roads).
7. Watches and Warnings triggered in Targeted Annual Warning System (Coates et al. 2022).
8. Value of biological samples from harvest for population monitoring.

The details of the sage-grouse hunting season structure are outlined in the 5-year Oregon Upland Game Bird Hunting Season Framework, most recently approved in 2025. The 2025 framework offers a 9-day season in early September under a controlled (lottery) hunt structure, with a season limit of two sage-grouse.

Hunters who successfully draw a controlled hunt permit are mailed a postage-paid return envelope to send one wing from each harvested bird back to ODFW for analysis. This sample typically represents about 1–2% of the population in units open to harvest. Oregon's early September sage-grouse hunting season maximizes the opportunity to gather biological information from the wings provided by hunters because it occurs before most sage-grouse have completed wing molt. Information gathered from hunter-harvested and returned wings have provided important information for monitoring Oregon's sage-grouse populations, including age and sex ratios, annual productivity, peak hatching dates, and nest success. Hunters are also sent a series of hunter harvest surveys, first by email, then by postcard for non-respondents. This information accurately estimates annual sage-grouse harvest in each WMU with an average response rate of over 70%. ODFW provides a report on the results of the wing analysis and hunter harvest surveys as part of the annual population report. Hunter engagement is important to the success of this management approach. The department should consider ways to better communicate wing analysis and harvest survey results to participants in both surveys.

Development of an updated population model to estimate Oregon's breeding sage-grouse abundance (see Section 3) indicated that ODFW has been underestimating the size of Oregon's sage-grouse populations by approximately 30% since 2011. While the updated population model is used to calculate fall population estimation, ODFW managers intend to keep sage-grouse controlled hunt permits in a range similar to recent years (2017–2025), conservatively setting harvest rates while maintaining an adequate sample of hunter-harvested wings (1–2% of projected fall population) to track population demographics as required for implementation and effectiveness monitoring.

*Falconry*
Under current regulations, falconers in Oregon may pursue sage-grouse in any areas open to controlled sage-grouse hunting from September 1–January 31, with a daily bag limit of 1 bird and a season limit of 2 birds.

ODFW has conducted occasional surveys of falconer harvest in Oregon and found very low sage-grouse harvest. In 2014, 4 of 31 licensed falconers in the state reported pursuing sage-grouse, and the average harvest over the previous 3 years was 3 birds statewide. In 2021, 48 falconers reported their activity for the previous year and harvested a total of 2 sage-grouse. As of 2025, there were 155 registered falconers in Oregon. Occasional harvest activity surveys of falconers are useful to evaluate potential effects the longer sage-grouse falconry season and should be continued as needed.

**Translocation protocols**

This document relies on guidance from the ODFW Health and Population Lab, Association of Fish and Wildlife Agencies (AFWA) and the Western Association of Fish and Wildlife Agencies (WAFWA) on best practices for undertaking translocation of sage-grouse (ODFW 2017, Burco et al. 2018, AFWA 2020, Schroeder et al. 2025).

Translocation, the movement of wild animals from one location to another, is a fundamental tool for bolstering grouse populations, particularly in the absence of natural dispersal (Zimmerman et al. 2019). Translocations fall into two categories: augmentation and reintroduction. Augmentations of existing populations have a higher likelihood of success than reintroductions based on extensive documentation of numerous efforts (Schroeder et al. 2025). In Oregon, the topic of translocation is relevant when considering augmentation of struggling populations, such as the Baker PAC, or when receiving requests to relocate Oregon sage-grouse to other states or provinces.

*Science Review*
It is important to understand why a population has declined prior to considering translocations. Typically, subpopulations decline due to lack of habitat quantity and quality creating vulnerability to environmental events, which may be exacerbated by lack of genetic diversity. Lack of connectivity between populations can lead to inbreeding depression and lack of heterozygosity (Davis et al. 2015). Genetic bottlenecks may cause severe consequences including poor fertility and hatching rates (Briskie and Mackintosh 2004, Bui et al. 2010). The benefits of augmentation in isolated populations have been documented in grouse, resulting in increased genetic variation, fertility, hatching rates, and population size (Bouzat et al. 1998, Westemeier et al. 1998, Zimmerman et al. 2019).

Individual grouse populations may benefit from translocation if they are limited by genetic heterogeneity, effective population size, and/or dispersal ability. Small or isolated populations can experience genetic drift, inbreeding depression, and mutational accumulation. These situations can result in limiting the ability of the population to recover from stochastic events such as extreme weather, catastrophic events such as mega-wildfires, and normal fluctuations in predation rates, disease, and habitat quality (Bouzat et al. 1998, Brook et al. 2002, Bellinger et al. 2003, Bateson 2016, Schroeder et al. 2025). The importance of genetic diversity in a population should not be underestimated and can be improved with outcrossing (Brook et al. 2002). Attempts to recover a population by habitat improvement failed to halt the decline of the Illinois population of the greater prairie-chicken *(Tympanachus cupido)* until inbreeding depression was addressed (Westemeier et al. 1998).

Calculation of effective population size, that proportion of a population expected to pass on their genetic information from one generation to the next, is affected by population demographics (population size, clutch size, sex ratios, etc.) and reduced due to the lek mating system where few males do the majority of breeding (Allendorf and Ryman 2002). Based on work involving sharp-tailed grouse (McNew et al. 2017), using an effective population rate of 16–19% (Schroeder 2000, Stiver 2008), 3,200 sage-grouse in a distinct population would be able to maintain genetic diversity and be considered a viable population (Schroeder 2024). At a minimum, an interim population of ≥350 sage-grouse has the potential for viability with some level of external supplementation (McNew et al. 2017, Schroeder 2025).

Schroeder et al. (2025) collected documentation of 8,595 individual translocated sage-grouse, with the earliest movements in Oregon taking place in 1941 (Batterson and Morse 1948). Factors limiting success included small numbers of birds translocated, short duration, dispersal away from release sites, older birds less likely to contribute to productivity, and insufficient habitat and spatial scale (Toepfer et al. 1990, Schroeder 2025). Alternatively, yearling translocated females exhibited lower nest initiation rates than adult resident or previously translocated females in Utah and were less likely to raise a brood in their first year of release (Duvuvuei et al. 2017).

Selection of the source population should consider abundance and trend and similarities of latitude and environment with the recipient population. Logistical considerations that minimize holding time should be part of the source population selection process. Removal of birds from a source population should not have negative effects on that population and should be implemented during peaks in the population cycle. Poor reproductive effort in times of environmental stress, such as drought, could lead to poor genetic contribution to the receiving population. Duvuvei et al. (2017) recommend translocating a higher ratio of adult to yearling females for more immediate effect on population growth in the receiving population.

Successful restoration efforts of prairie grouse (*Tympanachus* spp.) were positively related to project duration, number of birds released, release method, and season of release (Snyder et al. 1999). Projects releasing > 100 grouse were 8.8 times more likely to succeed. Soft release methods improved project success 3.1 times more than hard-release techniques. Spring releases also improved project likelihood of success (Snyder et al. 1999). An analysis of 56 sage-grouse translocations associated successful efforts with capturing reproductively active birds on leks at night in March and April, rapid transport and release following capture, and release sites that discouraged extensive post-release travel (Reese and Connelly 1997). Toepher et al. (1990) recommended summer translocations of prairie grouse adults due to increased survival in a season of abundant food, cover, and buffer prey species, in addition to reduced mobility due to molting.

Newly translocated birds experience physiological stress, including elevated stress hormones and reduced body weight, during translocation due to the trauma of capture, handling, transportation, and release into a novel environment (Dickens et al. 2009). Careful consideration of release method and location is critical to reducing both stress and post-release movement. One of the challenges observed in translocation efforts is the lack of fidelity to the release site (Toepfer et al. 1990, Ebenhoch et al. 2019). Translocated birds in Washington that survived to a second year post-introduction exhibited reduced daily movements compared to their first year, which corresponded to increased survival and productivity (Ebenhoch et al. 2019). Coates et al. (2006) found that Columbian sharp-tailed grouse *(Tympanachus phasianellus columbianus)* travelled less when released into habitat previously selected for nesting by other grouse.

Another approach that shows promise involves translocating brood-rearing females with their chicks, making it less likely a hen will abandon the less mobile chicks and the release location, particularly with the use of an acclimation pen with remote release (Meyerpeter et al. 2021). A further novel approach to this method involves adding additional chicks to a translocated hen's brood which limits impacts to source populations by relocating fewer adult females (Thompson et al. 2015, Lindenauer et al. 2024). A specially designed crate to protect chicks in transport and acclimation pen are described by Meyerpeter et al. (2021).

*Oregon's Translocation Protocols*

In-state translocation planning requires submission of "ODFW Wildlife Translocation Approval Form A". This form involves detailing the reasons for translocation, the number and type of species to be moved, and the location of capture and release. The form will be submitted by the biologist leading the project and approved by ODFW veterinary staff, ODFW Region of capture, and ODFW Wildlife Division. ODFW veterinary staff will coordinate with the lead biologist on sample collection, capture and transport methods, disease risk assessment, and consultation with the Oregon Department of Agriculture State Veterinarian if necessary.

Out-of-state translocations or importations additionally require "ODFW Wildlife Translocation Approval Form B", or in the case of movements to or from Mexico or Canada, Form "C". These forms outline Certificate of Veterinary Inspection and additional import/export permits and travel plans.

It is important to consider health risks and surveillance for pathogens that may affect either the source birds or the receiving population and take mitigating measures to prevent disease transmission (ODFW 2017). Recommended health screening in captured sage-grouse may include macroparasites such as *Dispharynx nasuta* (proventricular worm), *Trichostrongylus cramae*, and *T. tenuis* (cecal threadworm); microparasites including *Eimeria dispersa*, *E. angusta* (coccidiosis), *Leucocytozoon bonasae*, and *Plasmodium pedioecetii* (both red blood cell parasites); and infectious diseases such as infectious bronchitis and reticuloendotheliosis viruses, *Histomonas meleagridis*, *Pasteurella multocida*, and West Nile Virus (Oregon Department of Fish and Wildlife 2017).

Requests from out-of-state or province recipient agencies require a formal letter addressed to the Director of the Oregon Department of Fish and Wildlife detailing the translocation proposal, including health screening, number/sex of birds requested per year, suitability of release sites, trapping methods and logistics, and plans for post-release monitoring and reporting (AFWA 2020). The letter should be sent far enough in advance to allow adequate time for consideration, decision-making, and if approved, logistical preparation (Schroeder et al. 2025).

ODFW's responsibilities to the requesting agency include a prompt acknowledgement of the formal request, a target date for a decision, and identification of the appropriate staff liaison. Decisions will be made in a timely manner, and approvals may depend on additional conditions outlined by the department, including identification of source population(s), notification of affected staff and partners, consulting with land managers of source population, and creating a public outreach plan. ODFW may choose to consult with the WAFWA Sage- and Sharp-tailed Grouse Technical Committee for guidance or review of translocation proposals.

All translocation plans should determine specific goals, ecological purpose, and address technical and/or biological limitations of the process using an experimental approach and consider simulation modeling and spatially explicit models (Seddon et al. 2007). It is critical to analyze the success of translocation efforts, both in the short- and long-term, to inform future actions by post-release and long-term population monitoring and documentation of methods (Toepher et al. 1990, Reese and Connelly 1997). Success can be measured by the life span and reproductive fitness of translocated individuals and the maintenance of the population through time.

Best management practices include:

1. Selecting a source population that will be minimally affected by removal of individuals and similar as possible to the receiving location in habitat, elevation, and latitude.
2. Projects should last a minimum of 5 years, assuming there are adequate source populations.

3. Soft release techniques utilizing primarily hens with chicks are most likely to be successful in keeping the translocated birds on site.
4. Habitat at the release location should be adequate to support additional sage-grouse on the landscape.
5. All adult translocated birds should be banded and at least a sample of birds fitted with transmitters for monitoring survival and movement (see Trapping and Marking, Section 8).

**Position on captive rearing**

The WAFWA Sagebrush Initiative has explored the issue of captive rearing in sage-grouse (WAFWA 2017). They concluded that while it is possible to rear sage-grouse in captivity, the captive birds experience low hatchability and survival rates. It may be possible to collect wild eggs to hatch in captivity and transplant those chicks under existing brood hens, but not without impact to source populations. Post-release survival of captive reared Galliformes is estimated between 10–30%, at best. A captive rearing program in Canada found fewer than 1% of pen-reared sage-grouse over a 6-year period survived to the following breeding season post-release (Coleing et al. 2024). The Attwater's Prairie-Chicken Recovery Project has developed improved techniques that result in survival of up to 30% of released birds, but captive rearing was only undertaken to prevent extinction of the species.

While it is important to advance the knowledge of sage-grouse husbandry, the department takes the position that captive rearing should only be considered in extreme circumstances to prevent extirpation of the species. Without addressing the root causes of sage-grouse decline, these programs would take resources that are better directed toward habitat conservation. Releasing captive-reared birds into a degraded landscape would be ineffective and should not be considered a replacement for sagebrush habitat conservation.

**Trapping and Marking**

Research questions regarding wildlife space use and demographics often require handling and marking of animals. These activities should be considered with caution, and biologists should agree that the data to be gained is worth the potential stress imparted with the disturbance of trapping and marking. In this section we will review the current literature regarding best management practices when trapping, handling, and marking sage-grouse. Applicants for ODFW Scientific Collection Permits should address each of these topics specific to sage-grouse research projects.

*Science Review*

*Capture*

Spotlighting sage-grouse at night and capturing birds with a hoop net is a widely used method for subsequent marking, and less commonly, vehicle-mounted net guns, cannon nets, or rocket nets (Giesen et al. 1982, Wakkinen et al. 1992). The spotlighting and hand netting method uses bright lights (either mounted on a vehicle or more typically handheld) and noise (music, machinery noise, etc.) to disorient birds, mask sounds of approach, and cause the birds to reveal their location (Labisky 1959, Cummings and Hewitt 1964, Drewien et al. 1967, Connelly et al. 2003*b*, Baxter et al. 2013, Perry et al. 2021). Personnel carry long-handled nets to capture the disoriented birds. An analysis of factors affecting capture success in Utah found precipitation, frost, vegetation density, and larger flock sizes negatively affected capture success (Radke 2024). Capture success improved with capture crew size up to 4 personnel, then declined. Captures initiated on foot rather than vehicle also improved capture success (Radke 2024) and likely reduces stress to the birds (Jonathan Dinkins, pers. comm).

#### *Handling*

Best practices for handling birds involve quickly securing captured birds by pinning the bird to the ground under the net to minimize tangling, feather loss, and stress from struggling. Placing a dark hood over the head can help calm the bird but can impede monitoring of vital signs. Multiple personnel processing a bird will help minimize handling time, but handlers should minimize the number of headlights shining on the bird and talk softly only when necessary. Female sage-grouse should be banded with a Size 7 and males banded with a Size 8 aluminum butt end band with a unique identifying number and a contact phone number and/or website for reporting band recoveries. Band ends should be placed flush with no overlap or sharp edges.

Venipuncture (blood draw), disease testing, and euthanasia of injured or diseased birds should conform to recommendations in WAFWA's *Guidelines for Health Screening and Sampling of Galliforms* (WAFWA Wildlife Health Committee 2019). Unless involved in a translocation effort, birds should be gently released in the same area of capture. When releasing, ensure no obstructions (e.g., fence, etc.) are in the line of flight. Release slightly away from other personnel by placing bird on the ground as far from the releasing individual's body as possible while still maintaining control of the bird's wings.

#### *Fitting Transmitters*

In addition to banding, placing transmitters on captured sage-grouse is a common practice, but should be considered carefully when working with sensitive sage-grouse populations. Transmitter weight (maximum 3% of body weight inclusive of transmitter and all harness/attachment equipment), attachment style, and reflectivity of the unit has the potential to affect energetics and mortality risk of the marked bird, which may be exacerbated if the bird is experiencing stress (Barron et al. 2010).

Beginning around 2010, GPS (global positioning systems) transmitters began to replace VHF (very high frequency) as the preferred method for tracking sage-grouse activity. The GPS transmitters provide highly detailed spatial and temporal data that can be acquired remotely without further disturbance to the animal. VHF transmitters are attached using a collar, while the larger GPS transmitters are attached via backpack and positioned dorsally on the rump of the bird (Figure 8.2). A recent innovation involves a VHF necklace coupled with a GPS tag also attached to the back of the necklace with a weight of 28.5g or less.

**Figure 8.22.** Photos showing the necklace-style very high frequency (VHF) collar (left) and backpack-style global positioning systems (GPS) transmitters (right) attached to female greater sage-grouse in the Pahsimeroi Valley of Idaho, USA (Stevens et al. 2023).

Recent studies suggest negative effects on survival of sage-grouse hens with rump-mounted backpack-style transmitters. Severson et al. (2019) found lower annual and season-specific survival of hens with backpack-style GPS transmitters than those with VHF collars in Nevada and California. Similarly, Foster et al. (2018) found differences in survival estimates among GPS-marked hens with backpacks versus VHF necklace-style transmitters in post-fire habitat. Over a 7-year period in Idaho, satellite GPS transmitters reduced spring/summer survival of sage-grouse hens when compared to VHF collars, but did not affect likelihood of nesting, nest success or timing of initiation (Stevens et al. 2023). Initial results comparing survival of VHF-only, VHF/GPS necklace, and Platform Terminal Transmitter (PTT) backpack suggests lower survival with PTT backpack than the other two attachments, which had similar survival (Stephanie LeQuier, research in progress).

GPS transmitters can have a reflective dorsal solar panel that could make sage-grouse more visible to predators, particularly in habitats with less than optimal cover (Foster et al. 2018). Manufacturers have adapted the design to make the panels less reflective. Scuffing the panel with steel wool can reduce shine on the units with no observable impact to battery recharge. GPS transmitters continue to be manufactured at lighter weights and allow for less observer disturbance than VHF transmitters. Stevens et al. (2023) suggests that the backpack harness or its attachment methods may be driving decreased survival. The proportional weight of GPS transmitters to the mass of the bird had a negative effect on survival (Severson et al. 2019).

These attachments have the potential to affect flight mechanics by creating a weight distribution imbalance (Barron et al. 2010).

Skin abrasions and lacerations have been documented in male sage-grouse fitted with backpack harnesses. Kircher et al. (2020) developed a modified harness design using PVC tubing placed over the elastic Teflon ribbon of the backpack, though Lundblad et al. (2024*a*) did not detect a difference in survival or device retention with the modified design.

#### *Marking Male Sage-grouse*

While the majority of studies examining demographics in sage-grouse are focused on hens, questions of male sage-grouse space use and lek attendance are important for informing population models. Studies with necklace-style attachments found the collars likely affected both vocalizations and lek attendance (Fremgen et al. 2017, Gibson et al. 2013). Males are likely to experience adverse effects due to their complex breeding display and vocalizations that involve inflating esophageal air sacs on the breast, strutting, and complex wing motions. Transmitters could impede these movements. Additionally, lekking male sage-grouse enter a metabolic deficit, losing an estimated 23% of their body mass during the breeding season (Beck and Braun 1978, Hupp and Braun 1989). Therefore, additional stress caused by wearing a radio collar could affect both mating success and survival of males (Gibson et al. 2013).

#### *Marking Sage-grouse Chicks*

Questions regarding monitoring chicks post-hatch to determine survival rates have been addressed using subcutaneous implants or sutures to attach radio transmitters to hatchlings. While this method can be done in the field with apparent minimal impact to chick survival (Burkepile et al. 2002, Gregg et al. 2007), the need to recapture chicks to replace transmitters with a 21–35-day battery life is a considerable stressor. Young chicks are susceptible to adverse effects of brood hens being flushed by observers (Street et al. 2022). Survival of chicks with sutured transmitters was positively related to chick body mass at the time of marking (Malley et al. 2024). Other methods for determining survival post-hatch include flushing of radio-marked hens with broods, and the use of camera traps to video broods (Street et al. 2022, Dungannon 2022), both of which are likely to underestimate brood numbers.

#### *Recommendations*

When considering study design and reviewing scientific collection permit applications, biologists should consider the balance of benefits from the data acquired using marked birds against potential bias to data and harm to the birds. Standardized methods and training of personnel by experienced mentors can help minimize impacts to study subjects. Attention to minimizing capture stress, feather loss, and handling time, should be emphasized. Researchers should carefully consider tracking device type and metrics, including attachment type, and select the least invasive option that addresses their research objectives.

### Summary

Management decisions made outside the scope of habitat management have the potential to impact sage-grouse at the individual level. Sage-grouse can be sustainably harvested in some populations in Oregon. Sage-grouse harvest benefits ODFW by maintaining the species' status as a game bird in Oregon and by providing important demographic information from hunter-harvested and returned sage-grouse wings. Translocation is an important tool for improving genetic diversity in isolated populations, but protocols must consider minimizing potential impacts to the source populations and maximizing post-release site fidelity. We provide a position statement on captive rearing, which should not take the place of more sustainable conservation practices. Trapping and marking sage-grouse is common in research projects. We provide the best management practices for researchers seeking a scientific collection permit from ODFW for sage-grouse.

**Recommendations**

1. Incorporate the updated population model (see Section 3) into a harvest management framework that maintains harvest at a conservative level (<5% of the projected fall population by WMU) and provides an adequate sample of wings (1–2%) to evaluate population demographics within hunted units.
2. When setting harvest permit numbers, account for extenuating factors such as wildfire, isolated populations, Targeted Annual Warning System watches and warnings, PAC-scale population trends, poor harvest rates, vulnerability to harvest, and genetic bottlenecks.
3. Consider ways to further engage sage-grouse hunters through communication of wing analysis results, harvest survey results, and volunteer opportunities related to sage-grouse management and conservation.
4. Maintain existing falconry seasons for sage-grouse.
5. Utilize translocation as a tool to supplement declining sage-grouse populations and improve genetic diversity of isolated populations. Translocation should only occur when the quantity and quality of the habitat receiving translocated sage-grouse is adequate to support additional birds and when the translocation effort can be sustained for at least 5 years.
6. Incorporate the best available science when considering translocation, including movement of hens and broods, soft release techniques, monitoring, and selection of source populations.
7. Captive rearing for sage-grouse is not a viable management technique and should not be undertaken in Oregon, particularly at the expense of habitat restoration.
8. Incorporate best practices for trapping and marking sage-grouse, including minimizing the effects of transmitters on survival.

## Section 9: Summary and Recommendations

The previous sections of this document detail the science and process that ODFW will utilize to manage sage-grouse in Oregon. A summary of each section and the accompanying recommendations from each section are provided in Section 9 for quick reference.

### Section 1: Introduction

The decline of Oregon's sage-grouse populations and the loss of sagebrush habitats have been of significant conservation concern since the mid-20th century. Over the past 75 years, many regulatory and management actions have been enacted to address these concerning sage-grouse population trends and declines in habitat quantity and quality in Oregon. Conservation efforts were accelerated in 2005 with the establishment of ODFW's 1st edition of the *Greater Sage-Grouse Conservation Assessment and Strategy for Oregon* (CAAS) and again in 2011 with the updated 2nd edition of the CAAS. The scope of sage-grouse conservation in Oregon was broadened in 2015 with the publication of the *Oregon Sage-grouse Action Plan* (Action Plan), which was adopted by the Governor's Executive Order 15-18 as the overarching plan for Oregon, and specified the roles and responsibilities of conservation partners across Oregon's Sage-Grouse Conservation Partnership. The 3rd edition of the CAAS, this document, defines, clarifies, and updates how ODFW will meet our obligations under the Action Plan. The CAAS is not prescriptive but emphasizes the need for iterative adaptive management within a collaborative social context.

### Section 1 Recommendations

1. Consider objectives, actions, and reports in the context of proactively addressing USFWS ESA listing criteria.
2. Utilize an adaptive management framework (e.g., Williams et al. 2009) by incorporating iterative implementation and effectiveness monitoring for conservation actions and adjusting management actions as necessary.
3. Consider the effects of single-species management actions on other sagebrush obligate and sagebrush associated species.
4. Review the Greater Sage-Grouse Conservation Assessment and Strategy for Oregon on a 5-year basis and determine if an update to the document is necessary based on major changes to the status of sage-grouse populations or habitats in Oregon.

### Section 2: Leverage Science to Address Threats

Landscape-scale impacts of wildfire, invasive annual grasses and weeds, and conifer encroachment in the context of a highly human-influenced landscape and changing climate, have lowered the demographic rates of sage-grouse and caused local extirpation of the species from large areas of its historic range in Oregon. Many additional factors can contribute to depressed rates of sage-grouse adult, nest, brood, and juvenile survival, including disease, parasites, predation, harvest, pesticides, and collisions. The scale of threats is daunting, but the best available science shows that it is critical to grow the remaining high quality intact sagebrush habitats while protecting these high quality habitats from incursion by landscape altering threats. Prioritization frameworks are emerging to provide tools to managers and Sage-Grouse Local

Implementation Teams to maximize the effectiveness of conservation actions in the sagebrush ecosystem.

**Section 2 Recommendations**

1. Prioritize addressing the primary, landscape-scale threats of wildfire, invasive annual grasses, and conifer encroachment.
2. Focus conservation actions to increase the overall sage-grouse carrying capacity of the landscape, specifically to improve adult female, nest, and brood survival.
3. Engage in cooperative planning to develop a sage-grouse habitat spatial strategy based on both sage-grouse demographic information and habitat conditions.
4. Utilize prioritization frameworks, such as Threat Based Strategic Conservation, to strategically identify the most valuable investments in habitat restoration and uplift within Oregon's sage-grouse range.
5. Support research to quantify the demographic impact of IAG invasion on sage-grouse populations, including experimental techniques to improve understory habitat conditions.
6. Support research to evaluate climate-driven effects on sage-grouse populations, including the effects of site-specific resistance and resilience on Oregon's sage-grouse population strongholds.
7. Improve ODFW's understanding of the effects of large-scale development, particularly mining and renewable energy, on sage-grouse habitat use and demographic impacts.
8. Continue to investigate the impacts of high-density raven populations on local sage-grouse productivity and habitat use.
9. Support the development of a model evaluating sage-grouse fence collision risk using sage-grouse GPS location data. This model would be used to prioritize fence marking or fence removal efforts.
10. Engage in discussions regarding wildfire and fuel break designs and management, supporting those actions which have no impact to sage-grouse habitats while effectively reducing the risk of wildfire spread within sage-grouse habitats.

**Section 3: Monitoring and Assessment of Oregon's Sage-grouse Populations**

Spring lek surveying is the primary method ODFW uses to monitor sage-grouse populations. Section 3 provides a systematic methodology for conducting lek surveys, including ground and aerial surveys. This section outlines the process of sharing sensitive sage-grouse data. An updated and comprehensive list of lek conservation statuses is provided to include all possible lek situations, regardless of survey history. These definitions exceed the categories in the previous CAAS and those used by WAFWA. In cooperation with the USGS, ODFW developed an updated population model which accounts for imperfect detection, variable rates of lek attendance, and presently unknown leks. The updated model improved Oregon's sage-grouse population estimates using current modeling methodologies, informed by the best available data. PAC-scale population trends (1980–present) are also presented, providing context to population changes at smaller scales. Methods for monitoring sage-grouse production are also provided and are now based on hunter-harvested wing collections rather than driving brood routes. Based on the new population model and considering sage-grouse populations in Oregon oscillate over 6–

12-year cycles, we recommend revising ODFW's population goal to manage sage-grouse statewide to maintain or enhance their distribution and abundance oscillating around the 2003 spring breeding population level, approximately 53,000 birds, over the next 50 years. Additionally, we recommend revising ODFW's sage-grouse population objectives to manage Oregon's sage-grouse populations to maintain stable or increasing population trends statewide and at the PAC-scale. We recommend assessing population trends between nadirs (troughs) of the population cycles at the statewide and PAC-scales.

**Section 3 Recommendations**

1. Utilize improved scientific models to track sage-grouse populations at the statewide and PAC-scale.
2. Using the updated population model, set a goal to manage sage-grouse statewide to maintain or enhance their distribution and abundance oscillating around the 2003 spring breeding population level, approximately 53,000 birds, over the next 50 years.
3. Set objectives to manage Oregon's sage-grouse populations to maintain stable or increasing population trends statewide and at the PAC-scale. Population trends should be assessed between nadirs (troughs) of the population cycles at the statewide scale and PAC-scale.
4. Utilize hunter-returned wings to contribute to Oregon sage-grouse demographic knowledge and inform ODFW's harvest management framework.
5. Update lek conservation status definitions to include all leks, regardless of survey history.
6. Invest in research to maximize the efficiency of ODFW's annual lek monitoring effort.

**Section 4: Mapping Oregon's Sage-grouse Range**

Oregon utilizes a core-area approach to sage-grouse conservation, which involves identifying the most important habitats necessary to conserve 90% of Oregon's sage-grouse populations. Section 4 details the methodology used to model and then refine ODFW's sage-grouse core and low-density habitat map, which was most recently updated in December of 2023. The updated core habitat was geographically divided into biologically relevant sage-grouse management units, referred to as Sage-Grouse Priority Areas for Conservation (PACs). In the 2011 CAAS, these biologically relevant management units were referred to as 'core areas', where in the 2025 CAAS, the terminology was updated to 'PACs'. The updated sage-grouse habitat map is used by the ODFW Greater Sage-Grouse Habitat Mitigation Program to mitigate impacts of large-scale development to significant sage-grouse habitat, and by DLCD as a Goal 5 resource, of which land use rules are applied. Oregon's significant sage-grouse habitat map is also used to help land managers (e.g., private landowners, BLM, DSL, and others) prioritize habitat restoration and uplift efforts to benefit local sage-grouse populations.

