Appendix 8. Strategic Framework Tools and Details for the Resistance and Resilience Matrix and the State-and-Transition Model Approach

This appendix provides greater detail on tools available to support the Action Plan's strategic framework and actions outlined in Sections III and IV, respectively. These include conceptual approaches and models that help support decision-making, as well as technical tools that improve the State's ability to guide development and conservation actions to ensure the best outcomes for sage-grouse and sage-steppe habitats.

i. Resistance and Resilience Matrix

As discussed in this Action Plan, the sagebrush-steppe habitats that support the greater sage-grouse are threatened by the expanding number of large and hot wildfires, which are influenced by the distribution and expansion of invasive, non-native annual grasses. However, all sagebrush-steppe habitats are not equally sensitive to disturbance. Those that are able to better retain their structure and dynamics in spite of stresses like wildfires, invasive plant species, occasional heavy grazing, and drought events are described as more *resistant* to change. Those that are able to more quickly recover after disturbance to the original state are described as more *resilient* (Holling 1973; Folke et al. 2004). Patterns of resistance and resilience within the sage-grouse planning area have implications for management planning and can be used to help allocate management efforts across the range of the sage-grouse in Oregon.

The Resistance and Resilience Matrix concept was developed by Chambers and others (2014) and based on considerable research (Chambers et al. 2013). It was developed to fill a gap in the available management tools by providing a tool to managers that matched the very large scale of the invasive species-wildfire feedback loop threatening sage-grouse. The basic assumption for this tool is that management and treatments for invasive annual grasses and altered fire regimes can be guided by the resistance and resilience of the sagebrush-steppe plant communities.

The Resistance and Resilience Matrix is a simplified framework to identify high, moderate, and low resistance and resilience, based on broad-scale soil moisture and temperature regimes (Table 1). It is well matched to the primary threats to sage-grouse in terms of spatial extent and strategic level. For this plan, we have interpreted the matrix to represent areas at low, moderate, and high risk of invasion by annual grasses (Figure 1). These risk categories provide baseline information considered important in prioritizing areas where management and conservation actions should be implemented within the sage-grouse planning area in relation to plant invasion. Ultimately, these relationships can be used to prioritize management actions in a scientifically defensible manner within Oregon's sage-grouse habitat.

Table 1. Generalized categories of resilience and resistance used with soil temperature and moisture regimes.

Resilience and resistance	Soil temperature and moisture regime	Risk of annual grass invasion
High	Cold & Moist (Cryic) Cool & Moist (Frigid/Xeric)	Low
Moderate	Warm & Moist (Mesic/Xeric) Cool & Dry (Frigid/Aridic)	Moderate
Low	Warm & Dry (Mesic/Aridic)	High

Resistance and resilience information can be used to guide the selection of management goals under Strategy Level I. For example, some locations will respond well to restoration efforts, whereas others are more likely to benefit from preventative measures. In areas of low resistance and resilience and high risk of invasion, restoration of degraded areas (such as those dominated by invasive annual grasses) is either unlikely to succeed or would be extremely expensive. In such cases, management emphasis should be on preventive measures, such as controlling invasive annual grasses or establishing fuel breaks to reduce the spread of wildfire.

Likewise, the Resistance and Resilience Matrix can be used to address the threat of invasive annual grasses, by prioritizing management of areas with low resistance and resilience where annual grasses do not yet dominate the plant communities (e.g., >65% sagebrush land cover with a desirable perennial grass understory). An emphasis on prevention within high-quality sites with low resistance and resilience is consistent with the low probability of success for restoration efforts should wildfire or invasive plants spread into them. At Strategy Level II, additional site-level information will be used to verify site conditions and refine specific management treatments, locations, schedules, and so forth.

With respect to the threat of conifer encroachment, for sites with high resistance and resilience, priority can be given at Strategy Level 1 to areas that are in the early stages of conifer invasion (i.e., conifers are present but do not dominate the site and sagebrush land cover remains greater than 25%). Restoration priority will be assigned to early stages of conifer encroachment due to these sites' increased level of conservation contribution and the higher risk associated with restoration of conifer-dominated sites where depleted understory vegetation already exists (see state-and-transition model in next section). As with invasive grasses, Strategy Level II information will be used to verify and refine the specific actions, locations, and schedules for management.

In moderate resistance and resilience areas, multiple threats may be present or possible, and both prevention and restoration may be management possibilities; local conditions will dictate the selection of the appropriate management and conservation goals. For example, restoration efforts may be more successful on relatively mesic and cool northerly aspects as opposed to warmer and drier southerly aspects.

