Disturbance Response Grouping of Ecological Sites Increases Utility of Ecological Sites and State-and-Transition Models for Landscape Scale Planning in the Great Basin

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Case Study

Disturbance Response Grouping of Ecological Sites Increases Utility of Ecological Sites and State-and-Transition Models for Landscape Scale Planning in the Great Basin

By Tamzen K. Stringham, Patti Novak-Echenique, Devon K. Snyder, Sarah Peterson, and Keirith A. Snyder

On the Ground

- Ecological sites often occur at scales too small for application in planning large-scale vegetation treatments or post-fire rehabilitation.
- Disturbance Response Groups (DRGs) are used to scale up ecological sites by grouping ecological sites based on their responses to disturbances.
- A state-and-transition model (STM) is created for the DRG and refined through field investigations for each ecological site thereby creating STMs that function at both DRG and ecological site scales.
- The limited availability of ecological site descriptions hinders their use in large-scale management planning and may be a factor associated with the observed lack of application of available STMs
- Standardization of ecological site mapping tools for GIS platforms would increase the utility of DRGs, STMs, and ecological site descriptions for many land managers in the western United States.

Keywords: ecological site, state-and-transition model, disturbance response group, landscape-scale management, GIS.

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Ecological site descriptions have provided ecologically based guidance for land management decisions for more than 60 years[1]; however, the majority of utility has been realized on private lands primarily due to issues of scale. The spatial extent of individual ecological sites is determined through the correlation of sites to soil survey map units and provides a potentially valuable tool for management. Soil surveys are made by describing and classifying soils in the field and delineating their areas on maps, but different intensities of field study and degrees of detail in mapping are utilized by soil survey teams based upon the intended purposes for the soil survey. For rangeland applications, third-order soil surveys are conducted at the 1:24,000 to 1:63,360 scale and are appropriate for land uses that do not require precise knowledge of small areas or detailed soil information.[2] Therefore, it is not unusual to have multiple ecological sites correlated to one soil map unit (Fig. 1). Further complicating the issue of scale is the size of rangeland management units. For example, the average grazing allotment size in Nevada exceeds 60,000 acres[3] and rangeland wildfires vary in size often exceeding thousands of acres (i.e., wildfires in 2016 in Nevada have ranged in size from 832 to 122,292 acres).[4] Ecological sites have not been widely used by public land management agencies as a tool for management planning because they typically occur on the landscape at scales too small for landscape-scale decision-making.

However, recognizing the utility of ecological sites and the associated state-and-transition model (STM) for decision support, the Bureau of Land Management in Nevada has partnered with Nevada Natural Resources Conservation