**Section 4 Recommendations**

1. Maintain a map of sage-grouse core, low-density, and general habitat that is formally reviewed on a minimum 10-year basis and, if needed, recommended for update.
2. Include a robust partner and public review process for habitat map updates.
3. Coordinate closely with DLCD on future map updates, public input, and adoption.

4. Support research to GPS-mark sage-grouse in PACs where ODFW has little or no information on habitat or space use, especially to inform connectivity corridors among seasonal habitats.

**Section 5: Monitoring Oregon's Sage-grouse Habitat**

To facilitate their annual survival and production, sage-grouse require high quality sagebrush habitats, consisting of overhead canopy cover of sagebrush and a healthy understory of forbs and perennial grasses. Since the mid-20$^{th}$ century, Oregon's sagebrush ecosystem has suffered conversion to other habitats and has declined in both quantity and quality. A minimum of 70% sagebrush cover in high to intermediate ecostates is necessary to maximize sage-grouse population persistence. Oregon is not currently achieving this objective primarily due to the loss of sagebrush following large wildfires and subsequent conversion to poor quality ecostates, in addition to historic sagebrush removal and conversion. Prioritizing the protection of existing high quality habitats from conversion to poorer quality ecostates is critical to stabilize sage-grouse populations in Oregon.

**Section 5 Recommendations**

1. Adopt "Threat-Based Ecostates" as a tool for monitoring habitat quality and quantity.
2. Habitat Objective 1: Manage a minimum of 70% of greater sage-grouse range for sagebrush habitat in ecostates A (good condition shrubland), B (good condition grassland) and A-C (intermediate condition shrubland) and prioritize the protection and growth of these areas.
3. Habitat Objective 2: Manage sagebrush habitats to achieve a net conservation gain of intact sagebrush communities (ecostate A) and maintain stable or increasing amounts of sagebrush and perennial grassland habitats in ecostates A, B, and A-C, at the statewide and PAC-scale.
4. Engage with BLM and other land managers to design fuel breaks that optimize function while minimizing direct and indirect impacts to wildlife habitats.
5. Encourage federal land managers to prevent populations of free-roaming equids from exceeding AML in herd ranges overlapping sage-grouse core or low-density habitats.
6. Engage with cooperating land managers to provide advice and expertise on the best practices to improve sagebrush habitat conditions.
7. Support efforts to improve remote sensing techniques and data which inform Threat Based Ecostates geospatial layers.

**Section 6: Cooperation and Collaboration**

We provide a brief overview of the major partners and partnerships operating in Oregon's sagebrush biome and discuss how ODFW coordinates and collaborates with these entities. Given the scope and scale of the issues facing sage-grouse in Oregon, these partnerships are critical to the recovery of the species, which will depend upon our ability to improve the overall health of Oregon's sagebrush ecosystem. Project implementation occurs on the local scale and is ideally driven by Local Implementation Teams. LITs can refer to Oregon's sage-grouse conservation and management documents (e.g., Oregon Sage-grouse Action Plan and CAAS) for guidance and to help prioritize projects which are likely to provide the greatest benefit to sage-grouse populations. ODFW provides local expertise, capacity support, and funding for these partnerships.

**Section 6 Recommendations**

1. Continue to engage as a significant partner within the Oregon SageCon Partnership.
2. Provide guidance, expertise, participation, and funding, when available, to support the Sage-grouse Local Implementation Teams. LITs need not be stand-alone entities but could be associated with other existing collaboration groups.
3. Provide guidance, expertise, and funding, when available, to support conservation planning, actions, and research on private and public lands.
4. Consult with BLM, counties, DLCD, tribes, watershed councils, SWCDs, and other administrative entities which operate within sage-grouse habitat.
5. Consult with non-governmental organizations that are invested in sage-grouse conservation by addressing concerns, providing expertise and input on proposed actions, and contributing funding and capacity when available.

**Section 7: Sage-grouse Regulatory Mechanisms**

While most conservation actions are voluntary or incentivized, there are regulations in place to protect sage-grouse at the state and federal level, addressing one of the major concerns of the USFWS when considering the listing of sage-grouse, the inadequacy of regulatory mechanisms. ODFW's Sage-Grouse Mitigation Program was not yet in effect when the 2011 CAAS was approved. Oregon Administrative Rules guiding large-scale development in sage-grouse habitat were adopted in 2015 and are administered by both ODFW and DLCD. The goal of ODFW's mitigation program is to first avoid, then minimize, impacts to sage-grouse habitat before pursuing mitigation in the form of credit projects. There are limits on the pace and scale of mitigation that can occur in sage-grouse habitat, and the sage-grouse OARs have been largely successful in limiting fragmentation and disturbance caused by large-scale development. Since the implementation of these rules, there have been few large developments in Oregon's sage-grouse PACs, as reported by DLCD. Federal agencies (USFWS, BLM, and USFS) also have regulatory authority (e.g., ESA, FLPMA) related to sage-grouse populations or habitats.

**Section 7 Recommendations**

1. Utilize the best available science to inform mitigation values through ODFW's Habitat Quantification Tool.
2. Cooperate with all permitting agencies to follow the mitigation hierarchy of "avoid, minimize, mitigate".
3. Develop accurate and clear communication resources to help developers, landowners, and regulatory agencies understand the relationship between sage-grouse regulatory mechanisms and land use permitting.
4. Coordinate with those mitigation banks in Oregon which supply mitigation credits as an agreed-upon solution for offsetting large-scale development in sage-grouse habitat.
5. Monitor the effectiveness of mitigation measures via sage-grouse demographic responses.

## Section 8: Sage-grouse Management Protocols

Management decisions made outside the scope of habitat management have the potential to impact sage-grouse at the individual level. Sage-grouse can be sustainably harvested in some populations in Oregon. Sage-grouse harvest benefits ODFW by maintaining the species' status as a game bird in Oregon and by providing important demographic information from hunter-harvested and returned sage-grouse wings. Translocation is an important tool for improving genetic diversity in isolated populations, but protocols must consider minimizing potential impacts to the source populations and maximizing post-release site fidelity. We provide a position statement on captive rearing, which should not take the place of more sustainable conservation practices. Trapping and marking sage-grouse is common in research projects. We provide the best management practices for researchers seeking a scientific collection permit from ODFW for sage-grouse.

### Section 8 Recommendations

1. Incorporate the updated population model (see Section 3) into a harvest management framework that maintains harvest at a conservative level (<5% of the projected fall population by WMU) and provides an adequate sample of wings (1–2%) to evaluate population demographics within hunted units.
2. When setting harvest permit numbers, account for extenuating factors such as wildfire, isolated populations, Targeted Annual Warning System watches and warnings, PAC-scale population trends, poor harvest rates, vulnerability to harvest, and genetic bottlenecks.
3. Consider ways to further engage sage-grouse hunters through communication of wing analysis results, harvest survey results, and volunteer opportunities related to sage-grouse management and conservation.
4. Maintain existing falconry seasons for sage-grouse.
5. Utilize translocation as a tool to supplement declining sage-grouse populations and improve genetic diversity of isolated populations. Translocation should only occur when the quantity and quality of the habitat receiving translocated sage-grouse is adequate to support additional birds and when the translocation effort can be sustained for at least 5 years.
6. Incorporate the best available science when considering translocation, including movement of hens and broods, soft release techniques, monitoring, and selection of source populations.
7. Captive rearing for sage-grouse is not a viable management technique and should not be undertaken in Oregon, particularly at the expense of habitat restoration.
8. Incorporate best practices for trapping and marking sage-grouse, including minimizing the effects of transmitters on survival.

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## Glossary and Abbreviations

**Ac** - acre

**Action Plan** – The 2015 *Oregon Sage Grouse Action Plan*

**AFWA** – Association of Fish and Wildlife Agencies

**AML** – Appropriate Management Level, specific to free-ranging equids

**AOC** – Association of Oregon Counties

**Areas of High Population Richness** - Mapped areas of breeding and nesting habitat within core habitat that support the 75th percentile of breeding bird densities (i.e., the top 25%).

**AUM** – Animal Unit Month

**BLM** – Bureau of Land Management

**CAAS -** *Greater Sage-Grouse Conservation Assessment and Strategy for Oregon*, including the 2005, 2011, and current version of this document.

**CCAs** - Candidate Conservation Agreements (USFWS)

**CCAAs** – Candidate Conservation Agreements with Assurances (USFWS) **CITES** – Convention on Internal Trade in Endangered Species of Wild Flora and Fauna

**CEQ** – Council on Environmental Quality

**Core habitat** - Mapped sagebrush types or other habitats that support greater sage-grouse annual life history requirements that are encompassed by areas: a) of very high, high, and moderate lek density strata; b) where low lek density strata overlap local connectivity corridors; or c) where winter habitat use polygons overlap with either low lek density strata, connectivity corridors, or occupied habitat." The map of core sage-grouse habitat is maintained by ODFW.

**CRP** – Conservation Reserve Program (USDA-NRCS)

**CSA** – Core Sagebrush Area

**Development action** - Any human activity subject to regulation by local, state, or federal agencies that could result in the loss of sage-grouse habitat. Development actions may include but are not limited to construction, and operational activities authorized or conducted by local, state, and federal agencies. Development actions also include subsequent re-permitting of existing activities proposing new impacts beyond current conditions.

**Direct impact** - An adverse effect of a development action upon sage-grouse habitat which is proximal to the physical footprint of the development action in time and place.

**DLCD** – Oregon Department of Land Conservation and Development

**DOGAMI** – Oregon Department of Geology and Mineral Industries

**DPA** – Defense Production Act

**DSL** – Oregon Department of State Lands

**EA** – Environmental Assessment

**EFSC** – Energy Facility Siting Council

**ESA** – Endangered Species Act

**FLPMA** – Federal Land Policy and Management Act

**FRESC** – Forest Rangeland Ecosystem Science Center

**Functionality** – The ability of habitat to meet sage-grouse seasonal and/or year round life history needs (e.g., breeding, early rearing, wintering, migratory) and sustain sage-grouse populations.

**General habitat** – Occupied (seasonal or year-round) sage-grouse habitat outside of core and low-density habitats.

**Ha** - hectare

**HQT** – Habitat Quantification Tool, related to ODFW's mitigation program

**IAGs** – Invasive annual grasses, particularly cheatgrass *(Bromus tectorum)*, medusahead *(Taeniatherum caput-medusae),* and ventenata *(Ventenata dubia)*.

**ILF** – In-lieu fee fund, related to sage-grouse mitigation

**Indirect impacts** – Adverse effects to sage-grouse and their habitat that are caused by or will ultimately result from implementation of a development action, with such effects usually occurring later in time or more removed in distance as compared to direct effects.

**LCDC –** Oregon Land Conservation and Development Commission

**LIT** – Sage-grouse Local Implementation Team

**LMP** – Land Management Plan

**Low-density habitat** – Areas of mapped sagebrush types or other habitats that support greater sage-grouse that are encompassed by areas where: a) low lek density strata overlapped with seasonal connectivity corridors; b) local corridors occur outside of all lek density strata; c) low lek density strata occur outside of connectivity corridors; or d) seasonal connectivity corridors occur outside of all lek density strata." The map of low-density sage-grouse habitat is maintained by ODFW.

**LUPA** – Land Use Plan Amendment (BLM)

**NGO** – Non-governmental organization

**NRCS** – Natural Resources Conservation Service

**OAR** – Oregon Administrative Rule

**ODFW** – Oregon Department of Fish and Wildlife

**ODOE** – Oregon Department of Energy

**ORS** – Oregon Revised Statute

**OSU** – Oregon State University

**OWEB** – Oregon Watershed Enhancement Board

**PACs (Priority Areas for Conservation)** – ODFW's biologically relevant sage-grouse management units (previously, 'core areas'). PACs are core sage-grouse habitats, geographically divided into biologically relevant management units.

**P-R Funds** – Pittman-Robertson Funds, federal excise taxes on the sale of certain hunting and shooting equipment that are distributed to states for management of wildlife.

**PRM** – Permittee responsible mitigation, related to Oregon's sage-grouse mitigation program
**PTT** – Platform Terminal Transmitter
**RFP** – Request for Proposals
**RFPA** – Rangeland Fire Protection Association
**RIBBITS –** Regulatory In-Lieu Fee & Bank Info Tracking System, federal mitigation database
**RMP** – Resource Management Plan (BLM)
**ROD –** Record of Decision
**SageCon** – Oregon Sage-grouse Conservation Partnership
**SCD –** Sagebrush Conservation Design
**SWCD** – Soil and Water Conservation District
**TAWS** – Targeted Annual Warning System
**TNC** – The Nature Conservancy
**USDA** – United States Department of Agriculture
**USFS –** United States Forest Service
**USGS** – United States Geological Service
**USFWS** – United States Fish and Wildlife Service
**VHF** – Very High Frequency, related to transmitters
**WAFWA** – Western Association of Fish and Wildlife Agencies
**WERC** – Western Ecological Research Center
**WMU** – Wildlife Management Unit

# Appendices

## Appendix 1: Population Monitoring Guidelines

### Oregon Sage-Grouse Lek Monitoring Guidelines - January 2025

The Oregon Department of Fish and Wildlife (ODFW) sage-grouse lek monitoring guidelines were updated in January 2025, based on the Western Association of Fish and Wildlife Agencies (WAFWA) published 'Standards for Collection and Reporting Greater Sage-Grouse Lek Count Data' (hereafter, WAFWA Guidelines; Cook et al., 2022). ODFW's lek monitoring guidelines differ slightly from the WAFWA Guidelines but some of the language within this document is taken directly from the WAFWA Guidelines where applicable to Oregon. Refer to the WAFWA Guidelines for further details on some of these lek monitoring definitions, protocols and procedures.

### Introduction

Each spring, male sage-grouse attend leks, or strutting grounds, to display for and breed with female sage-grouse. Counting the number of males attending leks is the primary method of monitoring sage-grouse populations in Oregon, and across the range of the species in western North America. This protocol standardizes collection of sage-grouse lek count data in Oregon and is designed to effectively provide unbiased data for ODFW to evaluate sage-grouse population status and trends at several spatial scales, annually.

Individual leks are those locations where 2 or more male sage-grouse congregate to perform their strutting display during at least 2 breeding seasons within a 10-year period. This is the requirement for a lek to be added to Oregon's centralized sage-grouse lek database. Once a lek location has been confirmed with two or more displaying males for two years, Oregon requires only one or more displaying males present at the lek location within a 10-year period for the lek to be considered 'Occupied'. In addition to individual lek locations, Oregon identifies lek complexes as those situations where two or more individual leks are closely associated (e.g., majority of males may display at any of the known lek locations within a complex during a given breeding season or across multiple breeding seasons). This association of multiple individual leks can be identified in the field by lek observers, using data from GPS-marked males, or assumed based on geographic proximity. Typically, if two or more individual leks are within 1 mi (1.6 km) of the next closest known lek, these leks are grouped and considered a single lek complex.

Oregon's definition of 'lek complex' is similar to the WAFWA Guidelines definition of 'lek'. Oregon does not use the term lek to describe the collective individual lek locations within lek complexes because ODFW and other Oregon sage-grouse conservation partners are interested in tracking the attendance and spatial distribution of individual leks within lek complexes annually. Importantly, all individual leks within a lek complex must be surveyed on the same morning to avoid biases associated with the intra-season movements of males within a complex. Identifying the individual leks within a lek complex also acts as a more effective communication tool among lek observers to ensure all the closely associated leks within a lek complex are surveyed on the same morning.

## Lek Data Management

ODFW maintains and manages Oregon's centralized sage-grouse lek database, which contains all known lek locations and associated lek surveys, 1941–present. Requests for sage-grouse lek data in Oregon must go through ODFW as a Public Records Request, and a Data Sharing and Non-Disclosure Agreement with the requesting entity must be established prior to ODFW providing the requested lek data. ODFW has longstanding agreements in place with the cooperating federal agencies which assist with sage-grouse lek monitoring (BLM and USFWS), and updated lek data are provided by ODFW to cooperating agencies annually.

Oregon's sage-grouse lek complexes are uniquely named and identified by a 6-character code, where the first 2 characters reflect the county where the lek complex is located, and the last 4 digits represent the unique lek complex number. For example, MA0100 identifies lek complex number 100 in Malheur County. Similarly, individual leks within lek complexes are uniquely named and identified. For example, MA0100-02, named Wilson Creek #2, is the second of four individual leks within the MA0100 lek complex. Each individual lek has a unique name and alpha-numeric identifier, even if there is only one individual lek within a lek complex. For example, lek HA0050-01, named Steens South Loop, is the only individual lek within the HA0050 lek complex. Lek locations are spatially identified as the GPS location of the activity center of the individual lek. Lek locations can shift over time as the activity center shifts; generally, the GPS location is updated in the database when a shift in the activity center is > 0.1 mi (0.16 km). To avoid confusion among leks with a similar name (e.g., "Dry Creek"), observers should always use the alpha-numeric identifier when referring to leks, and most importantly when reporting lek counts.

## Lek Count Protocol

Lek counts are used to assess sage-grouse population size and trends; the following protocol must be followed to ensure unbiased estimates:

Male sage-grouse begin attending leks in early March and often continue through early May. Lek counts should be conducted only between 15 March–30 April each year to coincide with peak female attendance.

Lek counts should be conducted only from 30 minutes before sunrise to 2 hours after sunrise.

Lek counts should be conducted during mornings with clear to partly cloudy skies, little to no wind, and no precipitation. Lek counts should not be conducted if weather conditions (i.e., wind gusts >15 mph (24 km/h), rainy or snowy conditions) or disturbance (i.e., humans, livestock, predators, other wildlife, etc.) precludes normal display activities.

For unbiased estimates of population size and trends, a minimum of 50% of the 'Occupied' or 'Occupied-Pending' lek complexes within a geographic scale of interest (i.e., PAC, WMU, BLM District, statewide, etc.) should be counted at least 2 times, annually. Lek complexes should be counted at 7–14-day intervals. If a geographic scale of interest contains <10 active or active pending leks, a minimum of 80% of these leks should be counted at least once annually.

All known ‘Occupied’ or ‘Occupied-Pending’ lek complexes on accessible public or private lands should be counted a minimum of every 3 years.

**Lek Count Procedures**

Sage-grouse lek counts from the ground should be conducted by a trained observer viewing the lek through a spotting scope or binoculars from a concealed location, generally > 200 yards from the lek to avoid disturbing the sage-grouse. The observer should record survey information (i.e., lek identifier and name, date, time, weather conditions) at the beginning of the survey; data may be recorded electronically or on paper datasheets in the field. The observer should count the sage-grouse on the lek from right to left, or left to right, recording the number of males, females, and sage-grouse of unknown sex, and report each separately. The observer should survey each lek until the maximum male count recorded has remained the same for two or more consecutive counts, and for a minimum of 15 minutes.

**Presence-Absence Lek Checks**

Presence-absence sage-grouse lek checks report lek activity when a lek count cannot be obtained, documenting the lek status as active/detected or not detected during a given breeding season. For example, if an observer visits a known lek location outside of the dawn lek count timeframe or when weather conditions preclude a lek count and the observer detects male sage-grouse at the lek, this lek may be active during the given breeding season and an observer should return on a subsequent morning to conduct a lek count. Additional signs of activity include documentation of fresh sage-grouse droppings, feathers, or tracks. Importantly, if sage-grouse or sage-grouse sign are not observed at a known lek when the lek is visited outside of the lek count timeframe or viewed under conditions that preclude a lek count, the lek should not be reported as ‘inactive’ during the given breeding season. Rather, the observer should report neither sage-grouse nor sage-grouse sign were detected during the presence-absence lek check.

Although presence-absence checks for activity at sage-grouse leks may provide some useful information (e.g., prioritization for subsequent lek count), the structure of Oregon’s centralized sage-grouse lek database precludes the utility of presence-absence checks. Oregon tracks annual lek activity status based on lek counts and does not incorporate presence-absence checks into annual reporting of population status or trend at any geographic scale. Presence-absence lek checks should be collected opportunistically and reported but should not be prioritized over lek counts.

**Aerial Lek Search Protocol and Procedures**

Systematic aerial sage-grouse lek surveys have been conducted in Oregon since the 1990’s, and the majority of known lek locations in Oregon can be attributed to these aerial surveys. Aerial lek searches are important for locating previously unknown lek locations and for documenting lek location shifts over time. Aerial lek searches by helicopters (9 seasons) and fixed-wing aircraft equipped with infrared camera technology (1 season) were conducted consistently during each sage-grouse breeding season from 2016 through 2025, supported by a cooperative financial assistance agreement between ODFW and BLM. ODFW assessed the utility of aerial infrared lek searches compared to helicopter lek searches and determined lek detection probabilities of the aerial infrared methodology were lower than helicopter surveys. Pending funding availability, helicopter surveys should continue to be used annually to document spatial distribution of sage-grouse leks in Oregon, and supplement data collection on the ground when necessary due to access challenges. Aerial lek searches by helicopter should be prioritized in sage-grouse core habitat/PACs and adjacent low-density habitat based on sage-grouse population trends and status, time since the last aerial lek search of an area, and in response to emerging needs (e.g., assess population response to wildfires).

Aerial lek searches should be conducted between March 25–April 15 to coincide with peak female attendance at leks. Like lek counts, aerial lek searches should be conducted only from 30 minutes before sunrise to 2 hours after sunrise, and only during mornings with clear to partly cloudy skies, little to no wind, and no precipitation. Aerial lek searches should not be conducted if weather conditions preclude normal display activities.

Helicopters should generally fly transects at ¼-mi intervals, oriented in a north to south direction, to maximize detection probability of displaying male sage-grouse under optimal early-morning light conditions. Helicopters should maintain speeds around 50 mph and stay 50–100 feet above ground level while conducting lek searches. When displaying male sage-grouse are spotted from the helicopter, observers should obtain a male count by hovering far from the lek to avoid flushing the birds. If the birds flush prior to detection or during the aerial count, observers should record the maximum number of males identified and the total number of sage-grouse counted as the birds flush. Observers should record whether male sage-grouse were initially observed displaying or if the birds were only observed after they were flushed. Observers should obtain and record an accurate GPS location of any sage-grouse discovered during the aerial lek search, and these locations should be subsequently surveyed on the ground for verification of any potential new leks.

**Aerial Lek Count Protocol and Procedures**

Aerial sage-grouse lek counts are infrequently necessary to supplement ground counts when survey effort goals are not being met within a given geographic scale of interest (e.g., PAC-scale). Several PACs contain areas with significant access challenges, such as remote terrain with poor road conditions [i.e., Louse Canyon PAC] or a high proportion of private lands preventing access [i.e., Cow Valley PAC], and may require occasional aerial survey effort to meet lek survey goals. Aerial lek counts may be conducted using helicopters or fixed-wing aircraft equipped with infrared imaging and high-definition camera technology. Although aerial lek counts have lower detection probabilities than ground lek counts, aerial counts are often able to record the number of displaying males at a given lek location under ideal conditions when following established survey protocols. Counts of displaying males may be recorded in the database while counts of flushed birds from the aircraft should only be used document the lek status as active/detected during a given breeding season.

Aerial lek counts should be conducted between 15 March–30 April. Like ground lek counts, aerial lek counts should only be conducted from 30 minutes before sunrise to 2 hours after sunrise, and only during mornings with clear to partly cloudy skies, little to no wind, and no precipitation. Aerial lek counts should not be conducted if weather conditions preclude normal display activities. Due to the lower detection probabilities of aerial lek counts, a minimum of 2 visits to each lek monitored using this method should be required to enter these count data into the lek database.

Use of aerial drone technology for conducting wildlife surveys is expected to increase during the next decade. As noted in the WAFWA Guidelines, drones have not been widely used for counting sage-grouse leks to date, and there is currently limited research evaluating the efficacy of drones for conducting lek surveys or evaluating the potential disturbances of drones to breeding sage-grouse at leks. ODFW may utilize drones for conducting aerial lek counts in the future, depending on the cost and effectiveness of this method. Refer to the WAFWA Guidelines Drone Protocol for specific details on the recommended methodology for use of drones to conduct sage-grouse lek surveys.

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## Appendix 2: Population Analysis Methodology

This information product has been peer reviewed and approved for publication as a preprint by the U.S. Geological Survey.

# Estimating greater sage-grouse population sizes within the state of Oregon, USA 2017–2024

Brian G. Prochazka[1a], Peter S. Coates[1], Austin L. Nash[1], Shawn T. O'Neil[1], Skyler T. Vold[2], Adrian P. Monroe[3], Cameron L. Aldridge[3]

[a]Corresponding author: bprochazka@usgs.gov

[1]U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA, USA, 95620-9648

[2]Oregon Department of Fish and Wildlife, 237 Highway 20 South, P.O. Box 8, Hines, OR, USA, 97738-9428

[3]U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Avenue, Building C, Fort Collins, CO, USA, 80526-8118

**Keywords:** abundance, lek attendance, N-mixture model, population size, sex-ratio, simulation

## Abstract

We fit an *N*-mixture model to lek (breeding area) count data to estimate annual population sizes of greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) within the state of Oregon, USA between 2017–2024. Population estimates were delineated among 24 Priority Areas for Conservation (PACs) and considered additional sources of information including male-to-female sex ratios, lek attendance rates, numbers of unmodeled leks, and the existence of unsampled/unknown leks. In 2024, the state of Oregon was estimated to contain approximately 41,875 sage-grouse (95% credible interval [CRI] = 38,980–54,634), which was down from a high of 50,869 (95% CRI = 41,794–66,238) in 2017. A nadir (low point) was identified during 2019, when the median statewide population estimate was 30,644 birds. A complete population oscillation was not evident during the inferential period based on local maxima that were observed during the start (2017) and stop (2024) years of analysis. In addition to estimating population sizes, we evaluated *N*-mixture model estimates for precision and accuracy after

randomly removing single and repeat counts in 10% increments (relative to total sample size). We estimated an increase in absolute bias of approximately 1.6% for every 10% reduction in effort.

## Introduction

Estimating the size and trajectory (trend) of wildlife populations is a key component of effective species management. For greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse), there has been a wealth of information about trends, but considerably less has been published on population size. This is particularly troubling considering the prevalence and duration of population declines documented throughout much of the species' range (Coates et al., 2021). The few studies that have presented information on population size have been relatively narrow in geographic scope, presented the value as an index thereby limiting its utility, or failed to account for leks that were not modeled due to data limitations or logistical constraints (Garton et al., 2011; McCaffery and Lukacs, 2016; Shyvers et al., 2018; Coates et al., 2021). Historically popular approaches to modeling population size have required data that are difficult to collect at scale (e.g., time intensive), such as individual identification (e.g., capture–recapture) or systematic repeated surveys that use distance sampling to estimate detectability. Sage-grouse are a cryptic, low-density species when not on their breeding sites (i.e., leks), so commonly used bird monitoring protocols (e.g., Integrated Monitoring in Bird Conservation Regions, Breeding Bird Survey, eBird) are inadequate because detections are too few and far between. This, in part, could explain the current lack of information on population sizes for sage-grouse across their geographic range and through time.

Recent advances in population modeling have provided an opportunity to better address questions of population size by estimating a biologically meaningful value ("true" abundance) from data that can be collected over large spatiotemporal scales with relative ease. Using only replicated counts of individuals across space and time, these models (hereafter, N-mixture models) can produce separate estimates of latent abundance and detection probability. Covariates can be fit within state (i.e., latent abundance) or observation likelihoods to improve parameter estimation and inform future sampling designs (e.g., when or how intensively to focus monitoring efforts). Additional sources of information can be included, within or outside the model, to further refine abundance estimates. Specific to sage-grouse, these additional sources of information could include male-to-female ratios, lek attendance rates, and numbers of unknown or unmodeled active leks. Here, we estimated sage-grouse population abundance in Oregon, USA, using N-mixture models of sage-grouse male counts at leks, combined with ancillary harvest data to inform sex ratios, priors on lek attendance to account for the non-breeding or non-lek-breeding cohort, derived parameters to account for unmodeled leks, and complementary statistical methods to estimate currently undetected leks. Results improve upon the previous best available estimates on population size for the state of Oregon and can be used directly in conservation and land management plans within the state.

## Methods

### *Data*

We used sage-grouse lek count data provided by the Oregon Department of Fish and Wildlife (ODFW) to estimate annual population sizes of sage-grouse within the state of Oregon between 2017–2024. Data spanned the geographic range of sage-grouse within the state (Fig. 1), with all lek counts spatially linked to one of 24 population units referred to as Priority Areas for Conservation (PACs; included Low-Density areas). Leks located outside of PAC boundaries were assigned to the nearest PAC using the sf package (v 1.0-16) in R (R Core Team, 2024).