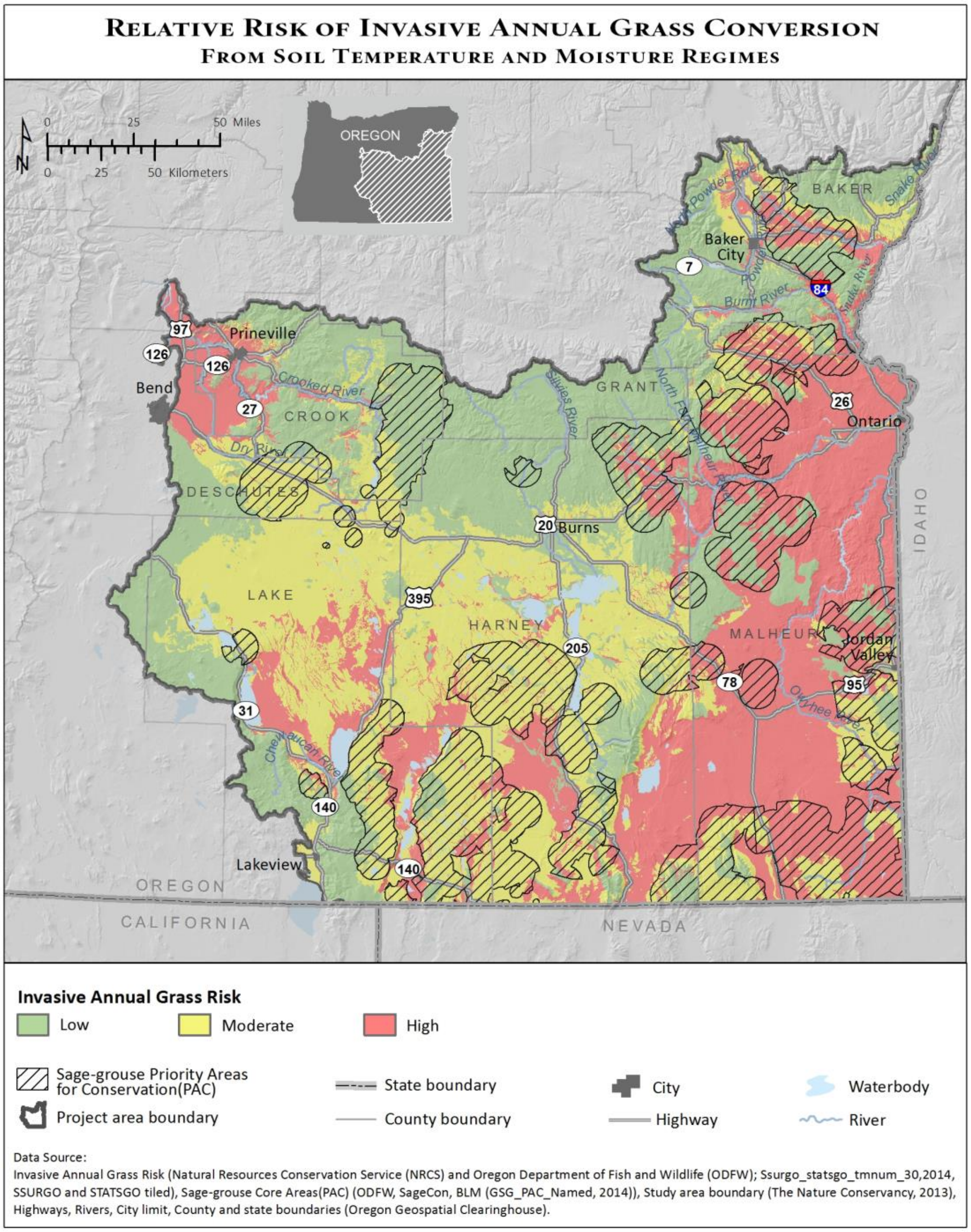

Figure 1. Relative risk of invasive annual grass conversion from soil temperature and moisture regimes. Risk was determined using empirical research that described the relationship between soil temperature regimes, soil moisture regimes, plant communities' capacity to recover after fire or other disturbance (resilience), and plant communities' capacity to remain intact (resistance) in light of a disturbance such as the introduction of cheatgrass (Chambers et al. 2014; Folke et al. 2004; Redford et al. 2011). Soil temperature and moisture regimes that coincided with shrub-steppe habitats were placed into resilience and resistance categories to indicate risk of invasion (areas that are more or less likely to be invaded by invasive annual grasses). Soil data was obtained and combined from two USDA-NRCS spatial databases: SSURGO and STATSGO.

ii. The State-and-Transition Model Approach

As described in Section III, state-and-transition models (STMs) are used to address site-specific management issues by the State of Oregon in this plan. It is important to note that there are other methods that can be used to assess site conditions, such as the Habitat Assessment Framework (HAF) used by the Bureau of Land Management (BLM) in its Resource Management Plan (RMP) Amendment,[1] but several advantages of STMs are that they can be used to describe site conditions, have been linked to management practices, help describe how habitats change based on different actions over time, and can be used with modeling software to predict change over time. This appendix provides additional information about the suite of STMs that will be used in the Action Plan.

The basic building blocks for the STM approach are vegetation "states," which represent a gradient ranging from desired to undesired states or conditions, "transitions," which represent drivers of change between states such as management actions, wildfire, invasion by exotic plant species, and inappropriate grazing (Figure 2, Figure 3, Figure 4). The most desirable vegetation states in each of the STMs provide potential year-round habitat for sage-grouse (green), followed by vegetation that is sufficient for seasonal use by sage-grouse (yellow), and an undesirable state in which vegetation is unusable by sage-grouse and is considered nonhabitat (red).

It is important to remember that the states within these models should not be taken as exact matches for the compositional and structural characteristics of plant communities on the ground. Different STMs have been created for each of the major sagebrush vegetation types: the low-elevation sagebrush communities (Figure 2), the mid-elevation sagebrush communities (Figure 3), and the high-elevation sagebrush communities (Figure 4). States within these models are meant to characterize common management or habitat problems within an elevation range and topographic setting. Matched to each state are management practices necessary to maintain a desired state or to "transition" the plant community toward a desired state. Movement between states can represent either desired or undesired change, depending on a site's initial conditions and the direction of change.

