Using careful site selection and plastic tree shelters to improve post-fire ecological restoration of highly invaded California native plant communities

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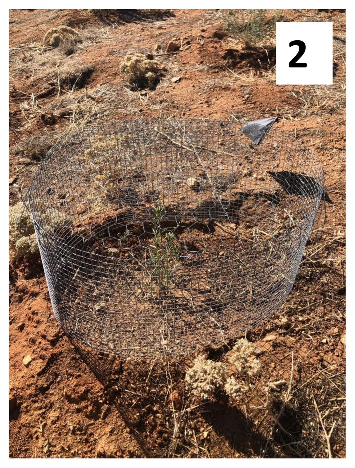
Introduction

- As wildfire frequency in California is increasing, native plant communities are experiencing increased invasion by non-native grasses (5). Restoration methods that are rapid, relatively low-cost, and that can improve native plant recruitment are needed to resist further invasion.
- Plastic tree shelters are typically used to protect seedlings from herbivory, but they have also been shown to improve plant growth by limiting direct sunlight and wind exposure and increasing soil moisture availability (1, 2, 3, 4, 6).
- **Objective:** This study examined how tree shelters affect seedling germination and establishment in a restoration of a highly invaded California native mixed chaparral and coastal sage scrub community in the Copper Fire area of the Angeles National Forest.
- **Hypothesis**: Sheltered seedlings will experience higher germination and growth rates than exposed seedlings due to mitigation of physical stresses by tree shelters.

Experimental Design

Treatments

1. **Shelter** – seedlings protected from herbivory and excessive solar radiation and wind exposure by 30 cm tall, 10 cm diameter Tree Pro Protector made from single-walled recycled polyethylene; ventilated.
2. **Cage** – seedlings protected from herbivory by 30 cm tall, 50 cm diameter cage made from 19-gauge hardware cloth and topped with 20-gauge chicken wire mesh.
3. **Exposed** – seedlings not protected from herbivory or solar radiation and wind exposure by anything.



Methods

- The study incorporated 30 sites, encompassing a broad range of slopes, with one replicate of each treatment at each site.
- Sites were weeded of non-native, invasive grasses and forbs prior to and shortly after seeding.
- Seeds of the following three species were collected locally and treated with the best-known protocols for increasing germination rates prior to seeding: *Eriogonum fasciculatum*, *Salvia leucophylla*, and *Salvia mellifera*.
- The following abiotic measurements were taken on nine replicates of the Shelter and Exposed treatments and three replicates of the Cage treatment:
  - Total solar radiation at 10 cm above the soil surface
  - Soil moisture at 6 cm below the soil surface
  - Air temperature at 10 cm above the soil surface
- The following seedling data were collected on eight replicates of each treatment:
  - Number of seedlings
  - Seedling height
  - Aboveground seedling volume