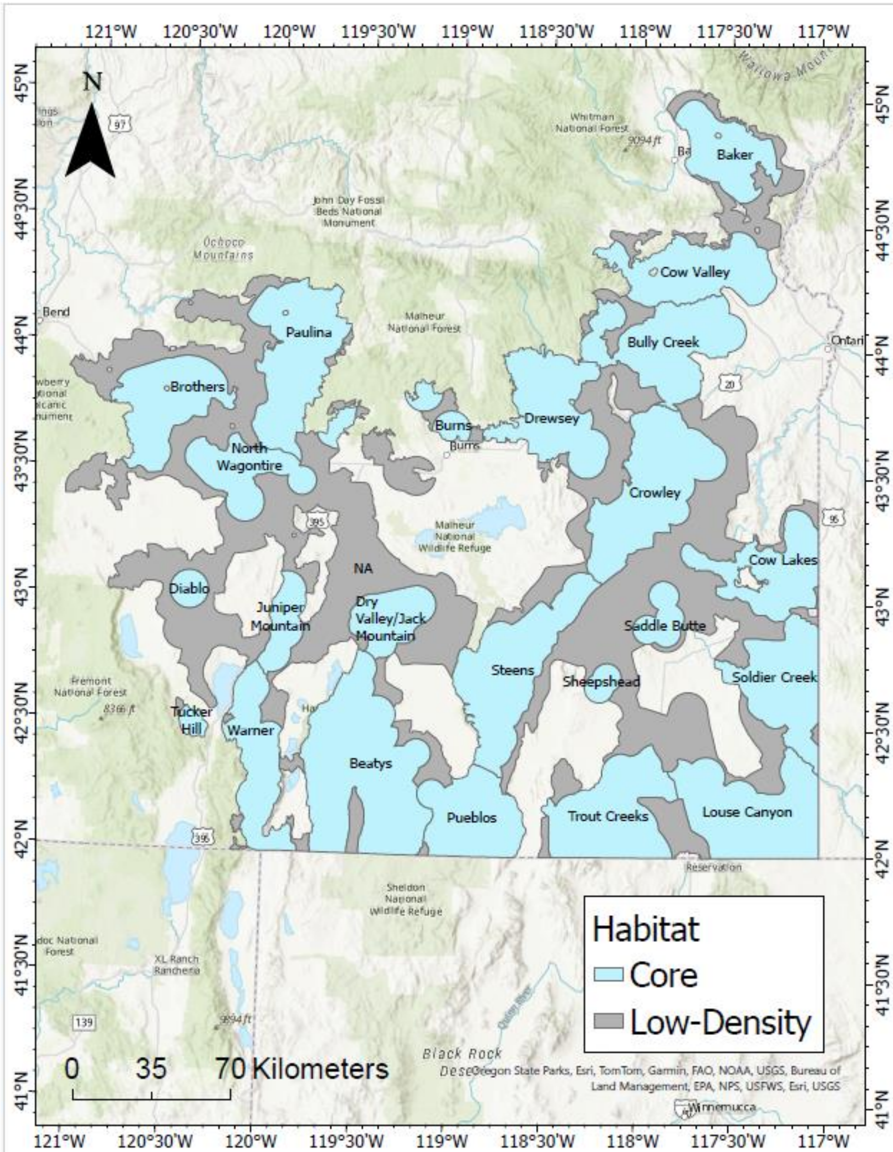


**Figure 1.** Greater sage-grouse (*Centrocercus urophasianus*) Priority Areas for Conservation within the state of Oregon, USA. Habitat is delineated as Core (cyan polygons) and Low-Density (gray polygons).

To produce a dataset appropriate for modeling, we first filtered lek count data using previously established methods (Monroe et al., 2016; O'Donnell et al., 2021). We selected surveys that were conducted within seasonal and diurnal periods of peak lek attendance. Seasonal peaks in lek attendance were targeted by restricting the dataset to surveys occurring between March 1 and May 31 of each year (Blomberg et al., 2013; Jenni and Hartzler, 1978; Wann et al., 2019). Diurnal peaks in lek attendance were targeted by restricting the dataset to surveys occurring between 30 minutes before and 120 minutes after local sunrise (Monroe et al., 2016). When multiple counts were recorded during the same day, we retained the maximum count, assuming the count met date and time criteria. We also required leks to be counted at least once per year during five separate years (between 2017–2024) with at least two years producing a maximum count that was ≥2 males.

### *Investigating rates of lek switching*

Prior to modeling, we investigated the potential for high rates of lek switching (i.e., individual male sage-grouse attending >1 lek within the same breeding season) among proximal leks, which if left unresolved could yield double counts and inferences about population size that were biased high. We therefore constructed two separate matrices from the filtered lek count dataset. The first was a distance matrix representing pairwise distances among all leks. The second was a time series correlation matrix of Pearson's correlation coefficients constructed from pairwise combinations of coincident lek counts (lek counts conducted on the same day). Lek pairs with fewer than five coincident counts were discarded from this portion of the analysis. Correlation coefficients were then grouped according to pairwise distances binned at 200-m increments (range = 0–374.6 km). Significant rates of lek switching were evidenced by distributions of correlation coefficients that were entirely below zero. Approximately 2.6% of the 1,793 distance bins investigated had a maximum correlation coefficient less than zero. The only proximal bin to have a maximum correlation coefficient less than zero was the >0–200-m bin (mean = -0.25; range = -0.41 – -0.11). The remaining bins with a maximum correlation coefficient less than zero were from leks that were >315-km apart, which precluded a lek switching mechanism. Due to the small number of leks (<1%) that could be affected by lek switching and the relatively low rate (evidenced by a moderately negative correlation coefficient), we opted to model all leks independently rather than aggregate proximal leks.

### *Identifying active, unmodeled leks*

We recorded the number of leks that did not meet filtering criteria and were therefore not included in models. Of those unmodeled leks, we identified a subset that provided some evidence of continued activity (≥2 counts of ≥1 male between 2017–2024 and no zero counts during 2023–2024) and used them to calculate a derived abundance parameter in our model (detailed in modeling section). We refer to those unmodeled active leks as $leks^{+}$. For the leks that were modeled, we converted their survey date and time information to ordinal date and time since sunrise (TSSR). Ordinal date and TSSR were standardized by subtracting the sample mean and dividing by the sample standard deviation.

### *Modeling lek count data*

We fit an *N*-mixture model (Kery and Schaub, 2012; Royle, 2004) to repeated counts, across space and time, of male sage-grouse attending leks. This yielded separate estimates of latent abundance and detection probability. The latent abundance ($N_{lt}$) for each lek ($l$) and year ($t$) was defined as the product of the previous year's abundance ($N_{lt-1}$) and finite rate of population change ($\lambda_{lt-1}$):

$$N_{lt} \sim Poisson(N_{lt-1}\lambda_{lt-1}) \quad (1)$$

Initial population sizes were specified using uniformly distributed priors bounded by half the minimum male count (lower bound) and twice the maximum male count (upper bound) observed per lek between 2017–2024:

$$N_{l1} \sim uniform(\frac{\min(c_{lst})}{2}, 2\max(c_{lst})) \quad (2)$$

Lek-level estimates of population change were modeled on a log-scale using a normal distribution and vague priors for mean and standard deviation parameters:

$$\log(\lambda_{lt}) \sim normal(r_t, \sigma_r^2) \quad (3)$$

$$r_t \sim uniform(-1,1) \quad (4)$$

$$\sigma_r^2 \sim uniform(0,25) \quad (5)$$

The observed counts ($c_{lst}$), which included within-year temporal replicates ($s$), were assumed to follow a binomial distribution with survey-level detection probability ($p_{lst}$):

$$c_{lst}|N_{lt} \sim binomial(N_{lt}, p_{lst}) \quad (6)$$

Covariates for ordinal date and TSSR were modeled on the logit scale, allowing for the mean detection probability to vary across a season and within a morning (Monroe et al., 2019):

$$logit(p_{lst}) = \beta_0 + \beta_1 time_{lst} + \beta_2 time_{lst}^2 + \beta_3 date_{lst} + \beta_4 date_{lst}^2 + \beta_5 date_{lst}^3 \quad (7)$$

A standard deviation parameter for detection probability was included to account for unmodeled sources of variation in the detection process:

$$\sigma_p^2 \sim uniform(0{,}25) \quad (8)$$

### *Simulations to evaluate sampling effort*

To explore the influence of sampling effort on estimation of abundance, we ran four separate models on progressively smaller, subsampled versions of the dataset by randomly reassigning observed counts with NA values. These simulated levels of varying sampling intensity resulted in distributional shifts in the proportion of leks receiving 0–3 counts within a single breeding season (Fig. 2).

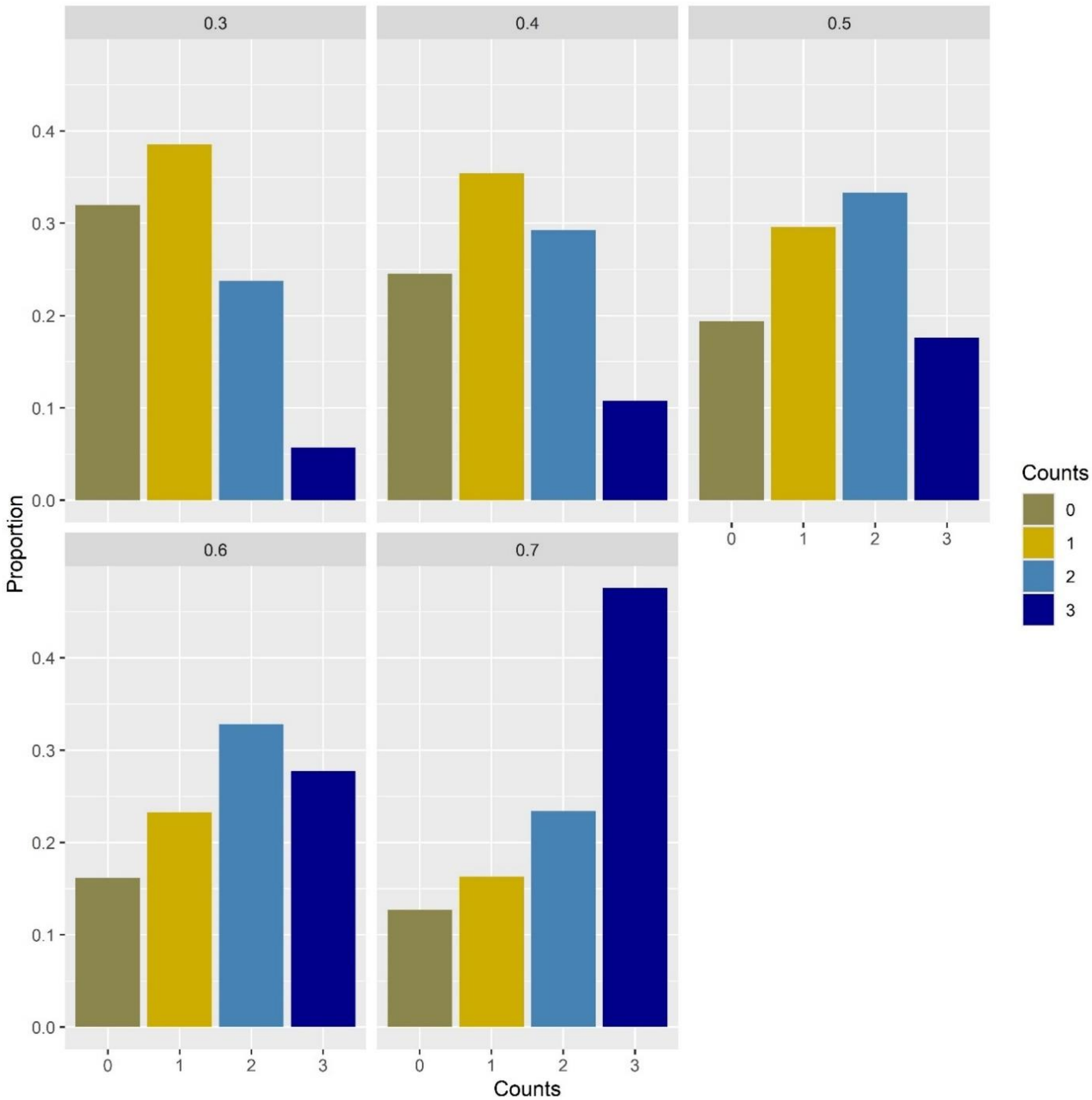


**Figure 2.** The average proportion of greater sage-grouse (*Centrocercus urophasianus*) leks (breeding areas) that received 0–3 counts per breeding season (recorded during separate days) between 2017–2024. Individual panels depict varying levels of lek count effort with 30–70% (listed in title; 0.3–0.7) of leks receiving 2–3 counts per breeding season (i.e., repeat counts; blue tones). The reference dataset (0.7) depicts current maximal lek count efforts carried out by the Oregon Department of Fish and Wildlife, and their partners, based on data that were deemed suitable for *N*-mixture model analysis (see Methods for more detailed information on lek count criteria). Proportions less than 0.7 represent smaller datasets created from random, simulated reductions in the number of observed counts.

Lek count efforts during the most recent 8-year period (2017–2024) resulted in repeat counts (2–3 counts per breeding season) for approximately 70% of modeled leks. Simulated reductions in sampling effort resulted in 30–60% of modeled leks having within-season repeat counts (*reduced models*). Parameter estimates of abundance from *reduced models* were compared to estimates from the same model fit to data collected under the current maximal sampling intensity (i.e., 70%, *reference model*) to evaluate the impacts of increasingly sparse data on parameter accuracy and precision. We calculated bias and coverage statistics for the derived parameters of abundance calculated at the PAC level. Bias was calculated as the mean difference between the median estimate of the *reference model* and the median estimate of the *reduced model*, divided by the median estimate of the *reference model* (multiplied by 100 to produce a percentage). Coverage was calculated as the percent of the *reduced model's* 90% credible intervals (CRIs) that overlapped the median of the *reference model's* counterpart parameters.

### *Derived parameters for improved estimation of abundance*

Despite advantages of working within an *N*-mixture framework, lek count data still impose several limitations on the scope of model inference. First, lek count data are typically restricted to males and even when females are included, the sex ratio may not reflect the true population value. To obtain estimates of total population size, additional information about the female proportion of the population must be included. Estimates of male population size can be supplemented by assuming a regionally constant sex ratio. However, previous studies conducted from different areas of the geographic range of sage-grouse have provided evidence for spatial variation in sex ratios (Guttery et al., 2013; Prochazka et al., 2024; Shyvers et al., 2023). To obtain a sex ratio estimate specific to Oregon, we utilized hunter-harvested wing data collected by the ODFW between 1995–2023, corrected for age-specific harvest susceptibility (Hagen et al., 2018). The resultant, long-term mean sex ratio of 1.82 females per male (95% CRI = 1.76–1.88) was multiplied by *N*-mixture estimates of male abundance to obtain an estimate of female abundance.

Another limitation inherent to lek count data is that not all males attend at least one lek within a breeding season (Blomberg et al., 2013; Wann et al., 2019). This is especially true for juvenile or yearling males, which may utilize areas proximal to leks, but still outside of detectable range. Because these individuals are not available for detection, the model cannot account for their absence and additional information is required to account for their contribution to total population size (Monroe et al., 2019). For this, we used an informative prior from a study of GPS-marked male sage-grouse monitored during multiple breeding seasons (Wann et al., 2019), and which represented the age-weighted average peak lek attendance rate (0.58; 95% CRI = 0.46–0.71).

The final issue with lek count data, as it pertains to estimates of total population size, is that not all active leks in existence are present in the data. To account for this, we estimated the number of unknown leks likely to exist on the landscape at present using a larger subset of the ODFW lek count database that spanned 85 years (1940–2024). First, we calculated the number of new leks added to the database on an annual basis between 1940–2023. This calculation was conducted at the PAC level using a cumulative sum for each year. For example, the number of unknown leks per PAC in 2022 was calculated as the sum of new leks added per PAC during 2023 and 2024. We then used an autoregressive technique (Generalized Regression Neural Network [GRNN]; *tsfgrnn* package, v 1.0.5) to forecast a time series of future values (Martínez et al., 2022) per PAC and used the value at time step $t = 1$ (i.e., number of new leks likely to be discovered beyond 2024) to represent the number of unknown leks likely to exist at present time (Fig. 3; Table 1).

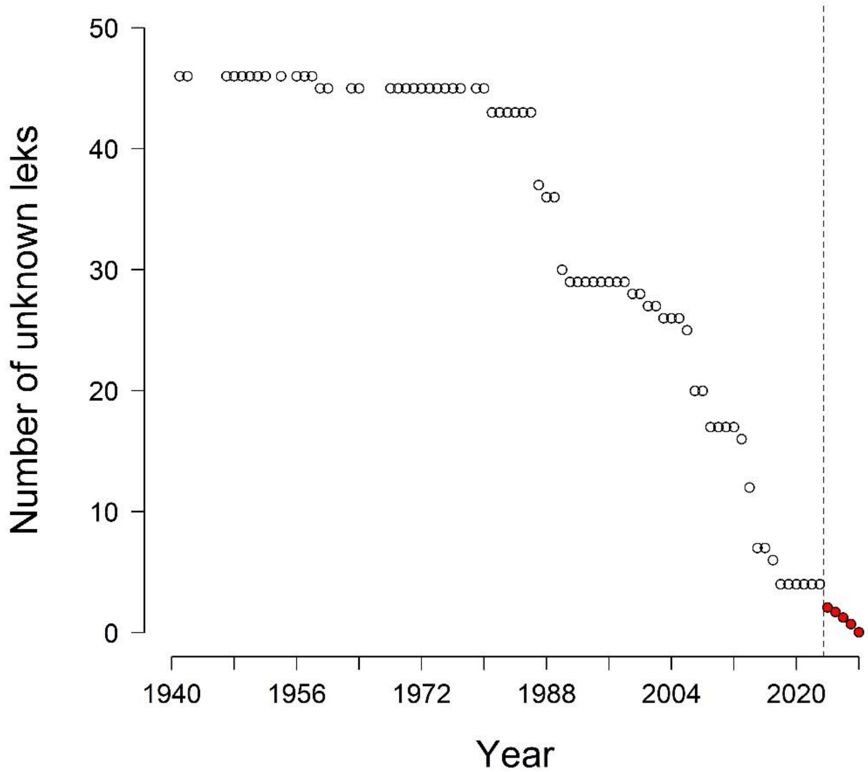


**Figure 3.** Number of greater sage-grouse (*Centrocercus urophasianus*) leks (breeding areas) missing from the Oregon Department of Fish and Wildlife (ODFW) lek count database between 1940–2024, within the Pueblos Priority Area for Conservation (PAC), calculated as the cumulative sum of new leks added to the database during all subsequent years. Predictions (red circles) of the number of unknown leks likely to exist during four future years, based on the application of a Generalized Regression Neural Network (GRNN) to the observed data (open circles).

**Table 1.** Predictions of the number of unknown greater sage-grouse (*Centrocercus urophasianus*) leks (breeding areas) likely to exist (during 2024) within Priority Areas for Conservation (PACs) based on the application of a Generalized Regression Neural Network (GRNN) to lek count data collected within the state of Oregon, USA between 1940–2024.

| Priority Areas for Conservation | Estimated number of unknown leks |
|---|---|
| Baker | 0 |
| Beatys | 7 |
| Brothers | 0 |
| Bully Creek | 0 |
| Burns | 0 |
| Cow Lakes | 0 |
| Cow Valley | 0 |
| Crowley | 0 |
| Diablo | 0 |
| Drewsey | 1 |
| Dry Valley/Jack Mountain | 1 |
| Juniper Mountain | 0 |
| Louse Canyon | 3 |
| Low-Density Areas | 0 |
| North Wagontire | 0 |
| Paulina | 0 |
| Pueblos | 3 |
| Saddle Butte | 0 |
| Sheepshead | 0 |
| Soldier Creek | 3 |
| Steens | 3 |
| Trout Creeks | 0 |
| Tucker Hill | 0 |
| Warner | 0 |

Each of the previous corrections applied to $N$-mixture estimates were based on inherent limitations of lek count data. Limitations that we introduced prior to modeling, in the form of observation criteria (e.g., date of survey, time of survey, number of counts), resulted in an even narrower geographic scope. We corrected for these user-imposed limitations by calculating derived parameters of abundance based on PAC-level numbers of unmodeled leks (i.e., $leks^{+}$). Like the GRNN predictions of numbers of unknown leks (i.e., missing from database altogether), we multiplied the annual average, PAC-specific, lek-level abundance (corrected for attendance and sex-ratios) by the number of unmodeled, active leks within a PAC.

### *Model tuning and investigation*

All models were run using Markov chain Monte Carlo techniques implemented in JAGS (Plummer, 2003) using the statistical programming language and software package R (R Core Teams, 2024). We ran 150,000 iterations on each of three chains, discarding the initial 100,000 iterations as burn-in. The remaining 50,000 iterations were thinned by a factor of 50, resulting in 3,000 posterior samples for inference. For each model we evaluated fit using posterior predictive checks (Bayesian p-values) based on chi-square discrepancy test statistics (Conn et al., 2018; Kéry and Royle, 2015). We assessed model convergence using the r-hat statistic (Brooks and Gelman, 1998).

## Results

The ODFW lek database, restricted to the years 2017–2024, contained 13,521 individual lek counts from 1,182 leks. The average number of counts per lek was 11.44 (SD = 7.78), or 1.43 counts per lek per year (SD = 0.97). When we restricted the dataset to the leks and counts that were modeled (based on a 70% effort for repeated measures) we were left with 6,573 counts recorded from 385 leks. The average number of counts per lek from the reduced dataset was 17.07 (SD = 6.02), which equated to 2.13 counts per lek per year (SD = 0.75). The number of active leks that were not modeled ($leks^{+}$) from that dataset was 126. Nearly 40% of active unmodeled leks were in the Beatys ($n$ = 29) and Cow Valley ($n$ = 19) PACs. Louse Canyon ($n$ =12), Trout Creeks ($n$ =11), Warner ($n$ =10), and Soldier Creek ($n$ =10) also had high numbers of active unmodeled leks. The remaining 671 leks, based on our criteria, were either inactive or infrequently surveyed between 2017–2024.

We found the model to fit the data well based on a Bayesian p-value equal to 0.51 (Fig. 4). The model also demonstrated convergence based on a maximum r-hat statistic of 1.06.

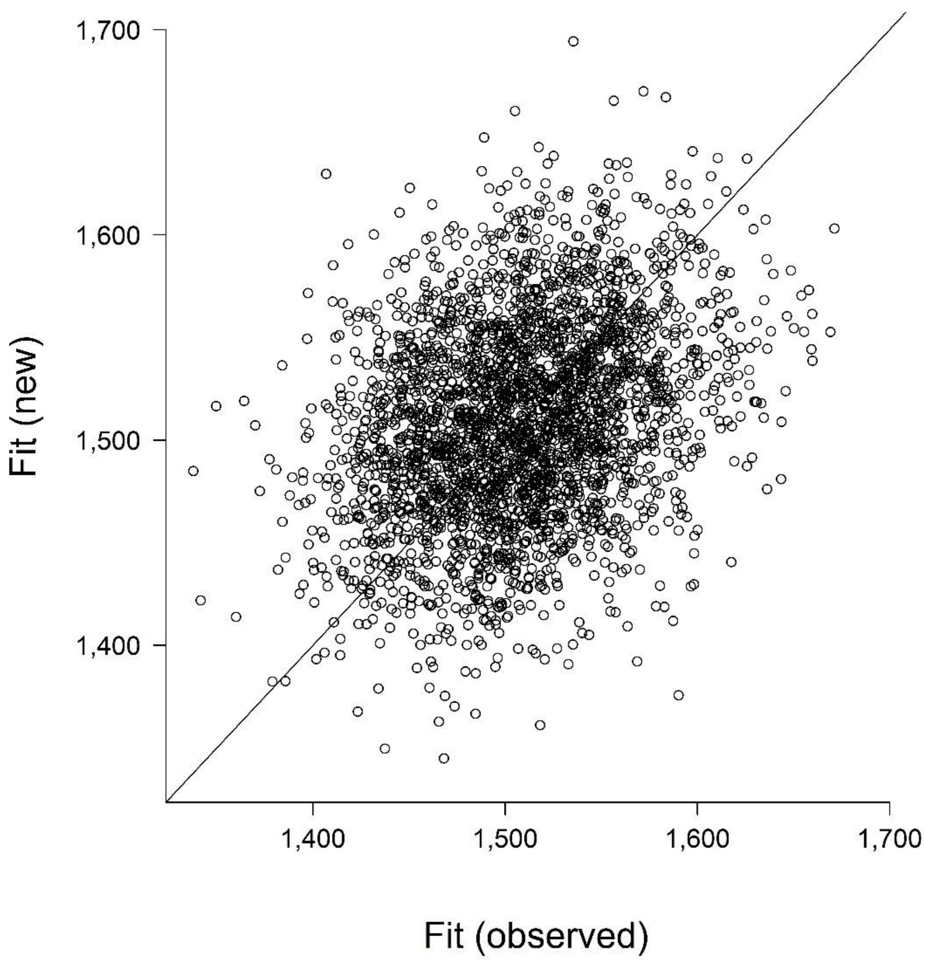


**Figure 4.** Graphical posterior predictive check of *N*-mixture model adequacy based on chi-square discrepancy measure. The *N*-mixture model was fit to greater sage-grouse (*Centrocercus urophasianus*) lek (breeding area) count data that spanned eight years (2017–2024) and covered the species' range in the state of Oregon, USA. The Bayesian *p*-value is equal to the proportion of points above the 1:1 line.

The average detection probability across all surveys was estimated to be 0.54; however, there was considerable variation (Fig. 5) with the 95% CRI spanning 0.23–0.82.

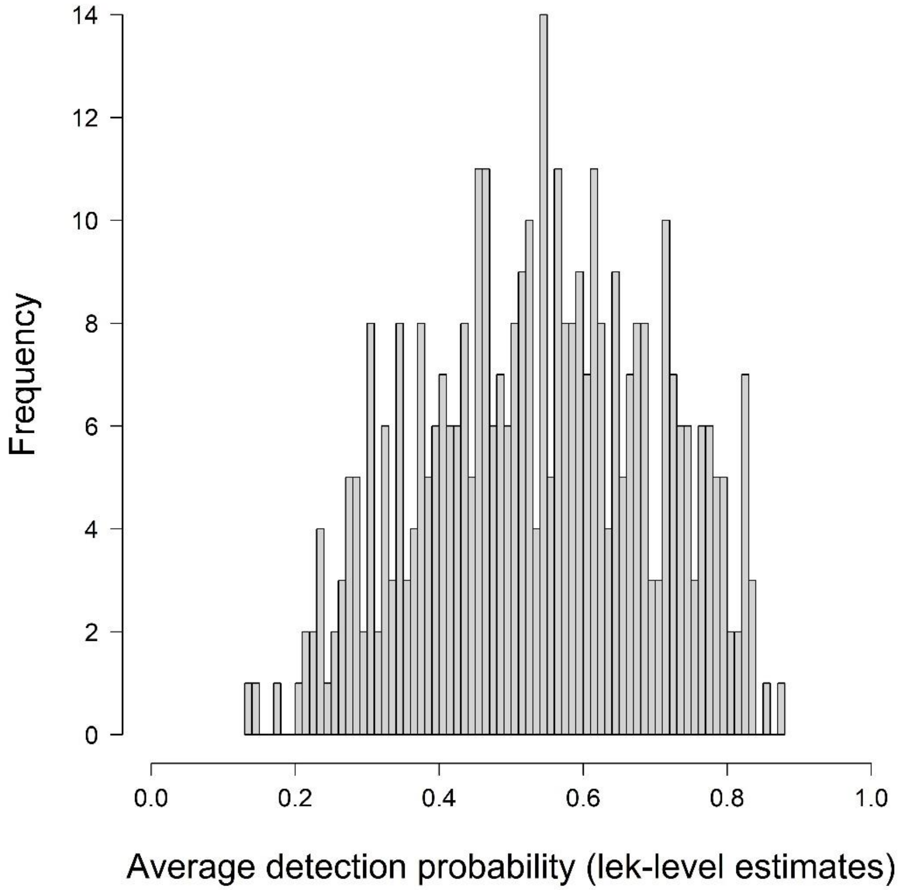


**Figure 5.** Estimates of the average detection probability of male greater sage-grouse (*Centrocercus urophasianus*) attending leks (breeding areas) based on an *N*-mixture model that was fit to count data spanning eight years (2017–2024) and covering the species' range in the state of Oregon, USA.

Time since sunrise (TSSR) had a considerable negative effect on detection probability (Fig. 6) with the highest values observed 30 minutes prior to sunrise (0.65; 95% CRI = 0.56–0.72) and the lowest values at 120 minutes after sunrise (0.19; 95% CRI = 0.09–0.33). Detection probabilities remained above 0.5 until 42 minutes after sunrise then declined after.