By focusing on restoring or maintaining habitat for sage-grouse based on generalized vegetation community structure and dynamics, conservation success using the STMs is measured by shifting—or transitioning—acreage from undesirable or less desirable states to preferable states (red to yellow, or yellow to green), or ensuring that sites in more desirable states (yellow or green sites) do not shift to undesirable or nonhabitat states (red). It is

[1] See BLM RMP Amendment Final Environmental Impact Statement (FEIS), Table 2-4, on page 46 (in the online PDF) and on page 2-39 (in the document), entitled "Fine and Site Scale Seasonal Habitat Indicators and Desired Condition Values for Greater Sage-Grouse Habitat on Oregon BLM Lands in the Planning Area." Available online: http://www.blm.gov/or/energy/opportunity/files/final/ORGRSG_Ch2_508.pdf

important to note that vegetation structure and dynamics provide only a generalized model of sagebrush vegetation and, as such, only provide a generalized representation of sage-grouse habitat and utilization potential by sage-grouse. Additional assessment methods would be required to provide detailed site-specific habitat quality data such as sagebrush height and proximity to human disturbances. Each STM has a corresponding table that summarizes the

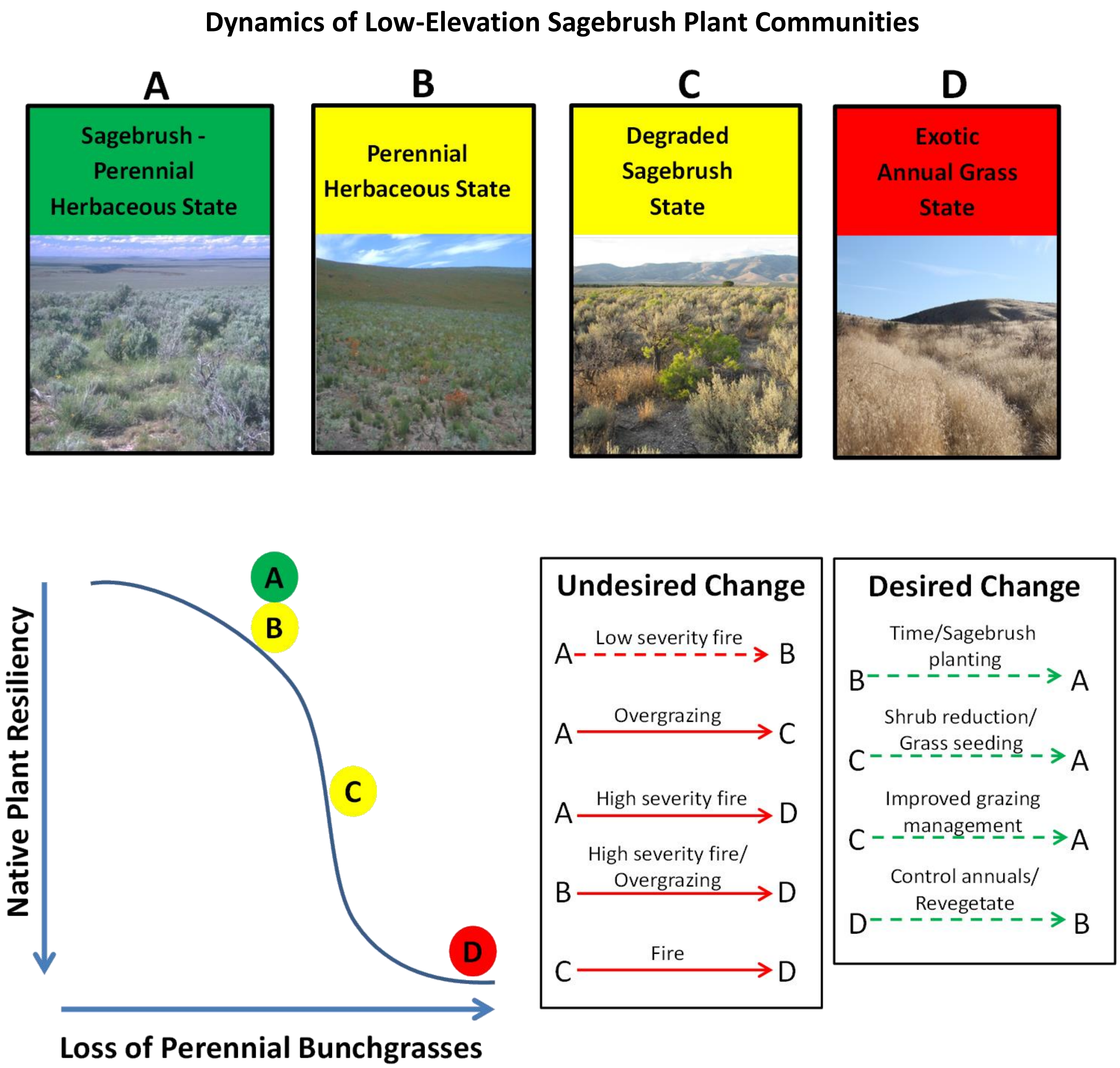

Figure 2. Dynamics of low-elevation sagebrush plant communities. At Strategy Level III (Site-Specific Management), a generalized state-and-transition model (STM) can be used for managing Oregon's sage-grouse habitat in low-elevation sagebrush plant communities with warm and dry or cool and dry soil temperature/moisture regimes (Miller et al. 2013). Resiliency is lower for communities on warm and dry sites. States (top) shaded in green indicate potential year-round habitat suitability for sage-grouse. States shaded in yellow and red indicate potential seasonal habitat and nonhabitat, respectively. "Native plant resiliency" (lower left) indicates the relative likelihood that a plant community will recover to a native plant–dominated state following disturbance; the likelihood decreases with loss of large perennial bunchgrasses. Movements between states (lower right), or transitions, are depicted with solid arrows for persistent transitions, while nonpersistent transitions are arrows with dotted lines.

