Post-fire Recovery of Mountain Sagebrush in the Intermountain West, USA

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BACKGROUND

Fire frequency estimates for mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) communities of the Intermountain West can be inferred from:

(1) Tree-ring-based fire chronologies at the forest-shrubland ecotone.

(2) Rates of post-fire sagebrush recovery and rates of competitive exclusion by tree invasion, bounding a minimum and maximum mean fire return interval compatible with mountain big sagebrush life history traits.

Figure 1. (a) Mountain Big Sagebrush fire regime compatibility , (b) pinyon pine encroaching into mountain sagebrush , and (c) fire-scarred tree on shrubland-forest ecotone.

VARIABILITY IN RECOVERY RATE

- ❑ **Recovery time can be highly variable! What explains this between-site variation?**
- ❑ **Productivity? Is recovery rate faster in more productive sites?**
- ❑ **Stochastic weather? Is the timing of precipitation important to recovery rate through interactions with sagebrush phenology?**

Table 1. We used the following spatial variables and historic precipitation estimates (derived from PRISM data) to construct candidate models that explained post-fire recovery rates.

Variable code	Description	Influence on Mechanism	Influence on Recovery
TSF	Time since fire	(+) recruitment/reproduction	+
Spatial heterogeneity			
Heatload	Function of slope/aspect/latitude	(-) Water balance	-
SoilDepth	Average soil depth	(+) Water balance/N,P,K	+
Elev	Elevation	(+) Water balance	+
JanMin	30-yr avg. of Jan. min. temp.	(+) Snowpack	+
AugMax	30-yr avg. of Aug. max. temp.	(-) Seedling survival	-
Phosphorous	Total Phosphorous	(+) limiting nutrient	+
Nitrogen	Total Nitrogen	(+) limiting nutrient	+
%Sand	% Sand (proxy for soil texture)	(+) Seed burial/water balance	+
Temporal heterogeneity			
G0	Apr-Sep precip. year before fire	(+) Seed production	+
W0	Oct-Mar precip. year before fire	(+) Seed germination	-
G1	Apr-Sep precip. year of fire	(+) Fuel moisture/fire intensity	+
W1	Oct-Mar precip. after fire	(+) Germination/establishment	+
G2	Apr-Sep precip. year after fire	(+) Seedling survival	+

FIELD METHODS

We measured canopy cover of mountain big sagebrush and co-occurring woody species at 27 historic fires with paired-control sites using a 100-m line-intercept method. Burn ages were stratified between the Colorado Plateau, Utah Highlands and Great Basin..

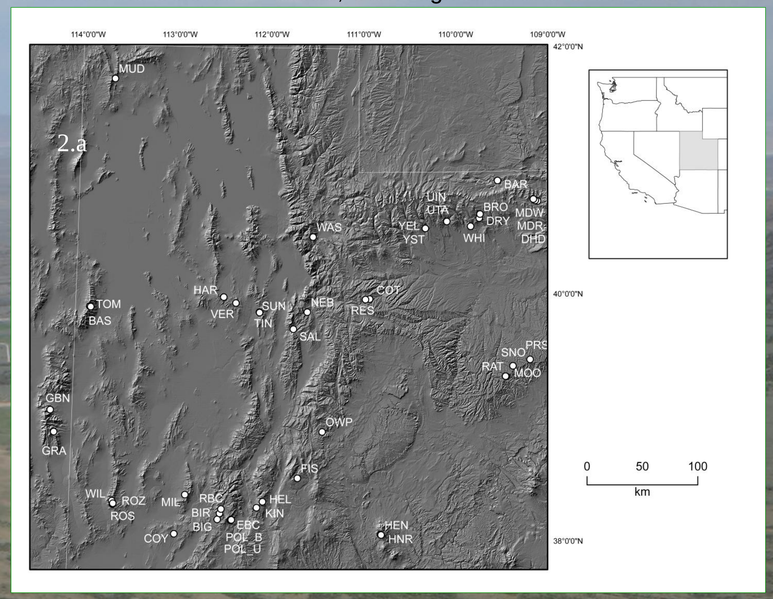


Figure 2. (a) Locations of study sites in Utah and Nevada. A subset of these sites were used that were paired with a control, (b) from left, root crowns for aging sagebrush, measuring cover, and fire-scarred ponderosa pine stump in mountain sagebrush with stage-2 pinyon pine encroachment.

ANALYSIS AND RESULTS

We calculated a response variable as a % recovery of a nearby unburned control transect to relativize recovery rate by site potential.

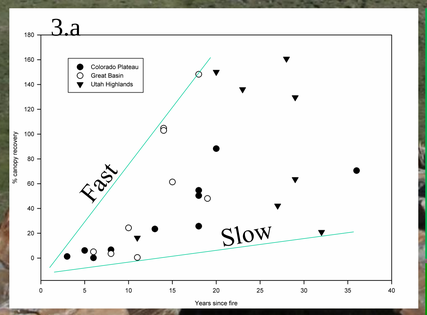


Figure 3. (a) Variability in post-fire recovery ranged from 14 years to predicted values of greater than 100 years with an average of 39 years predicted by a linear regression model explaining only 23% or the variance (b) examples of control and burned sites.