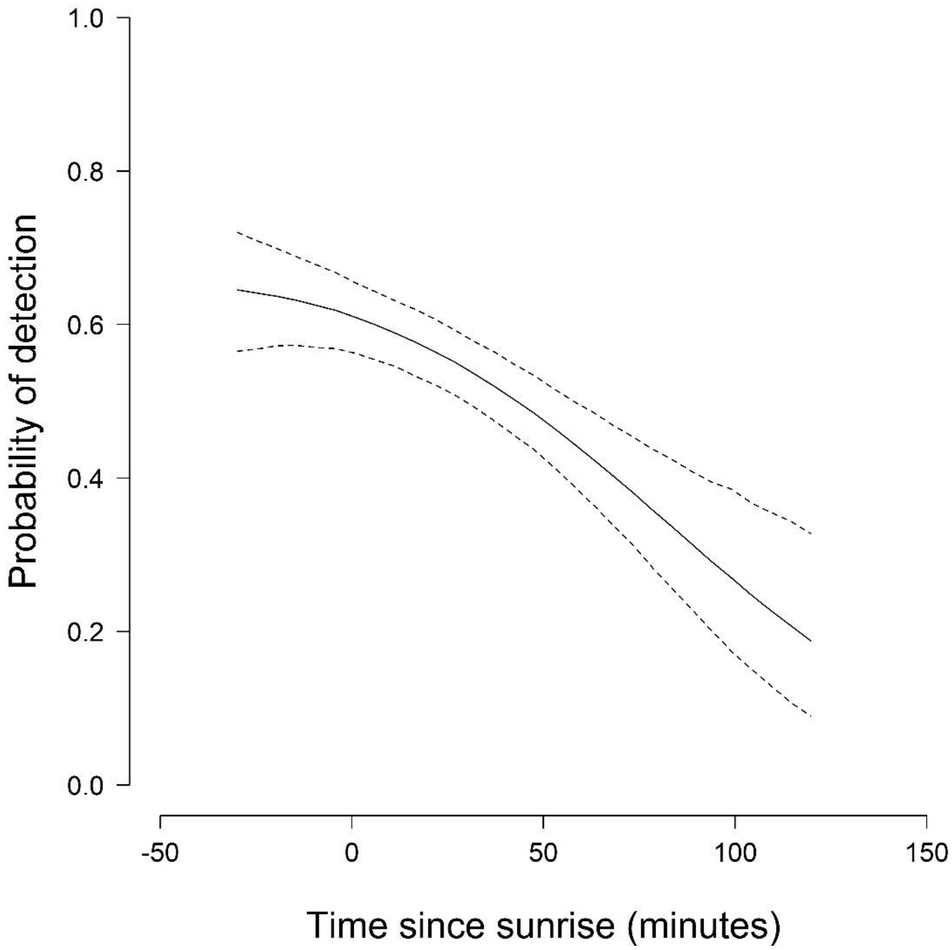


**Figure 6.** The effect of time since sunrise (in minutes) on the detection probability of male greater sage-grouse (*Centrocercus urophasianus*) attending leks (breeding areas) within the state of Oregon, USA. Predictions are based on an *N*-mixture model fit to lek count data collected between 2017–2024. The median estimate is depicted using a solid black line. The 95% credible interval is depicted using dashed lines.

We did not detect an effect of ordinal date on detection probability (Fig. 7); credible intervals were wide with considerable overlap across all days investigated.

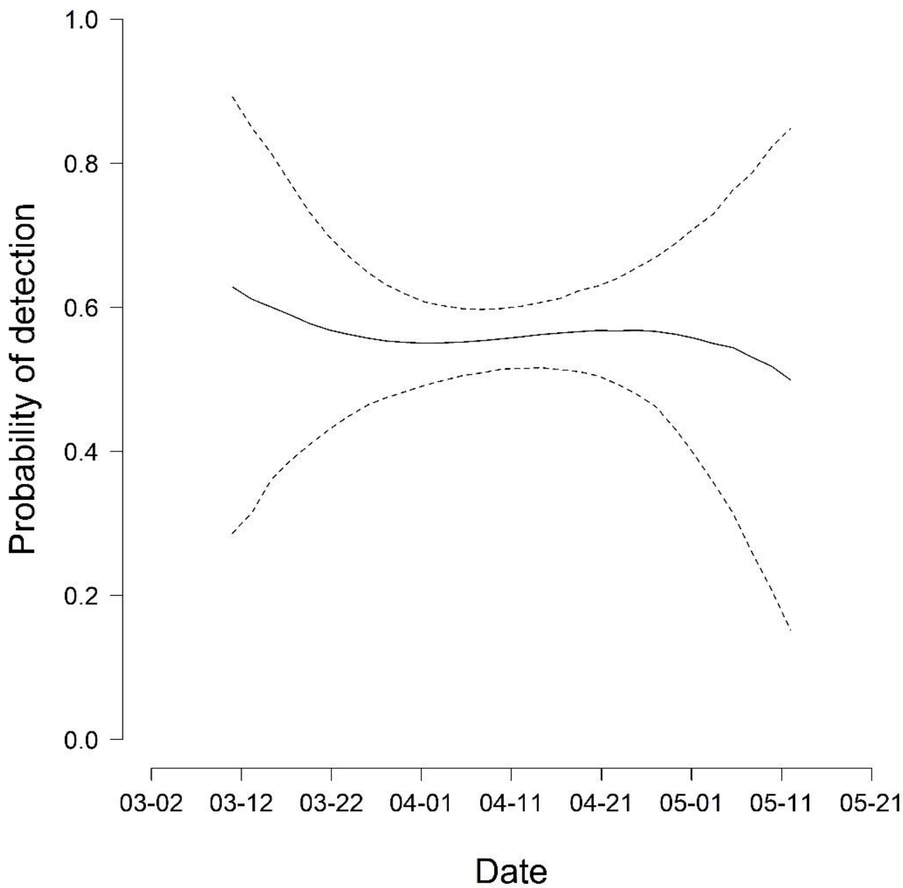


**Figure 7.** The effect of date on the detection probability of male greater sage-grouse (*Centrocercus urophasianus*) attending leks (breeding areas) within the state of Oregon, USA. Predictions are based on an *N*-mixture model fit to lek count data collected between 2017–2024. The median estimate is depicted using a solid black line. The 95% credible interval is depicted using dashed lines.

In 2024, the state of Oregon was estimated to contain approximately 41,875 sage-grouse (95% CRI = 38,980–54,634), which was down from a high of 50,869 (95% CRI = 41,794–66,238) in 2017. A nadir (low point) was identified during 2019, when the median statewide population estimate was 30,644 birds (95% CRI = 25,106–39,917) (Fig. 8).

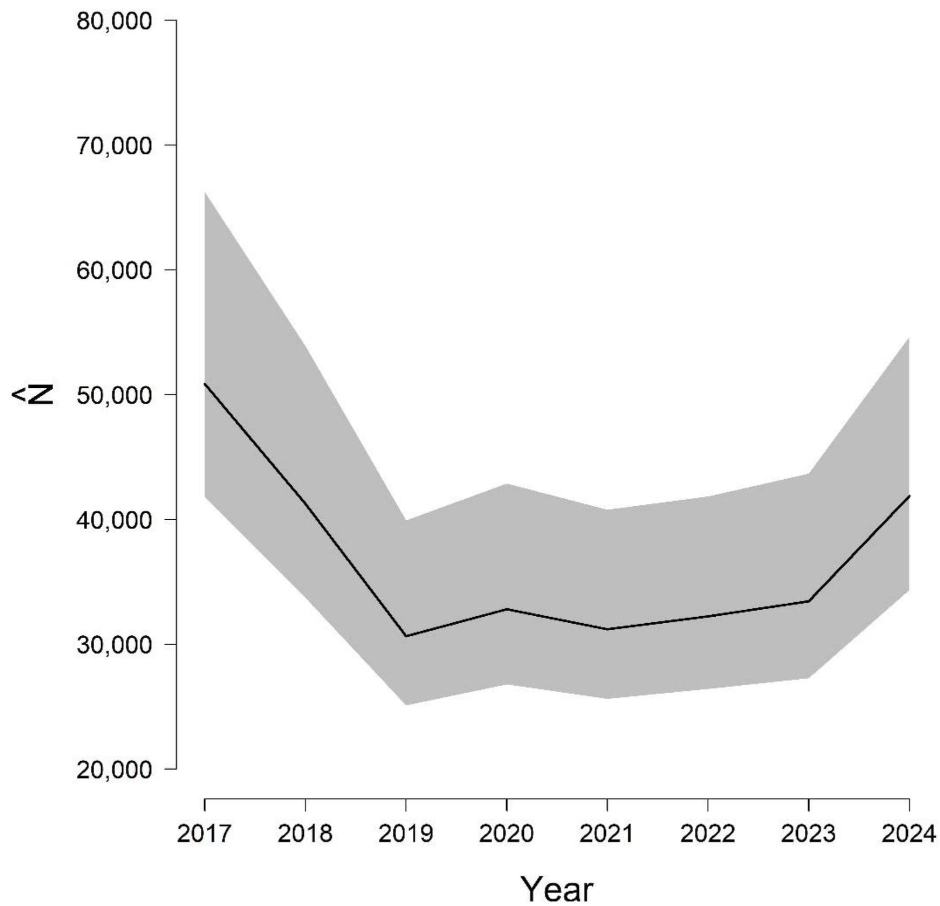


**Figure 8.** *N*-mixture model estimates of greater sage-grouse (*Centrocercus urophasianus*) abundance for the state of Oregon, USA between 2017–2024. The median (black line) and 95% credible interval (gray polygon) are plotted.

A complete population oscillation was not evident during the inferential period based on local maxima that were observed during the start (2017) and stop (2024) years of analysis. References to population change reported here are likely biased low compared to trends reported elsewhere using nadir-to-nadir trend estimation methods (Coates et al., 2021).

Substantial variation was observed across PACs in both the size and trajectory of the population. The greatest declines were observed within the Cow Lakes, Diablo, North Wagontire, Paulina, Sheepshead, and Soldier Creek PACs (Fig. 9). As of 2024, each of those PACS represented approximately 0.1% (Diablo), 0.4% (Sheepshead), 0.9% (North Wagontire), 2.6% (Cow Lakes), 4.1% (Paulina), and 5.9% (Soldier Creek) of the state's total population size.

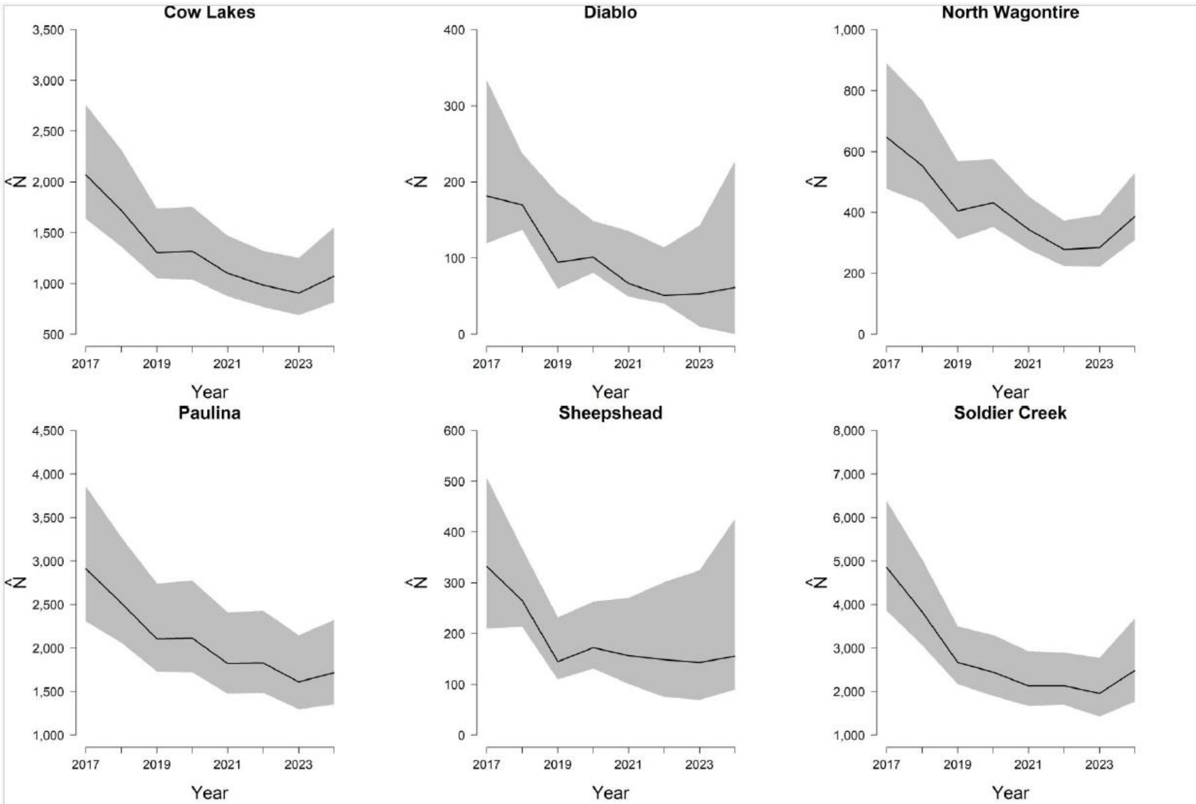


**Figure 9.** *N*-mixture model estimates of greater sage-grouse (*Centrocercus urophasianus*) abundance within Priority Areas for Conservation (PAC) located in the state of Oregon, USA between 2017–2024. PACs depicted (Cow Lakes, Diablo, North Wagontire, Paulina, Sheepshead, Soldier Creek) are identified in the title of each figure. The median (black line) and 95% credible interval (gray polygon) are plotted for each PAC.

PACs that experienced growth during the 8-year period were Dry Valley/Jack Mountain, Juniper Mountain, Louse Canyon, and Steens (Fig. 10). Those PACs represented 0.6% (Juniper Mountain), 1.8% (Dry Valley/Jack Mountain), 6.7% (Steens), and 11.3% (Louse Canyon) of the state's total population size during 2024.

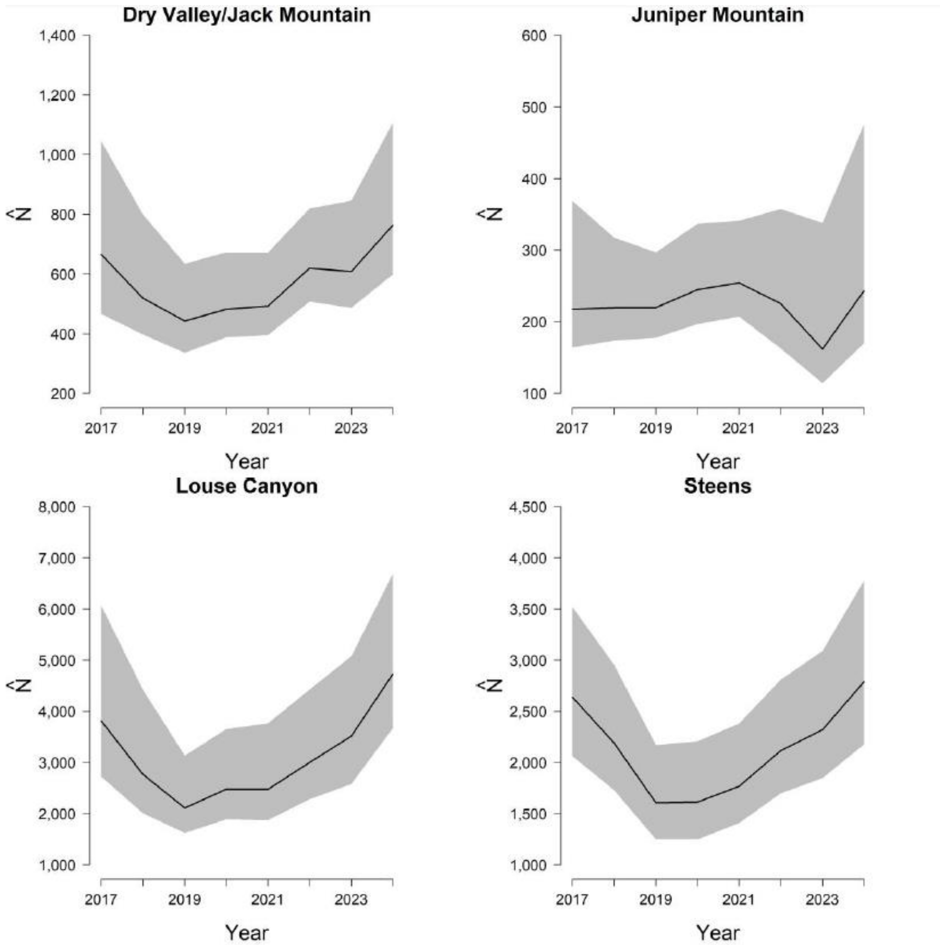


**Figure 10.** *N*-mixture model estimates of greater sage-grouse (*Centrocercus urophasianus*) abundance within Priority Areas for Conservation (PAC) located in the state of Oregon, USA between 2017–2024. PACs depicted (Dry Valley/Jack Mountain, Juniper Mountain, Louse Canyon, Steens) are identified in the title of each figure. The median (black line) and 95% credible interval (gray polygon) are plotted for each PAC.

Beatys remained the largest PAC across the 8-year period (Fig. 11), losing approximately 7% of its maximum population size (2017 value) and currently sustaining around 7,427 (95% CRI = 5,991–9,846) birds (approximately 17.7% of the 2024 state total). Diablo remained the smallest PAC across the entire timeframe (Fig. 11) and the PAC with the greatest losses overall (approximately 66%). Diablo was estimated to have had 181 birds (95% CRI = 120–334) in 2017 and is now estimated at 61 birds (95% CRI = 0–227) in 2024.

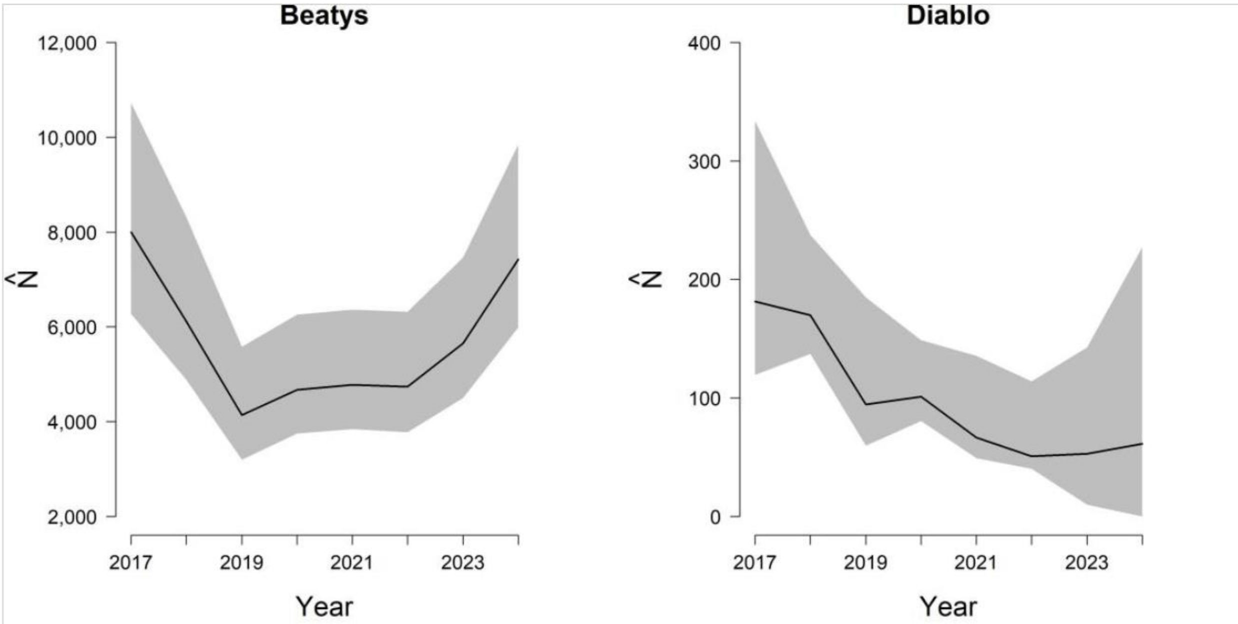


**Figure 11.** *N*-mixture model estimates of greater sage-grouse (*Centrocercus urophasianus*) abundance within Priority Areas for Conservation (PAC) located in the state of Oregon, USA between 2017–2024. PACs depicted (Beatys and Diablo) are identified in the title of each figure. The median (black line) and 95% credible interval (gray polygon) are plotted for each PAC.

The remaining 12 PACs cumulatively accounted for approximately 46.0% of the state's total population size during 2024. The smallest of those PACs were Burns (151; 95% CRI = 117–237), Tucker Hill (215; 95% CRI = 171–320), and Saddle Butte (444; 95% CRI = 357–658), representing 1.9% of the 2024 total (Fig. 12).

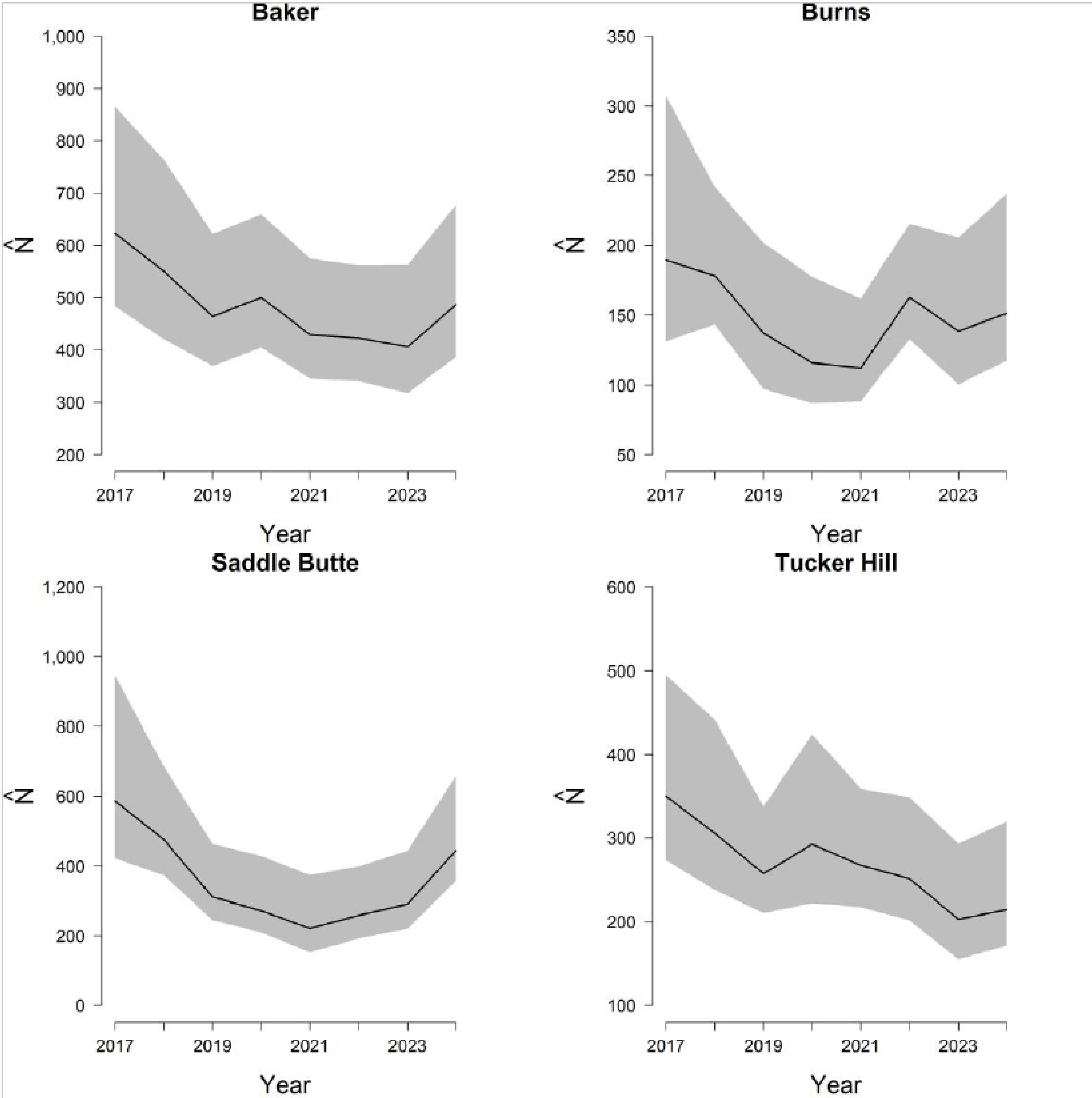


**Figure 12.** *N*-mixture model estimates of greater sage-grouse (*Centrocercus urophasianus*) abundance within Priority Areas for Conservation (PAC) located in the state of Oregon, USA between 2017–2024. PACs depicted (Baker, Burns, Saddle Butte, Tucker Hill) are identified in the title of each figure. The median (black line) and 95% credible interval (gray polygon) are plotted for each PAC.

Baker (487; 95% CRI = 386–678) and Brothers (961; 95% CRI = 769–1,307) contained considerably fewer sage-grouse compared to PACs of similar geographic size, which could be a product of their geographic location and general isolation (Figure 1). For example, the Cow

Valley (1,821; 95% CRI = 1,402–2,637) and Bully Creek (2,947; 95% CRI = 2,234–4,154) PACs, located just south of Baker, share a common border with very little Low-Density areas between them (Figure 1). Additional border connections exist among Bully Creek, Crowley (2,221; 95% CRI = 1,745–3,052), and Drewsey (1,460; 95% CRI = 1,119–2,007), with each of those PACs having considerably larger population sizes compared to Baker. PACS possessing even greater connectivity potential (beyond the borders of Oregon), located in the southern portion of the state, include Pueblos (2,203; 95% CRI = 1,778–2,921), Trout Creeks (3,039; 95% CRI = 2,366–4,132), and Warner (3,301; 95% CRI = 2,604–4,517). Those PACs alone represented approximately 20% of the state's total population size during 2024.

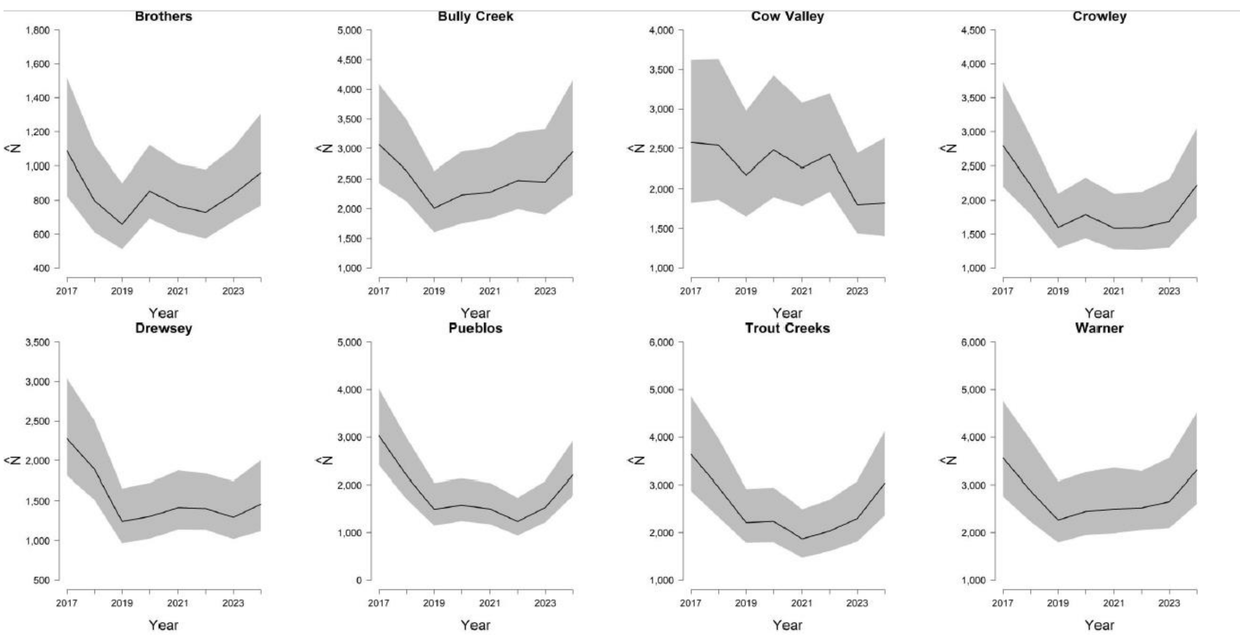


**Figure 13.** *N*-mixture model estimates of greater sage-grouse (*Centrocercus urophasianus*) abundance within Priority Areas for Conservation (PAC) located in the state of Oregon, USA between 2017–2024. PACs depicted (Brothers, Bully Creek, Cow Valley, Crowley, Drewsey, Pueblos, Trout Creeks, Warner) are identified in the title of each figure. The median (black line) and 95% credible interval (gray polygon) are plotted for each PAC.

Low-density areas accounted for just 1.5% (634; 95% CRI = 445–965) of Oregon’s total population size during 2024 (Fig. 14) despite covering nearly 38% of the species’ mapped habitat within the state (Figure 1).

