# The Effect of Post-fire Rehabilitation and Climate on Fire Regimes in Wyoming Sagebrush Steppe

**Chris Bowman-Prideaux[1]\*, Beth A. Newingham[2], and Eva K. Strand[3]**

[1] Department of Forest, Rangeland, and Fire Sciences, University of Idaho, Moscow, Idaho 83844; bowm9710@alumni.uidaho.edu

[2] Agricultural Research Service, Reno Nevada 89512; Beth.Newingham@usda.gov

[3] Department of Forest, Rangeland, and Fire Sciences, University of Idaho, Moscow, Idaho 83844; evas@uidaho.edu

\* Correspondence: bowm9710@alumni.uidaho.edu

**Supplementary Materials:**

**Table S1.** Geospatial data extracted from shapefiles and raster data sets and used in in the predictor matrix for the nonparametric multiplicative regression analyses.

| Predictor Variable | Note | Source |
|---|---|---|
| **Treatment and Fire History** | | |
| Aerial treatments | Total number (pre- and post-fire treatments) | Seeding treatment shapefiles from multiple sources: |
| Drill treatments | Total number (pre- and post-fire treatments) | • Jarbidge and Bruneau Field Office, BLM[4], Idaho (personal communication) |
| Total treatments | Total number (drill and aerial) | |
| First treatment year | First year a seeding treatment occurred[1] | • Mountain Home Air Force Base, D.O.D. (personal communication) |
| First treatment | First type of seeding treatment | |
| First post-fire treatment year | First year a seeding treatment after a fire[2] | • National Operations Center, BLM [1] |
| First post-fire treatment | First type of seeding treatment | • Land Treatment Digital Library, USGS[4] [2] |
| Pre-fire treatment | Type of seeding treatment before the most recent fire | |
| Post-fire treatment | Type of seeding treatment after the most recent fire | |
| First fire year | First year a fire burned the site | BLM Idaho fire perimeters [3] |
| **Resistance and Resilience** | | |
| Index rating | Resistance and resilience index rating [4] | Sage Grouse Initiative [5] |
| **Anthropogenic Features** | | |
| Distance to nearest road | Within 5 km radius, calculated | TIGER 2015 Roads [6] |
| Total road length | Within 5 km radius, calculated | |
| Total area of private land | Within 5 km radius, calculated | BLM Idaho Surface Management Agency [7] |

| | | |
|---|---|---|
| Elevation (10 m resolution) | Digital elevation model | National Elevation Dataset [8] |
| **Climate³** | | |
| Maximum temperature | Monthly, seasonal, annual | Parameter-elevation relationships on independent slopes model [9] |
| Minimum temperature | Monthly, seasonal, annual | |
| Maximum vapor pressure deficit | Monthly, seasonal, annual | |
| Minimum vapor pressure deficit | Monthly, seasonal, annual | |
| Precipitation | Monthly, seasonal, annual | |

1. Seeding treatment applied for any reason (e.g.- sagebrush removal, prescribed fire, or wildfire).
2. Prescribed fire or wildfire.
3. These variables include the 30-year average for each month, season, and the annual (16 variables in total).
4. **United State government agency abbreviations: BLM- Bureau of Land Management, U.S**.G.S.- U.S. Geological Survey.

Data Citations

1. NOC, *Completed vegetation treatments. U.S. Department of the Interior (DOI), Bureau of Land Management, Idaho State Office, GIS Staff. https://catalog.data.gov/dataset/vegetation-treatment-area-completed-polygonbd74a, Accessed: March 1, 2015.* 2014.

2. Pilliod, D.S. and J.L. Welty. *Land Treatment Digital Library: U.S. Geological Survey Data Series 806. Online at http://pubs.er.usgs.gov/publication/ds806 (March 2013).* 2013; Available from: https://ltdl.wr.usgs.gov/.

3. BLM. *Historic fire perimeters. U.S. Department of the Interior (DOI), Bureau of Land Management, Idaho State Office.* 2015; Available from: https://catalog.data.gov/dataset/fire-perimeters-historic-polygon, Accessed: March 1, 2015.

4. Maestas, J.D., et al., *Tapping soil survey information for rapid assessment of sagebrush ecosystem resilience and resistance.* Rangelands, 2016. **38**(3): p. 120-128.

5. SGI. *Ecosystem resilience and resistance*. 2016; Available from: https://map.sagegrouseinitiative.com/ecosystem.

6. Division, G., *TIGER 2015 Roads*, U.S.C.B. U.S. Department of Commerce, Editor. 2015: USDA Geospatial Data Gateway.

7. BLM, *BLM Idaho Surface Management Agency (Surface Ownership)*, B.o.L.M.B. U.S. Department of Interior, Idaho State Office, Editor. 2015.