E. fasciculatum

S. leucophylla

S. mellifera

Results

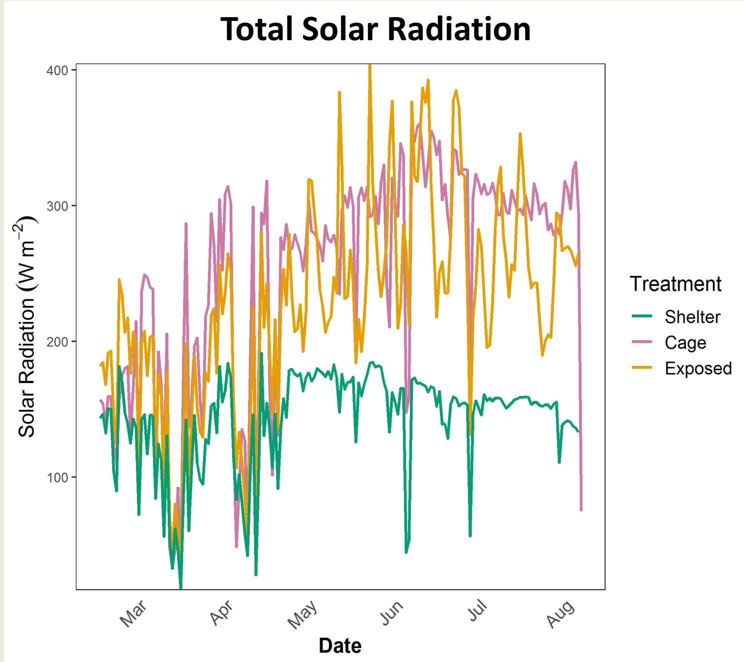


Figure 1. Shelter treatment let in 36% less radiation on average than Exposed. Total solar radiation at 10 cm above the soil surface measured continuously from March to August, 2020. Data are daily averages across three replicates of each treatment.

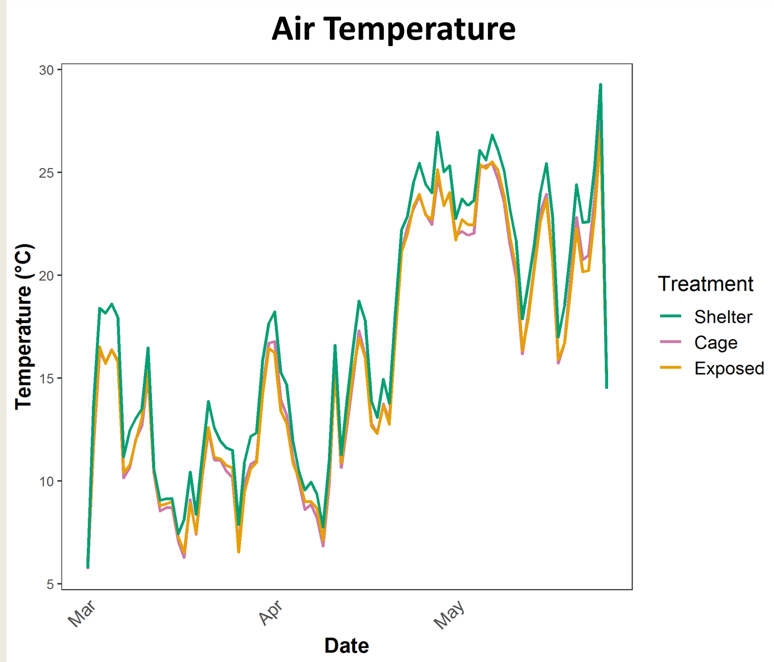


Figure 2. Shelter treatment had higher air temperature than both Cage and Exposed. Air temperature measured every 30 minutes from March 1 to May 26, 2020. Data are daily averages across two replicates of each treatment. The average daily temperatures for Shelter, Cage, and Exposed treatments were 17.2°C, 15.9°C, and 15.9°C, respectively.