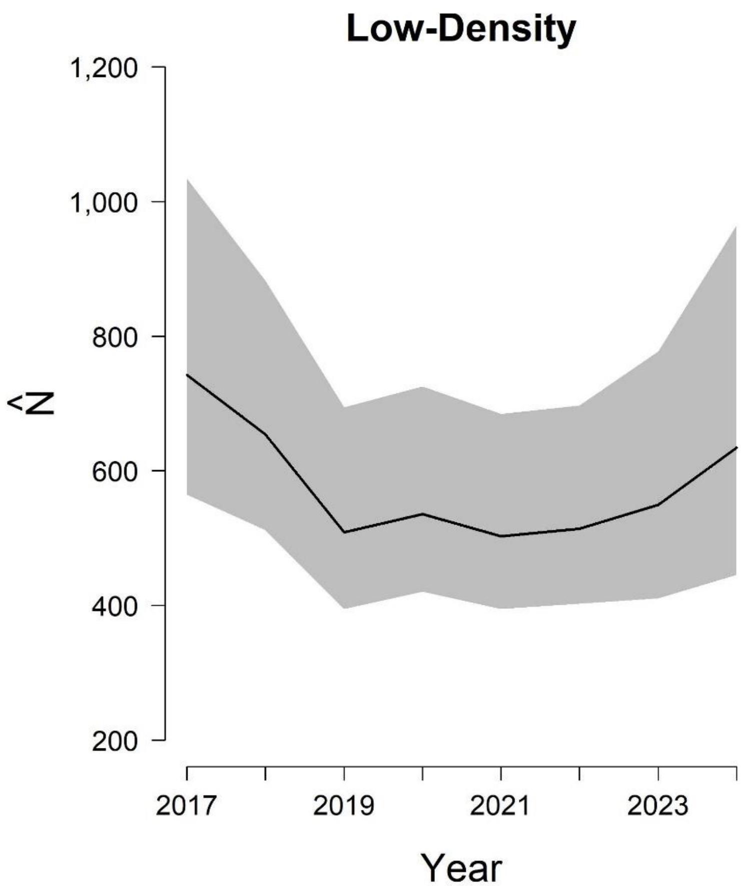


**Figure 14.** *N*-mixture model estimates of greater sage-grouse (*Centrocercus urophasianus*) abundance within Low-Density areas of the state of Oregon, USA between 2017–2024. The median (black line) and 95% credible interval (gray polygon) are plotted.

Evaluations of sampling intensity (percent of leks receiving repeated counts) revealed a negative trend between effort and bias with a reduced amount of effort corresponding to an increase in absolute bias (Table 2).

**Table 2.** Evaluations of an N-mixture model fit to greater sage-grouse (*Centrocercus urophasianus*) lek (breeding area) count data collected within the state of Oregon, USA between 2017–2024. Four separate models with different levels of sampling intensity (30–60% of leks received repeated counts, *reduced models*) were compared to the same model fit to a dataset based on current maximal effort (70%, *reference model*). Bias was calculated as the mean difference between the median estimate of the *reference model* and the median estimate of the *reduced model*, divided by the median estimate of the *reference model*, multiplied by 100. Coverage was calculated as the percent of the *reduced model's* 90% credible intervals (CRIs) that overlapped the median of the *reference model's* counterpart parameters.

| Model | Overlap | Bias |
|---|---|---|
| 30% effort | 96.88% | -6.21% |
| 40% effort | 95.31% | -5.24% |
| 50% effort | 100.00% | -3.03% |
| 60% effort | 100.00% | -2.08% |

All bias estimates were negative indicating that as effort decreased, abundance estimates tended to increase. The average number of birds estimated per PAC between 2017–2024 was 1,560. Bias estimates of -2.08% (60% effort), -3.03% (50% effort), -5.24% (40% effort), and -6.21% (30% effort) corresponded to PAC-level abundance estimates that were 32, 46, 80, and 95 birds larger than the reference model, respectively. Using the 2024 median, state-wide estimate of 41,875 birds, those same percentages corresponded to abundance estimates that were 871 (60% effort), 1,269 (50% effort), 2,194 (40% effort), and 2,600 (30% effort) birds larger than the reference model. The increase in absolute bias was less than 1% (0.95%) between efforts equaling 60% and 50%, but more than doubled when reducing the effort from 50% to 40% (2.21%). The 90% CRIs overlapped the median estimate of the *reference model* 100% of the time for the 50% and 60% effort scenarios (Table 2), whereas 40% and 30% scenarios produced results that were less than 100% at 95.31% and 96.88%, respectively.

## Discussion

We fit an N-mixture model to within-season replicated lek counts of male sage-grouse collected from the state of Oregon, USA between 2017–2024. Models revealed a state-wide population estimate of 41,875 sage-grouse in 2024, which was down from a high of 50,869 in 2017 (start year of analysis). The population's lowest point during the 8-year period occurred in 2019 when there was an estimated 30,644 sage-grouse across the entire state. Population management units

(Priority Areas for Conservation; PACs) showed considerable variation in geographic size, making population comparisons difficult. However, PACs located in the south and southeastern portions of the state tended to support greater numbers and densities of birds. Moreover, they tended to exhibit greater post-nadir rebounds (i.e., increases in population size between 2019–2024) despite comparable rates of bird loss leading up to the nadir (i.e., decreases in population size between 2017–2019). For example, the top four largest PACs, by 2024 population size (Beatys, Soldier Creek, Warner, Trout Creeks), declined 44% between 2017–2019 (20,034–11,275), but increased 44% between 2019–2024 (11,275–16,251; net change = -18%). Conversely, the four smallest PACs (Juniper Mountain, Sheepshead, Burns, Diablo) declined by a lesser amount (35%) between 2017–2019 (920–596) but made marginal gains (2%) after the nadir (596–612; net change = -34%). These initial results could signify the potential for an Allee effect and may suggest a need for future investigations to determine whether the smaller, isolated, and low-density PACs require greater attention or possible intervention (e.g., translocation).

The observation component of our model produced median lek-level detection probabilities that ranged from 0.23–0.82 (mean = 0.54). Investigations of temporal covariates provided some insights about the variability in detection, while being inconclusive for others. Specifically, the data and model supported a strong relationship between detection probability and time since sunrise with earlier times producing significantly higher rates of detection. Conversely, we failed to find support for a relationship between day of year and detection probability. We attribute this apparent lack of relationship to the narrow date range (11-March–12-May) of surveys used in this analysis, a period that corresponds with peak lek attendance and therefore lower variability in lek counts (Monroe et al., 2016; Wann et al., 2019). Based on these findings it may be possible to extend the sampling period slightly on both ends, particularly if the current window is constraining field operations associated with other projects or species. At the very least, these findings suggest that greater emphasis could be placed on the time of day rather than the day of year (restricted to the breeding season), when conducting a lek count within the state of Oregon.

We found that reductions in sampling effort corresponded with increases in absolute bias. Bias estimates were consistently negative with greater reductions in effort producing higher estimates of abundance. Specifically, we observed a 1.6% increase in absolute bias for every 10% reduction in effort. Though small, compared to the annual capacity of sage-grouse populations to grow and decline, these biases could lead to a significant amount of error when estimating population trends if observers introduced a strong temporal trend in sampling intensity (e.g., 10% reduction year over year for multiple years). This is something we did not observe for the data and period investigated. Despite the relationship to bias, we did not find a strong link between data sparsity and coverage (the percent of the *reduced model's* CRIs that overlapped the median of the *reference model's* parameters). Even the extremely disparate datasets (e.g., 30% effort) contained the target value within their CRIs more than 95% of the time. This would suggest minimal impact on long-term trend estimation. However, precision of estimates in year-over-year changes in population size could be drastically reduced. It is important to note that the simulated replacement of repeat counts with NA values was accomplished using a random process. Assuming managers implement a more targeted approach to reduced sampling in the future (e.g., narrow in on peak attendance hours and dates), the results could yield a less significant bias than what was estimated here.

## Data availability

The sage-grouse lek data used in this analysis are managed by the Oregon Department of Fish and Wildlife (ODFW). The ODFW can be contacted for information related to data availability.

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## Conflict of interest disclosure

The authors of this preprint declare that they have no conflict of interest relating to the content of this article.

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## Appendix 3: Sage-grouse Habitat Modeling Methodology

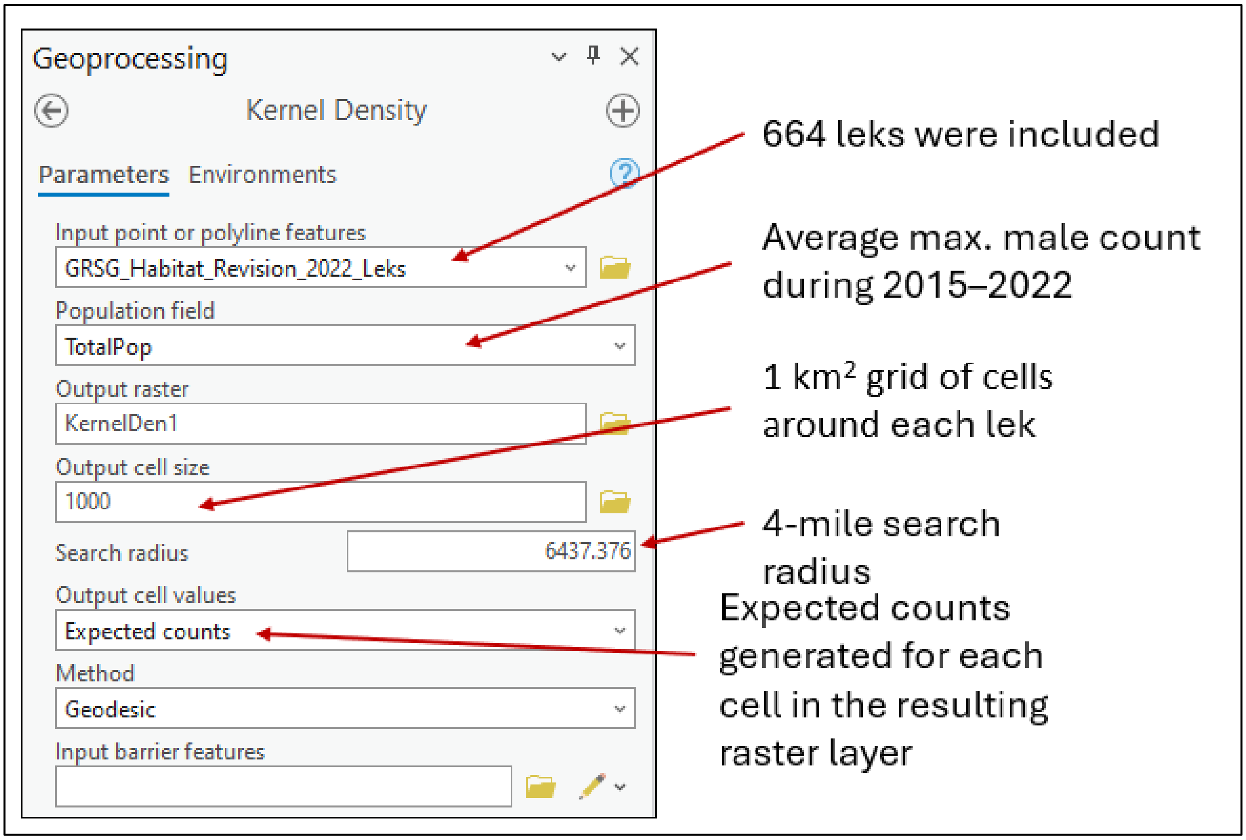
ODFW defines three types of significant sage-grouse habitat in Oregon, core, low-density, and general habitats, and maintains maps delineating geographic areas of these habitat types. During 2021–2023, the Department updated Oregon's significant sage-grouse habitat map, utilizing the best available sage-grouse data to appropriately inform sage-grouse conservation efforts in Oregon. ODFW's framework for delineating core and low-density habitats was established in the 2011 version of the CAAS and is updated in the 2025 CAAS, as detailed in Section 3. The first step of the framework is the model, which is based on the Doherty et al. (2011) landscape-scale 'core area' classification of sage-grouse breeding habitats using relative abundances from lek data (see below, *Breeding Density*). Next, the model incorporates 'local' and 'seasonal' connectivity corridors among core areas (below, *Connectivity*), and then incorporates known winter sage-grouse concentration areas (below, *Winter Habitat*).

**Breeding Density**

Using the Doherty et al. (2011) approach, average maximum counts of male sage-grouse at known lek sites were used to identify breeding densities within Oregon's sage-grouse range.

Leks included in the analysis (n=664) were those with ≥ 1 male recorded as the maximum count during an 8-year period (2015–2022). For those leks not surveyed within the 8-year timeframe but which had males present during the most recent survey (n=4), the percent change in males from the year of the last survey compared to 2022 was used to estimate lek size in 2022 (Hagen 2011). For example, lek CR0127-02 was not surveyed since 2004, and had 10 males in 2004. The trend at common leks between 2004 and 2022 was -0.233, so the estimated population for CR0127-02 in 2022 is (10 × 0.767 = 7.67 males).

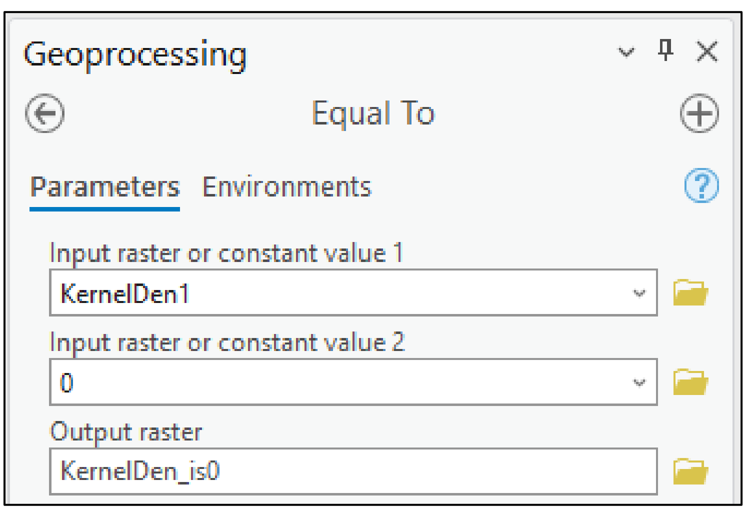
The lek locations and count data were the two inputs for a kernel density analysis (Worton 1989) conducted within ArcGIS Pro, which populated a grid of 1-km$^2$ raster cells within sage-grouse breeding habitat (within 6.4 km of leks), where each cell represented the expected count of male sage-grouse as a function of the number and proximity of surrounding leks. The Kernel Density tool was used to generate a 1-km$^2$ grid of cells around lek points, where the layer [2023_GRSG_Habitat_Revision_Leks.shp] was used for 'input point features', the field TotalPop was used for 'Population Field', the output cell size was 1000 (output cell will be 1 km x 1 km), and the Search Radius was defined as 6,437.376 meters (4-mi radius). Output cell values were defined as 'Expected Counts' and the Method was defined as 'Geodesic'.

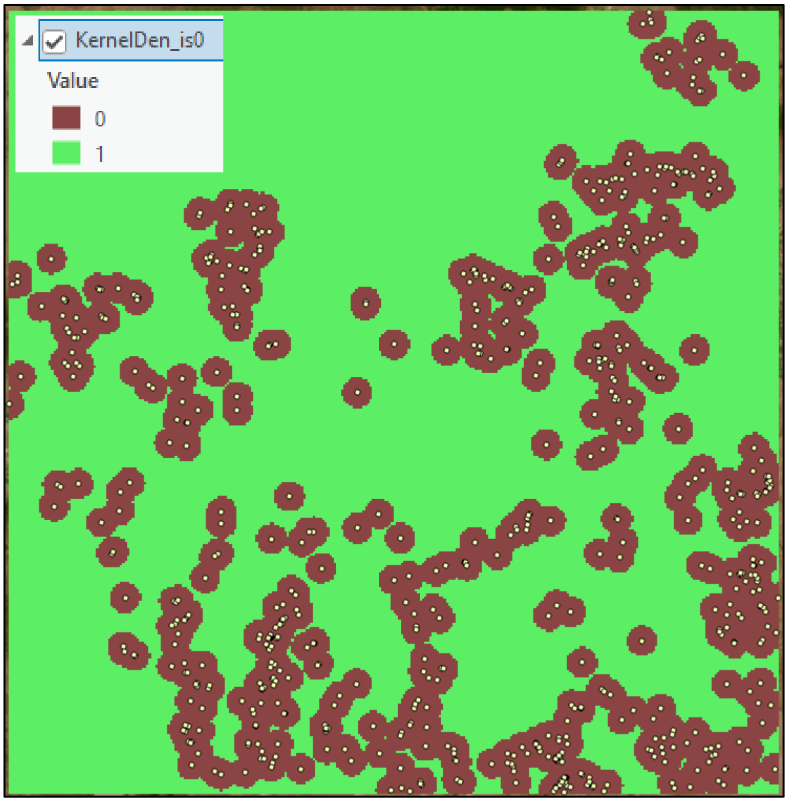



Once the Point Density raster layer was created, the 0 values need to be removed before reclassifying the cells into stratum. This is a two-step process.

First, separate the 0 values in the Point Density raster from all other values.

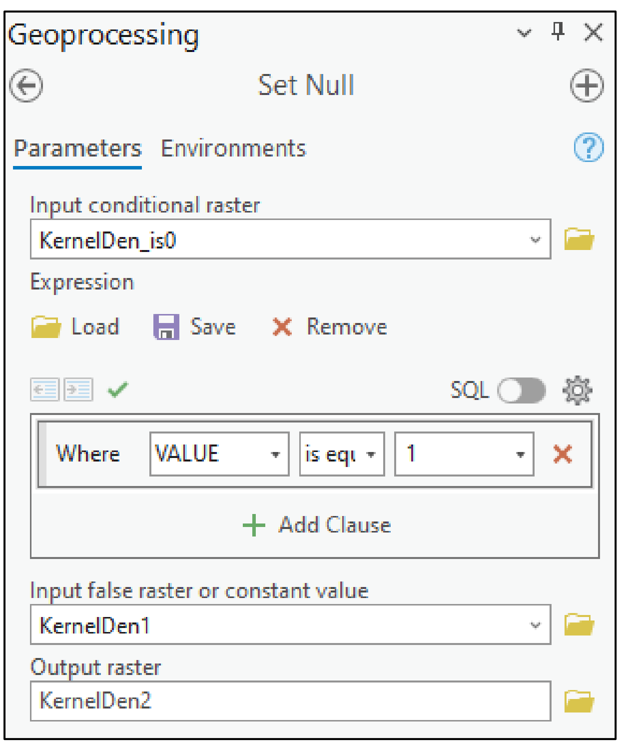
Geoprocessing steps: Spatial Analyst Tools -> Math -> Logical -> Equal to

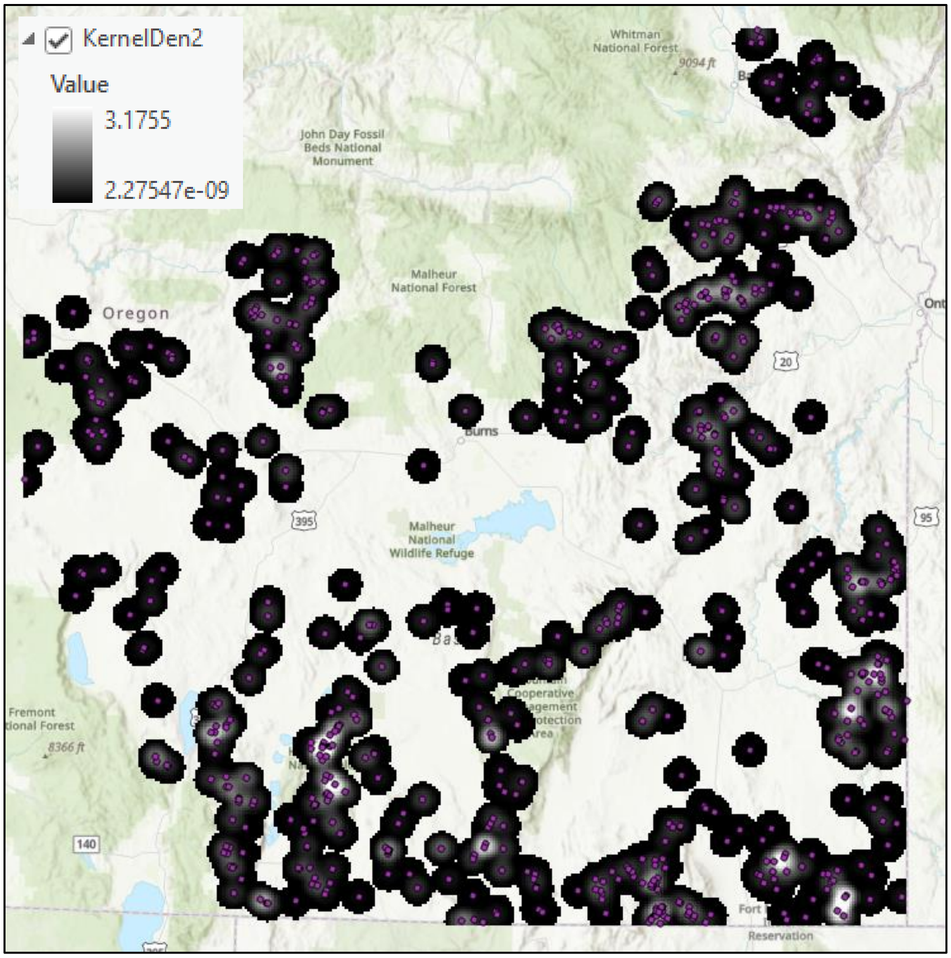




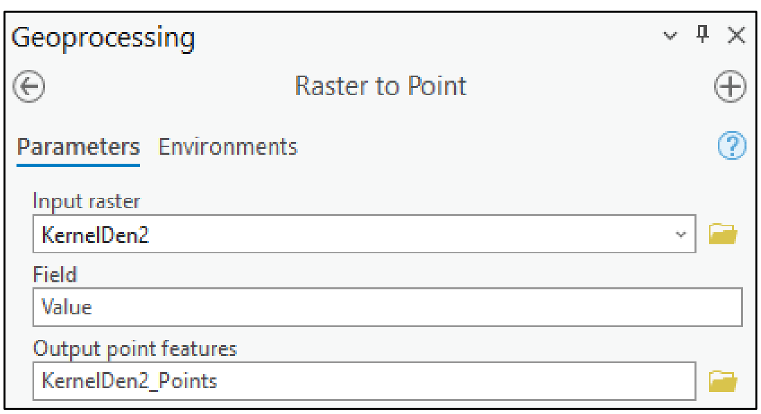

Next, set all those values = 1 (areas outside of the leks) equal to null, and create a new raster layer without the null cells.

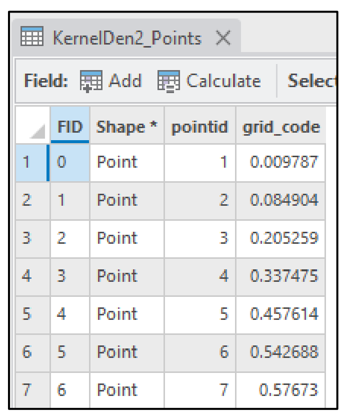
Geoprocessing steps: Spatial Analyst Tools -> Conditional -> Set Null





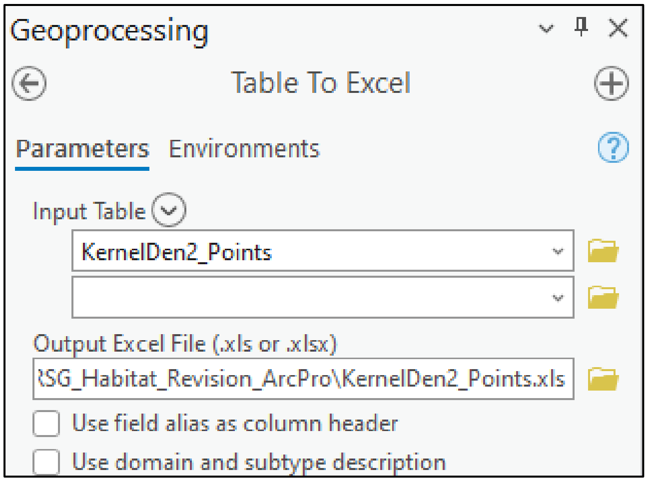

Once the kernel density raster is created and the null values are removed, the raster is converted to a point shapefile. The attribute table of this point shapefile is exported to excel to summarize the expected counts for each cell in the raster.





KernelDen2_Points

Field: Add Calculate Selec

| | FID | Shape * | pointid | grid_code |
|---|---|---|---|---|
| 1 | 0 | Point | 1 | 0.009787 |
| 2 | 1 | Point | 2 | 0.084904 |
| 3 | 2 | Point | 3 | 0.205259 |
| 4 | 3 | Point | 4 | 0.337475 |
| 5 | 4 | Point | 5 | 0.457614 |
| 6 | 5 | Point | 6 | 0.542688 |
| 7 | 6 | Point | 7 | 0.57673 |



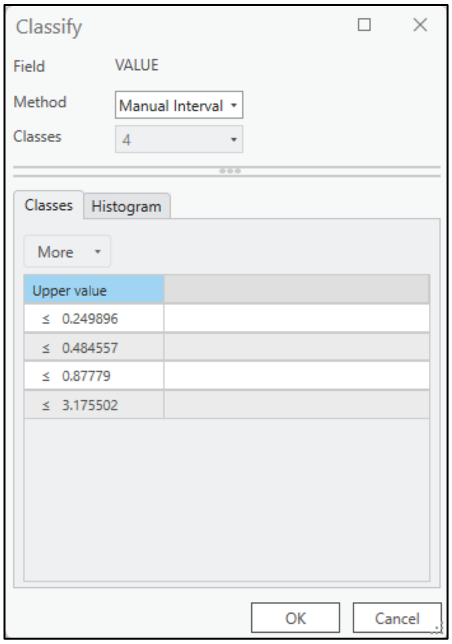

In the attribute table (and exported Excel spreadsheet), grid_code is the value of each pixel in the Kernel Density raster. The sum of this column is 6032.574083.

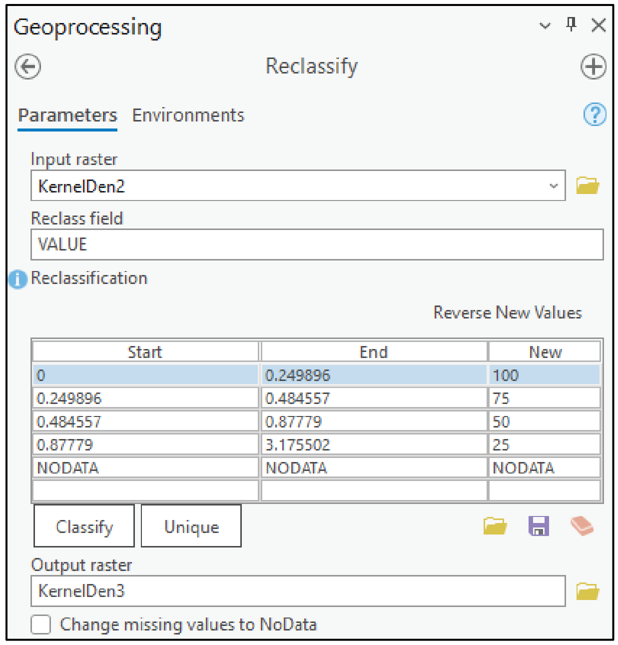
Next, add a new column [PctCounts] to this spreadsheet and calculate the percentage of the total sum of values for each cell [i.e., (grid_code/6032.574083)*100]. Add a column [Stratum] to the spreadsheet, sort ascending (largest values to smallest), then calculate the stratum [25, 50, 75, and 100%] by dragging the values in grid_code down until the sum of this column is 25, 50, 75, and 100. Label these values in column Stratum, respectively.