8. USGS. *National Elevation Dataset*. 2012 [cited 2013 March 1]; Available from: https://datagateway.nrcs.usda.gov/GDGOrder.aspx.

9. Daly, C. *United States average monthly and annual precipitation, 1981-2010 (4km; BIL)*. 2013; Available from: http://www.prism.oregonstate.edu/.

**Table S2**. Treatment histories for sites by the total number of aerial or drill seeding. Sites labeled "never seeded" have no recorded seeding treatment since 1950.

| Treatment Type | Treatment (n) | Sample size |
|---|---|---|
| Aerial | 0 | 313 |
| | 1 | 177 |
| | 2 | 65 |
| | 3 | 16 |
| | 4 | 1 |
| | 5 | 1 |
| Drill | 0 | 264 |
| | 1 | 244 |
| | 2 | 57 |
| | 3 | 8 |
| Never seeded | - | 199 |

**Table S3.** The number of sites treated by aerial or drill seeding on site with a history of 0-7 fires,.

| | Fire (n) | Seeding (n) | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | ≥3 |
| **Aerial** | **0** | 160 | 3 | 0 | 0 |
| | **1** | 55 | 60 | 0 | 0 |
| | **2** | 65 | 65 | 24 | 0 |
| | **3** | 17 | 25 | 16 | 5 |
| | **4** | 7 | 15 | 12 | 8 |
| | **5** | 6 | 6 | 10 | 2 |
| | **6** | 3 | 3 | 2 | 2 |
| | **7** | 0 | 0 | 1 | 1 |
| **Drill** | **0** | 126 | 30 | 5 | 2 |
| | **1** | 52 | 59 | 4 | 0 |
| | **2** | 57 | 75 | 19 | 3 |
| | **3** | 13 | 35 | 14 | 1 |
| | **4** | 9 | 22 | 10 | 1 |
| | **5** | 5 | 16 | 2 | 1 |
| | **6** | 2 | 6 | 2 | 0 |
| | **7** | 0 | 1 | 1 | 0 |
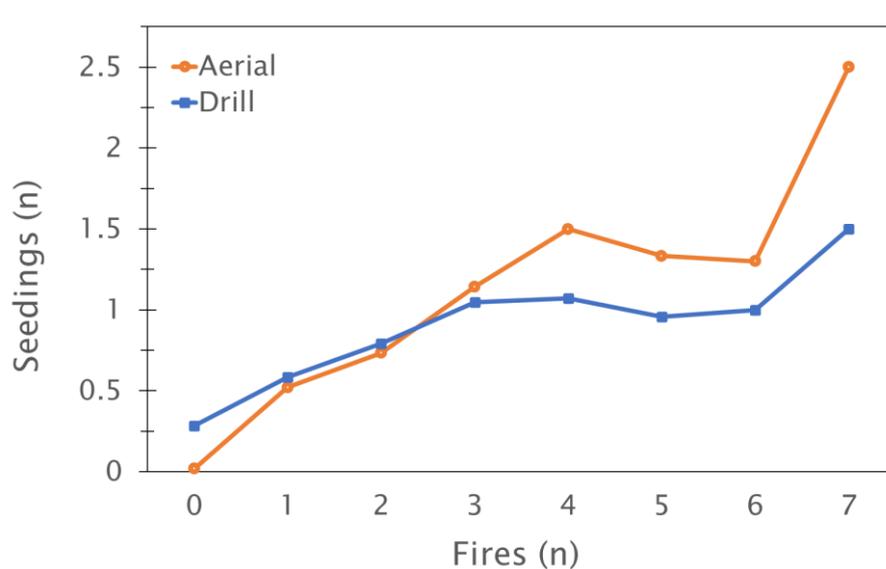
**Figure S1.** The weighted average number of aerial and drill seedings for sites that had 0-7 fires.

**Table S4.** The relative contribution of biomass from each functional type to the NMS ordination. The ordination explained 90% of the variation in data (axis 1- $R^2$=0.628; axis 2- $R^2$=0.272).