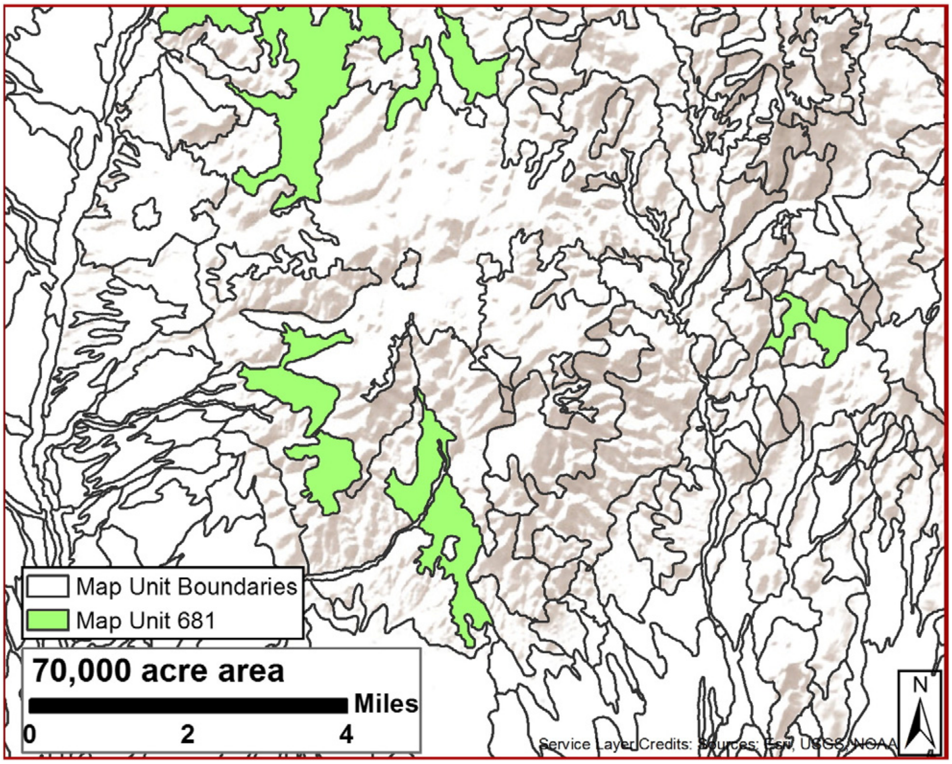

Figure 1. This illustration shows the complexity of a management unit. A total of 237 individual soil map units are shown in this 70,000-acre area. There are 9 polygons of map unit 681, totaling 4,200 acres. This map unit is highlighted to show the distribution of these polygons as they repeat across the landscape. Map unit 681 has three component soil series described: 45% Chad, 20% Cleavage, and 20% Softscrabble. Each of these are mapped to unique ecological sites, but the Chad soil at 45% is the dominant condition.

Service (NRCS) and the University of Nevada, Reno (UNR) in 2009 with the goal of formulating a team that could 1) expedite development of scientifically-sound STMs, and 2) provide a mechanism for utilizing STMs for decision support at scales larger than the individual ecological site. We present an overview of the process utilized for upscaling ecological sites and development of STMs along with a case study in which these tools were used for post-fire stabilization and rehabilitation planning.

Upscaling Ecological Sites into Disturbance Response Groups

The team of scientists, professional land managers, consultants, and interested stakeholders led by Dr Tamzen Stringham (UNR) and Patti Novak-Echenique (NV-NRCS) developed a process that examines local knowledge, soil mapping data and published literature on soils, plant ecology, plant response to various disturbances, disturbance history of the area, and any other important attributes necessary to sort pre-existing ecological sites into groups of ecological sites *based on their responses to natural or human-induced disturbances.*[5,6] These groups are referred to as Disturbance Response Groups (DRGs) and are defined as groups of ecological sites that respond similarly to disturbance, reaching the same state or endpoint although the rate of adjustment may vary by site.[7,8] This process is applied at the Major Land Resource Area (MLRA) scale with the entire MLRA being considered during the grouping effort. MLRAs are geographically associated land resource units made up of multiple ecological sites (Fig. 2). Relevant disturbances for each MLRA are identified by the team, however the primary disturbances in the Great Basin are wildland fire, insect herbivory, grazing by domestic livestock and wild horses, off-road vehicle use, and climatic events such as drought. Additionally, active vegetation management activities including tree removal methods, brush management treatments, and rangeland seeding are considered important. Environmental attributes identified as major controllers of ecological site response to disturbance include precipitation zone and soil temperature and moisture regimes.[9] Soil texture, soil depth, and depth to restrictive layers are also considered important. Extensive literature review and professional knowledge is utilized to determine vegetation dynamics in response to stressors and disturbances of the various plant communities that occur on each ecological site.[7,8] Finally, a generalized draft STM is created for the DRG and used as a template for discussion during field investigations.