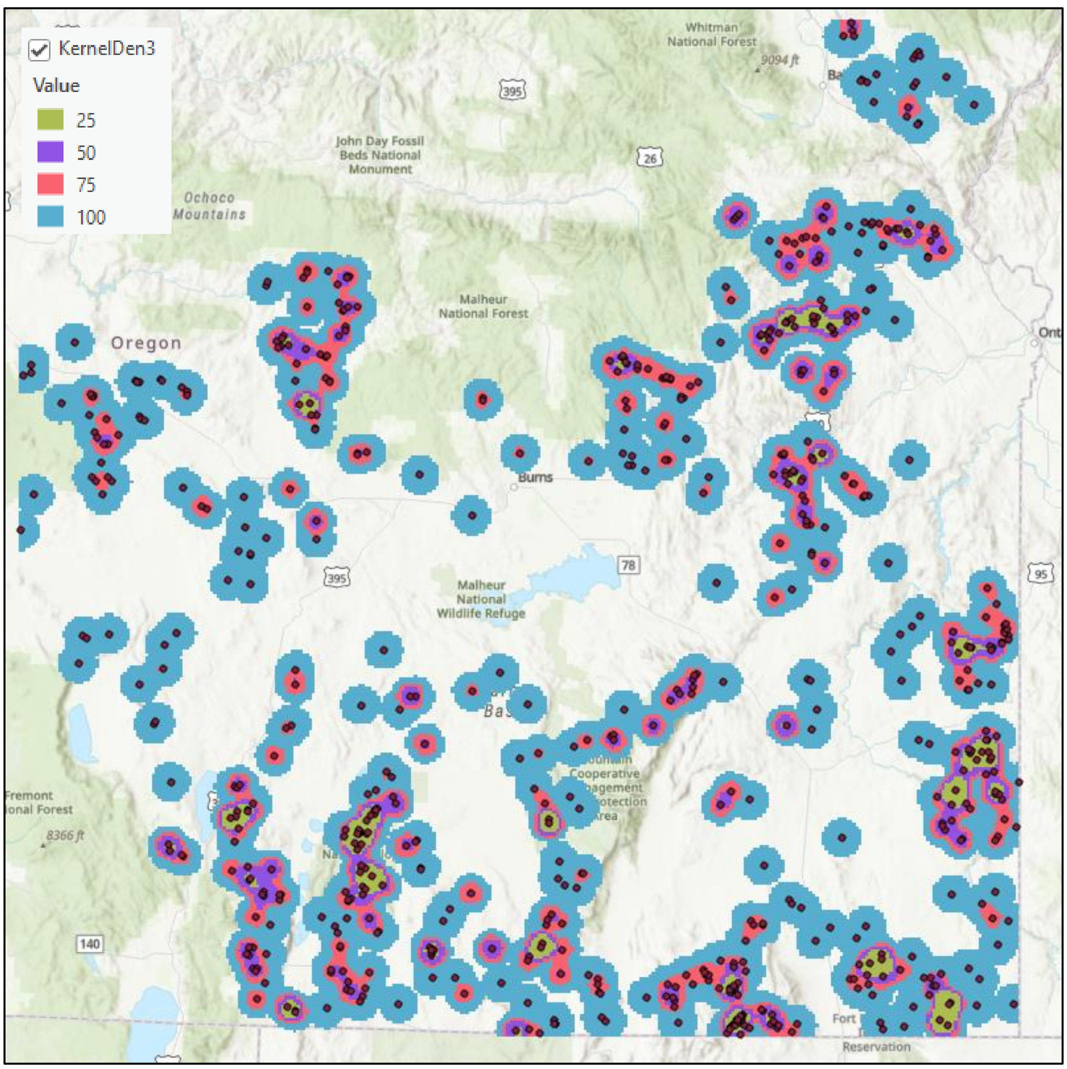
For reference, in the 2022 analysis, the 25% stratum classification was grid_code 0.877886712551116–3.17550158500671, the 50% stratum classification was 0.484594851732254–0.877790093421936, the 75% stratum classification was 0.249898299574852–0.484557032585144, and the 100% stratum classification was 0.000000000000000–0.249895647168159.

The Kernel Density raster is reclassified into 4 classes [25%, 50%, 75%, and 100% stratum], using the values determined above.

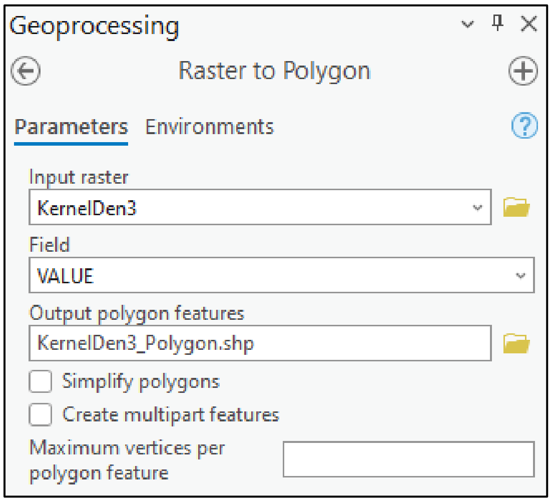
Geoprocessing steps: Spatial Analyst Tools -> Reclass -> Reclassify

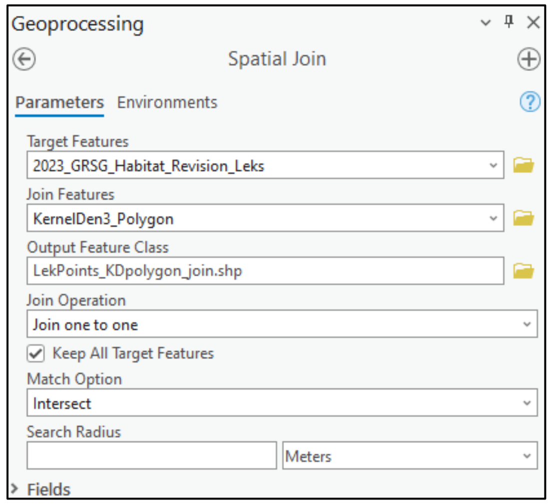

Classify
Field VALUE
Method Manual Interval
Classes 4
Classes Histogram
More
Upper value
≤ 0.249896
≤ 0.484557
≤ 0.87779
≤ 3.175502
OK
Cancel


Geoprocessing
Reclassify
Parameters Environments
Input raster
KernelDen2
Reclass field
VALUE
Reclassification
Reverse New Values
Start End New
0 0.249896 100
0.249896 0.484557 75
0.484557 0.87779 50
0.87779 3.175502 25
NODATA NODATA NODATA
Classify
Unique
Output raster
KernelDen3
Change missing values to NoData

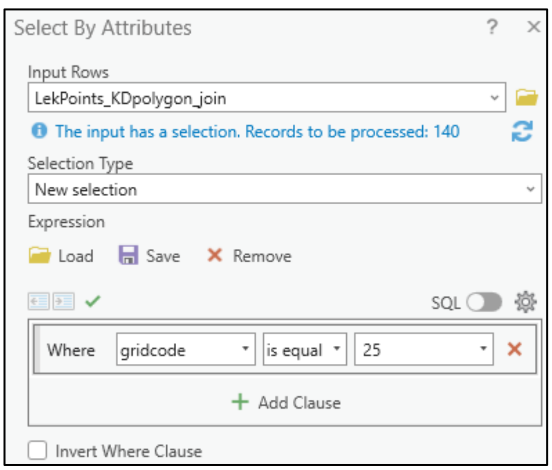

KernelDen3
Value
25
50
75
100
Whitman National Forest
9094 ft
395
John Day Fossil Beds National Monument
26
Ochoco Mountains
Oregon
Malheur National Forest
Burns
78
395
Malheur National Wildlife Refuge
95
Fremont
onal Forest
8366 ft
140
Reservation

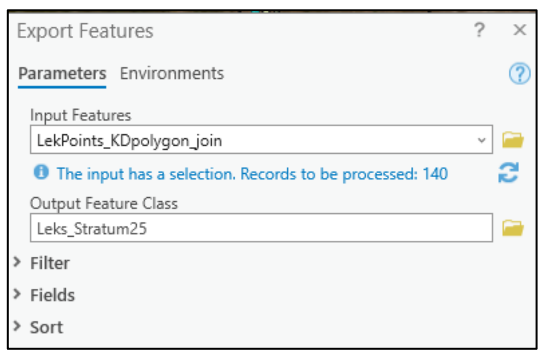
Next, leks are classified relative to their abundance values from the Kernel Density and Reclassify steps, and will placed into 1 of 4 lek density groups, of which each strata contained 25% (very high density), 50% (high density), 75% (moderate density) and 100% (low density) of the known breeding population. The Kernel Density raster is converted to a polygon layer and spatially joined with the lek layer.

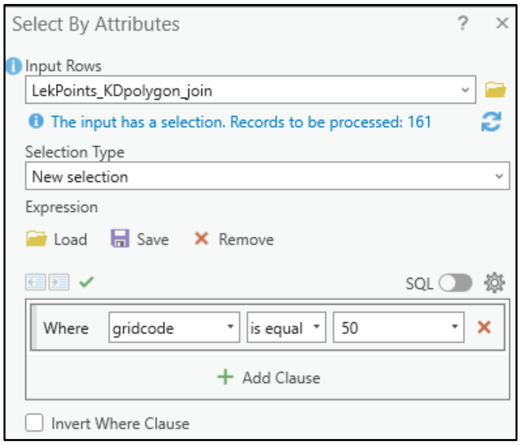



Then, export those leks within each strata (i.e., very high density, high density, moderate density, and low density) to a new layer.




Select By Attributes
Input Rows
LekPoints_KDpolygon_join
The input has a selection. Records to be processed: 161
Selection Type
New selection
Expression
Load
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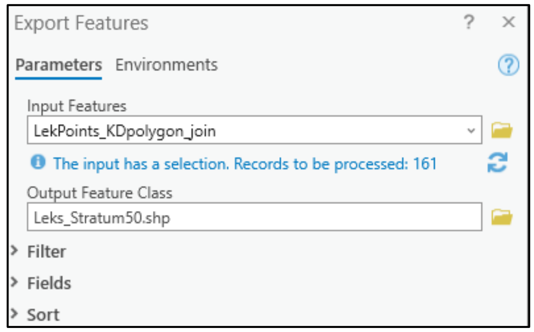
Remove
SQL
Where
gridcode
is equal
50
Add Clause
Invert Where Clause


Export Features
Parameters
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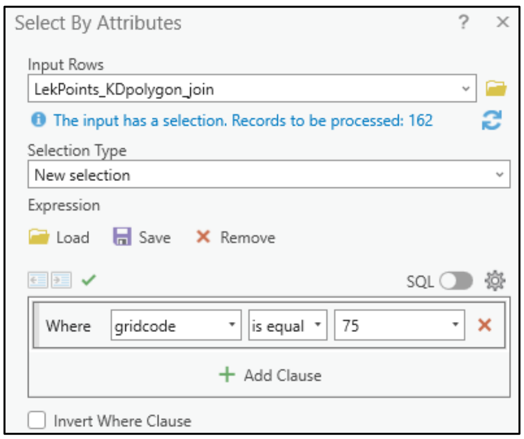
Filter
Fields
Sort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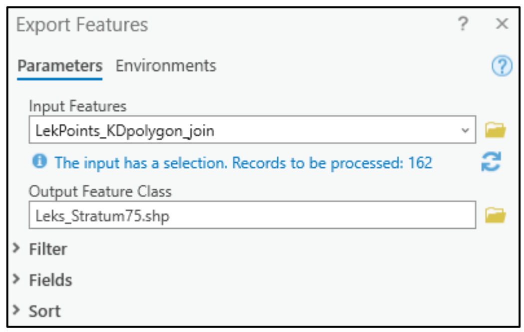
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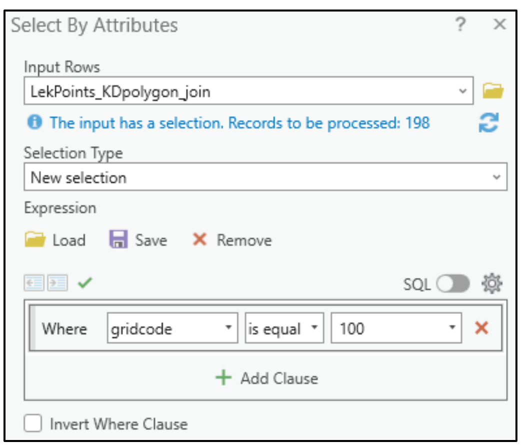
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Where
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is equal
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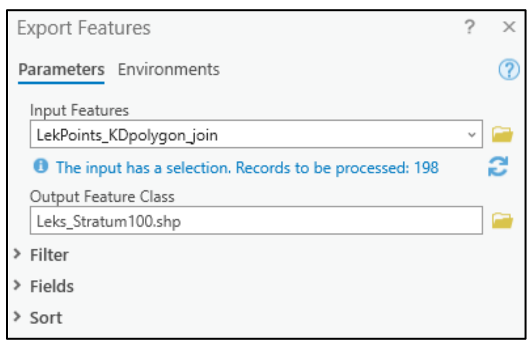
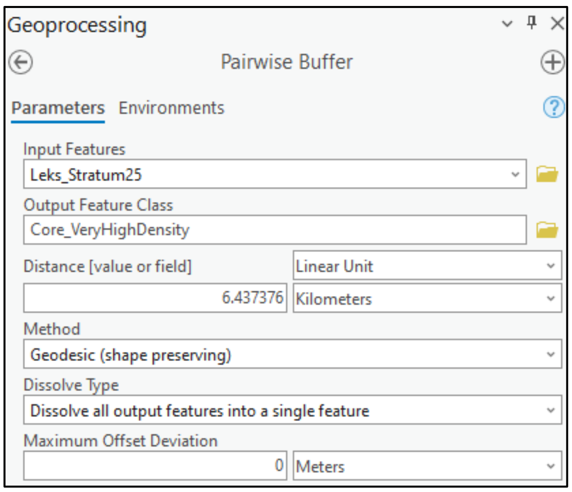
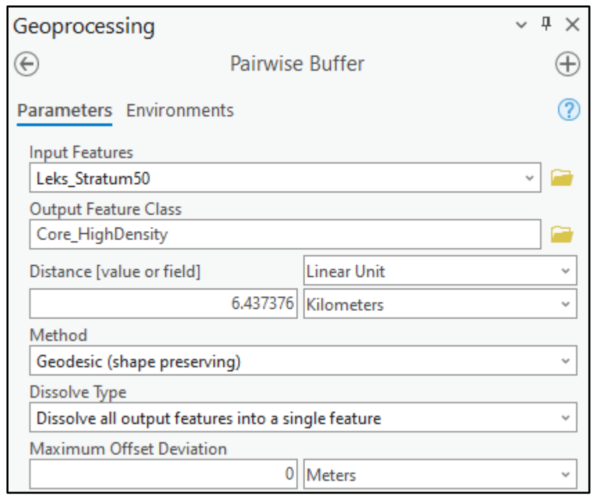
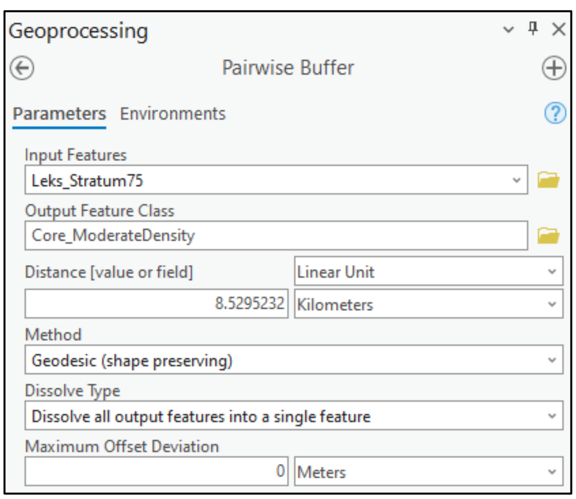
Invert Where Clause

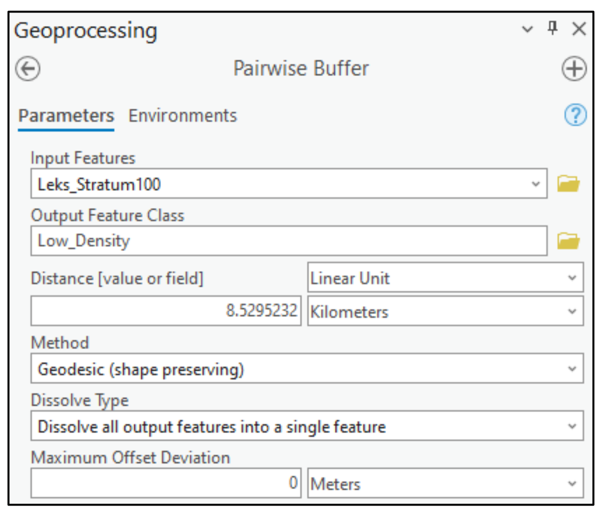

Export Features
Parameters
Environments
Input Features
LekPoints_KDpolygon_join
The input has a selection. Records to be processed: 198
Output Feature Class
Leks_Stratum100.shp
Filter
Fields
Sort

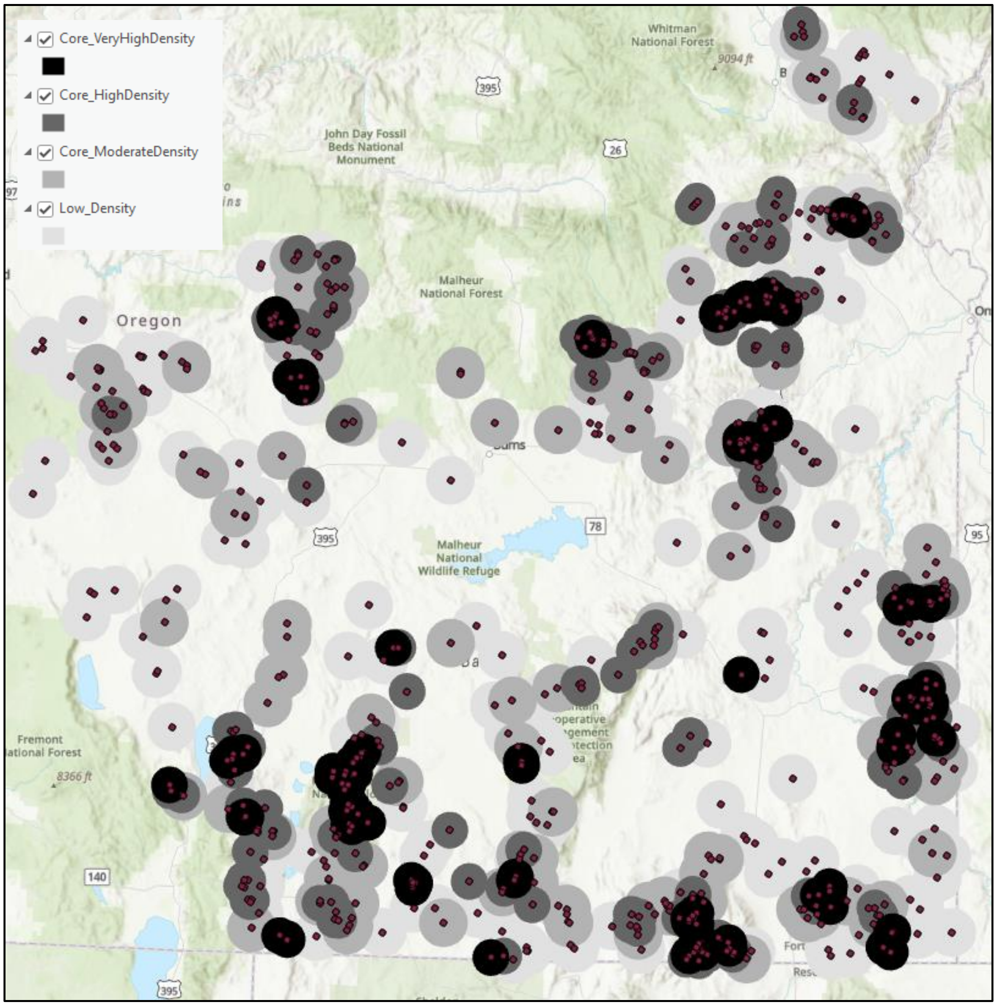
Lastly, leks classified as very high-density or high-density stratum (25% and 50%, respectively) are buffered by 6.4 km (4.0 mi) and leks classified as moderate-density or low-density stratum (75% and 100%, respectively) are buffered by 8.5 km (5.3 mi) to delineate the potential nesting areas associated with each lek stratum. The 6.4 km radius is used to define the extent of breeding habitat for the high-density strata because female sage-grouse distribute their nest spatially in relation to lek locations, where >80% of nests are located within a 6.4 km radius of leks in Oregon (ODFW 2009). The larger radius (8.5 km) is used to define the extent of breeding habitat for the moderate- and low-density strata as the spatial requirements to support breeding populations in low-abundance areas or fragmented landscapes are greater (Doherty et al. 2011; Hagen 2011).



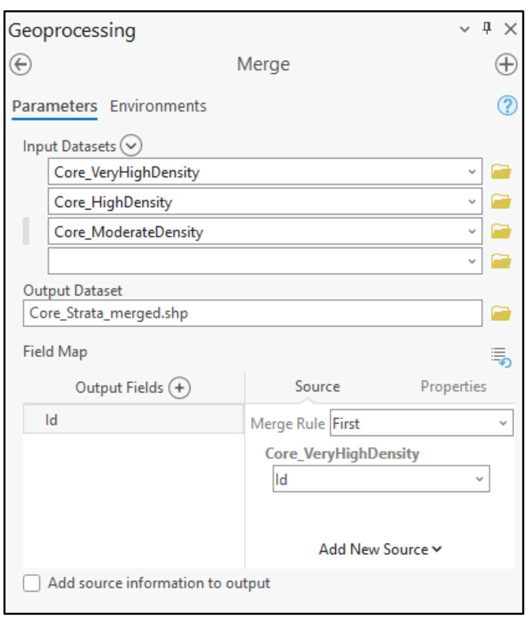



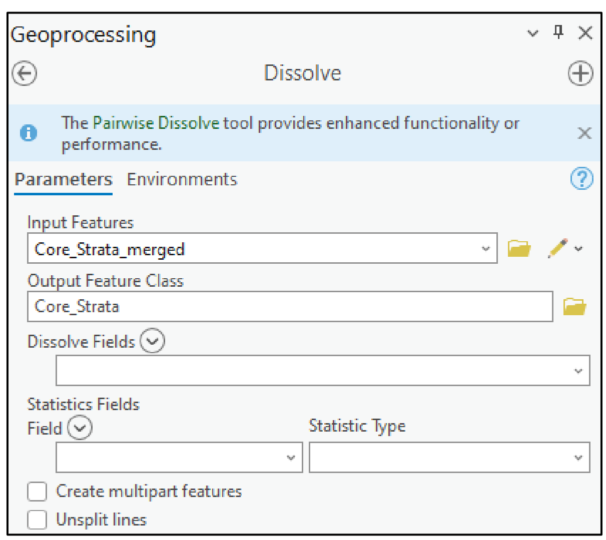






The core habitat polygons (25%, 50%, and 75%) are then merged and dissolved.



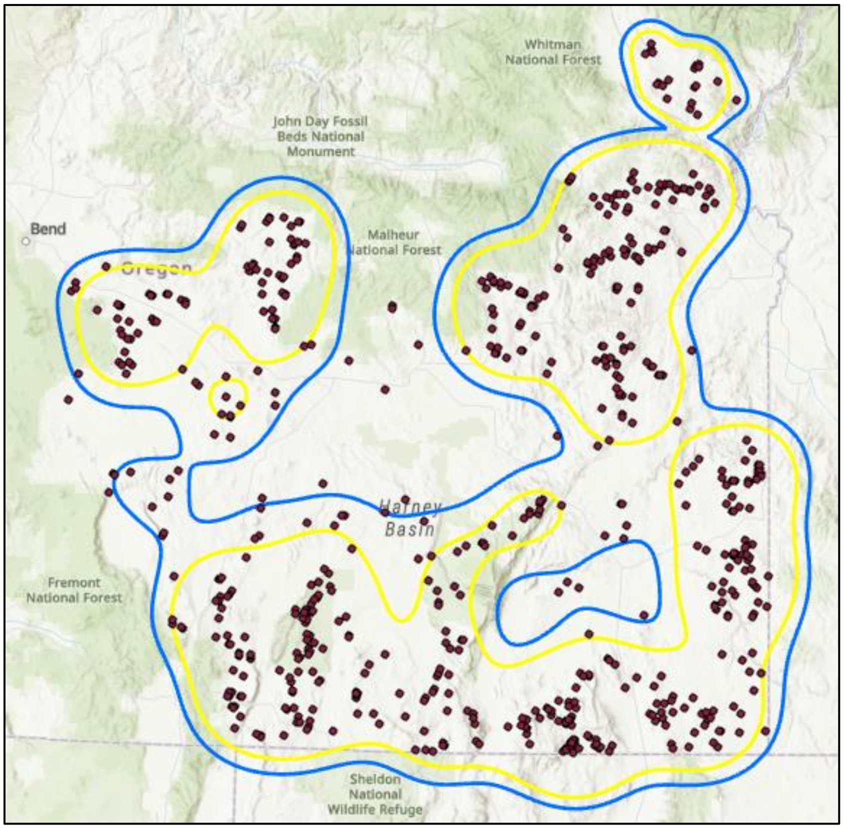
**Connectivity**

The next step of the habitat modeling framework delineates 'local' and 'seasonal' connectivity corridors among core areas. Similar to modeling Breeding Density, kernel densities are estimated using all the leks (n=664) included in the previous step. The connectivity analysis is conducted in Program R using the 'kernelUD' and 'getverticeshr' functions in R package 'adehabitatHR' so the utilization distribution and h-value can be specified, neither of which can be specified in the ArcGIS Pro Kernel Density tool.

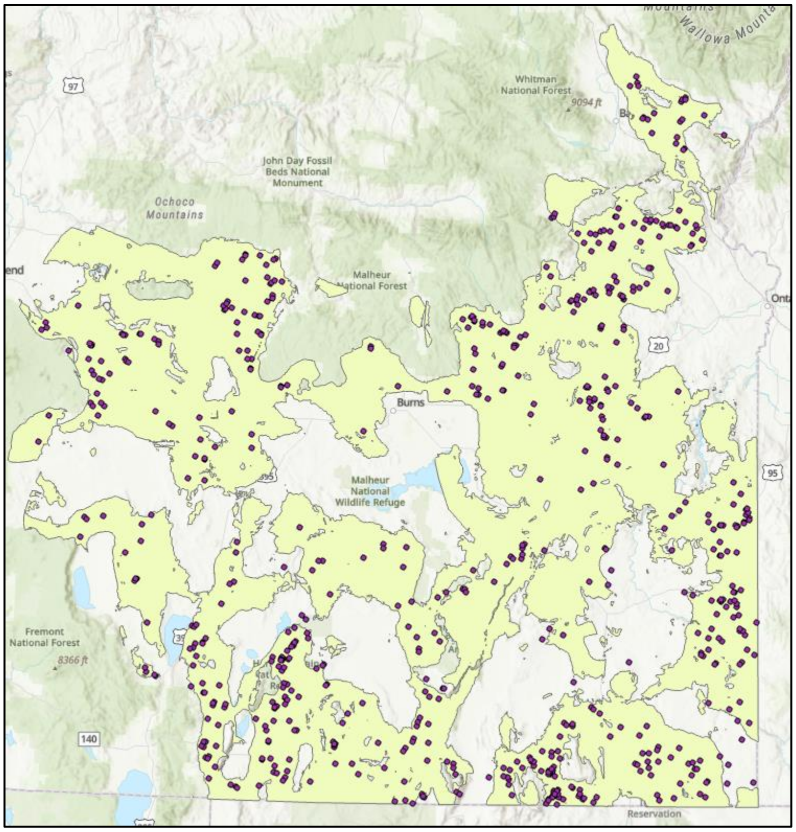
Two types of connectivity corridors were mapped, local corridors and seasonal corridors, using 75% and 90% kernel density utilization distributions, respectively. The search radius is specified as 16 km to approximate the average maximum extent of movement between breeding areas and other seasonal habitats (i.e., brood-rearing, summering, wintering; Hagen 2011). Grid cell size is specified as 1000 meters. Leks in the Baker PAC are modeled separately from the rest of the range because including the Baker PAC leks overestimated the size of the connectivity corridors between Baker PAC and Cow Valley PAC. The resulting polygons were then merged.

```
#### Kernel Density Estimation, Utilization Distribution ####

## 75% Utilization

# Baker leks excluded
connectivity_KD_75_NoBaker <- kernelUD(leks_noBaker_spatial, grid = 1000, h = 16000)
image(connectivity_KD_75_NoBaker)
connectivity_75_NoBaker <- getverticeshr(connectivity_KD_75_NoBaker, percent = 75)
plot(connectivity_75_NoBaker, col="grey",axes=T)
points(leks_noBaker_spatial)

# Baker leks
connectivity_KD_75_Baker <- kernelUD(leks_Baker_spatial, grid = 1000, h = 8000)
image(connectivity_KD_75_Baker)
connectivity_75_Baker <- getverticeshr(connectivity_KD_75_Baker, percent = 75)
plot(connectivity_75_Baker, col="grey",axes=T)
points(leks_Baker_spatial)
```

```
## 90% Utilization

# Baker leks excluded
connectivity_KD_90_NoBaker <- kernelUD(leks_noBaker_spatial, grid = 1000, h = 16000)
image(connectivity_KD_90_NoBaker)
connectivity_90_NoBaker <- getverticeshr(connectivity_KD_90_NoBaker, percent = 90)
plot(connectivity_90_NoBaker, col="grey",axes=T)
points(leks_noBaker_spatial)

# Baker leks
connectivity_KD_90_Baker <- kernelUD(leks_Baker_spatial, grid = 1000, h = 8000)
image(connectivity_KD_90_Baker)
connectivity_90_Baker <- getverticeshr(connectivity_KD_90_Baker, percent = 90)
plot(connectivity_90_Baker, col="grey",axes=T)
points(leks_Baker_spatial)
```

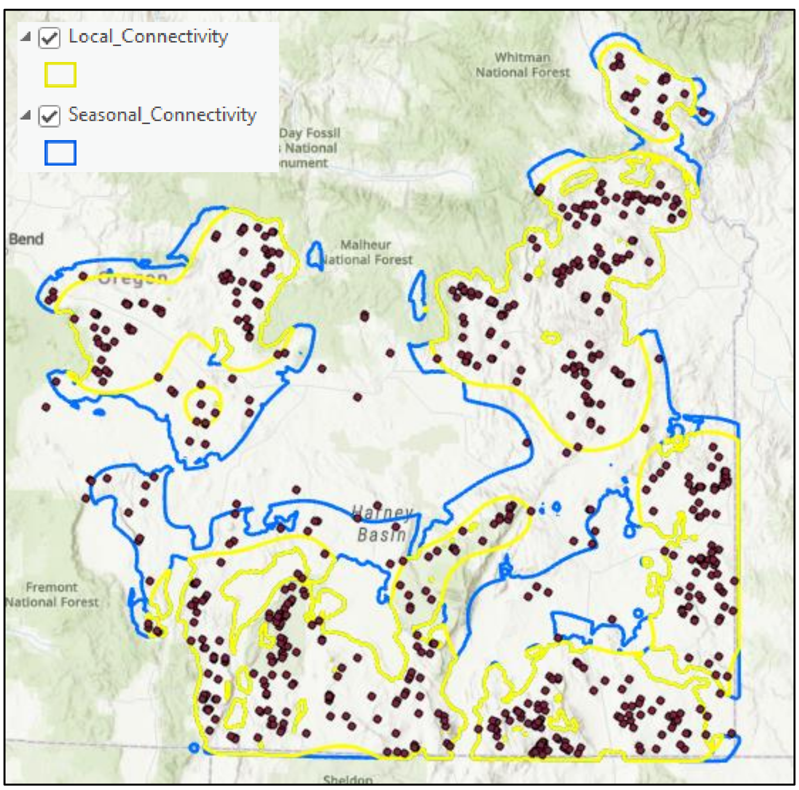



Next, the local and seasonal corridors are clipped to occupied sage-grouse habitat. The breeding habitat model from Doherty et al. 2016 was the best sage-grouse habitat model available as of December 2022, and was used for this step in the analysis in 2022. For reference, the Doherty et al. 2016 sage-grouse habitat layer covered 95.6% (635 of 664 leks) of Oregon's known lek locations which were included in this analysis (average male count >0 during 2015–2022). Note, the Doherty et al. 2016 habitat layer shows spring breeding habitat, so there are areas of summer and winter habitat that this model likely excludes. Additionally, for this step in the analysis, the habitat edges are buffered to 2 km to account for habitats difficult to map at the ecotone of juniper woodlands and forested types.




