1. *Clenet, D.R.*, **K.W. Davies**, D.D. Johnson, J. Kerby. 2019. Native seeds incorporated into activated carbon pods applied concurrently with indaziflam: A new strategy for restoring annual-invaded communities? Restoration Ecology 27:738-744. (ARIS 115 # 358793; Submitted 10-18-18; Accepted 1/28/19)

# A new seed enhancement technology for revegetating exotic annual grass-invaded rangelands.

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Exotic annual grasses, like cheatgrass, ventenata, and medusahead, can be undesirable forage because of their annual variability and their propensity to burn. High ground cover of invasive annual grasses can lead to a fire-annual grass cycle where each burn increases the cover of annual grass and is, therefore, more likely to burn again. Revegetation of annual grass-dominated areas can be difficult because desirable perennial bunchgrasses do not establish well from seed when annual grasses are present. In order to increase the likelihood of revegetation success, managers often attempt to revegetate following a burn and will spray pre-emergent herbicides, like imazapic, to control annual grasses. Unfortunately, to avoid herbicide damage to seeded species, seeding must be delayed a year or more. This delay allows annual grasses to re-dominate, decreasing effectiveness of revegetation attempts, and bringing managers back to square one.

Herbicide protection pods (HPPs) are a new seed enhancement technology developed by the ARS in Burns, OR that allow desired seed to be seeded at the same time that herbicide is applied to control annual grasses. HPPs incorporate desired seed into a pod with activated carbon and other ingredients (Fig. 1). The activated carbon in HPPs deactivates the herbicide directly around the seed, allowing them to grow while weeds are controlled. As a relatively new technology, research on HPPs has been limited to a few grass species and the results have only been followed for one year. In this study, we applied this technology in the field to test the success of using HPPs with seven different species, following the results over two years.

This study was applied in the area burned by the cinder butte fire in Eastern Oregon at two separate sites. Both sites were fenced to exclude grazers, then seeded with five perennial grass species and two shrub species in 2017. The species were: crested wheatgrass, bluebunch wheatgrass, squirreltail, basin wild rye, Sandberg bluegrass, Wyoming big sagebrush, and antelope bitterbrush. Each species in the study was seeded with seed incorporated into HPPs and as bare seed in rows. Directly after seeding, imazapic was applied at 12 oz/acre. Growing season precipitation (April-July) was below average in 2018 and above average in 2019. Plant cover and density of seeded species in the HPP rows and bare seed rows were measured in June of 2018 and 2019. Annual grass cover was measured within the treatment area and outside of the treatment area at each site to evaluate the effectiveness of the imazapic application.

Invasive annual grass control using imazapic was effective at both sites and control decreased in the second year. We found that bluebunch wheatgrass density (Fig. 2A) and cover were four and five times greater in the HPP rows compared to the bare seed rows by 2019. Crested wheatgrass density (Fig. 2B) and cover were greater in HPP rows compared to bare seed. Basin wild rye and

Sandberg bluegrass density was also greater in HPP rows compared to bare seed. In 2019, Wyoming big sagebrush density was almost seven times greater and sagebrush cover was about three times greater in the HPP compared to bare seed rows (Fig. 3A and 3B). Antelope bitterbrush did not survive past emergence due to rodent herbivory and therefore were not measured.

In conclusion, HPPs are a seed enhancement technology which allows for the simultaneous seeding of desired species and pre-emergent herbicide application to control annual grasses. In this field study, HPPs protected non-native and native desirable perennial bunchgrass species and Wyoming big sagebrush from a high rate of imazapic at two different sites, allowing these plants to establish a greater number of robust individuals. The greater establishment success seen in this study may be because HPPs allow a greater window of time for desired species to establish without competition from invasive annual grasses. However, it is also important to consider that this study encompassed a year (2019) with above average precipitation. The results seen here may not be the results seen when consecutive years following a seeding have below-average precipitation. While HPPs cannot overcome precipitation limitations, they are another valuable tool in the rangeland revegetation toolbox. This data, and previous studies, indicates that the use of HPPs increases the probability of establishing perennial-dominated communities that will be resistant to re-dominance by exotic annual species, limiting the annual grass-fire feedback cycle and providing forage for livestock and wildlife.

Further research and refinement of HPPs are warranted, especially with other pre-emergent herbicides and different pod sizes and formulation. More important though, will be scaling up the production of HPPs to decrease their cost and make them readily available for revegetation projects.

