Impacts of fog drip on survivorship and growth of native herb and shrub seedlings on Santa Rosa Island

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Introduction

Dwindling oak groves

Overgrazing on Santa Rosa Island, California (Fig 1) led to loss of topsoil in ridgeline groves of endemic island oaks (*Quercus tomentella*). Non-native ungulates have been removed from the island since 2013, but heavy losses in oak populations had been evident by the early twentieth century, and the remaining oaks' roots and underlying bedrock remain exposed in the absence of stabilizing vegetation, (Fig 2, Ref 1).

Figure 1. Map of the Northern Channel Islands, with Santa Rosa Island indicated in yellow.

Figure 2. Island oak (*Quercus tomentella*) grove on Soledad Ridge, Santa Rosa Island; tree roots and sandstone bedrock visibly exposed. Photograph by Julianne Bradbury.

Restoration techniques

If native herbs and shrubs can be established in the barren bedrock surrounding oak groves, they may help to stabilize the remaining substrate and begin the long process of rebuilding topsoil.

Figure 3. STAR fellow Julianne Bradbury holding a planting pillow, newly constructed for installation at Soledad Ridge, Santa Rosa Island. Photograph by Kathryn McEachern.

Planting pillows, burlap sacks filled with planting mix and secured to the ground, can be used as incubation structures for seedlings by providing amenable microhabitat while roots develop and gradually penetrate into the underlying substrate (Fig 3).

Capturing fog drip

Condensed fog is an important source of moisture for upland plants on Santa Rosa Island (Ref 2). Native shrubs have been observed to thrive in the canopy edge of existing oaks, possibly in response to moisture dripping from the mature tree's overhanging branches (Fig 4). Similarly, fencing structures have been observed to collect and deposit captured fog (Fig 5). This study examines whether canopy edge "dripline" position or man-made fog capture structures improve growth and survivorship for shrub and herb seedlings planted in ridgeline oak groves.

Figure 4. Coyote brush (*Baccharis pilularis*) volunteers thriving in the dripline of an island oak (*Quercus tomentella*) canopy on Soledad Ridge, Santa Rosa Island. Photograph by Julianne Bradbury.

Figure 5. Moisture evidently collected and deposited by fencing immediately following a fog event on Soledad Ridge, Santa Rosa Island. Photograph by Julianne Bradbury.

Methods

Figure 6. Map of Grove 6 on Soledad Ridge, Santa Rosa Island; canopy edge of island oaks (*Quercus tomentella*) outlined in white, planting pillow sites indicated with green dots. GPS data collected by Julianne Bradbury and processed by Jim Roberts, NPS.

Figure 8. STAR fellow Rebecca Bernard digging a trench to install a planting pillow on Soledad Ridge, Santa Rosa Island. Photograph by Julianne Bradbury.

Figure 10. Planting pillow with 2" seedlings of coyote brush (*Baccharis pilularis*), purple needle grass (*Stipa pulchra*), and yarrow (*Achillea millefolium*) on Soledad Ridge, Santa Rosa Island. Photograph by Julianne Bradbury.

Figure 7. Newly filled and sewn planting pillow seated on a sack full of hand-mixed planting substrate. Photograph by Julianne Bradbury.

Figure 9. Fog hat installed on a planting pillow on Soledad Ridge, Santa Rosa Island. Photograph by Julianne Bradbury.

Figure 11. STAR fellow Julianne Bradbury measuring seedlings planted into planting pillows on Soledad Ridge, Santa Rosa Island. Photograph by Rebecca Bernard.

1. 16 plots selected along oak canopy (Fig 6)
   - Spaced roughly 5m apart, with adjustments to accommodate accessibility and to establish variety of aspect among plots
   - Each site marked for installation of 3 pillows: one directly at the dripline of the canopy, two 2m outside the dripline beyond the canopy
2. Burlap sacks filled with planting substrate (Fig 7)
   - Equal parts soil and leaf litter, sourced from surrounding area
   - One cup humate (soil conditioner) per 10 gallons soil/leaf mixture
3. Pillows installed (Fig 8)
   - Shallow (~5cm) trenches dug with hand pick
   - Pillows attached to substrate with 6" steel staples at each corner
   - Borders lined with cobbles and surface mulched with gravel from surrounding area
4. Fog hats installed (Fig 9)
   - One open canopy pillow randomly selected at each plot
   - Triangular section of fog capture fencing, approximately 70cm tall and 90cm wide, secured to the substrate uphill of the selected pillow with two 6" staples
5. Pillows planted with seeds and 2" seedlings (Fig 10)
   - 1 coyote brush (*Baccharis pilularis*) in uphill position
   - 1 yarrow (*Achillea millefolium*) in downhill position
   - 2 purple needle brush (*Stipa pulchra*) in lateral positions
   - 3-4 pre-treated seeds of island ceanothus (*Ceanothus arboreus*) adjacent to purple needle grass and yarrow seedlings, total of 10 seeds per pillow
6. Pillows watered
   - Immediately after planting
   - Approximately once per week over the following 5 week period
7. Species specific parameters measured 5 times during month following planting (Fig 11)
   - Coyote brush: height, canopy length and width, and stem diameter
   - Yarrow: length of longest leaf, canopy length and width, # of live and dead leaves
   - Purple needle grass: height, # of live and dead culms
   - Island ceanothus: # of germinated seeds
   - All species: survivorship
8. Each parameter analyzed for differences between treatments using one way analysis of variance.

Preliminary Results

At the end of 5 weeks of observation following planting, survivorship of seedling plants was 97%.