Detailed field investigations are conducted for each ecological site group (DRG) within the MLRA by senior personnel including Stringham, Novak-Echenique, BLM staff, and a soil scientist in order to refine the generalized draft STMs and individual ecological site STMs into robust models appropriate for land management applications. Multiple locations for each DRG are visited and the following data is recorded: 1) soil pedon description (recorded on NRCS form

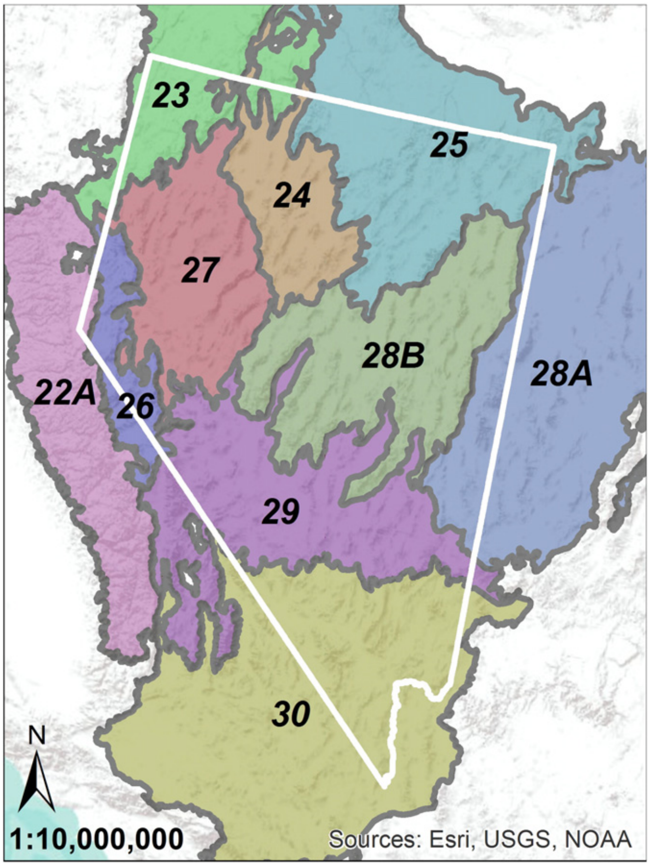

Figure 2. Major Land Resource Areas, Nevada.

232); 2) plant community composition by weight (according to USDA-NRCS[10]); 3) Rangeland Health Assessment[11]; 4) number of deep-rooted perennial bunchgrasses per square meter[12]; 5) resistance and resilience assessment[13]; 6) estimated number of pinyon or juniper per acre; and 7) determination of ecological state and community phase. The development of generalized DRG scale STMs, in concert with specific ecological site scale STMs, expedites the creation of robust STMs across MLRAs while providing a scalable decision support tool for management application. STMs for MLRA 28B, 28A Nevada, 25 Nevada, and 24 Nevada are available online.[i] STMs for MLRA 23 Nevada and 26 Nevada are in progress.

Challenges for Western Landscapes

In the western United States, megafires over the past decade have resulted in a renewed focus on pre-suppression vegetation management and post-suppression rehabilitation. Megafires are defined by the National Interagency Fire Center as a fire that burned at least 100,000 acres.[14] Nationally, annual average acres burned by wildfire increased from 2.9 million in the 1980s to 3.3 million in the 1990s and then doubled to 6.6 million acres burned per year from 2000 to 2009.[15] Nationally, this upward trend has continued with nearly 6.6 million acres per year burned from 2010 to 2015,[16] and during the 2012 to 2014 fire seasons over 1.2 million acres per year of greater sage-grouse habitat burned in the western United States.[15] The upward trend in acres burned per year has been the impetus for the Department of the Interior (DOI); US Department of Agriculture (USDA); tribes; other Federal, state, and local agencies; private industry; and various nongovernmental organizations (NGOs) to work together to implement presuppression, landscape scale vegetation management projects in an effort to reduce the frequency and intensity of rangeland fires and to rapidly restore lands affected by fire.[15] Nevada BLM is incorporating the use of DRGs and associated ecological site information into pre-suppression vegetation management and post-fire rehabilitation efforts, however application of STMs for management planning is not as apparent. Below we present a case study overview of a recent post-fire emergency stabilization and rehabilitation plan developed for the Anderson Fire located within the Virginia Mountains Complex (VMC) located in MLRA 26.