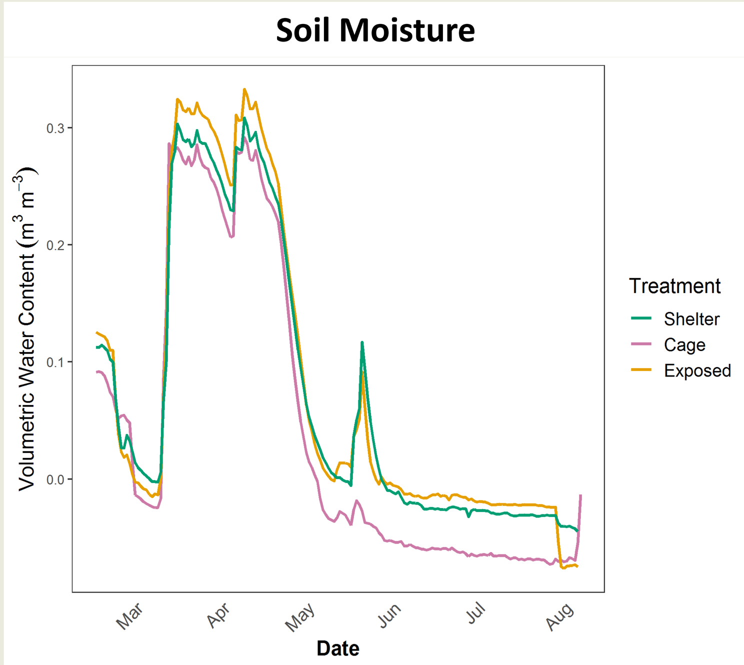


Figure 3. No differences between Shelter and Exposed treatments; Cage had lowest soil moisture. Soil moisture measured as volumetric water content (VWC) continuously from March to August, 2020. Data are daily averages across three replicates of each treatment. Cage treatment displayed 52% less soil moisture than the Shelter treatment and 56% less than the Exposed.

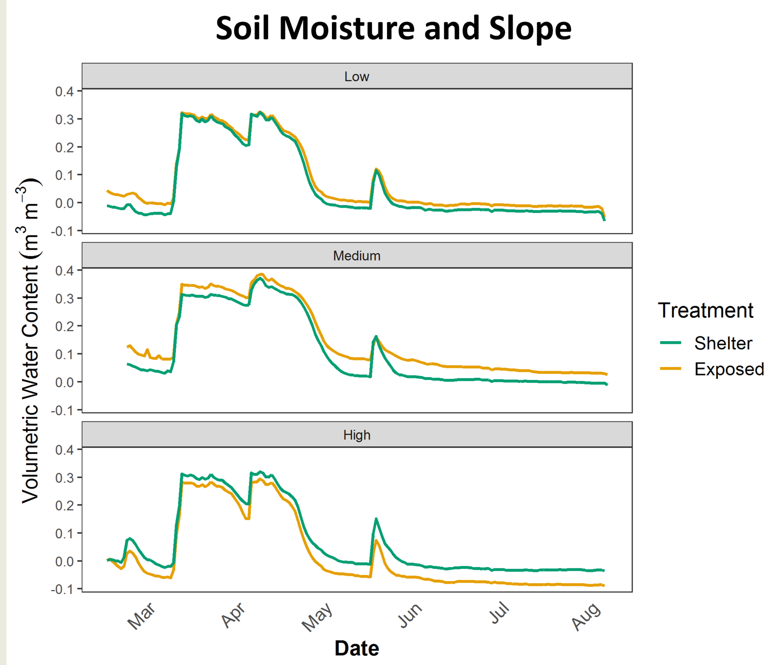


Figure 4. Shelter treatment had higher soil moisture than Exposed on high slopes. Soil moisture measured as volumetric water content (VWC) continuously from March to August, 2020. The top panel represents sites with Low slopes, middle panel represents sites with Medium slopes, and bottom panel represents sites with High slopes. For each slope category, data are daily averages across two replicates of Shelter and Exposed treatments. High slopes had the lowest average soil moisture.