Coyote brush

Mean change in height (Fig 12) is significantly different among treatments; mean change in stem diameter (Fig 13) and mean change in canopy area (Fig 14) are not significantly different among treatments.

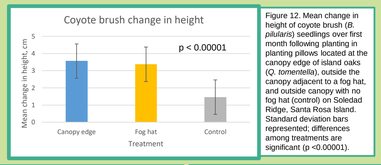

Figure 12. Mean change in height of coyote brush (*B. pilularis*) seedlings over first month following planting in planting pillows located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars represented; differences among treatments are significant (p <0.00001).

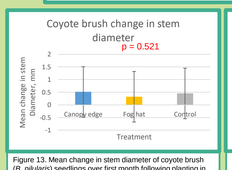

Figure 13. Mean change in stem diameter of coyote brush (*B. pilularis*) seedlings over first month following planting in planting pillows located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars respresented differences among treatments are non-significant (p=0.521).

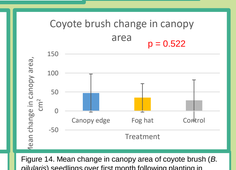

Figure 14. Mean change in canopy area of coyote brush (*B. pilularis*) seedlings over first month following planting in planting located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars represented; differences among treatments are non-significant (p=0.522).

Yarrow

Mean change in canopy area (Fig 15), mean length of longest leaf (Fig 16), and mean change in ratio of necrotic leaves (dead/live) (Fig 17) are all not significantly different among treatments.

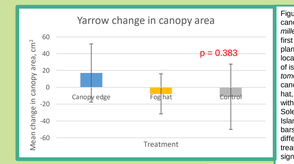

Figure 15. Mean change in canopy area of yarrow (*A. millefolium*) seedlings over first month following planting in planting pillows located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars represented; differences among treatments are non-significant (p=0.383).

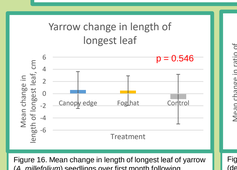

Figure 16. Mean change in length of longest leaf of yarrow (*A. millefolium*) seedlings over first month following planting in planting pillows located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars represented; differences among treatments are non-significant (p=0.546).

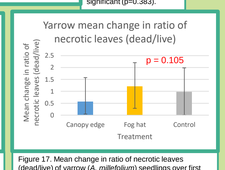

Figure 17. Mean change in ratio of necrotic leaves (dead/live) of yarrow (*A. millefolium*) seedlings over first month following planting in planting pillows located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars represented; differences among treatments are non-significant (p=0.105).

Purple needle grass

Mean change in height (Fig 18) and mean change in number of live culms (Fig 19) are both not significantly different among treatments

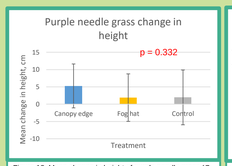

Figure 18. Mean change in height of purple needle grass (*S. pulchra*) seedlings over first month following planting in planting pillows located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars represented; differences among treatments are non-significant (p=0.332).

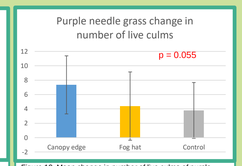

Figure 19. Mean change in number of live culms of purple needle grass (*S. pulchra*) seedlings over first month following planting in planting pillows located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars represented; differences among treatments are non-significant (p=0.055).

Island ceanothus

Total number of seeds germinating was significantly different among treatments during the first month following planting (Fig 20). However, survivorship of seedlings was only 19%; apparent herbivory was observed on the majority of seedlings, and herbivorous insects were observed in the immediate area.

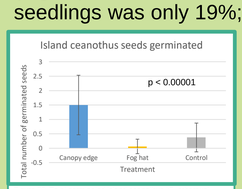

Figure 20. Total germinated island ceanothus (*C. arboreus*) seeds over first month following planting in planting pillows located at the canopy edge of island oaks (*Q. tomentella*), outside the canopy adjacent to a fog hat, and outside canopy with no fog hat (control) on Soledad Ridge, Santa Rosa Island. Standard deviation bars represented; differences among treatments are significant (p<0.00001).

Discussion and Long-term Monitoring

Survivorship for planted seedlings was very high over this initial period following planting, indicating that planting pillows provide amenable habitat that may minimize mortality due to transplant shock. Only a handful of parameters demonstrated significant results over this initial time period, but it is worth noting that all species demonstrated maximum initial growth and fitness in canopy edge pillows. Plants in fog hat pillows demonstrated intermediate growth and success for most parameters, but showed the least growth and success in some cases (coyote brush change in stem diameter, yarrow ratio of necrotic leaves, purple needle grass change in height, island ceanothus seeds germinated). Continued monitoring is necessary to determine the long-term effects of different treatments: survivorship for all species, coyote brush height and canopy area, yarrow canopy area, and purple needle grass height will be measured monthly over the next year to examine the effect of different treatments through both wet and dry seasons.

References

[1]Davidson, A.D., A.K. McEachern, T.J. Coonan, W.T. Bean, A.J. Armstrong, & B.R. Hudgens. 2014. Channel Islands National Park: Natural Resource Condition Assessment. Natural Resource Technical Report NPS/CHIS/NRTR-2014/XXX. National Park Service, Fort Collins, Colorado.

[2]McEachern, K., T. Atwater, P.W. Collins, K. Faulkner, & D.V. Richards. 2016. Chapter 24: Managed Island Ecosystems. Pages 755-78 in: H. Mooney and E. Zavaleta editors, Ecosystems of California. University of California Press, Oakland. 984 pps.

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