Virginia Mountains Complex: Anderson Fire

On 29 July 2016, lightning ignited numerous fires near Reno, Nevada. The VMC was composed of five separate wildland fires totaling 59,727 acres.[4] Shortly after the fires were contained, the BLM contacted UNR and requested DRG maps for the fire areas. The Anderson Fire, one of the five fires, burned approximately 16,276 acres (Fig. 3). Although the fire footprint occurs entirely in MLRA 26, the soil map units within the fire boundary are correlated to ecological site descriptions from MLRA 23, which is located approximately 11 miles north of the fire boundary.

To create the requested DRG map, soil maps were derived from the NRCS Gridded Soil Survey Geographic database (gSSURGO) for Nevada.[17] A statewide map was generated with ecological sites aggregated by Dominant Condition using the NRCS Soil Data Management Tools for ArcGIS. Mapping by Dominant Condition enables visualization of the dominant ecological site within each soil map unit, thus simplifying the list of soil map unit components. By selecting Dominant Condition, we acknowledge there may be a loss of information; however, this is the only method currently available to visualize dominant ecological sites and has been used previously to visualize soils geospatially.[18]

To create the dominant ecological site map, the soil map was joined in ArcGIS to a table that included MLRA, DRG number, and ecological site ID for all sites within the MLRAs of interest within the fire perimeters: MLRA 23 and 26. The soil map units were then dissolved to merge map units by MLRA/DRG, and set to display DRG with labels showing the MLRA number and DRG number. Finally, we cross-referenced the maps with a table of more detailed DRG information to identify the correct STM to use for management. MLRA 23 STMs are currently in development,

