



Rehabilitation planning at the landscape scale. The Martin Fire as a case study

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Abstract:

The Martin Fire, which ignited on July 5, 2018, in Nevada's Great Basin, burned over 177,750 hectares of shrubland, profoundly impacting rangeland ecosystems and wildlife habitats. This case study examines the methods and spatial datasets used to inform post-fire rehabilitation efforts, providing a framework for large-scale landscape restoration. Legacy grazing practices, compounded by an Aroga moth infestation, had degraded the herbaceous understory and increased fuel loads, further challenging recovery. Within the Bureau of Land Management's (BLM) 30-day Emergency Stabilization and Rehabilitation (ESR) planning window, tools were employed to evaluate pre-fire conditions, assess resilience, and prioritize rehabilitation needs.

Key methods included the use of Disturbance Response Groups (DRGs) to classify plant communities by their response to disturbances and the integration of remote sensing and ground-based vegetation data to map plant functional group cover. Near-real-time annual grass mapping, validated against ground measurements, highlighted areas prone to invasive species dominance, while soil texture and precipitation data-informed microclimate resilience assessments. Historical wildfire data provided context for evaluating past rehabilitation outcomes, and guiding strategies for the current fire rehabilitation effort.

Results revealed substantial variability in vegetation recovery, influenced by pre-disturbance conditions and environmental factors. Areas with resilient soils and adequate herbaceous cover recovered well, while those dominated by invasive annual grasses or dry fuels exhibited poor recovery. Herbicide treatments showed a notable reduction in bare ground and a temporary increase in annual vegetation, emphasizing the role of targeted interventions.

This study demonstrates the utility of spatial datasets and collaborative planning in addressing large-scale disturbances. While implementation remains complex, the lessons learned from the Martin Fire provide valuable insights for improving future wildfire rehabilitation strategies, emphasizing the importance of integrating ecological data to support decision-making at the landscape scale.

Introduction

On July 5, 2018, the Martin Fire ignited near Paradise Valley, Nevada, and over the course of several days, it consumed approximately 177,750 hectares of shrubland in the Great Basin, USA. Driven by strong winds, the fire devastated iconic landscapes and wildlife habitats. The affected area included the Owyhee High Plateau, a historically productive ranching region where plant communities had become dominated by woody vegetation. Legacy grazing practices had diminished the herbaceous understory, reducing its resilience to fire. Compounding the issue, a recent Aroga moth (*Aroga websteri*) infestation had defoliated and killed large portions of sagebrush across the region, leaving abundant dry fuel and a depleted seedbed for post-fire recovery.

This paper discusses the strategies and tools used to advise and support post-fire rehabilitation efforts in the wake of this disaster. Effective rehabilitation at this scale requires tools to assess pre-disturbance conditions, map plant communities, group areas by their disturbance response, evaluate the likelihood of natural recovery without intervention, and identify the most effective rehabilitation techniques. Within the 30-day window mandated by the Bureau of Land Management (BLM) for developing a rehabilitation plan and applying for Emergency Stabilization and Rehabilitation (ESR) funding, we aimed to provide a straightforward and effective framework for addressing this challenge.

The BLM's rehabilitation planning process was highly collaborative, incorporating input from local landowners, stakeholders, ranchers, wildlife managers, and rangeland professionals. The Stringham Rangeland Ecology Laboratory contributed resources to this effort, and this paper shares the datasets and visualization techniques employed during the planning process. While the efficacy of some rehabilitation measures is evaluated, the primary focus is on demonstrating how existing datasets can be integrated to enable rapid assessment and planning at such a large scale.

The tools developed by the Stringham Rangeland Ecology Laboratory, including Disturbance Response Groups (DRGs) as described in Stringham et al. (2016) and later works (Phipps and Stringham, 2024), were instrumental in assessing rangeland response to disturbances of this magnitude. These tools provided a framework for prioritizing resources and efforts in a triage-like manner, given the limited resources available for rehabilitating the entire burn area.

While numerous physical and political challenges influenced the implementation of the rehabilitation plan, this case study demonstrates the value of collaborative efforts and the practical application of these tools in addressing large-scale disturbances. As wildfires of this scale become increasingly common, the lessons learned from the Martin Fire rehabilitation process can inform future disaster response and landscape restoration efforts.

Methods

Once the Martin Fire was extinguished by regional wildland firefighters, the Bureau of Land Management (BLM) fire management teams provided final fire extent mapping (Personal communication, Phipps, 2018). To evaluate fire intensity, the BLM collected additional imagery and produced Burned Area Reflectance Classification (BARC) data. Using ArcGIS, the fire boundary was overlaid onto spatial datasets to guide response planning and assess pre-fire conditions. Relevant base data, including political boundaries and geographic information, were compiled to support subsequent analyses.