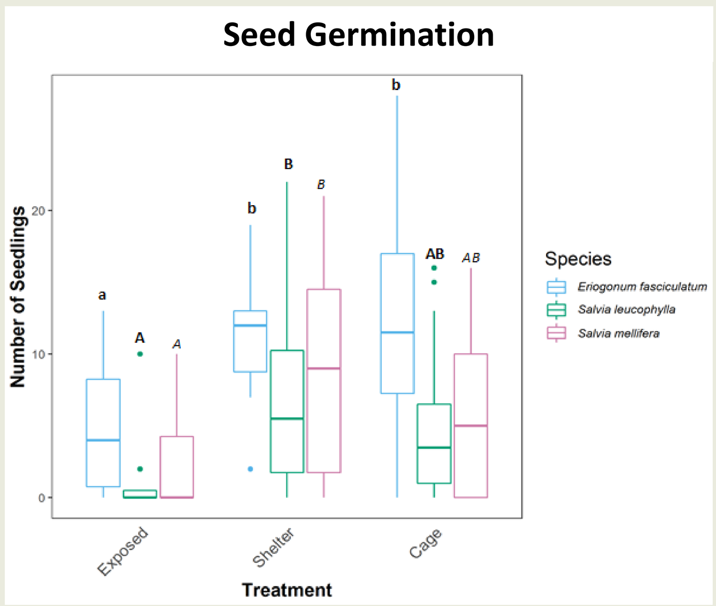


Figure 5. Germination was higher in Cage and Shelter treatments compared to Exposed. Number of seeds germinated in each treatment averaged across eight replicates of each treatment and separated by species. Letters indicate significant differences between treatments within each species. Differences in germination were statistically significant among treatments (two-way ANOVA, $F_{2, 135} = 17.18$, $P < 0.001$) and species ($F_{2, 135} = 9.42$, $P < 0.001$), but the interaction between treatments and species was not significant ($F_{4, 135} = 0.68$, $P = 0.607$).

- *Eriogonum fasciculatum* germinated at a higher rate in both Shelter and Cage treatments than Exposed.
- Both *Salvia* species germinated at a higher rate in Shelter treatment than Cage and Exposed.

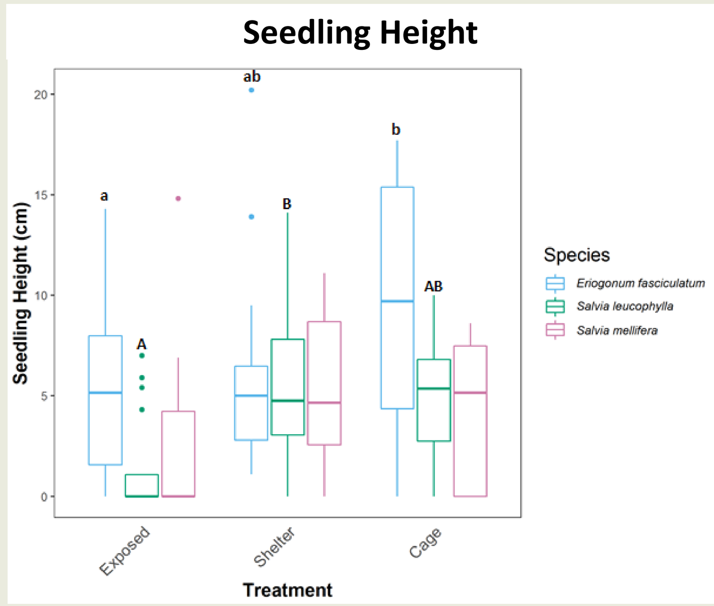


Figure 6. Seedlings were taller in Cage and Shelter treatments compared to Exposed. Height of tallest seedling in each subplot averaged across eight replicates of each treatment and separated by species. Letters indicate significant differences between treatments within each species. Differences in seedling height were statistically significant among treatments (two-way ANOVA, $F_{2, 135} = 7.65$, $P < 0.001$) and species ($F_{2, 135} = 6.94$, $P < 0.01$), but the interaction between treatments and species was not significant ($F_{4, 135} = 1.59$, $P = 0.18$).

- *Eriogonum fasciculatum* seedlings were significantly taller in Cage treatment than Exposed.
- *Salvia leucophylla* seedlings were significantly taller in Shelter treatment than Exposed.

