Project title: Development of tools and technology to improve the success and planning of restoration of big sagebrush ecosystems

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Project Summary:

Shrub-dominated ecosystems of the Great Basin are being threatened by disturbances, typically wildfire followed by encroachment of invasive plants (e.g., cheat grass). To mitigate these threats and future changes in the climate to big sagebrush (*Artemisia tridentata*), restorationists require a knowledge base and tools to inform them of the most appropriate seed sources to plant to greatly enhance the success of restoration under contemporary and future climates. We propose to develop climate-responsive seed transfer zones based on associating plant quantitative traits and ecophysiological data from common gardens to the climate of the seed source.

Project Proposal:

Background and Need

Big sagebrush is a cornerstone of arid ecosystems in the intermountain West, mitigating soil erosion, fostering plant and animal biodiversity, storing carbon and providing cover and forage for wildlife, such as the greater sage-grouse. However, these sagebrush-dominated ecosystems are being compromised by increased fire frequency and size, followed by encroachment of invasive plants (e.g., cheat grass). Many of the seed mixes used in the cold semi-arid deserts of intermountain West for restoration incorporate big sagebrush. In 2012 the Bureau of Land Management and state agencies requested over 1 million pounds of big sagebrush seed for restoration projects. Much of the seed will likely be planted a considerable distance away from where it was collected with no knowledge of its likelihood of being adapted to these environments or its impact to local populations of big sagebrush. The long-term sustainability of restoration projects involving big sagebrush is contingent on defining its adaptive genetic variation, and how this variation is association with contemporary and future climates. Restoration of big sagebrush requires the following: 1) a basic understanding of the evolutionary relationships and within-species patterns of genetic structure, 2) knowledge of plant-climate associations from common garden trials and development of species distribution models for contemporary and future climates, 3) an effective and rapid means of detecting big sagebrush subspecies in seed collections, and 4) a means of delivering seed zone maps and tools to users.

A prerequisite to the development of restoration guidelines is a thorough understanding of the evolutionary/taxonomic relationships of species and populations. This has been the initial focus our research, resulting in recent publications (Bajgain *et al.* 2011, Richardson *et al*. 2012). This research has been essential for the ongoing analysis of common garden trials, and the preliminary evaluation of electronic nose technology as a diagnostic tool for detecting subspecies in big sagebrush. For the common garden data analyses, grouping big sagebrush based on genetic data, not just morphology, can have a major impact on the interpretation and outcome. Similarly, electronic nose analysis, an approach to detect differences from plant volatiles, is contingent on accurate assessment of the evolutionary relationships among species and populations of big sagebrush. This device could be a rapid means for seed distributors and vendors to distinguish subspecies from seed or leaves. Both the development of seed zones from adaptive genetic responses and electronic nose diagnostics are direct applications for land managers. Our research proposal capitalizes on ongoing GBNPSIP ($35,000 yearly) and National Fire Plan sponsored research ($72,000 yearly).

Objectives

Described below are the individual research project descriptions required to meet decision support and delivery needs of users:

- Develop ecological genetic models: Data collected from plant responses over four years (2009-2013) in replicated common gardens of big sagebrush will be associated with climate variables found at each seed collection site. These data and analyses are the foundations for seed transfer zone development.
- Species climatic profile: An estimate of the big sagebrush species distribution will be developed from presence and absence points. This mapped distribution will serve to overlay seed zone information based on ecological genetic data for the contemporary climate and future climates (decades 2030 and 2060) using circulation models and carbon emission scenarios.
- Website development: Seed transfer zone information will be delivered to users via a website that illustrates mapped seed zones for big sagebrush under contemporary climates and predicted seed zones and species distributions based on climate scenarios for decade 2030.
- Big sagebrush subspecies diagnostic tools: Seed collection and banking for restoration requires accurate subspecies identification. A major problem for seed warehouses is determining whether the subspecies identification of harvested seed is correct. Mislabeled big sagebrush seed is a major culprit in failed restoration seedings. We are in the development phase of assessing the use of an electronic nose to differentiate subspecies of big sagebrush based on volatile chemicals. Preliminary results suggest this device can distinguish chemical profiles at the

subspecies level. Such a device would be a cost effective and efficient means of certifying big sagebrush seed for deployment in restoration.

