Using plastic tree shelters and mechanical weeding practices to improve post-fire ecological restoration of highly invaded California native plant communities

Mark Mazhnyy
Effects of high fire frequency on shrublands

- Reduced recovery time for shrubs between fires
  - Higher shrub mortality
- Increased annual grass cover
  - Benefited by increased fire frequency and reduced competition from shrubs
Restoration via seeding into tree shelters

- **Lowered costs**
  - Via local seed collection and seeding on site

- **Potential higher establishment**
  - Tree shelters protect seedlings from herbivory and facilitate seedling growth by altering microclimate around seedling like a nurse plant
  - Stress gradient hypothesis
    - Positive interactions more common in high stress environments
      - Slopes vs. flat areas
      - South-facing vs. north-facing slopes
Questions and hypotheses

1. How do plastic tree shelters affect seedling germination and establishment, represented by seedling presence and survival?
   a. Hypothesis: Sheltered seeds will experience higher germination and survival rates than the exposed seeds due to amelioration of physical stresses by tree shelters.

2. How does the facilitative effect of tree shelters change along an environmental gradient of site slopes and aspects?
   a. Hypothesis: The facilitative effect of tree shelters on seed germination and seedling establishment will be most apparent in the harshest environmental conditions (e.g. steep, south-facing slopes).
Site description

- ANF near Santa Clarita, CA
- 2002 Copper Fire (8k hectares)
- Plant communities: coastal sage scrub, chaparral, Douglas fir, riparian
- Highly invaded by non-native grasses and forbs
  - Cattle grazing
  - Frequent fires
- Mediterranean climate
  - Avg. annual precipitation 420 mm
  - Study precipitation
    - 2020: 188.5 mm
    - 2021: 47.6 mm
Treatments

- Shelter + seed
- Cage + seed
- Exposed + seed
- Outplant
Study species

- *Salvia leucophylla*
- *Salvia mellifera*
- *Eriogonum fasciculatum*

- Seed collected locally and treated prior to seeding to increase germination rate
- 2 replicates per species per treatment at each site
- Seeded in January 2020
- Outplants added in March 2021
Data collected

- $P_S$ - seedling presence (proportion of subplots with any seedlings present)
- $P_L$ - seedling survival (proportion of subplots with surviving live seedlings present)
- Total solar radiation
- Soil moisture
Abiotic effects of shelters

- Shelters reduced total solar radiation by nearly 30%
- Shelters retained about 5% more soil moisture during dry summer, fall, and early winter months than Exposed
  - Soil shading by shelters may lead to higher soil moisture retention
Seedling presence ($P_S$)

- **Slope**
  - Seedling presence ($P_S$) highest in the Shelter treatment on steeper slopes

- **Aspect**
  - Seedling presence ($P_S$) highest in Shelter treatment across all aspects
Slope and seedling survival ($P_L$)

- Seedling survival ($P_L$) higher in the Shelter treatment on most steep slopes even with decreased overall survival in second year
  - Likely due to higher soil moisture retention in Shelter treatment on steep slopes
  - May also be due to prevention of soil erosion and seedling burial
Aspect and seedling survival ($P_L$)

- Seedling survival ($P_L$) higher in Shelter treatment than others on nearly all aspects in both years
  - Low overall $P_L$ on S-facing aspects likely due to higher solar radiation in fall and winter combined with low overall precipitation this season
Cost analysis

- Cost of outplanting nearly 8x higher than cost of seeding into shelters
  - Due to purchasing nursery-raised outplants and watering them during establishment
- Cost of each seeded treatment per surviving seedling was 2.5x higher for Cage and 2x higher for Exposed than Shelter

### Costs of seeding and outplanting methods (including shared costs).

<table>
<thead>
<tr>
<th>Category</th>
<th>Material Expenditures ($)</th>
<th>Travel Expenditures ($)</th>
<th>Labor Hours</th>
<th>Total Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establishment</td>
<td>1538.27</td>
<td>521.34</td>
<td>83.62</td>
<td>3732.01</td>
</tr>
<tr>
<td>Monitoring</td>
<td>0.00</td>
<td>208.53</td>
<td>36.67</td>
<td>941.93</td>
</tr>
<tr>
<td>Total</td>
<td>4673.94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outplanting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establishment</td>
<td>5866.00</td>
<td>9071.20</td>
<td>1010</td>
<td>35137.20</td>
</tr>
<tr>
<td>Monitoring</td>
<td>0.00</td>
<td>782.00</td>
<td>45</td>
<td>1682.00</td>
</tr>
<tr>
<td>Total</td>
<td>36819.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shared</td>
<td>794.54</td>
<td>1798.60</td>
<td>245.53</td>
<td>7503.74</td>
</tr>
</tbody>
</table>

### Seeding costs for the Shelter, Cage, and Exposed treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Material Expenditures ($)</th>
<th>Travel Expenditures ($)</th>
<th>Labor Hours</th>
<th>Total Cost ($)</th>
<th>Number of Subplots with Live Seedlings</th>
<th>Cost per Surviving Seedling ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelter</td>
<td>1538.27</td>
<td>729.87</td>
<td>120.29</td>
<td>4673.94</td>
<td>99</td>
<td>47.21</td>
</tr>
<tr>
<td>Cage</td>
<td>2141.63</td>
<td>729.87</td>
<td>231.08</td>
<td>7493.10</td>
<td>65</td>
<td>115.28</td>
</tr>
<tr>
<td>Exposed</td>
<td>438.57</td>
<td>729.87</td>
<td>120.29</td>
<td>3574.24</td>
<td>37</td>
<td>96.60</td>
</tr>
</tbody>
</table>
Conclusions and Acknowledgments

- Shelters reduced solar radiation, increased soil moisture, and had higher seedling presence and survival than the other treatments on steep slopes and south-facing aspects.
- Shelters are recommended for low-cost plant community restoration in arid and semiarid environments.

Project funding sources:
- National Fish and Wildlife Foundation (NFWF), CSU Agricultural Research Institute (ARI), and Cal Poly Pomona (CPP)