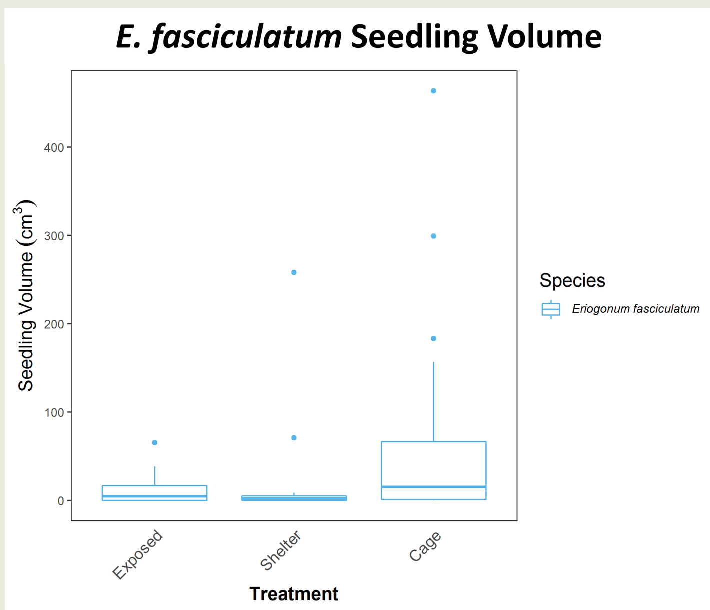


Figure 7. Seedlings were largest in Cage treatment. Aboveground volume of tallest seedling in each subplot averaged across eight replicates of each treatment. There were no significant differences between treatments (one-way ANOVA, $F_{2, 45} = 2.59$, $P = 0.086$).

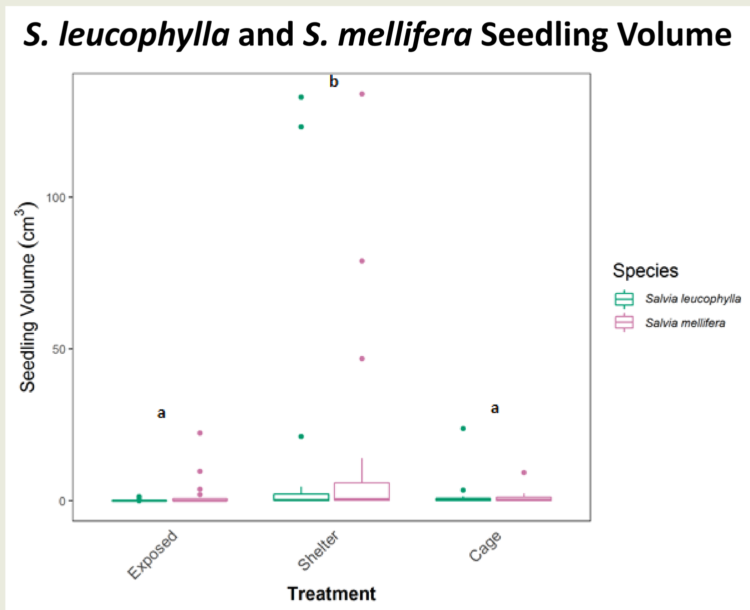


Figure 8. Seedlings were larger in Shelter treatment compared to Cage and Exposed. Aboveground volume of tallest seedling in each subplot averaged across eight replicates of each treatment and separated by species. Letters indicate significant differences between treatments (two-way ANOVA, $F_{2, 90} = 4.96$, $P < 0.01$).

Discussion

Abiotic data

- **Air temperature:** Shelter treatment retained higher air temperatures than both Cage and Exposed treatments.
- **Solar radiation:** Shelter treatment let in 36% less radiation than Exposed treatment.
- **Soil Moisture:** Shelter and Exposed treatments were no different in soil moisture retention overall, likely due to high temperatures inside shelters. Shelter treatment exhibited higher average soil moisture than Exposed on high slopes, indicating shelters may be useful on steep sites.

Seedling data

- **Germination:** *E. fasciculatum* seedlings germinated at a higher rate in both Shelter and Cage treatments compared to Exposed. Both *Salvia* species germinated at a higher rate in the Shelter treatment compared to Exposed.
- **Seedling height:** *E. fasciculatum* seedlings were taller in the Cage treatment compared to Exposed, and *S. leucophylla* seedlings were taller in the Shelter treatment compared to Exposed.
- **Aboveground seedling volume:** *E. fasciculatum* seedlings were largest in the Cage treatment, while the two *Salvia* species were largest in the Shelter treatment.

Restoration Implications

The tree shelters (left) may be better suited for growing shade-tolerant species that do not exhibit early lateral growth. The cages (right) may be better suited for growing species that are adapted to high light and exhibit early lateral growth.

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