ecological states and also lists conservation objectives, threats, and applicable conservation measures associated with transitions for each state (see Harney County CCAA for this detail).

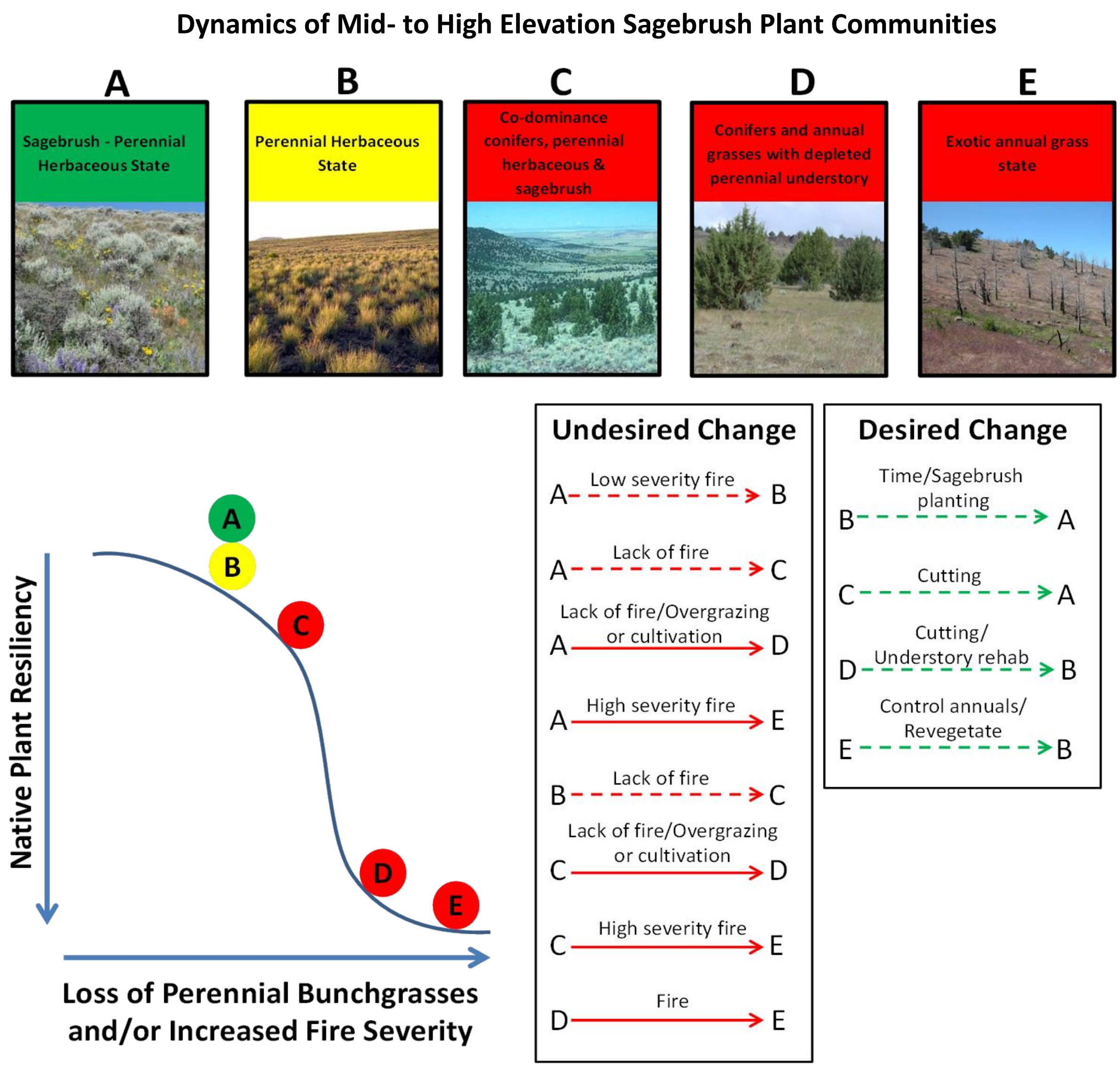

Figure 3. Dynamics of mid-to-high elevation sagebrush plant communities. At Strategy Level III (Site-Specific Management), a generalized state-and-transition model (STM) can be used for managing Oregon's sage-grouse habitat in mid-to-high elevation sagebrush plant communities in Oregon with a warm and moist soil temperature/moisture regime (Miller et al. 2013). States (top) shaded in green indicate potential year-round habitat suitability for sage-grouse. States shaded in yellow and red indicate potential seasonal habitat and nonhabitat, respectively. "Native plant resiliency" (lower left) indicates the relative likelihood that a plant community will recover to a native plant–dominated state following disturbance; the likelihood decreases with loss of large perennial bunchgrasses and increasing fire severity. States with increased woody plant fuel loading (C and D) can be less likely to burn due to decreased fine fuel loading, but are more likely to experience higher-severity fire when they do burn (Miller et al. 2008). Movements between states (lower right), or transitions, are depicted with solid arrows for persistent transitions, while nonpersistent transitions are arrows with dotted lines. Warm and dry sites often occur at the same elevation as cool and moist conditions, with differences being driven largely by aspect or other abiotic factors. Prescribed fire is depicted as a management option for reducing conifers on cool and moist sites, but not on warm and dry sites, due to the potential for fire to cause transition to annual-grass dominance in the latter.

