Restoring shrub-steppe after wildfire: shrub planting as a viable tool in habitat rehabilitation

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Hanford Reach National Monument

Designated by Presidential Proclamation 7319, June 9, 2000

195,000 acres superimposed over the Department of Energy (DOE) Hanford Site
Monument Environmental Setting

- **Hottest and Driest** part of Washington State
- **Rain shadow** of Cascade Mountains
- **6” precipitation** annually on average
- Most precipitation comes in winter
- Elevation range from 350 - 3,660 ft.
- Soils are primarily alluvial silts and sands deposited during the Ice Age Floods
Hanford Reach National Monument Management Goals

- Protect and restore the native habitats and biodiversity of the shrub-steppe ecosystem.

- Monitor, protect, and recover native plants and animals that are federally or state listed and any other species that are in any other way considered sensitive.
Fire History

277,354 Total acres
169,083 FWS acres
(56,406 have re-burned)

*Only includes fires over 300 acres
Example: 24 Command Fire

- National BAER Team
- Loss of life
- Loss of property
- 164,884 acres
Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*); spiny hopsage (*Atriplex [= Grayia] spinosa*); winterfat (*Eurotia lanata*); threetip sagebrush (*Artemisia tripartita*). Bars = 1 standard deviation. 2004 values with accompanying script letter are statistically lower than pre-fire values: $a = P < 0.0001$; $b = P < 0.005$; $c = P < 0.05$; $d = P < 0.10$.  

Changes in Shrub Cover
Nursery Stock Types and Treatments

- 10 cubic inch tublings
- 4 cubic inch tublings
- Bare Root Plants
  - Hydrogel
  - Mycorrhizae
Site Selection

- Native understory
- Shrubs pre-fire
- Large blocks

Methods

- Installed by professional planting crews
- 350-450 plants/acre
- ~ 10’ spacing
Sagebrush Monitoring Field Technique

- Plants mapped at time “zero” immediately post-planting and considered “Healthy”
- 100 meter transect as baseline
- 10-12 meters wide
- ~100 plants per transect
- Origin point randomly selected within planting polygons
- Plants classified as “Healthy”, “Stressed”, “Dead”
Environmental Variables recorded for each monitoring plot (02)

- Slope
- Aspect
- Heat Load Index
- Elevation
- Percent cover cheatgrass
- Percent cover Bluebunch wheatgrass
- Percent cover all perennial grasses
- Percent cover all grasses
2001 Plantings vs. 2002 Plantings

- Planted 173,348 plants
- 9 polygons, 500 acres
- 18 monitoring transects installed
- Monitored 1992 individual plants
- Approximately 1% of total planted

- Planted 717,403 plants
- 13 polygons, 1600 acres
- 26 monitoring transects installed
- Monitored 2880 individual plants
- Approximately 0.5% of the total planted
Overall Percent Survival of Plantings by Stock type

ANOVA  DF = 3, F= 5.66, p = 0.0025 : BR + significantly different from all other types
Stock Type % Survival by Planting Year, After 3 years

Chi-square test ($\chi^2 = 378.414; P < 0.0001$), pairwise chi-square Bonferonni corrected $\alpha$ ($\alpha = 0.05$).
% Flowering (Year 3, 2002 cohort only)

(PERMANOVA followed by Tukey HSD, P = 0.05).
## Correlations between Wyoming Big Sagebrush Survival (2002-04) and Environmental, Community and Treatment Variables

<table>
<thead>
<tr>
<th>Survival (%)</th>
<th>Alive + Stressed</th>
<th>Alive only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td>-0.23</td>
<td>-0.20</td>
</tr>
<tr>
<td>Slope</td>
<td>-0.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-0.45&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Aspect</td>
<td>-0.09</td>
<td>-0.10</td>
</tr>
<tr>
<td>Heat load index</td>
<td>0.33</td>
<td>0.31</td>
</tr>
<tr>
<td>Condition (±: BR = 1; tubling = 0)</td>
<td>-0.20</td>
<td>-0.16</td>
</tr>
<tr>
<td>Hydrogel (±)</td>
<td>-0.20</td>
<td>-0.16</td>
</tr>
<tr>
<td>Mycorrhizae (±)</td>
<td>-0.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.78&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sagebrush planted density</td>
<td>0.12</td>
<td>0.07</td>
</tr>
</tbody>
</table>

### Percent cover

<table>
<thead>
<tr>
<th></th>
<th>Alive + Stressed</th>
<th>Alive only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheatgrass</td>
<td>0.00</td>
<td>0.03</td>
</tr>
<tr>
<td>Bluebunch wheatgrass</td>
<td>-0.27</td>
<td>-0.30</td>
</tr>
<tr>
<td>All perennial bunchgrasses</td>
<td>-0.08</td>
<td>-0.11</td>
</tr>
<tr>
<td>All grasses</td>
<td>-0.31</td>
<td>-0.31</td>
</tr>
</tbody>
</table>

The symbol ± indicates presence-absence variables. Values accompanied by the following superscripts are significant:  
- a - $P < 0.0001$
- b - $P < 0.05$. 

National Wildlife Refuge System
Seasonal Precipitation 2001-2005

Data courtesy Hanford Meteorological Station (HMS), Hanford Site, Washington
Exploring BR + Mycorrhizae

- Wyoming big sagebrush forms mycorrhizal associations
- Plants in BR + & BR - treatments were sampled
- All roots were colonized with mycorrhizae, but a non-mycorrhizal fungus (unknown origin) was also present

Conclusion:
Wet years following 2002 plantings, combined with the application of mycorrhizal gel in addition to hydrogel, may have restricted oxygen to plant roots and decreased survival of BR + mycorrhizal treatment.
Pros and Cons

**Bare root Stock**

**PROS**
- Larger size initially
- Begin flowering sooner
- Easier to scale up production

**CONS**
- Variable stock quality
- Variable survival

**Tubling Stock**

**PROS**
- 4” similar to 10”
- Easier to install
- Consistent survival

**CONS**
- Longer time to flowering
- Monitoring more intensive
No recruitment of big sagebrush seedlings was recorded within the shrub seed treatment plots in 2004.
Economic Comparison

- **Dollars**

- **Initial Cost**
- **Cost Per Surviving plant**

- **4T 2001**
- **4T 2002**
- **10T 2001**
- **BR - 2001**
- **BR - 2002**
- **BR + 2002**
Conclusions After 3 Years Monitoring

- Plantings placed 249,410 surviving seedlings across ~2100 acres

- Densities ranged from 45 to 225 plants/acre

- Most planted seedlings in 2005 were vigorous and expected to develop a shrub component *in excess* of what would have established without active planting

- As surviving plants become reproductive, natural establishment should begin to augment plantations
Wrap up

• Out planting of nursery grown stock is more reliable than direct seeding as a method for restoring shrubs to the landscape

• Development of high-quality shrub-steppe habitat with in-tact native understory vegetation and microbiotic crusts favors planting over seeding

• Planting can have a comparable cost when compared to seeding, especially if several years of seeding are required to establish shrubs from seed