[i] Find the STMs for these MRLAs at http://ag.unr.edu/resources/MLRA.aspx

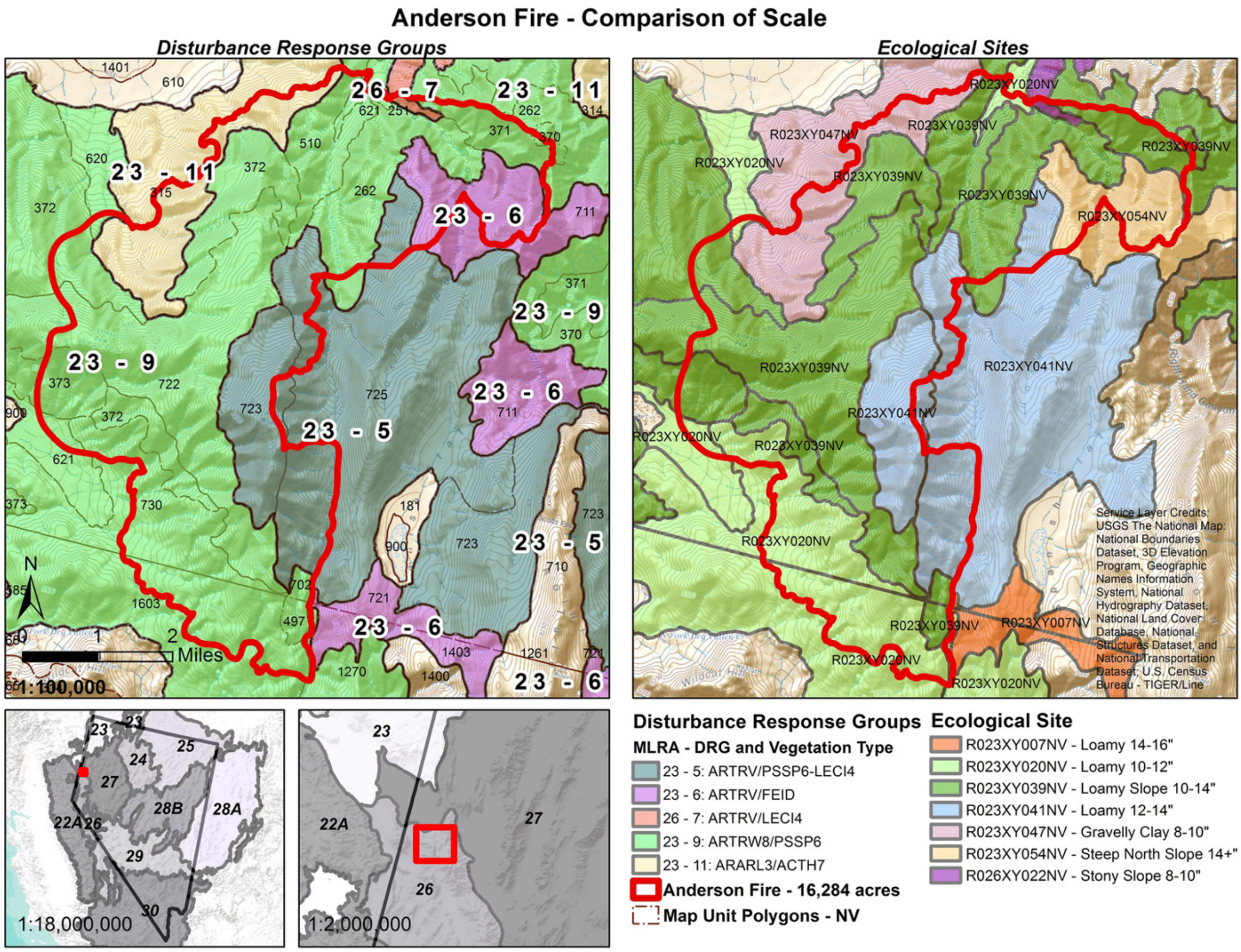

Figure 3. The Anderson fire shown with a comparison of a DRG map (left) and ecological site map (right). Soil Map Units are overlaid within the DRG map and are designated by three-digit labels whereas DRG units are labeled with larger hyphenated labels. Four prominent DRGs are displayed on the map. The lime green 23-9 DRG polygon contains eight soil map units with greater than 200 acres. The ecological site map indicates two different dominant ecological sites among these eight soil map units. The DRG map indicates that while there are two different ecological sites they are both members of the 23-9 DRG, thus the area can be managed at the DRG level utilizing the same STM (ARTRW8/PSSP6, Wyoming big sagebrush and bluebunch wheatgrass).

and draft STMs were provided by UNR to BLM for this effort.

Application to Decision-Making: Ecological Site vs. DRG Scale

The Anderson Fire demonstrates the importance of scale in ecological site mapping (Fig. 3). Wildland fires can reach tens of thousands of acres in size, and it is often unrealistic to treat each soil map unit or each unique ecological site as a separate management area. DRGs allow consolidation of soil map units and correlated ecological sites into larger polygons with the same STM. This simplifies the process of planning for fire rehabilitation because the generalized STM can function as a single planning tool for this larger polygon that represents a suite of ecological sites with similar responses to disturbance.

The Anderson Fire is a relatively small fire at 16,276 acres, but it demonstrates the utility of the DRG approach for rehabilitation planning. Within the fire boundary there were 18 unique soil map units and five dominant ecological sites (Fig. 3, Table 1), however in utilizing the DRG process two of the dominant ecological sites were combined to form DRG 23-9—Wyoming sagebrush (ARTRW8)/bluebunch wheatgrass (PSSPS) (Fig. 3, left panel). We recognize that other ecological sites occur within the DRG map boundary that may or may not be part of the DRG 23-9 group. However, within large-scale disturbances such as wildfire, DRGs provide managers with a planning tool based on the Dominant Condition (ecological site) of the consolidated polygon, allowing use of the generalized STM over a large planning area. The advantage of the DRG method is the "scaling up" of the ecological site concept that occurs by grouping neighboring map units with a dominant ecological site that is a member

Table 1. Soil and climate information for soil map units >200 acres contained in DRG 23-9 in the Anderson fire*