**Spring breeding habitat, as modeled by Doherty et al. 2016.**

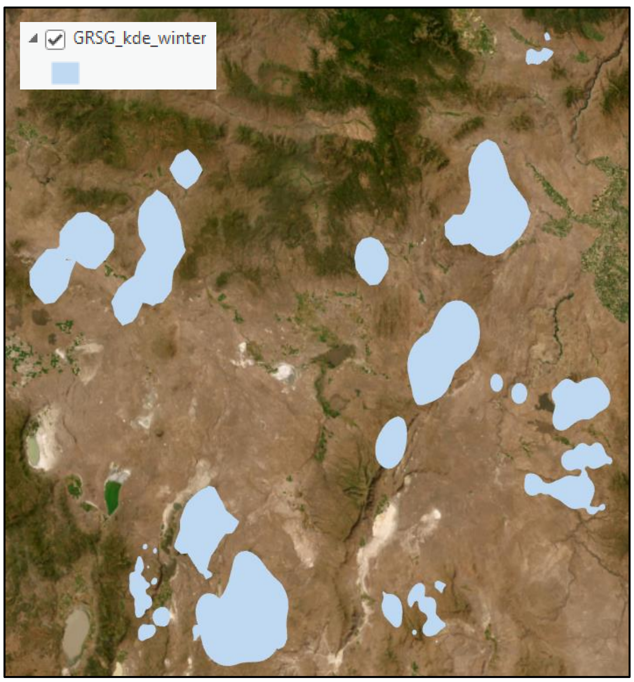
Local and seasonal connectivity corridors, clipped to sage-grouse habitat (Doherty et al. 2016).



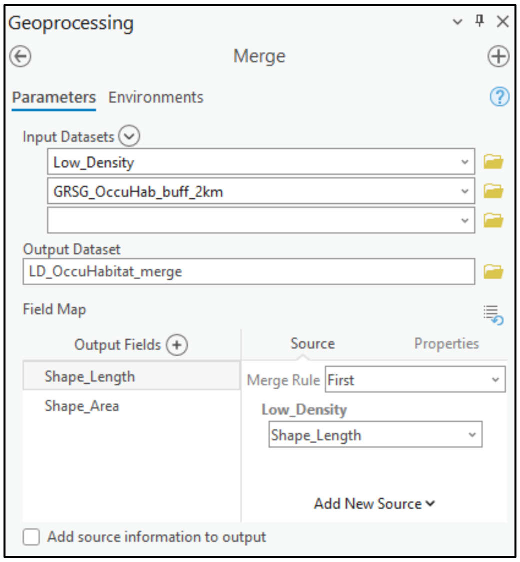
**Winter Habitat**

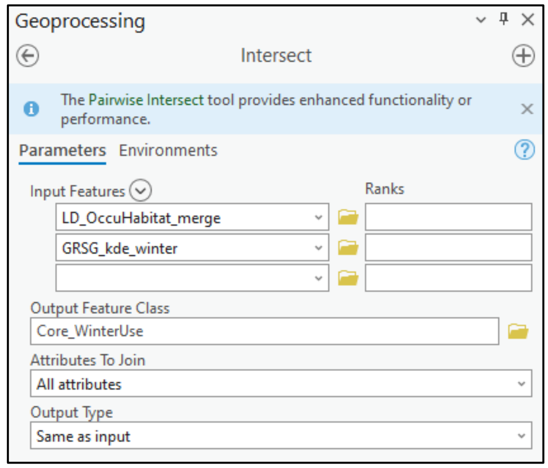
Sage-grouse show high fidelity to wintering areas, and their overwinter survival depends upon the availability of highly palatable sagebrush plants. Sage-grouse winter habitat use has been monitored in several areas of their range in southeastern Oregon, including within the Baker, Beatys, Brothers, Bully Creek, Cow Lakes, Cow Valley, Crowley, Paulina, Soldier Creek, Trout Creeks, and Warner PACs.

Using sage-grouse GPS and VHF location data collected during November–February from 1997–2022, 90% kernel density utilization distributions of sage-grouse winter use were delineated within each PAC.




Next, merge the low-density lek strata and occupied sage-grouse habitat, then intersect the winter habitat use polygons with the merged layer.

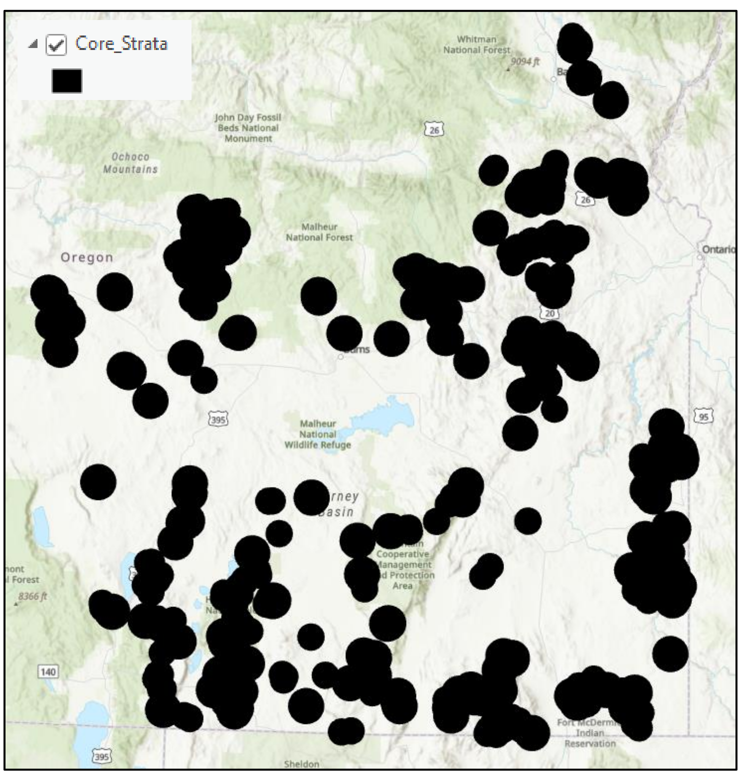


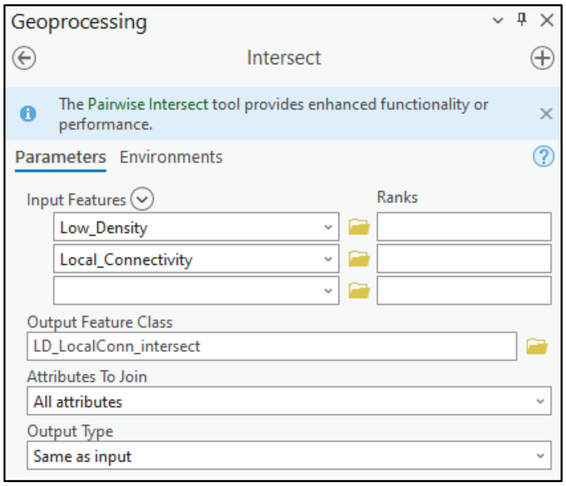

## Modeled Core Habitat Layer

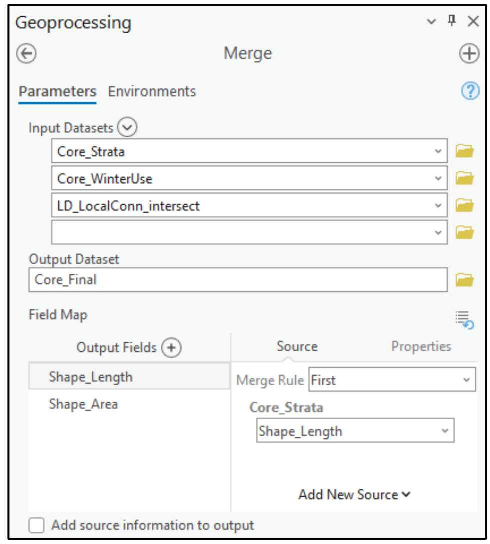
OAR 660-023-0115 defines "Core areas" as those of: very high, high, and moderate lek density strata; where low lek density strata overlap local connectivity corridors; or where winter habitat use polygons overlap with either low lek density strata, connectivity corridors, or occupied habitat.

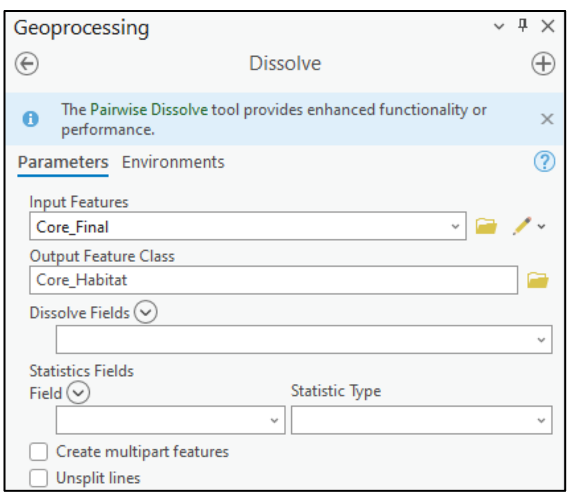
Merge very high, high, and moderate lek density strata polygons, then dissolve the resulting polygon.

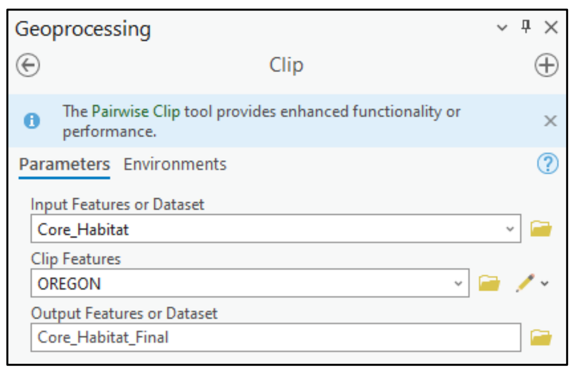


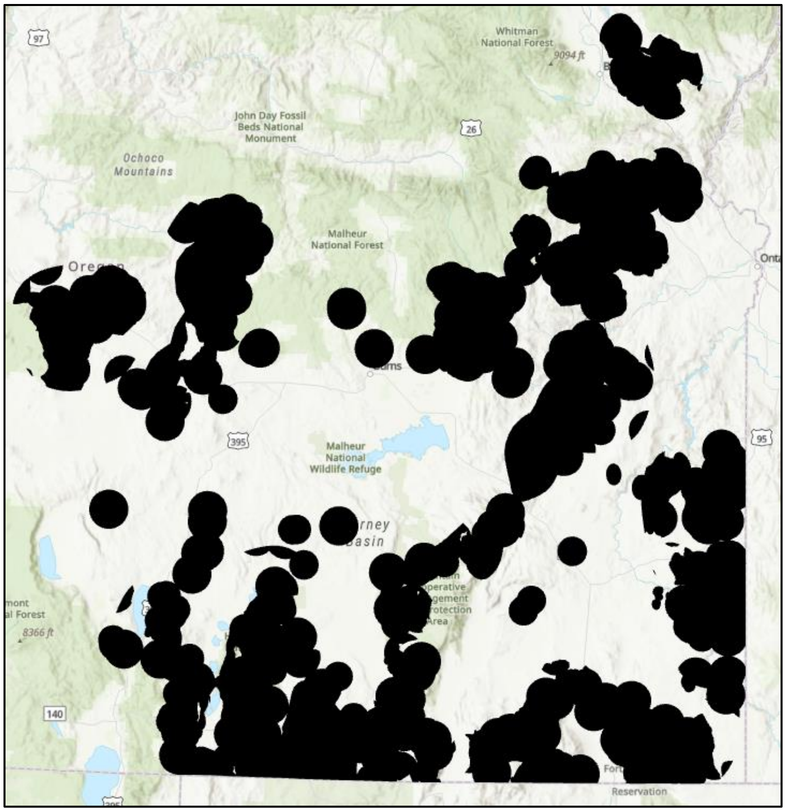
Intersect low-density strata and local connectivity corridors. Then, merge the Core Strata polygon, Core-Winter Use polygon, and Low Density-Local Connectivity polygon. Dissolve the resulting layer and clip it to the state of Oregon boundary. This is the final modeled core habitat layer.



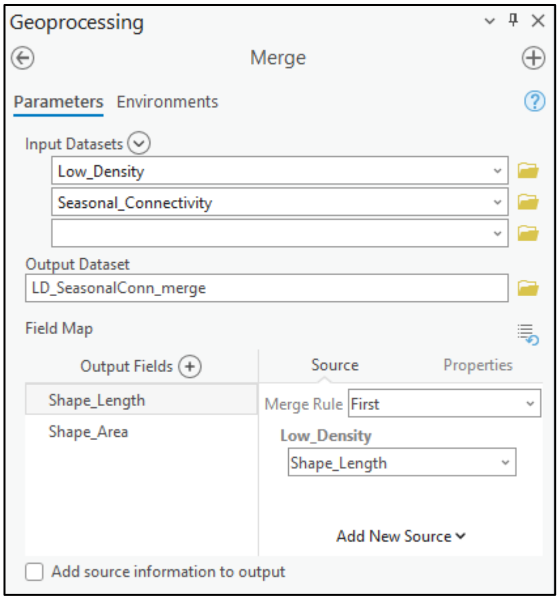


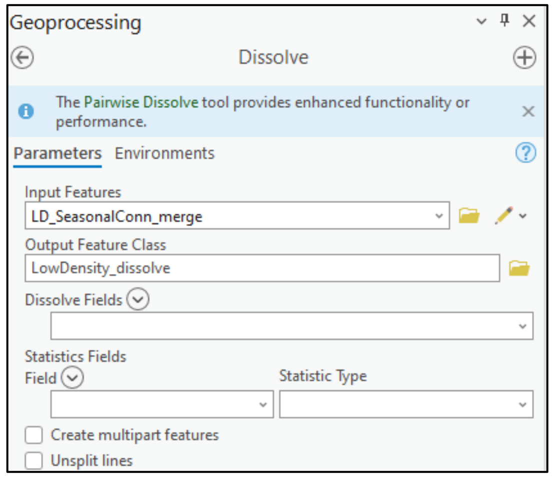

**Final modeled core habitat layer**

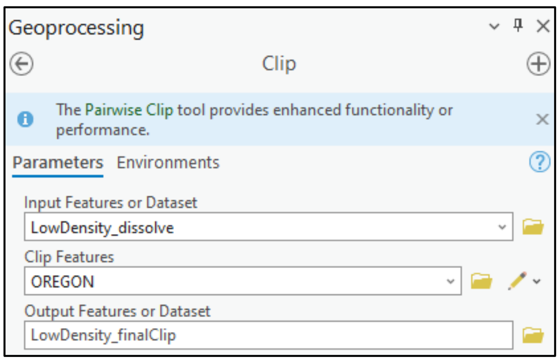
**Modeled Low-Density Habitat Layer**

OAR 660-023-0115 defines “Low density areas” as those where: low lek density strata overlap seasonal connectivity corridors; local connectivity corridors occur outside of all lek density strata; low density strata occur outside of connectivity corridors; or seasonal connectivity corridors occur outside of all lek density strata.

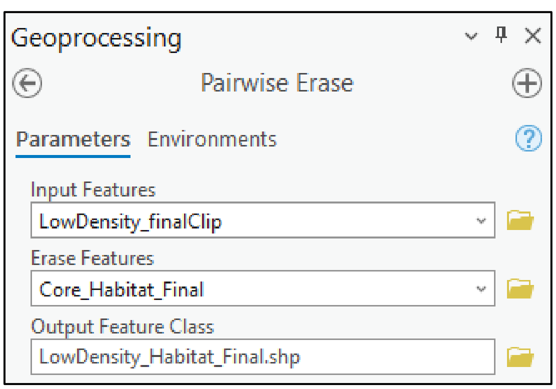
Merge the low-density lek strata polygon with the seasonal connectivity polygon. Dissolve the resulting polygon and clip to the state of Oregon boundary.

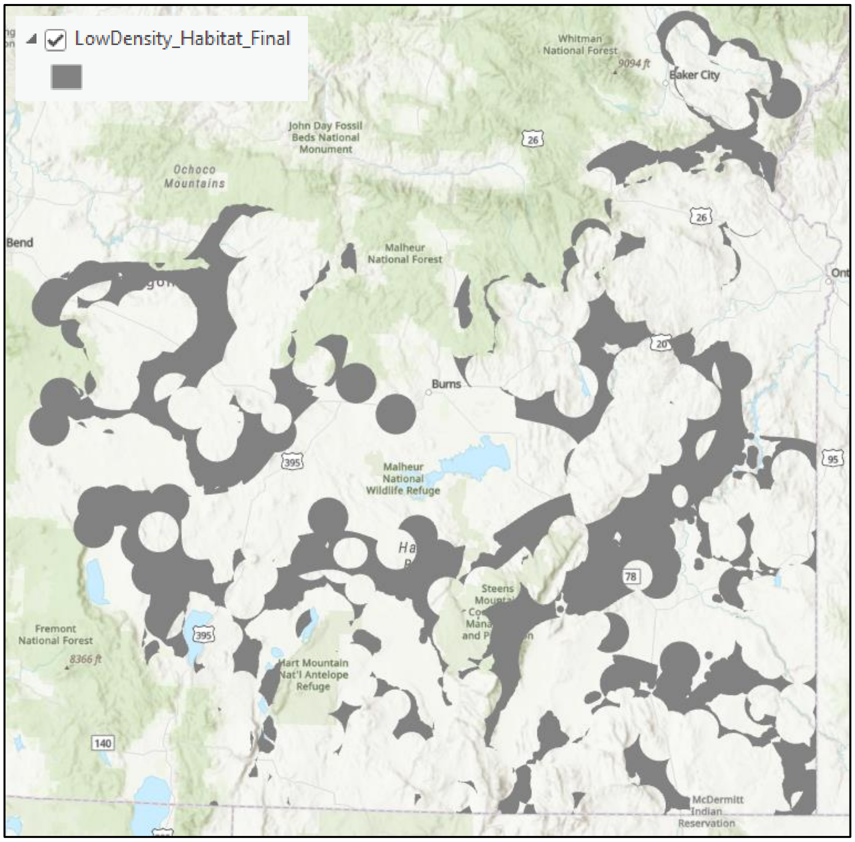


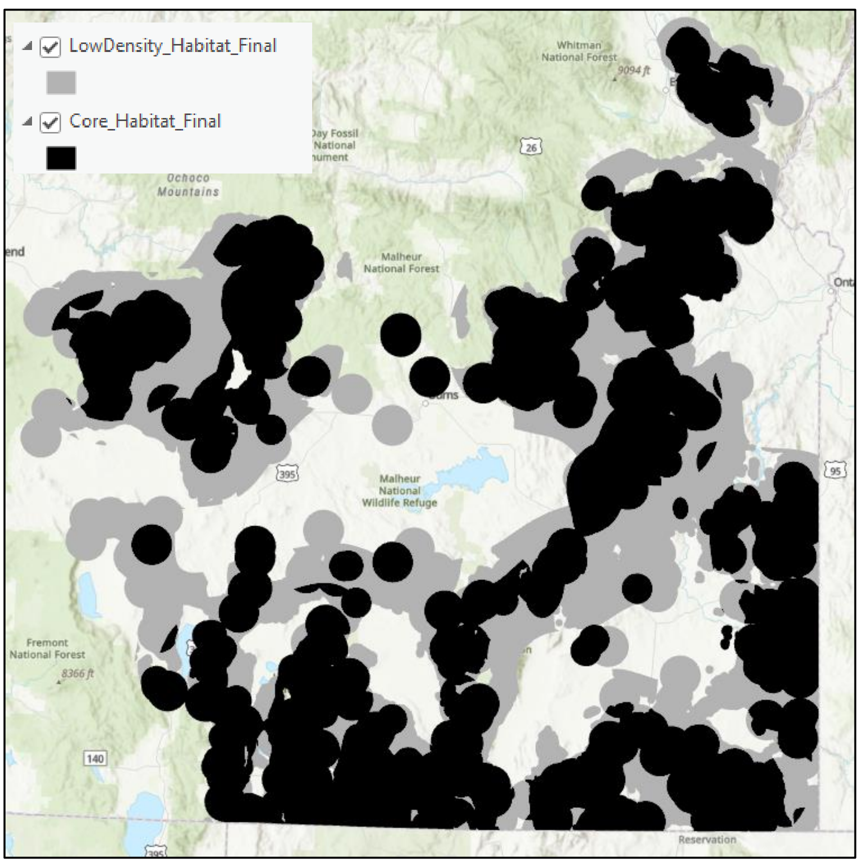




Erase the core habitat from low-density to get the final modeled low-density habitat layer.






**Final modeled low-density habitat layer**




**Final modeled core and low-density habitat layers**

**Literature Cited**

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Doherty, K. E., D. E. Naugle, H. Copeland, A. Pocewicz, and J. Kiesecke. 2011. Energy development and conservation tradeoffs: systematic planning for sage-grouse in their eastern range. Pp. 505-516 *in* S. T. Knick and J. W. Connelly. Greater Sage-Grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley, CA.

Hagen, C. A. 2011. Greater sage-grouse conservation assessment and strategy for Oregon: A plan to maintain and enhance populations and habitat. Oregon Department of Fish and Wildlife, Salem, Oregon, USA. 207pp. https://www.dfw.state.or.us/wildlife/sagegrouse/docs/GRSG_Conservation_Assessment_and_Strategy_April_25-11.pdf

Oregon Department of Fish and Wildlife [ODFW]. 2009. Recommendations for greater sage-grouse habitat classification under Oregon Department of Fish and Wildlife fish and wildlife habitat mitigation policy. Unpublished report, Salem, USA.

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## Appendix 4: Socio-Economic Profile and Analysis of Seven Oregon Counties Included in the Greater Sage-Grouse Conservation Strategy for Oregon

*Provided by Association of Oregon Counties*
*June 17, 2025*

The proposed Greater Sage-Grouse conservation strategy is focused on eight counties that are within the current range of the greater sage-grouse in Oregon:

| | |
|---|---|
| Baker | Klamath |
| Crook | Lake |
| Deschutes | Malheur |
| Harney | Union |

This socio-economic profile was prepared to provide decision makers with the socio-economic context for the counties included in the proposed management guidelines contained within the 2023 Strategy as presented to the Oregon Department of Fish and Wildlife Commission.

The eight counties affected by the Greater Sage Grouse are all located in the Central and Southeastern regions of Oregon. The region is characterized by low population density and relative isolation from larger economic markets. Residents of the area often must travel far distances to access services, retail, wholesale markets, and healthcare facilities to name a few.

The majority of lands in the counties are publicly owned (federal, state, or county) with Deschutes, Harney, Lake and Malheur having over 70 percent of their lands in state/federal ownership. Union County has the lowest percentage of public ownership, at 48%, but it still amounts to nearly half of land ownership in Union County being controlled, managed, and/or maintained by federal and state governments.

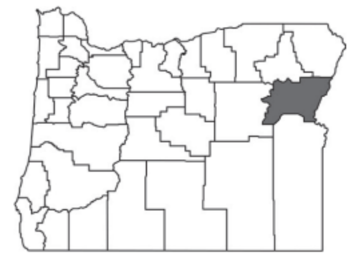
A significant portion of the populations in these eight counties earn their livelihoods from the region's natural resources and amenities. As a result, most of the counties' employment have heavier concentrations in farm and government sectors compared to the state's average overall distribution of employment by industry.

The region includes a mix of families who have resided in the area for generations such as ranchers, farmers, and millworkers as well as newcomers with a desire for rural living and an attraction to the region's stunning beauty and recreational opportunities.

*Authors Note: Although Klamath County is included in this report, it is considered within the "unoccupied range" since no known breeding populations have been documented since the mid 1990's.*

**Brief Profile of Counties**

*Baker County*

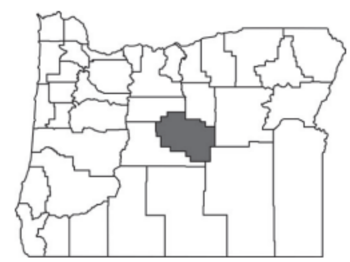


Baker County consists of 3,089 square miles and is bordered by Union, Wallowa, Grant and Malheur Counties. The county was once the largest gold producer in the northwest; however today the primary economic drivers for the county are agriculture, stock raising, and logging. With the opening of the Historic Oregon Trail Interpretive Center and the Wilderness Areas within the county, tourism has also contributed to the local economy.

Baker County is home to a portion of many national protected areas: Anthony Lakes Ski Area, Deer Flat National Wildlife Refuge, Hells Canyon National Recreation Area, Malheur National Forest and the Whitman National Forest. 53.7% of the total land area is owned and operated by the US Forest Service and the Bureau of Land Management.

The county's population has fluctuated over time due, in part, to the boom and bust nature of mining. The population in the most recent census was 16,910 living on a little more than 912,000 acres.

*Crook County*

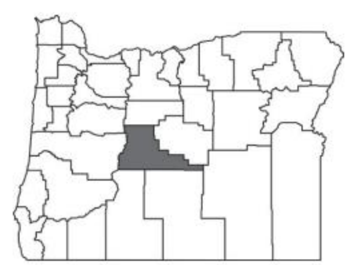


Located in the geographic center of the state, Crook County consists of 2,991 square miles and is bordered by Jefferson, Deschutes, Harney, Grant, and Wheeler Counties. The economy of Crook County was based on agriculture and forestry. The Ochoco National Forest's stands of ponderosa pine were the main source of timber for the logging industry within the county; however, with increased regulations and the need to diversify the industry, additional species of harvest had to occur.

Today, agriculture is supported by the development of irrigation districts, which permit the raising of hay, grain, and seed, while the timber mills have been primarily replaced with manufacturing of the secondary wood products industry. With 50.6% of the county being publicly owned, range and forest lands have allowed for the grazing of a sizeable livestock industry. The county has also recently benefited from the construction of data centers in the area.

Tourism has also provided an increase in the economic vitality of the county. Recreation in the mountains, streams, rivers, and reservoirs have brought an increase to hunting, fishing, camping, ATV and other activities which have helped to strengthen the economy and the creation of long running and new businesses in Prineville. The only incorporated town in the county.

*Deschutes County*

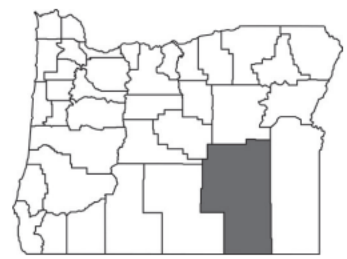


Deschutes County is the most recent of Oregon's 36 counties having been officially established in 1916. These 3,055 square miles are located in the central portion of the state. The county includes portions of the Cascade Mountain range as well as the central high desert plateau.  It is bordered by Jefferson, Crook, Klamath, and Lake, Lane and Linn counties.