|  | Axis 1 | | | Axis 2 | | |
|---|---|---|---|---|---|---|
|  | r | r-sq | tau | r | r-sq | tau |
| Perennial Bunchgrass | -0.468 | 0.219 | -0.331 | 0.636 | 0.404 | 0.427 |
| Annual grass | 0.073 | 0.005 | 0.097 | -0.925 | 0.855 | -0.789 |
| Forb | -0.217 | 0.047 | -0.06 | -0.341 | 0.117 | -0.256 |
| Shrub | 0.941 | 0.886 | 0.841 | 0.049 | 0.002 | 0.095 |
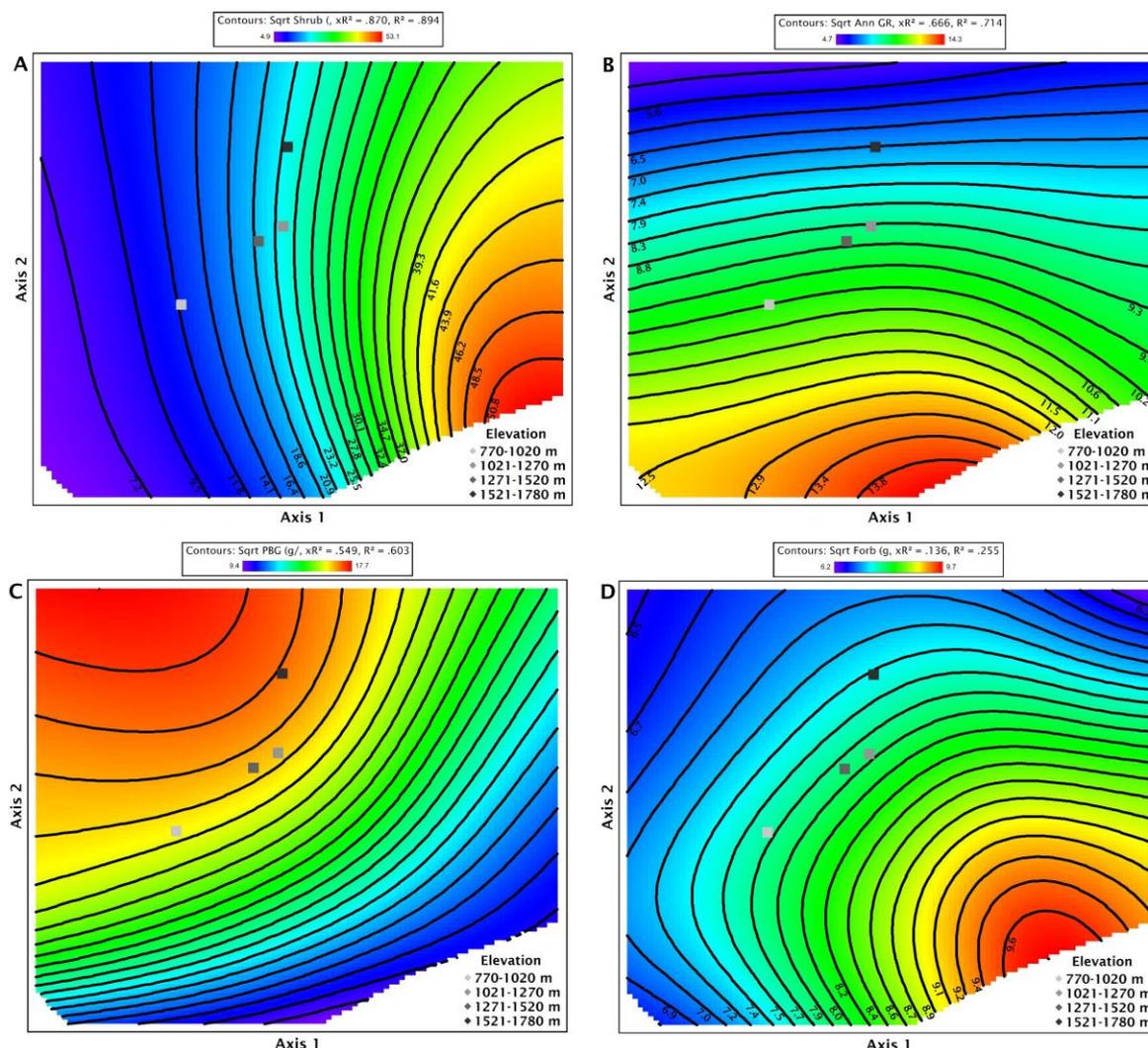
**Figure S2.** Contour maps showing where shrub (A), annual grass (B), perennial bunchgrass (C), and

**Table S5**. Multiple comparisons between different seeding treatments nested within elevation ranges. Seeding treatments were on unburned (n=11) and burned sites (n=56). Significant differences based on the False Detection Rate adjusted alpha ($\alpha$=0.0115) noted with (*) while all comparisons with a p < 0.05 are indicated in bold. The *T*-statistic indicates how different each group is while A is the chance corrected within-group similarity. The table is sorted by lowest to highest p-value.