Methods

Common gardens

Collection of seed began in the autumn of 2009. A total of 93 seed sources were collected, largely by collaborators, in 11 western states. In January 2010, seeds were planted in greenhouse containers. Up to ten families from each of 56 seed sources (Figure 1) were outplanted at each of the three common gardens located at Orchard, Idaho, and Ephraim, and Ephraim Canyon, Utah. Outplanting of seedlings occurred in May and June of 2010. First-year measurements were conducted in October and November of 2010. Yearly measurements included mortality, height, stem diameter and crown area. In addition, ecophysiological measurements were also collected in 2011 including carbon isotope ratios to measure water use efficiency. In 2012 seed yield was estimated from seed harvested from two plants from each seed source at the Orchard and Ephraim Canyon gardens. This will be used as a measure of fitness. Continued monitoring and quantitative measures will continue through this year, 2013.

Climate profile

Presence and absence points of big sagebrush collected throughout the range will be used to develop a climate profile, an estimate of the distribution. Since this profile is based on climate, predictions in the range shift of the species or subspecies from climate change can be analyzed by mapping this profile onto climate surfaces adjusted to GCM (general circulation models) and carbon emission scenarios for 2030 and 2060.

Climate associations

Climate variables extracted from climate surfaces (Rehfeldt 2006) from each of the seed source sites will be used to predict plant response data from the common gardens. The relationship between climate and plant responses, an ecological genetic model, will be mapped within the climate profile. Mapping will be done using a gridded (1 km^2) climate surface for contemporary and future climates (2030 and 2060).

Electronic nose

Electronic nose (e-nose) devices use electronic sensors to distinguish differences in the type and intensity of volatile organic compound emitted by organisms. Big sagebrush subspecies are known to have different aromas. Our preliminary results suggest an e-nose can detect the differences between aromatic profiles between subspecies *vaseyana*, *tridentata* and *wyomingensis*. The critical diagnostic test for seed warehouses is between *wyomingensis* (tetraploid) and *tridentata* (diploid). We are currently evaluating the capabilities of this device to differentiation nearby samples of *wyomingensis* and *tridentata*. We will be testing a hand-held e-nose this summer. If successful this device could be a rapid test to determine subspecies and used as a seed certification step.

Geographic extent

The geographic extent includes big sagebrush habitats of the Great Basin and beyond (i.e., the range of big sagebrush).

Timeline of Schedules, Products and Outcomes

The proposed research can provide a comprehensive set of tools for managers in restoration of big sagebrush ecosystems. With the proposed research, the newly developed basic genetic information will serve as a platform to develop applied science products including seed transfer zones and electronic nose diagnostics. Our expected timeline for products and outcomes are as follows:

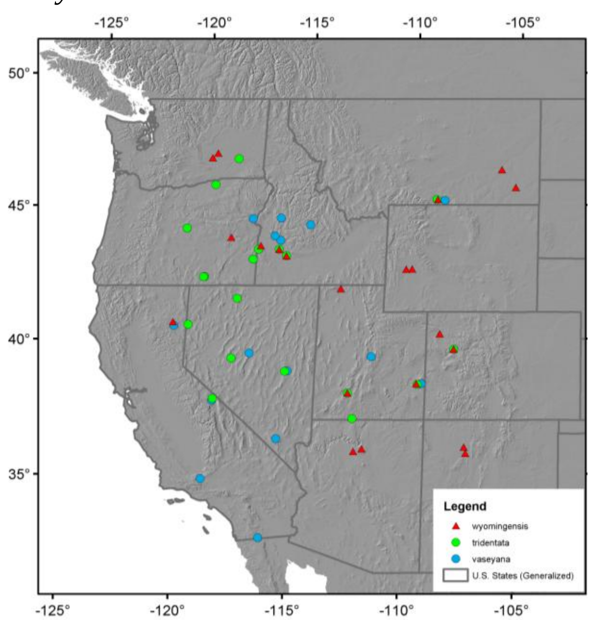
Product	Estimated completion date
Ecological genetic model	Summer 2014
Climate profile	Fall 2014
Website and seed transfer zone delineation	Summer 2015
E-nose	Summer 2014

Budget

FY2013-2014:	Amount requested	Matching (GBNPSIP)
Salary: Post-doc support	$30,000	$30,000
Travel	5000	5000
Total	35,000	35,000

Disclaimer regarding data sharing
There are no known restrictions to data sharing.

Figure 1. The location of 56 seed collection sites for *Artemisia tridentata* used in the common garden study. The symbols identify subspecies *wyomingensis, tridentata* and *vaseyana*.



References:

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