Disturbance Response Groups

Disturbance Response Groups (DRGs), as described by Stringham (2016), were clipped to the fire boundary to identify plant communities likely to exhibit similar post-fire responses. DRGs are based on Ecological

Sites, which are defined as “a distinctive kind of land with specific characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation” (NRCS, 2024). These groups cluster Ecological Sites by their resilience and response to disturbances such as wildfire. For example, areas dominated by plants capable of resprouting after fire are grouped together, while areas prone to invasive annual grass proliferation are classified separately. This analysis helped prioritize areas within the burn perimeter requiring stronger intervention and areas that may recover well without intervention.

Vegetation Monitoring Data

Pre-existing vegetation monitoring data were compiled across the burn area, including data from State-and-Transition Modeling, annual ranch monitoring, and national-scale efforts like the BLM’s Assessment, Inventory, and Monitoring (AIM) dataset and the NRCS National Resource Inventory (NRI). These datasets were normalized to display plant functional group and ground cover percentages, including categories such as annual grass, perennial grass, annual forbs, perennial forbs, shrubs, rock, litter, and bare ground. The point-based data were visualized in GIS, mapped to soil types and plant communities, and scaled using color ramps to highlight the relative dominance of functional groups.

Annual Grass Monitoring

Annual grass, a serious concern in the Great Basin, was of particular focus. Its presence increases wildfire spread and hinders post-fire recovery due to localized seedbeds that expand after disturbances. Near-real-time annual grass cover data (Boyte & Wylie, 2016) were used to map current grass cover across the burn area. Ground-based measurements collected using the Line-Point-Intercept method were assessed alongside remote sensing data to examine trends, revealing that remote sensing often underestimated annual grass cover. These comparisons informed adjustments and validated the data’s utility for large-scale assessments.

Multi-Source Remote Sensing Integration

The Multi-Resolution Land Cover Consortium (MRLC) Rangeland Condition Monitoring Assessment and Projection (RCMAP) products (Shi et al., 2022) were used to map plant functional group cover across the burn area. Ground-based data were compared to remote sensing values, and discrepancies were noted to interpret patterns across the larger landscape. Color-ramped visualizations of plant functional group cover allowed for efficient spatial assessments.

Precipitation and Soil Analysis

Annual precipitation strongly influences rangeland resilience (Chambers et al. 2013). However, the study area's remoteness limited access to on-site weather station data. Instead, precipitation data from PRISM (Daly et al., 2013) were modeled and categorized into zones familiar to resource managers. Recognizing PRISM’s limitations in capturing microclimates within the Basin and Range topography, the raster data were vectorized to better inform planning.

Soil characteristics, including texture and chemical properties, were analyzed using remotely sensed datasets (Chaney et al., 2016; Nauman et al. 2024). These datasets highlighted areas with high clay content, which retain water and support specific vegetation types, and regions with high pH levels, which may affect the efficacy of post-fire herbicide treatments like Imazapic.

Historical Wildfire Data

Historical wildfire perimeters from the U.S. National Interagency Fire Center were mapped and compared with annual grass cover data to evaluate past fire responses and rehabilitation outcomes. This overlay provided insights into the effectiveness of previous restoration efforts and informed current strategies.

Application to State-and-Transition Models

Plant functional group cover data were integrated with State-and-Transition models (Stringham and Snyder, 2017) to assess the likely post-fire trajectories of different areas. Areas with intact perennial bunchgrass understories were identified as more likely to recover without additional intervention due to a generally positive response to fire from perennial grasses, while shrub-dominated areas with limited herbaceous cover were flagged as at risk of transitioning to annual grass dominance.

This comprehensive, multi-scale analysis informed targeted rehabilitation strategies to optimize resource allocation and address post-fire challenges effectively.

Results

Variation in vegetation response was observed across the study area. Areas with poor pre-disturbance conditions, characterized by low perennial herbaceous biomass and abundant dry fuels such as Aroga moth (*Aroga websteri*)-killed stands of Wyoming Big Sagebrush (*Artemisia tridentata* var. *wyomingensis*), have visibly shown limited recovery. In contrast, areas with more resilient soils and favorable pre-disturbance conditions exhibited visibly better plant community recovery, often independent of rehabilitation efforts.

Visual observation of the remotely sensed cover data by plant functional groups appears to show evidence of the application of pre-emergent herbicides. Approximately three years after herbicide treatment, corresponding to the duration the chemical remains active in the soil, a clear pattern emerged: bare ground appears to have decreased while annual vegetation increased. These trends are visibly apparent in the data, and were not remeasured due to lack of funding, but are consistent with measurements acquired by other groups and local knowledge of the area.