Map Unit	Acres	Dominant ecological site name and vegetation	Soil surface texture	Soil temperature regime	Soil depth (in)	Epipedon	Average annual precip (in)	Annual mean temp (°F)
MU 722	3,342	Loamy Slope 10-14 (45% of map unit)	Very stony loam	Mesic	61.02	Mollic	10-15	44-48
MU 262	1,370	Loamy Slope 10-14 (57% of map unit)	Very stony loam	Mesic	33.86	Mollic	10-14	45-52
MU 371	476	Loamy Slope 10-14 (59% of map unit)	Gravelly loam	Mesic	43	Mollic	8-20	42-52
MU 372	1850	Loamy Slope 10-14 (70% of map unit)	Gravelly loam	Mesic	43	Mollic	10-20	43-48
MU 373	430	Loamy Slope 10-14 (43% of map unit)	Gravelly loam	Mesic	43	Mollic	10-14	44-50
MU 510	776	Loamy Slope 10-14 (60% of map unit)	Very stony loam	Mesic	61	Mollic	8-14	45-52
MU 730	1233	Loamy 10-12 (59% of map unit)	Cobbly loam	Mesic	64	Mollic	8-14	45-52
MU 1603	1046	Loamy 10-12 (89% of map unit)	Very stony loam	Mesic	89	Mollic	9-14	46-52

Note. Map units 251, 370, 497, 621, and 702 are <200 acres and are omitted from this table.
* **Adapted from NRCS Soil Survey Staff.**[17,20]

of the same DRG into a larger polygon for landscape management planning (see left panel Fig. 3). In this example, rehabilitation plans may be developed using the generalized STM developed for DRG 23-9 instead of two different STMs developed for the individual ecological sites. The STM for DRG 23-9 is presented in Figure 4.

Use of DRGs in Emergency Stabilization and Rehabilitation Planning

The VMC was declared 100% contained on August 6, 2016 and an Interagency Burned Area Emergency Response (BAER) Team was immediately dispatched to assess the fire impact and develop an emergency stabilization and burned