Table 2. Multivariate candidate models of mountain sagebrush recovery rate

Model	Number of parameters[b]	AIC_c value	Δ_i	ω_i	Adjusted R^2
TSF*Mar.1+ELEVATION	**6**	**21.44**	**0.00**	**0.4233**	**0.630**
TSF*G0+G2	**6**	**23.44**	**2.00**	**0.1560**	**0.601**
TSF*G0+W1	**6**	**23.44**	**2.00**	**0.1558**	**0.601**
TSF*Mar.1	**5**	**24.00**	**2.56**	**0.1179**	**0.581**
TSF*G0	**5**	**25.20**	**3.76**	**0.0647**	**0.562**
TSF*G0+ELEVATION	**6**	**25.45**	**4.01**	**0.0571**	**0.570**
TSF*W1+ELEVATION	**6**	**27.08**	**5.64**	**0.0252**	**0.544**

[b] number of independent variables plus the intercept and error term.

- ➢Whether or not a site recovers fast or slow may depend on **elevation** and:
- ➢**Summer precipitation in the year before fire** (seed production)
- ➢ **Winter/spring precipitation in the year after fire** (germination and establishment)

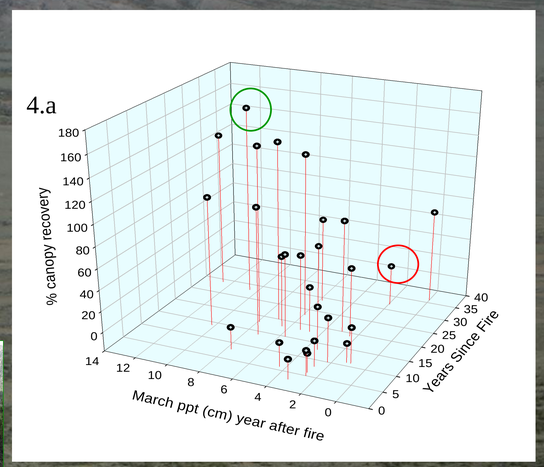
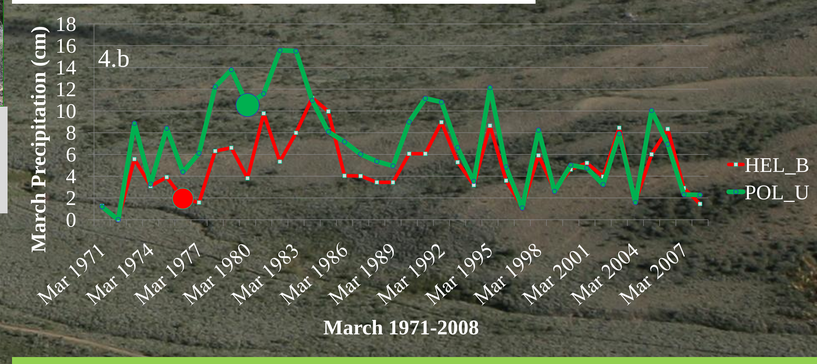


Figure 4.(a) Low amounts of March precipitation in the spring after fire explained slow recovery rates (b) The two circled points burned in 1975 (red) and 1979 (green). The 1975 burn has recovered to 20% of the pre-burn cover; the 1979 burn "over-shot" the pre-burn cover with 160% at sampling in 2007. Note the between-site differences in March precipitation in the late 1970s.



SUMMARY and MANAGEMENT IMPLICATIONS

- ➢Recovery rates of mountain sagebrush ranged from **14 years to more than 100 years** (based on current trajectories), and **averaged 39 years** across the Colorado Plateau, Utah Highlands and Eastern Great Basin.
- ➢The variance in recovery rate after accounting for site productivity with controls was not significantly related to soil depth, aspect, slope or soil texture.
- ➢Our data suggest that whether or not recovery happens quickly may depend on elevation and stochastic weather patterns including:
  1. **Summer precipitation in the year before fire** which we hypothesize boosts **seedbank** viability leading to higher rates of post-fire establishment from residual seedbank that survives the fire.
  2. **Spring precipitation in the year after fire**, providing favorable soil moisture for **germination and seedling survival.**

ACKNOWLEDGEMENTS: This research is supported in part by funds provided by the Rocky Mountain Research Station, Forest Service,U.S. Department of Agriculture, and by the Joint Fire Science Program (project 06-3-1-17). For field and lab work we acknowledge: Benjamin Bright, Todd Granberry, Miles Nielson, Brian Reeves, and Trenton Young.

Joint Fire Science Program