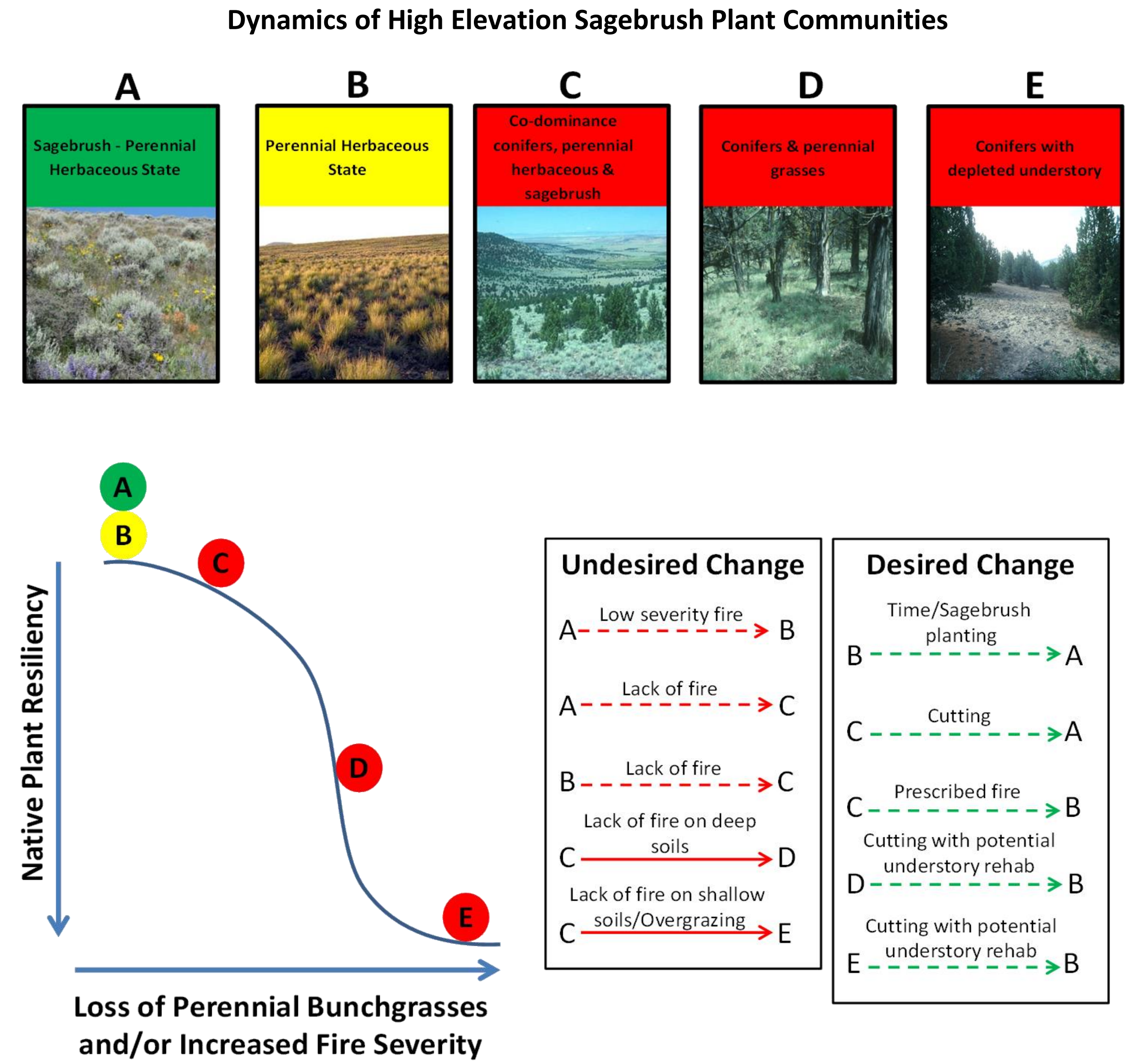

Figure 4. Dynamics of high-elevation sagebrush plant communities. At Strategy Level III (Site-Specific Management), a generalized state-and-transition model (STM) can be used for managing Oregon's sage-grouse habitat in high-elevation sagebrush plant communities with a warm/cool and moist soil temperature/moisture regime (Miller et al. 2013). States (top) shaded in green indicate potential year-round habitat suitability for sage-grouse. States shaded in yellow and red indicate potential seasonal habitat and nonhabitat, respectively. "Native plant resiliency" (lower left) indicates the relative likelihood that a plant community will recover to a native plant–dominated state following disturbance; the likelihood decreases with loss of large perennial bunchgrasses and increasing fire severity. States with increased woody plant fuel loading (C, D, and E) can be less likely to burn due to decreased fine fuel loading, but are more likely to experience higher-severity fire when they do burn (Miller et al. 2008). Movements between states (lower right), or transitions, are depicted with solid arrows for persistent transitions, while nonpersistent transitions are arrows with dotted lines.