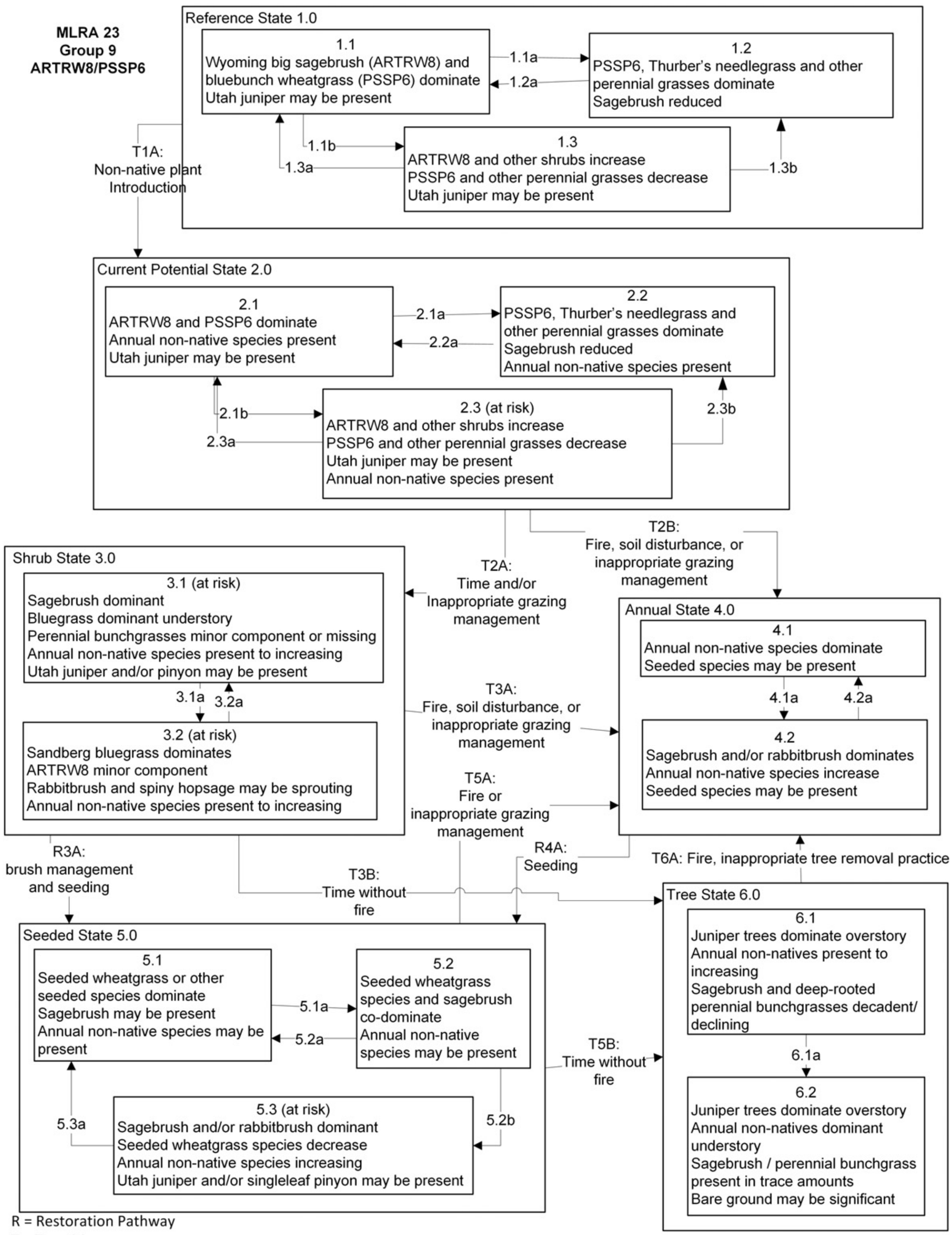

Figure 4. State-and-transition Model for Group 23-9, the dominant DRG from MLRA 23 within the Anderson fire perimeter.

area rehabilitation plan. The Interagency BAER Team identified the objective of wildlife habitat restoration as a primary focus for the Anderson Fire component of the VMC, based on the presence of 14,428 acres of burned greater sage-grouse habitat.[19] Utilizing information from a variety of sources, including DRG maps, burn severity maps, ecological site information, and NRCS Soil Mapper Rangeland Seeding Suitability data, the BAER team identified focal areas in which to plant sagebrush seedlings, apply herbicides for invasive annual grass suppression, and undertake aerial application of native grass and forbs. The BAER Team recognized the importance of treating invasive annual grass through the use of pre-emergent herbicide prior to revegetation efforts within the Wyoming sagebrush dominated DRG 23-9. In addition, the BAER Team identified approximately 1,500 acres within DRG 23-9 for focal plantings of Wyoming sagebrush seedlings in the fall of 2017. Furthermore, the BAER Team encouraged consultation with local scientists and rangeland conservationists to refine sagebrush planting locations and planting techniques.[19] In summary, the BAER Team utilized the DRG map and ecological site information, but application of the generalized STM was not apparent in the rehabilitation planning effort.

Recommendations for Improvements

Currently, incorporation of ecological site information and state-and-transition models in large-scale management planning is hindered by gaps in knowledge and training along with the lack of technology required to efficiently utilize these tools at large spatial scales. Utilization of STMs may be hindered by lack of available information indicating predisturbance ecological state or by general lack of knowledge on how to utilize STMs. Interagency BAER teams comprise individuals from multiple agencies and various backgrounds, suggesting knowledge of ecological site descriptions and STMs may be varied suggesting additional training may be warranted.

Furthermore, application of these tools for management planning are limited by the current lack of availability of ecological site descriptions from the NRCS Ecological Site Information System and the limited availability of large-scale geospatial soil mapping tools. Many land managers have ArcGIS software at their disposal and prefer to use this tool when faced with large-scale land management decisions such as fire rehabilitation. While NRCS has developed robust tools for visualizing soils for project areas of less than 100,000 acres (e.g., the Web Soil Survey[20]) the mapping products available for ArcGIS or other GIS platforms are lacking in their ability to produce detailed ecological site maps at larger scales. There is a need for a standardized and easy-to-use ecological site mapping tool for these GIS platforms to bring ecological site information to the fingertips of many more land managers. This tool would be particularly helpful for fire rehabilitation where the planning horizon is short.

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