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Herbivory Effects on Summer Drought Tolerance and Winter Survival of Wyoming Big Sagebrush Seedlings

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Abstract

Invasive species and fires have damaged many sagebrush habitats. Rehabilitation of these habitats requires reintroducing a keystone species, *Artemisia tridentata* (big sagebrush), which provides habitat and forage for many animals. Reestablishment of big sagebrush has proven difficult due to high seedling mortality. The purpose of this study was to determine herbivory effects on summer drought tolerance and winter survival of Wyoming big sagebrush (*A. tridentata* ssp. *wyomingensis*) seedlings. Seedlings outplanted at Kuna Butte-Idaho were exposed to different herbivory degrees by leaving them without tree-protectors or covering them with plastic or metal tree protectors. We measured survival, water potential, shoot size, and inflorescence occurrence to assess herbivory's effects on the seedlings. Herbivory in spring, presumably by ground squirrels, increased seedling mortality during summer, fall, and winter. A year and a half after outplanting, survival was 61.5, 82.4, and 89.7% for seedlings with no, plastic, and metal protectors, respectively ($p < 0.001$). Herbivory also arrested flower development; the percentage of plants producing flowers was threefold higher in plants with than without protectors. Reduction in leaf area due to herbivory may have prevented accumulating sufficient carbon reserves, leading to higher susceptibility to drought and low temperatures.

Herbivory effects on summer drought tolerance and winter survival of Wyoming big sagebrush seedlings

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Introduction

Artemisia tridentata (big sagebrush) plays important ecological roles by contributing to the development of a varied landscape and providing habitat and forage for local animals (Aldridge and Boyce 2007; Davies et al. 2007). Due to the critical roles of *A. tridentata* in sagebrush habitats, there is considerable interest in reestablishing this species after fires. Reestablishment, however, has proven difficult due to high seedling mortality (Brabec et al. 2017). In the present study, we investigated the extent to which herbivory, either directly or by decreasing the plant's ability to cope with abiotic stresses, affects survival.

Materials and Methods:

An experiment was started in October 2019. This experiment involved transplanting 450 ten-month old sagebrush seedlings (*A. tridentata* ssp. *wyomingensis)* to a site at Kuna Butte, Idaho (43° 26' 47.148'' N, 116° 26' 46.968'' W). Subsequently, the seedlings were assigned to one of three treatments: without tree-protectors, with plastic tree protectors, or with metal tree protectors (Fig. 1). Since transplanting, we have been recording the seedlings that experienced herbivory and seedling survival. Furthermore, throughout the summer, we measured the seedlings' water potential and estimated shoot size and percent of plants with inflorescences in early fall. Plant water potential was measured with a Scholander pressure chamber, and the shoot size was estimated from digital images using ImageJ.

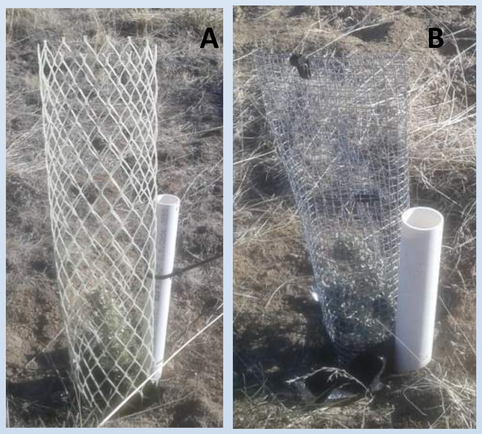

Figure 1. Tree protectors used in the experiment (A and B). Typical damage observed in unprotected seedlings (C). Likely herbivore responsible for the damage observed in early spring.

References

Aldridge CL, Boyce MS (2007). Ecol Appl 17:508–526. doi: 10.1890/05-1871

Davies KW, Bates JD, Miller RF (2007) .J Arid Environ 69:441–457. doi: 10.1016/j.jaridenv.2006.10.017

Brabec MM, Germino MJ, Richardson BA (2017) J Appl Ecol 54:293–302. https://doi.org/10.1111/1365-2664.12679

Results:

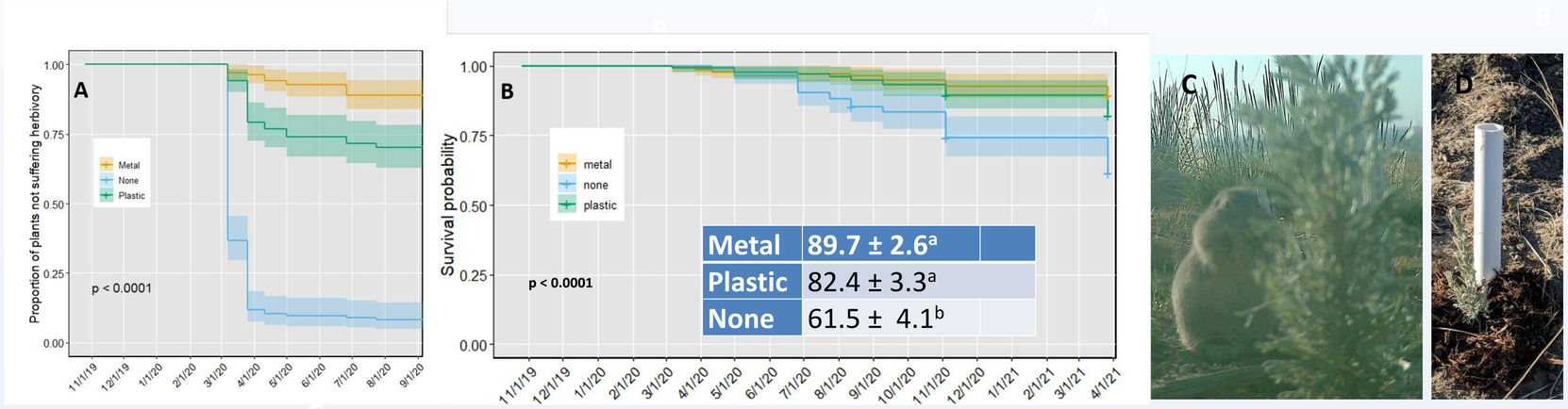

Figure 2. Impact of herbivory on survival of sagebrush seedlings transplanted on October 23, 2019. **A**, Probability of not suffering herbivory. **B**, Survival probability. **C**, Likely herbivore responsible for the damage in early spring. **D**, Typical damage observed in unprotected seedlings. Table in B indicates percent survival on March 27, 2021. Values followed by different letters are significantly different ($p < 0.01$).

The main damage due to herbivory occurred in March 2020. The extent of damage varied, but herbivory in most seedlings resulted in a loss of more than 60% of the shoot volume (e.g. Fig. 2D). Initially, the damage due to herbivory caused minimal differences in survival between treatments. However, the seedlings that suffered herbivory were more susceptible to mortality during summer drought and winter (Fig. 2B).

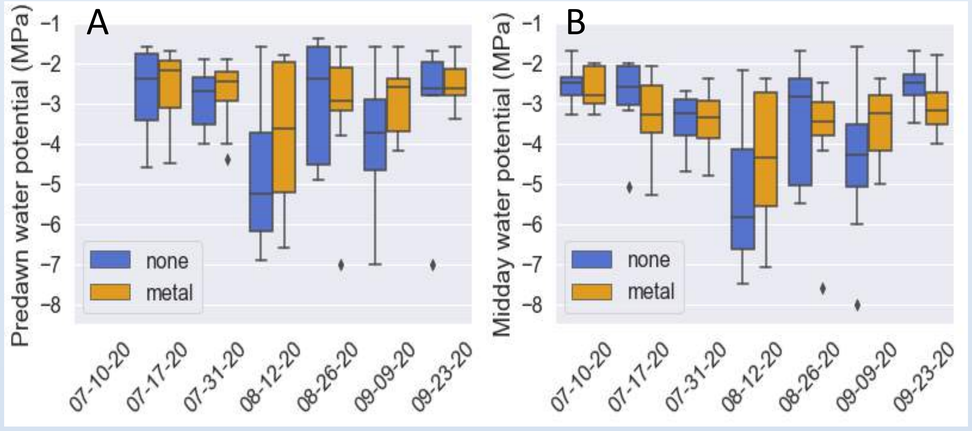

Figure 3. Predawn (A) and midday (B) water potential throughout the summer of 2020. Each boxplot represents the data from eight seedlings.

Herbivory did not have a significant effect on the median plant water potential. From mid-July to early September, most midday water potential values were below -3 MPa, which in sagebrush seedlings causes a reduction in stomatal conductance of more than 75%.

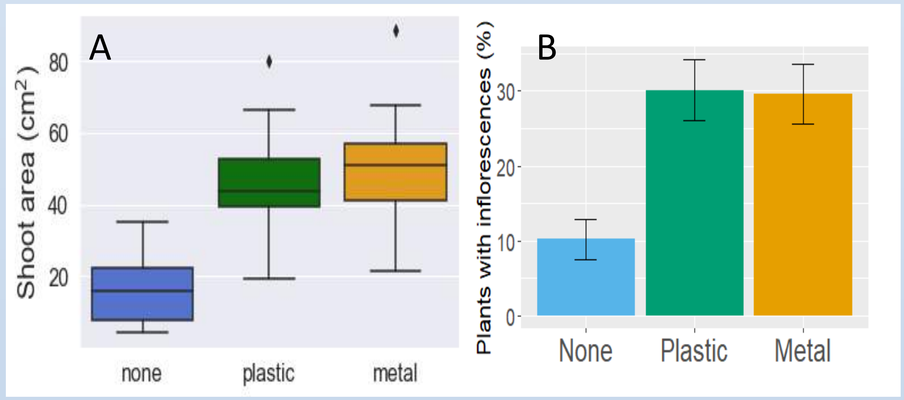

Figure 3. Effects of tree protectors on shoot size (**A**) and flowering (**B**) at the beginning of fall (9/23/2020). The percent of plants with inflorescences was calculated based on the surviving seedlings.

Conclusions:

- Herbivory in early spring, presumably by ground squirrels, increased seedling mortality during the summer, fall, and winter.
- Herbivory also arrested flower development. In plants with protectors, the percent of plants producing flowers was threefold higher than in plants without protectors.
- The mechanism by which herbivory increased mortality is unclear. The lack of noticeable differences in plant water potential between treatments suggests that herbivory did not markedly affect plant water status. The reduction in leaf area caused by herbivory may have prevented the accumulation of sufficient carbon reserves. Under this scenario, plants may be less able to withstand periods with low photosynthetic activity, such as those that tend to occur in late summer and winter due to drought and low temperatures, respectively.

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