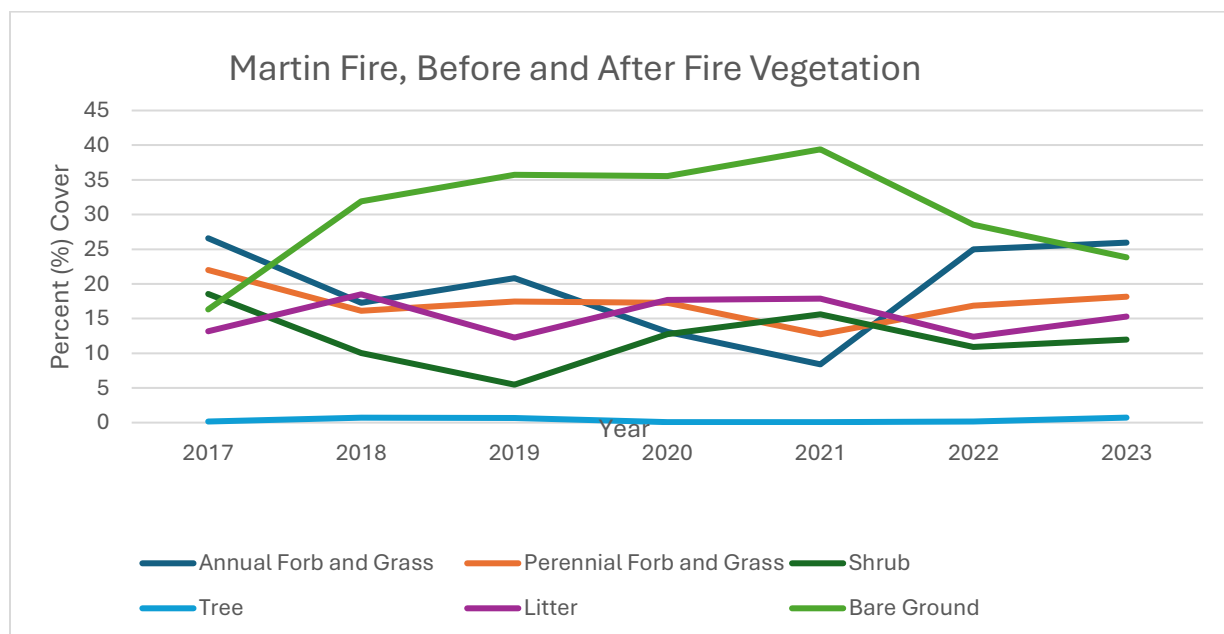


Figure 1: Data from the Rangeland Analysis Platform (RAP) summarizes vegetation response across the entire Martin Fire perimeter. These results average diverse plant community responses before and after the fire, capturing the variability across the landscape.

During site tours following the fire, it was visibly evident that perennial bunchgrass establishment was particularly evident in the southern portion of the study area, where aggressive cultivars like crested wheatgrass (*Agropyron cristatum*) performed well. Areas receiving additional soil moisture, such as drainages or slopes with reduced evaporation and solar gain (north- and northeast-facing aspects), also demonstrated stronger recovery of native vegetation which is dramatically visible on the landscape due to increased resilience in these microclimates.

Maps generated during the study, included in Appendix A, supported the development of a restoration plan by the BLM's Elko District Emergency Stabilization and Rehabilitation (ESR) Coordinator, Marissa Murphy. Her collaborative approach incorporated input from diverse stakeholders, which not only enhanced the plan's quality but also facilitated broader stakeholder support.

These findings highlight the importance of integrating vegetation, herbicide, and soil data to understand post-fire recovery dynamics and inform future rehabilitation efforts.

Discussion [Conclusions/Implications]

This case study highlights the use of spatial datasets and methods for post-wildfire rehabilitation assessment and planning, with a focus on their application across large spatial scales. The purpose of this discussion is to provide illustrative examples of these tools and techniques rather than to test specific hypotheses. Additional maps and spatial analyses will be included in the accompanying poster to be presented at IRC 2025.

While the implementation and success of post-wildfire rehabilitation involve a complex interplay of variables, many of which are beyond control, this study emphasizes the potential of emerging datasets and spatial methods to support effective planning. By demonstrating how these tools can be applied to large-scale rehabilitation efforts, we aim to contribute to the development of more efficient and informed decision-making processes in post-fire recovery.

The authors are actively engaged in further advancing this field and are working on additional tools to enhance rehabilitation planning at landscape scales. We welcome continued dialogue on this topic and encourage interested readers to contact us using the provided email addresses for further discussion.

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