Figure 1. Herbicide protection pods (HPPs) containing bluebunch wheatgrass seeds.

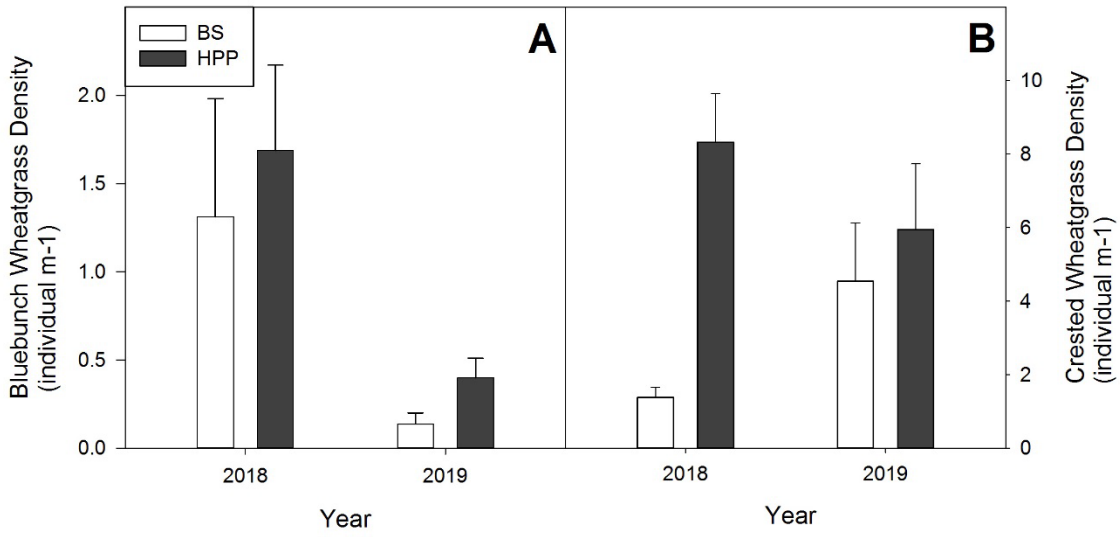


Figure 2. Bluebunch wheatgrass (A) and crested wheatgrass (B) density mean + SE for two treatments (HPP and BS) for 2018 and 2019.

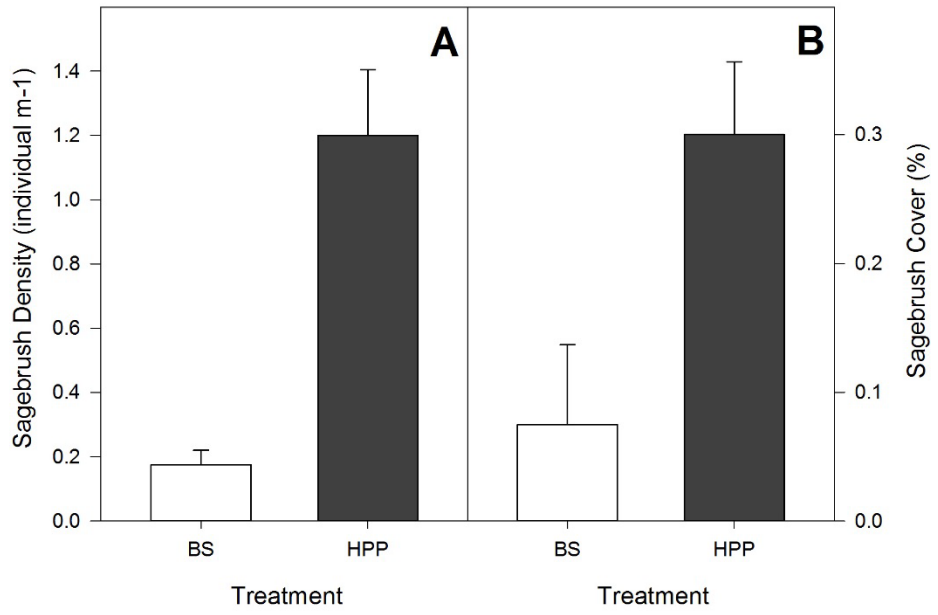


Figure 3. Sagebrush density (A) and cover (B) mean + SE for two treatments (HPP and BS) in 2019.