Principle industries in the county include timber and agricultural – primarily cattle and potatoes. Tourism also contributes to a booming economy in Deschutes County with destination resort communities like Black Butte Ranch, Eagle Crest, Pronghorn, and Sunriver leading the way. The Mount Bachelor ski area and High Desert Museum add to the tourism-based economy in the county as well.  Oregon State University Cascades Campus opened in 2001 and was expanded into a four year university campus in 2012.  The campus serves over 1000 students per term. Deschutes County only has 22.6% of the 3,055 square miles in private ownership, with the majority of the public land falling to the US Forest Service (Deschutes National Forest) for management.  Outside of the National Forest however, Deschutes County is home of over 500 known lava caves with tourists coming to the prominent Lava River Cave as well as many others in the region.

Deschutes County has seen significant population growth in the past 50 years.  In 1970, Deschutes County was the home to roughly 30,000 Oregonians.  Today, Deschutes County has over 206,000 residents and climbing.

*Harney County*
Harney County is located in the high desert county in the southeastern portion of the state.  It is Oregon's largest county by geographic size, 10,228 square miles, with only 25.9% of the total land area being in private ownership.  Harney County is bordered by Grant, Malheur, Lake, Deschutes and Crook Counties as well as the state of Nevada to the south.

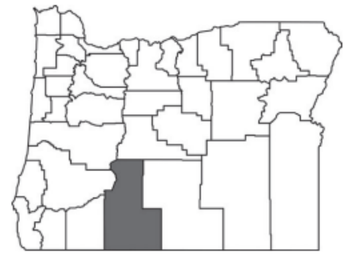


The three industries that have traditionally provided for the counties economic base, cattle raising, sheep raising and timber continued for many years.  However, with the railroad serving as a catalyst to the cattle industry, it contributed to its very decline but bringing farmers and sheep ranchers to the area – thus creating an increased competition for productive land.  In addition to these industries, the harvesting and breeding of wild horses also provided lucrative opportunities for the economic region of Harney County.  Today, tourism is on the rise with many attending the Malheur National Wildlife Refuge.

Although Harney County lands were open to homesteading from 1862 until 1934, the federal Bureau of Land Management still owns over 4 million acres.  Arid land in Harney County was donated to the state before irrigation and settlement.  All water development efforts failed under the Carey Act and eventually all land claims under the reclamation legislation were abandoned or nullified.

The population in Harney County was recorded in the 1890 census as 2,559 and rose steadily until the 1980s.  Today, the population sits right around 7,200.

*Klamath County*



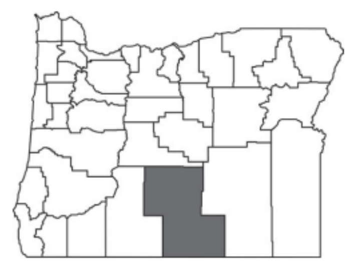
Located in south central Oregon, this county is bordered by Lake, Deschutes, Jackson, and Douglas counties, as well as the state of California. The county is 6,135 square miles with only 40% being in private ownership.

Klamath County's economy has been based on timber and agriculture historically. Seventy-Five percent of Klamath County is forested. The large stands of timber have resulted in the development of a prosperous wood products industry within the county. Despite the altitude, short growing season, low rainfall and cold winters, agriculture plays an important role as a leading part in the economic engine for the county. Excellent soil, irrigation practices, extensive sunshine and the introduction of crops such as potatoes and feed barley help achieve that purpose.

Tourism is also a huge draw for the local county's economy. Klamath Lake, the numerous mountains within the county as well as the state's only National Park, Crater Lake, attract tourists and recreational visitors to the county daily. Crater Lake sees approximately 500,000 people each year coming to the county. The Klamath Basin National Wildlife Refuges Complex, a set of six National Wildlife Refuges, seasonally draw some of the largest concentrations of waterfowl in all of North America. This area is world renowned for bird watching.

The population of Klamath County has seen a steady increase since the first census was taken in the county in 1890. Today roughly 70,000 people call Klamath County home.

*Lake County*



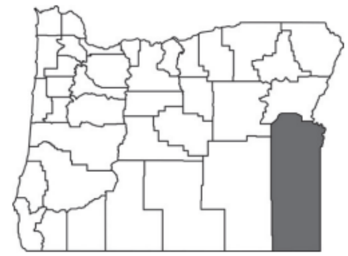
Named for the numerous lakes entirely or partially within its borders, the 8,358 square miles that encompass Lake County only has 26.9% private ownership. Lake County had a population of 944 in 1875 and has seen fairly steady growth over the years with a current population of roughly 8300 citizens.

Because of poor transportation connections with the rest of Oregon, the early economic orientation of Lake County was toward California. The county was part of the military courier route between The Dalles in Wasco County and the Presidio in San Francisco, California. The county did not acquire a railroad connection until almost 1900.

The traditional economy for Lake County is dependent upon lumber, agriculture, and government. With the low rainfall and short growing season, a combination of homesteading and irrigation has allowed for the raising of livestock and dry land hay and grain operations to thrive in the county. Lumber and wood products are taken from the Fremont National Forest. With the National Forest and regional Bureau of Land Management headquarters in the county, a stable economic base was able to be created – otherwise the county would be dependent solely on seasonal agricultural and timber production.

Tourism has become a growing industry in the county due to the many sites the county has to offer: Hart Mountain Antelope Refuge where 239 species of birds, 42 species of mammals and at least eight species of reptile can be seen, Hunter's Hot Springs and Old Perpetual Geyser (Oregon's only continuously erupting geyser), Goose Lake, as well as the recreational activities such as rock hunting and hang gliding.

*Malheur County*



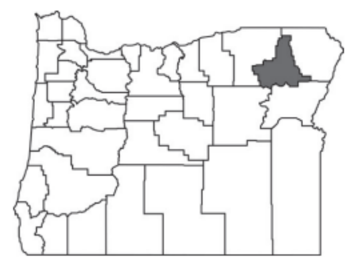
The only county in Oregon found in two separate time zones, Malheur County is bordered by Baker, Harney and Grant Counties as well as the States of Idaho and Nevada. It is the second largest county in the state with 9,926 square miles but only 27.8% is privately owned.

The county is 94% rangeland with the Bureau of Land Management controlling over 70% of the land. Irrigated fields in the county's northeastern corner, known as Treasure Valley, is the center of diversified farming practices.

The population of Malheur County has fluctuated since its incorporation; however today there are roughly 31,000 citizens of the county. More than half reside within the cities of Ontario, Vale, and Nyssa (Western Treasure Valley).

The majority of the county's economy comes from its two largest employers, a potato processor branded as Ore-Ida and the Snake River Correctional Institution, which is located five miles northwest of Ontario. Tourism is a large draw to the county as it is home to a portion of Deer Flat National Wildlife Refuge – a resting and wintering area for birds along the Pacific Flyway; the Malheur National Forest which contains the largest known organism by area in the world (an *Armillaria ostoyae* which spans 2,200 acres); and the Whitman National Forest.

*Union County*



Located in northeast Oregon and bordered by Umatilla, Wallowa, Grant and Baker Counties, Union County is nestled in the Grand Ronde Valley between the Blue Mountains and the Wallowa Mountains. With just over 2,000 square miles in the county, 52% is privately owned.

The initial economic interest in Union County was mining, but most of the mines were in the area annexed by Baker County in 1901. Over the years farming (wheat, fruit, vegetables, and grass seed), cattle, sheep, and timber replaced mining as the primary economic driver in the county. Nearby mountains and streams provide ample hunting, fishing, skiing, and camping opportunities to add tourism as a large economic driver for the county.

Tourist draws to the county include: Anthony Lakes and ski area, the Minam River, Mount Emily, the Blue Mountains, Umatilla, Wallowa-Witman National Forests, State Parks and Recreation areas, Hot Lake Hotel (originally build in the 1860s due to the nearby hot springs) and the Eagle Cap Excursion Train – a 63 mile heritage railroad line connecting the communities of Elgin (Union County) and Joseph (Wallowa County).

**Overall Look At The Impacted Oregon Counties**

The eight impacted counties, (called in this Appendix *'The Impacted Region'* is generically sparsely populated and has higher unemployment rates and a greater proportion of persons living below the poverty level than the statewide average. As you can see below, according to the USDA's *Percent of total population in poverty* last generated in 2023, Malheur County had a poverty percentage of 19.7%, where Deschutes County was 8.7%.

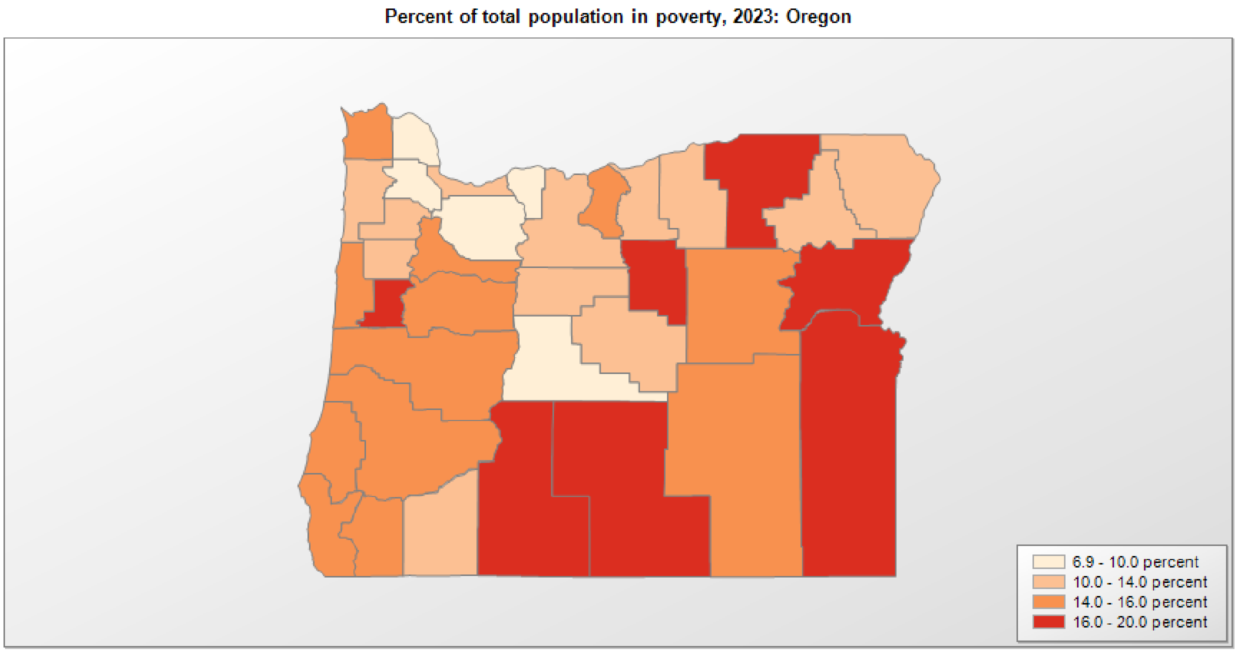



**Figure 1.** Percentage of total population in poverty in Oregon (2023).

**Table 1.** Percentage of population in poverty in the impacted region (2023)

| Area | Poverty % of Population |
|---|---|
| Baker | 16.2% |
| Crook | 12.8% |
| Deschutes | 8.7% |
| Harney | 15.2% |
| Klamath | 19.3% |
| Lake | 17% |
| Malheur | 19.7% |
| Union | 13.6% |

In the *impacted region*, population densities range from a low of less than one person per square mile in Harney County (0.7/sq. mi) to a high of 53.4 per square mile in Deschutes County. This is an increase for Deschutes County by an additional 15.2 people per square mile from the previous report.

In the May, 2025 Labor Force and Unemployment Report produced by the State of Oregon's Employment Department, April 2025 seasonally adjusted unemployment rates saw seventeen of Oregon's thirty-six counties had an unemployment rate at or below the statewide unemployment rate. For the counties located in the *impacted region*, only two counties' seasonally adjusted unemployment rate fell below the statewide rate of 4.7%. These unemployment rates mask significant underemployment with many workers as well as the individuals who have stopped looking for work entirely.

**Table 2:** Unemployment rate in the impacted region, as of April 2025.

| **Area** | **Unemployment Rate (April 2025)** |
|---|---|
| Baker | 4.8% |
| Crook | 5.1% |
| Deschutes | 4.3% |
| Harney | 4.5% |
| Klamath | 6.4% |
| Lake | 5.4% |
| Malheur | 4.2% |
| Union | 5.2% |
| OREGON | 4.7% |

According to the Oregon Employment Department's "Closer Look at Oregon's Median Household Income," the statewide median income in 2023 was $80,061 which, is higher than the U.S. median household income of $77,719 and at the time, was the 19$^{th}$ highest out of the various states in the nation. Oregon's median income in 2023 was higher than Idaho ($74,942) and Nevada ($76,364), but much lower than neighboring states California ($95,521) and Washington ($94,605). The household income in the impacted sage grouse counties are also on both sides of the state's statewide median household income.

**Table 3.** Median household income in the impacted region, as compared to national and statewide medians (2023).

| Area | Median Household Income |
|---|---|
| Deschutes | $95,4148 |
| OREGON | $80,061 |
| NATIONAL | $77,719 |
| Crook | $73,421 |
| Union | $63,524 |
| Baker | $59,123 |
| Harney | $56,649 |
| Lake | $56,518 |
| Klamath | $54,630 |
| Malheur | $53,762 |

The counties' economies have struggled with high unemployment rates, a greater than the statewide average of persons living below the poverty level, and large distances to many markets. Over the past few years, the COVID pandemic also had a significant impact on Oregon's counties throughout the state, but especially in the impacted region.

According to the Oregon Employment Department, the number of unemployed Oregon residents rose dramatically from February to April in 2020. In February 2020, the unemployment rate was 3.4%, however in April of 2020 the unemployment rate across Oregon was 13.3%.

**Economic Activities within the Region of the Sage-grouse Strategy**

*Ranching*

According to the Oregon Department of Agriculture, the top 20 most valuable agricultural commodities statewide, cattle is ranked second with half a billion dollars generated annually. In 2021, cattle accounted for $676.2 million across the 36 counties. This is an increase from the $587.8m generated the previous year. Most of the animals are raised in eastern and southern Oregon, primarily occurring in Malheur, Klamath, Harney, Baker, and Lake counties. In the Sage Grouse region, beef cows account for almost 60% of the total number of beef cows raised in Oregon (303,500 out of the total 525,000 raised in 2021 calendar year).

Depending upon the extent of measures that will be taken to conserve sage-grouse habitat, ranching activities may be affected by changes to livestock grazing under the Strategy, particularly the conservation of sagebrush habitats with lower forage values for livestock. The implementation of the Strategy, however, would likely not have the same regulatory impacts to grazing management in Oregon as a listing under the federal Endangered Species Act as ODFW is not a regulatory agency.

Sage-grouse habitat needs for breeding, nesting, and brooding coincide with periods when cattle are grazing on public lands. According to Greer (1995), the reliance of southeastern Oregon ranchers on public lands can appear insignificant when calculated on an acreage or AUM basis, but when calculated on a seasonal dependency basis, federal grazing is very important. AUM reduction should not be an automatic response to sage-grouse declines but requires analysis on a case-by-case basis. However, should land management agency regulation change, there would be an economic impact to ranchers.

Torell et al (2002) examined the impacts of reductions in federal grazing allotments assuming a listing of the sage-grouse on the federal Endangered Species list. They estimated the value of BLM spring forage for livestock production and the economic consequences of eliminating spring grazing and reducing grazing capacity on BLM lands to improve and maintain habitat for sage-grouse. Their analysis of Lake County ranchers revealed that the economic impact of sequentially reducing the availability of BLM AUMs ranged from about $10/BLM AUM removed for 50% and 75% BLM allotment reductions to $11.77/AUM with total elimination of BLM grazing. Annual net cash income was reduced to $21,808 per year or a 56% drop with a 100% BLM reduction. The average number of livestock reduced was about 33 percent. Under their model, Lake County ranchers suffered higher average economic losses from removing AUM's than from Jordan Valley, Idaho and Northeastern Nevada. The differences were due to ranchers' ability to substitute alternative forages as federal AUMs are eliminated. Substituting forages minimizes economic losses relative to the option of feeding hay and reducing cow herd size.

Torrell et al. (2002) noted that many ranchers need supplemental off ranch income with part-time ranchers relying on ranch income for about 20% of annual disposable income to full-time ranchers depending on the ranch for about 80% of disposable income. For those ranchers with limited off-ranch wealth and income, reducing public land grazing capacity by even marginal amounts was found to greatly impact the ability of ranchers to meet financial obligations and repay debt.

*Hunting and Wildlife Viewing*
According to a study by Dean Runyan and Associates, prepared for the Oregon Department of Fish and Wildlife and Travel Oregon, travel generated and local recreation expenditures were estimated at $972.9 million for the entire state for fishing, hunting, and wildlife viewing for 2008. For the eight counties in the Strategy, total estimated expenditures in these categories ranged from $9.2 million in Malheur County to $78.5 million in Deschutes County. Travel generated and local recreation spending is a significant boost for these counties, but it is unknown how much of these amounts are directly and indirectly attributed to sage-grouse hunting and wildlife viewing.

*Renewable Energy*

Wind energy turbines have become an increasingly common site in Eastern Oregon, tapping into the significant wind resources in the region. Most of the existing wind turbines are located along the Columbia River particularly in Sherman, Morrow, Gilliam, and Umatilla counties. There is increasing interest in wind turbine siting elsewhere in Eastern Oregon as the quality of wind is excellent and in some places even better than the Columbia River area. Not every area of the state, however, is good for placement of each type of renewable energy development, whether it be from biomass, solar, geothermal or wind because placement is dependent on the quality of the resource available.

The state of Oregon adopted legislation through the passage of SB 838 in 2007 (ORS Chapter 301) that sets forth comprehensive renewable energy policies to "accelerate the transition to a more reliable and more affordable energy system." The statute also declared that "by 2025 at least 8% of Oregon's retail electric load comes from small-scale renewable energy projects with a generating capacity of 20 megawatts or less." Overall, the state aims to have 25 % of its overall electrical generation derived from renewable sources by the year 2025.

After the boom of wind turbines on the landscape in the early 2000s, the new push in the renewable energy arena is around solar projects. The Oregon Legislature has passed many pieces of legislation to increase the number of solar projects on the landscape. Almost all of these solar projects are located east of the Cascades with a large number going in the Umatilla Basin region of the state, as well as Harney and Lake Counties.

Siting of wind turbines has had a major impact on the economies of Columbia River Eastern Oregon counties. Northwest Economic Associates (2003) studied the economic development impacts of wind power in three case studies, including Umatilla County and found that:

- The projects contributed to significant increases in employment, personal income, tax income and landowner net revenues.
- Tax effects, particularly property taxes were important.
- Non-market benefits may be important: wind power is a non-polluting, low impact, and non-extractive form of energy that provides large positive benefits to local economies but has a relatively light impact on communities and their infrastructure (schools, roads, and social services).
- Wind energy development does not involve the "boom and bust" economic and social conditions associated with other energy development.

The authors noted possible negative impacts of wind energy development, such as bird kills, damages to roads and impact on land values. M. Pedden (2006) confirmed these conclusions regarding rural communities with a review of a broad cross-section of data available from existing studies. Wind installations have a large direct impact on the economies of rural communities, especially those with few supporting industries. For example, Pedden noted that the installation of wind farms creates another industry in the community that becomes a large percentage of the local tax base and contributes to local businesses.

Ouderkirk and Pedden (2004) studied the economic impacts of the 24 megawatt Klondike Wind Farm Project in Sherman County. They concluded that the benefits of the Project were widespread in Sherman County and the surrounding region.

Employment from development, construction, and operations stimulated regional businesses and boosted personal income in the county. Sherman County realized substantial tax revenues, while individual farmers received additional income from royalty payments while still carrying on their farming operations.

Since many farmers and ranchers must supplement their income with outside sources of revenue, wind turbines can provide the additional revenue to improve the viability of their operations. According to the American Wind Energy Association (AWEA), wind farms can revitalize the economy of rural communities, providing steady income through lease or royalty payments to farmers and other landowners. Although leasing arrangements vary widely, a reasonable estimate for income to a landowner from a single utility-scale turbine is about $3,000 per year. For a 250-acre (~100 ha) farm, with income from wind at about $55 an acre, the annual income from a wind lease could be $14,000, with no more than 2-3 acres (0.8–1.2 ha) removed from production. Such a sum can significantly increase the net income from farming. Farmers can grow crops or raise cattle next to the towers. Wind farms may extend over a large geographical area, but their actual "footprint" covers only a very small portion of the land, making wind an ideal way for farmers and ranchers to earn additional income. Other renewable energy facility construction such as solar and geothermal projects may be affected by the recommendations depending upon the proposed location of those facilities and proximity to sage-grouse habitat and leks. These facilities could also affect counties' economies through construction, maintenance, and generation of electricity.

Unlike wind turbines however, photovoltaic projects (solar panels) do see a large footprint of agricultural lands taken out of production. Solar photovoltaic installation has seen an increase of 48% per year (on average) over the past decade and the current capacity in the nation is expected to double again over the next five years. The Oregon Legislature passed House Bill 3179 in 2023. This bill allowed a county additional authority in the siting of renewable energy facilities locally – specifically solar photovoltaic power generation facilities. A county now has the authority to permit locally, if they wish to take this additional authority, power generation facility more than 160 acres (~65 ha) but less than 240 acres (~97 ha) on high-value farmland. Counties have the authority to permit no more than 2,560 acres (~1,000 ha) on land that is predominately cultivated or lands that are predominately composed of soils that are soil classes I-IV; and no more than 3,840 acres (~1,550 ha) located on any other lands.

Outside of renewable energy facilities, counties also have the authority to permit solar panels on smaller scales in a land owner wanted to have the power generation on a much smaller scale. Some farmers have taken the solar panel projects to the next step in creating "agrivoltaics" on their property. Agrivoltaic is the practice of diffusing the competition between the two by measuring the economic value of energy production and agricultural uses on the same land. Research by Oregon State University has found some crops, particularly plants that prefer shade, can be more productive when planted alongside solar panels. Other Oregon State University research studies have found that shade provided by solar panels has increased the abundance of blooms and plants under the panels.

According to a study by Graham, Ates, Melathopoulos, et al through Oregon State University, found that between solar panels and grazing lambs / sheep in 2019 and 2020 the following:

- The lambs gained almost the same amount of weight in the two pasture types in both years.
- The daily water consumption of the lambs in the two pasture types in spring 2019 were similar during early spring, but lambs in open pastures consumed more water than those grazed under solar panels in the late spring period.  There were not any differences observed in water intake in the spring of 2020.
- Over the two-year period, solar pastures produced 38% less forage than open pastures.
- The return from grazing was $1,046 per hectare per year in open pastures and $1,029 per hectare per year in pastures with solar panels.

Counties in the Sage Grouse Region are working to protect farmland and habitat for the Sage Grouse by finding ways to incentivize developers to build their projects in urban areas instead of rural areas.  Klamath County as an example is working to have community solar projects developed in urban areas where the energy would primarily be used. Although the increase of solar photovoltaic and wind turbines is beneficial to the local economies, both economically and as a way to ensure reliable energy when it is needed by the residents, the potential downsides toward habitat are not entirely known.

Our current understanding of the impacts of solar facilities on wildlife is limited, despite the pace and scale of its development.  Environmental effects, such as soil erosion, changes in water use, and increases in local temperature are well documented (Barron-Gafford et al., 2016; Hernandez et al., 2014; Moore-O'Leary et al., 2017).  A few studies suggest that solar facilities could affect wildlife through exclusionary fencing, habitat destruction or alteration and direct mortality, but their relative scarcity highlights the need for additional research.  In particular, studies of wildlife behavioral response to solar facilities have been called for, including by working groups focused on bird interactions with solar facilities (ASCWG, 2020; ASWG, 2020); but such studies are largely still lacking from the literature (Lovich & Ennen, 2011; Northrup & Wittemyer, 2013, Chock et al. 2020).

One area of renewable energy facilities that do affect the Greater Sage Grouse in the impacted counties is that of predation around these facilities.  Golden eagles, ravens, and other raptors use the facilities as additional perches for hunting of the Greater Sage Grouse.  The Bureau of Land Management has stated that they are responsible for sage-grouse habitat on public lands, and because of this, BLM does not "have authority to take direct actions to control predator populations.  In addition, science shows that predator control measures are less effective and durable than identifying, conserving and restoring habitat and managing other uses of the land to avoid altering the vegetation and introducing novel predators." Examples of novel predators are ravens, red foxes, and skunks. Examples of primary predators are coyotes, badgers, golden eagles and other raptors.

**Table 4.** Socio-economic profile of Oregon counties with the potential to be affected by sage-grouse management, including Baker, Crook, Deschutes, Harney, Klamath, Lake, Malheur, and Union counties.

**Socio- Economic Profile**
**Oregon Counties Affected by Sage-Grouse Strategy**

| | Baker | Crook | Deschutes | Harney | Klamath | Lake | Malheur | Union | Oregon |
|---|---|---|---|---|---|---|---|---|---|
| Demographics | | | | | | | | | |
| Population, 2023 | 16,927 | 26,583 | 212,141 | 7,600 | 71,919 | 8,562 | 32,981 | 26,335 | 4,291,525 |
| Population, percent change, July 1, 2020 to December 2023 | 0% | 13% | 8% | 4% | 6% | 6% | 3% | 2% | 1% |
| Population, percent change, April 1, 2010 to December 2023 | 5% | 27% | 34% | 2% | 8% | 8% | 5% | 2% | 12% |
| High School Graduate or Higher, Percent of persons age 25+, 2018-2022 | 91.4% | 90.3% | 94.3% | 91.2% | 89.3% | 87.0% | 81.4% | 92.8% | 91.6% |
| Bachelor's degree or higher, percent of persons age 25+, 2018-2022 | 24.2% | 20.9% | 40.8% | 14.2% | 20.8% | 19.8% | 14.6% | 23.8% | 35.5% |
| Owner-occupied housing unit rate, 2018-2022 | 72.2% | 75.3% | 69.7% | 69.1% | 67.0% | 62.5% | 58.6% | 66.6% | 63.2% |
| Median value of owner-occupied housing units, 2018-2022 | $231,100 | $368,200 | $526,200 | $174,100 | $234,200 | $169,000 | $187,500 | $243,400 | $423,100 |
| Median household income, 2020 | $51,657 | $74,969 | $82,042 | $45,462 | $57,219 | $54,663 | $48,371 | $61,946 | $76,632 |
| Per capita income in past 12 months (in 2022 dollars), 2018-2022 | $32,672 | $38,484 | $46,765 | $26,910 | $31,260 | $29,400 | $22,145 | $31,640 | $41,805 |
| Persons in Poverty (2022) | 15.5% | 10.60% | 9.60% | 14.80% | 15.50% | 16.50% | 19.80% | 14.90% | 12.10% |
| Employment, October 2023 | | | | | | | | | |
| Civilian Labor Force | 7,179 | 10,751 | 101,266 | 3,578 | 30,033 | 3,542 | 12,768 | 12,019 | 2,155,402 |
| Employed | 6,936 | 10,207 | 97,924 | 3,467 | 28,794 | 3,398 | 12,383 | 11,622 | 2,083,582 |
| Unemployed | 243 | 544 | 3,342 | 111 | 1,239 | 144 | 385 | 397 | 71,820 |
| Seasonally Adjusted Unemployment Rate, percent | 4.1% | 5.6% | 3.6% | 3.9% | 5.0% | 4.8% | 3.6% | 3.7% | 3.6% |
| **Business** | | | | | | | | | |
| Total nonfarm employment, October 2023 | 5,520 | 7,010 | 95,760 | 2,420 | 23,860 | 2,240 | 12,140 | 10,690 | 2,003,600 |
| Geography | | | | | | | | | |
| Land area, 2020 (square miles) | 3,067.97 | 2,978.93 | 3,017.62 | 10,134.44 | 5.949.98 | 8138.61 | 9887.71 | 2036.94 | 95,995.98 |
| State / Federal Ownership, percent | | | | | | | | | |
| Persons per square mile, 2020 | 5.4 | 8.3 | 65.7 | 0.7 | 11.7 | 1 | 3.2 | 12.9 | 44.1 |
| Travel Generated and Local Recreation Expenditures ($ Millions, 2020) | | | | | | | | | |
| Fishing | $6.96 | $2.27 | $2.98 | $3.76 | $6.86 | $3.33 | $4.64 | $9.04 | $227.82 |
| Hunting | $10.61 | $1.44 | $27.07 | $0.56 | $1.73 | $16.74 | $18.66 | $2.09 | $396.87 |
| Wildlife Viewing | $23.33 | $2.91 | $18.86 | $7.29 | $29.94 | $6.86 | $0.90 | $2.45 | $578.75 |
| Total | $40.90 | $6.63 | $48.93 | $11.60 | $38.54 | $26.94 | $23.40 | $13.59 | $1,203.44 |