iii. Technical Tools for Conservation

Oregon's sage-grouse habitat covers a vast landscape and is dependent on a complex sagebrush-steppe ecosystem. This area also contains a diverse set of threats, habitat conditions, land ownerships, and management jurisdictions. As a result, it is critical to not only develop and maintain detailed spatial data related to these issues but to also provide the tools and systems needed to access, assimilate, and use these data, whether from the position of land managers, researchers, project planners, or the general public. While this plan utilizes a variety of data-rich tools, two decision support tools in particular are highlighted in this Action Plan, due to their utility for performing complex queries across Oregon's sage-grouse habitat and answering important questions about many of the issues discussed in this plan. These issues include (1) where potential impacts may have the most or least effect on sage-grouse, (2) where to focus which specific conservation actions (e.g., treatments of invasive plant species), and (3) where investment of resources would have the most impact on species recovery and habitat benefit. These two tools are ORegon Decision Support System for Sagebrush-Steppe (ORDSS) and ODFW's Compass.

a. ORegon Decision Support System for Sagebrush-Steppe

The ORegon Decision Support System for Sagebrush-Steppe (ORDSS) was developed concurrently with this Action Plan to assist decision makers, planners, and managers across all levels to assess threats to sage-grouse, strategically target actions, and reduce conflicts with economic development. It was also developed with the intention of providing a system for storing, managing, querying, and providing access to the large amount of spatial datasets that have been compiled and/or developed for the Action Plan as well as to provide a structure for querying the spatial datasets into the future and thus the continued support of planning for sage-grouse and other wildlife.

The ORDSS was designed to guide planning and adaptive management of public and private conservation investments and to inform mitigation processes where complex information is needed, especially at Strategy Level I. The primary intended user of the ORDSS is Oregon's statewide governance board, described in Section II.

More than 40 different GIS datasets were compiled within the ORDSS, including the resistance and resilience layer. All of the included data were the best available, most accurate, and most up-to-date data at the time of this plan's drafting, and were vetted by state and federal agency experts working on sage-grouse management. The datasets were organized into broad themes reflecting important aspects of sage-grouse ecology, landscape condition, land-use/land cover characteristics, and land management. All data layers were summarized in hexagons equivalent to one square mile in area. The hexagons allow users to query the data in a common assessment unit and provide results that are statistically sound and fit within regional mapping efforts. The originating datasets were all documented and retained, and can be used to refine answers to key questions and to further inform conservation management and land-use decisions and actions. Over time, these datasets and the ORDSS itself will be updated as new information becomes available.

The ORDSS was designed to handle a variety of questions from decision makers, managers, and planners that are expected to focus on the following topics: biology, ecology, resources, land use, and threats. Datasets have been organized accordingly, and a number of questions have been tested within this framework, including but not limited to:

- Where should we focus wildfire prevention efforts to protect the most important habitat for sage-grouse, while minimizing conversion to annual grasses?
- How should energy development projects be guided and directed across the landscape, to result in the least impact on sage-grouse?
- Where will investments in juniper control provide the most significant benefits to sage-grouse?

The ORDSS is designed to be flexible, and it includes simple tools that allow users with moderate GIS and database skills to customize or update data, adjust data weighting schemes within the themes, and add new themes and data. Future enhancements for the ORDSS include expanding the development potential theme to include other development types, adding a new theme to track ongoing conservation actions and inform monitoring of aspects of ecosystem recovery, and supporting planning activities relevant to Strategy Level II. It was designed to be adaptable to online mapping tools and may be made more widely available. Currently, all the primary datasets (Table 2) can be downloaded from the SageCon website (http://oregonexplorer.info/content/sagecon) or may be requested from ODFW.

Table 2. The ORegon Decision Support System for Sagebrush Steppe (ORDSS) contains a wide variety of datasets.

ORDSS Datasets
• Breeding bird densities • Habitat categories (odfw sage-grouse core area/priority area for conservation (pac), low density, occupied habitat) • Proximity to habitat categories • Probability of habitat use by sage-grouse • Proximity to leks by lek status • Sagebrush vegetation types • Proximity to summer habitat • Connectivity potential • Sagebrush land cover • Tree canopy cover • Dominant invasive annual grasses cover fire perimeters • Ecological integrity scores • Proximity to stands dominated by invasive annual grasses • Proximity to juniper • Resistance and resilience scores • Fire threat index • Wildland fire potential • Suitability for cheatgrass (*bromus tectorum*) • Suitability for medusahead (*taeniatherum caput-medusae* (l.) Nevski*)* • Roads • Housing density • Communication towers • Mines • Pipelines • Transmission lines by voltage class • Power plants • Pipelines • Railways • Agriculture • Avoidance buffers • Areas excluded from energy development by state and federal regulations • Distribution of geothermal solar and wind energy resources • Distance to transmission lines • ODFW crucial habitat score • Critical habitat under the federal ESA • Oregon's Conservation Opportunity Areas • The Nature Conservancy's ecoregional portfolio • Conservation Utility Score

b. ODFW Compass

ODFW's Compass (Centralized Oregon Mapping Products and Analysis Support System) is an online mapping application. It provides access to ODFW's spatial data library, requiring only a web browser to access datasets, including ODFW Sage-Grouse Core Areas, ODFW Conservation Opportunity Areas, ODFW Winter Big Game Ranges, and many others. Compass also contains layers produced by ODFW for the Western Governor's Association's Westwide Crucial Habitat Assessment Tool (CHAT) effort, which maps crucial habitat for high-priority fish and wildlife species across the entire western United States. Compass allows users to work with data within Oregon, and then expand their view beyond the Oregon borders using the CHAT interactive mapping application.