| Elevation-Seeding | vs. | Elevation-Seeding | *T* | A | p |
|---|---|---|---|---|---|
| **High-Aerial*** | **vs.** | **Low-Unseeded** | **-6.48** | **0.25** | **0.0002** |
| **High-Aerial*** | **vs.** | **Med High-Aerial** | **-3.92** | **0.19** | **0.0025** |
| **High-Aerial*** | **vs.** | **Low-Aerial** | **-3.51** | **0.21** | **0.0039** |
| **High-Aerial*** | **vs.** | **Med Low-Aerial** | **-3.02** | **0.10** | **0.0097** |
| **High-Aerial** | **vs.** | **Med Low-Unseeded** | **-3.01** | **0.12** | **0.0161** |
| **High-Aerial** | **vs.** | **Med High-Unseeded** | **-2.39** | **0.10** | **0.027** |
| **High-Unseeded** | **vs.** | **Med High-Aerial** | **-2.10** | **0.24** | **0.035** |
| **Med Low-Aerial** | **vs.** | **Med Low-Unseeded** | **-2.20** | **0.10** | **0.038** |
| **Med High-Aerial** | **vs.** | **Med Low-Drill** | **-1.94** | **0.16** | **0.044** |
| High-Aerial | vs. | High-Unseeded | -1.85 | 0.10 | 0.051 |
| Low-Unseeded | vs. | Med Low-Drill | -1.80 | 0.08 | 0.06 |

| | | | | | |
|---|---|---|---|---|---|
| Med Low-Drill | vs. | Med Low-Aerial | -1.71 | 0.08 | 0.07 |
| Med Low-Drill | vs. | Low-Aerial | -1.62 | 0.17 | 0.07 |
| Low-Unseeded | vs. | Med Low-Aerial | -1.54 | 0.06 | 0.08 |
| High-Aerial | vs. | Med High-Drill | -1.51 | 0.05 | 0.08 |
| Low-Unseeded | vs. | High-Unseeded | -1.43 | 0.08 | 0.09 |
| Low-Unseeded | vs. | Med Low-Unseeded | -1.31 | 0.06 | 0.10 |
| Med High-Aerial | vs. | Med Low-Aerial | -1.29 | 0.11 | 0.11 |
| Med Low-Unseeded | vs. | Low-Aerial | -1.12 | 0.10 | 0.13 |
| Med High-Aerial | vs. | Med High-Unseeded | -1.05 | 0.08 | 0.14 |
| Med Low-Aerial | vs. | Low-Aerial | -1.08 | 0.10 | 0.14 |
| Med High-Aerial | vs. | Med Low-Unseeded | -0.97 | 0.07 | 0.15 |
| Med High-Unseeded | vs. | Low-Unseeded | -0.85 | 0.04 | 0.17 |
| High-Unseeded | vs. | Med Low-Unseeded | -0.87 | 0.07 | 0.17 |
| Med High-Drill | vs. | Low-Unseeded | -0.77 | 0.03 | 0.19 |
| Med High-Aerial | vs. | Med High-Drill | -0.81 | 0.04 | 0.19 |
| Med High-Drill | vs. | Low-Aerial | -0.83 | 0.05 | 0.19 |
| Med High-Drill | vs. | Med Low-Unseeded | -0.55 | 0.02 | 0.22 |
| Med High-Unseeded | vs. | Low-Aerial | -0.53 | 0.05 | 0.25 |
| Med High-Unseeded | vs. | Med Low-Aerial | -0.47 | 0.02 | 0.26 |
| Med Low-Drill | vs. | Med Low-Unseeded | -0.27 | 0.01 | 0.28 |
| Med Low-Drill | vs. | High-Unseeded | -0.36 | 0.03 | 0.28 |
| High-Aerial | vs. | Med Low-Drill | -0.40 | 0.02 | 0.29 |
| Med High-Unseeded | vs. | Med Low-Unseeded | -0.03 | 0.00 | 0.35 |
| Med High-Drill | vs. | High-Unseeded | -0.19 | 0.01 | 0.36 |
| Med High-Drill | vs. | Med Low-Aerial | -0.13 | 0.00 | 0.37 |
| Med High-Unseeded | vs. | High-Unseeded | -0.03 | 0.00 | 0.39 |
| High-Unseeded | vs. | Med Low-Aerial | -0.11 | 0.01 | 0.40 |
| Med High-Drill | vs. | Med High-Unseeded | 0.24 | -0.01 | 0.49 |
| Med High-Unseeded | vs. | Med Low-Drill | 0.33 | -0.02 | 0.51 |
| Med High-Aerial | vs. | Low-Unseeded | 0.60 | -0.04 | 0.68 |
| Med High-Drill | vs. | Med Low-Drill | 0.76 | -0.03 | 0.77 |
| Low-Unseeded | vs. | Low-Aerial | 0.81 | -0.05 | 0.78 |
| Med High-Aerial | vs. | Low-Aerial | 0.50 | -0.09 | 1.0 |