Publicly available through the ODFW website (http://dfw.state.or.us/maps/compass/), Compass provides easy access to spatial data and information on potential impacts and other considerations related to greater sage-grouse conservation (Figure 5). Compass contains an online system of maps, data layers, and data documentation that assists users to make informed land-use decisions related to the sage-grouse and its habitat. In particular, it assists users with planning for large-scale, landscape-level projects such as projects related to energy, transportation, or conservation. These nonregulatory maps and data layers highlight potential impacts, and help identify potential opportunities within land-use project pre-planning phases.

Compass includes a series of ODFW habitat assessment layers, which use best available data in combination with ODFW priorities to highlight areas containing crucial habitat for fish and wildlife species, with a particular emphasis on high-priority species such as sage-grouse. The Compiled Crucial Habitat layer provides information on all species and habitats (aquatic and terrestrial), and a user can "drill down" into more detailed layers to get information on more specific aspects of the crucial habitat analysis. For example, the Terrestrial Species of Concern layer incorporates ODFW sage-grouse data and information, including ODFW Sage-Grouse Core Areas, sage-grouse lek locations, and other sage-grouse observation data to prioritize the landscape into six priority ranks. These six ranks range from Priority Rank 1 (most crucial habitat)—including Core Areas and documented identification of sage-grouse leks or observations—to Priority Rank 6 (least crucial habitat), which includes the parts of the landscape with no documented observations of high-priority species (but does include some overlap of species distribution models). All crucial habitat layers and priority rank definitions are provided, in detail, within the Compass data documentation page (http://dfw.state.or.us/maps/compass/data.asp).

In addition to the crucial habitat analysis layers, Compass includes many other ODFW data layers, as well as partner agency data that can be especially useful when looking at potential project impacts to sage-grouse habitat and habitat important to other species. Compass provides users with the ability to overlay sage-grouse Core Area and low-density boundaries with other ODFW datasets to get a more complete picture of what is occurring in a given area.

Users can also overlay partner data, such as roads and transportation infrastructure maintained by the Oregon Department of Transportation, the Protected Areas database maintained by the U.S. Geological Survey (USGS), and real-time and historic fire and fire perimeter data maintained and updated by GeoMAC, a partnership that includes USGS, the National Oceanic and Atmospheric Administration, the USFS, and others.

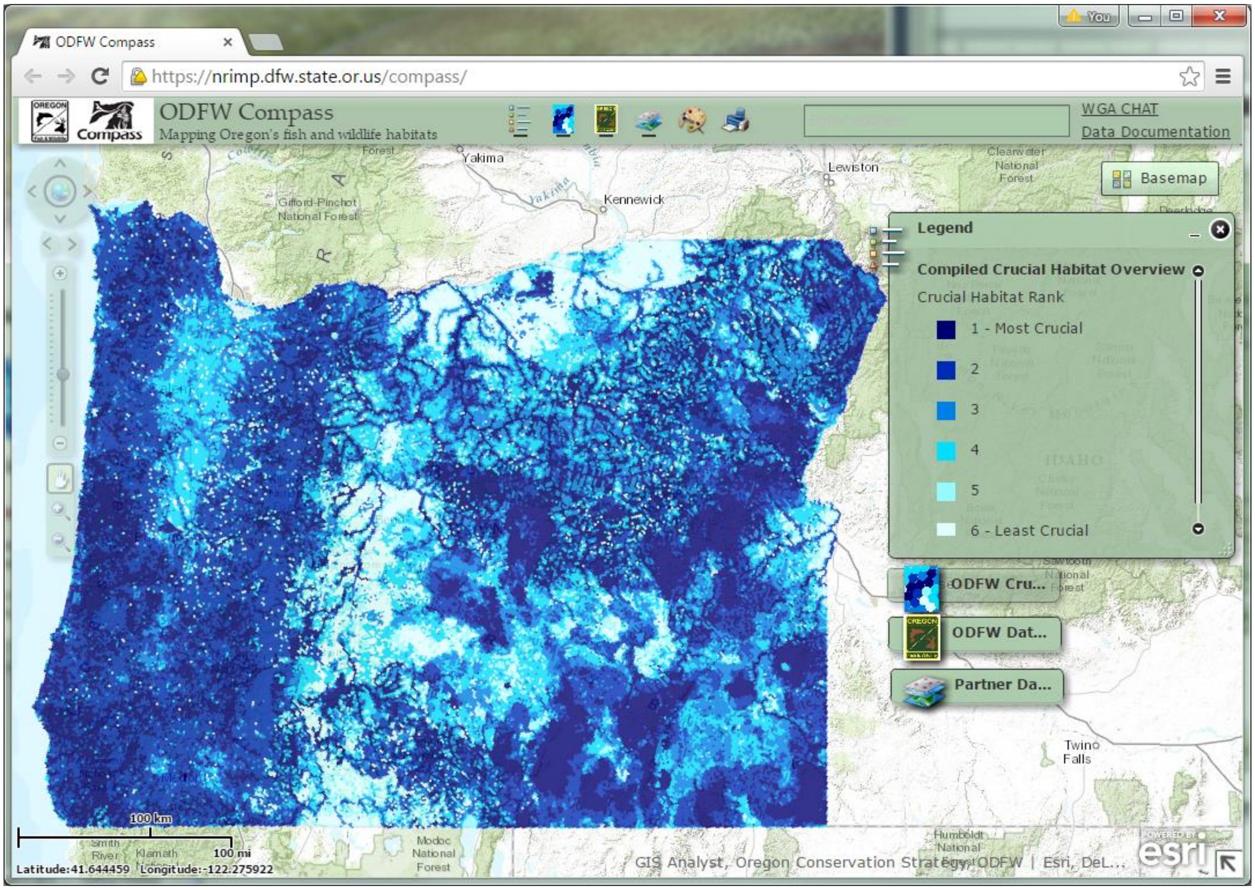

Figure 5. ODFW Compass (Centralized Oregon Mapping Products and Analysis Support System). Compass provides a wide variety of ODFW and partner data layers to users through an online mapping interface. Compass was developed as part of the Western Governors' Association Crucial Habitat Assessment Tool effort, designed to fill a multistate need for continuous, regional spatial data.

Compass and the ODFW crucial habitat analysis layers also provide additional connections to help guide users to data developed by ODFW partners, stakeholders, and neighboring state fish and wildlife agencies. The assessment units used within the crucial habitat analysis (one-square-mile hexagons) are the same units used in the ORDSS. This allows the two separate tools to be used in coordination with each other, and the specific data developed within each tool can be used within complex queries to highlight parts of the landscape that include specific habitat elements of concern. Additionally, because the crucial habitat layers were developed within the WGA CHAT effort (www.WestGovCHAT.org), these data layers can be viewed on a regional scale across state boundaries. This is especially helpful with respect to sage-grouse planning and habitat management, as some states (such as Oregon and Idaho) are incorporating high-priority datasets, such as sage-grouse Core Areas, at a similar level within their analysis, thereby providing seamless coverage of this data across the Oregon/Idaho boundary.

iv. Summary

Multiple tools are available to support the myriad of often complex decisions related to the implementation of conservation measures throughout the range of the greater sage-grouse in Oregon. They are in many ways interrelated and can work together to meet a diversity of decision-making needs. For example, the Resilience and Resistance Matrix supports the development of the state-and-transition models as well as ORDSS. The state-and-transition models describe the processes that need to be addressed, and have been used as the basis of spatial models that allow the state to monitor how different habitats within the greater-sage grouse areas change over time.

The two decision support tools described here allow decision makers to access and interpret the many different GIS datasets available, in Oregon and nationally, that support sage-grouse habitat recovery and protection. These tools also have been specifically designed to work together and complement each other. The tools use the same base assessment units, hexagons of one square mile in area, and cover Oregon's entire planning area for sage-grouse, in some cases extending beyond Oregon and into neighboring states. As a result, users can easily cross-query between these applications and utilize additional information for prioritizing areas of the landscape important to (a) sage-grouse, (b) other high-priority values (e.g., crucial habitat identified by ODFW), or (c) other Oregon resource values. For example, a user could use one or both tools to identify areas that contain important sage-grouse habitat but low values for ODFW crucial habitat in one or both tools. Users can highlight areas where the two tools show different results from similarly structured queries using maps, which is a function that may also highlight potential areas of resource conflict.

In addition, because they use the same assessment units, there is potential to grow the interactive capabilities of these tools over time. For example, enhancements to the Compass online interface could pave the way for integrating the ORDSS data layers and providing the public with customized reporting capabilities to answer common questions. The ORDSS layers can also be incorporated into future ODFW habitat updates, improving the crucial habitat assessment process, providing project planners with more consistent information, and producing even more collaboration between these two tools.

Two additional tools being developed to support plan implementation are the Habitat Quantification Tool and the Development Layer and Registry. The ORDSS is being used in the development of the Habitat Quantification Tool, which is designed to assess the impact of development and conservation actions under the mitigation approach outlined in Appendix 6. It will evaluate habitat and site conditions to determine project debits or offsets needed to compensate for impacts to important sage-grouse habitat and to determine available mitigation credits derived from credit-producing sites and projects. The Habitat Quantification Tool is on track for field testing in late 2015 and 2016.

The Development Layer and Registry is another tool that will be available to decision makers for mapping and quantifying the area of developed land in the sage-grouse range expected in winter 2015. The Development Layer portion of the tool has been developed as a prototype and used to determine baseline levels of developed land tied to land-use policy amendments approved by the Land Conservation and Development Commission. It will also be used by the Habitat Quantification Tool to estimate the direct and indirect impacts of proposed development projects. The Development Layer and Registry is being designed to integrate fully with the ORDSS and Compass.

Other tools exist that may be useful for planning and assessments related to sage-grouse monitoring, habitat restoration, and so forth. The tools identified here have direct ties to the Action Plan. All of the tools discussed above are envisioned to fit into a robust information system that can be used to support decision making at all levels, from statewide planning to site-scale planning and implementation, in tandem with the Action Plan.