PROJECT PROPOSAL TEMPLATE

Project Title:
Effects of genotype and management treatments of native and invasive herbs on success of sagebrush restoration

Project Leader:
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Project Summary (*3 sentences target*):

The increase in large wildfires at a time when habitat for Greater Sage Grouse and other species dependent on big sagebrush has also increased has led to substantial needs for big sagebrush seeds. Significant decisions on which sagebrush seed to use and on management treatments that affect competing herb layers on the same restoration sites affect the trajectory of habitat. This project will evaluate how seed source, specifically genotype and climate-of-origin, interact with landscape-scale and replicated treatments (fencing, herbicide application, mowing, and seeding).

Project Proposal:

Loss of big sagebrush habitat is a critical issue for the Great Basin, as this species provides key structure for ecosystem functioning and it also pivotal for convervation of sagebrush-dependent species, such as Greater Sagegrouse. Big sagebrush cannot resprout, and its seeding requirement for post-fire recovery is compounded by the small dispersal distances and loss of viability once seeds reach about 3 years age. In addition to more area being consumed in wildfires each year, more of the area is occurring in large patches, ranging up to ~1,000,000 acres as of 2012. Natural dispersal of seed into these vast burn areas is increasingly less likely, and the emergence of wind erosion on large burn areas poses yet another problem for seeds like sagebrush. Big sagebrush seeds germinate from near the surface, and they are relatively small and fragile, and thus would seem unlikely to germinate following scouring, burial in drifts, or friction with blowing sand/soil. Depletion of the seed bank and natural regeneration potential is an obvious issue for many areas affected by wildfire. The rapid loss of sagebrush habitat across the Great Basin, combined with increasing concern about conservating sage grouse, continues to promote interest in restoring big sagebrush within the Great Basin. Management plans for areas such as the Birds of Prey National Conservation Area have (or will) typically prescribe a desired abundance of big sagebrush on the landscape, and often plans will specify a certain number of acres with which sagebrush will be restored to.

The Emergency Stabilization and Rehabilitation (ESR) program can be viewed as one of the most significant conservation investments in the Great Basin, providing significant resources for reseeding following wildfires. With increasing fire occurrence, pressure on seed supplies is increasing. Sagebrush seeds are commonly aerial seeded over large burn areas, but may also be mixed with other herb species

and drill seeded, or may be planted as seedlings on smaller patches. Only rarely are local seeds available, and land managers are faced with making what could (perhaps should) be a difficult decision of what seed source to use. The seed source decision is critical, given that ESR funds are usually (or can be) a one-time investment for a given area and there may not be further opportunities to try to re-seed. Furthermore, big sagebrush is a genetically diverse species and also has high diversity in its climate responses. Given that it is relatively long lived, planting appropriately adapted seed sources would seem to be a key part of climate adaptation in land management. Unfortunately, there are currently no seed-zone maps available to provide transfer guidelines. Notable, Lysne and Pellant (2004) found that only a fraction of sagebrush seedings onto wildfire areas in Southern Idaho had big sagebrush, and a surprisingly large number of the seedings that were successful appeared to have an inappropriate seed source (eg. basin big sagebrush where the site type was Wyoming Big Sagebrush). For example, seeds from near central Utah have been used in a number of large seedings in southern Idaho. The bigger implication is that selection of appropriate seed sources may be a key way that the very large investments into seeding can be quickly tuned to achieve greater success in restoring sagebrush. This consideration is important, given that sagebrush restoration in rangelands has had very mixed success.

A number of sagebrush common-garden studies have been conducted in the Great Basin, and all of them reveal key ways that adult sagebrush differ in their genetics and in phenotype, particularly in climate response. These gardens were typically started by collecting seeds of the different genotypes from a range of locations, germinating the seeds in a greenhouse, and outplanting the resulting seedlings onto small sites (< 1 acre) that had relatively high seed bed treatments. Treatment typically included herbicide application to remove herb competition, soil treatments, and often planting was followed by irrigation. As a result, these common gardens have been most informative on the success of adult plants and thus the ability of the genotypes to persist on a site. While persistance is certainly a variable of concern, initial establishment is perhaps the more immediate concern for seeding or planting success. To my knowledge, there is no literature available to inform us on genetic differences in factors affecting seedling establishment for big sagebrush. In trees, there can be substantial genotype differences at different ontogenic stages. Our preliminary data (presented at 2nd Annual Great Basin Consortium Meeting) suggested that local adaptation (in this case to onset of chilling/sunlight stress in fall) is more evident in seedlings that are a few months old compared to adult plants.

Another major issue that has been addressed in mine reclamation but not so much in rangelands is the influence in the herb layer, and management treatments upon the herb layer, on success of big sagebrush. Fire, ESR treatments, and many of the land uses and management actions manipulate the abundance and species of herbs in sagebrush steppe rangelands. Post-fire treatments that can occur where sagebrush is seeding frequently involve herbicides or drill seeding other species. Grazing and mowing are other actions.
To my knowledge, there is little or no information to help predict how the overlaying of these herb treatments relates to sagebrush success. In the long term, the success of sagebrush plantings could also affect the abundance of herbs.

Sagebrush subspecies and their provenances (or genotypes) can differ in attributes such as growth rate, stress responses, water-use efficiency, depth of rooting, phenology with respect to chilling, and in other related variables. These factors are normally considered with respect to how sagebrush relates to the abiotic environment, but all of these factors should also affect how sagebrush competes with differnt types and abundances of herbs. Forbs and grasses can differ in a number of ways, but very strong differences in soil resources can occur under cheatgrass compared to a mixed native perennial grassland with some forbs. The cheatgrass site might have fleeting shallow soil water availability, and we might

predict that genotypes capable of quickly deploying a deep tap root in early spring might stand a better chance at competing in such conditions. Information like this would be valuable in seed selection for particular restoration sites, keeping in mind that re-burning of planting sites is also a concern that is aside from the large investments into sagebrush seeding and planting that are unlikely to wane in the near future.

Objective and overview:

The objective of our research is to evaluate how initial establishment of sagebrush is influenced by management treatments on the herb layer, and to determine how this affect varies among different genotypes of big sagebrush under different climate conditions.

The primary science products will be 1) a publication on the project, 2) several presentations to the Great Basin audience, such as the 3rd Annual Great Basin Consortium in 2013 and to Great Basin Science Delivery Project's webinar series (if invited), 3) field days/tours through the Great Basin Chapter of Society for Ecological Restoration, and 4) we will fold the information into current, ongoing efforts to develop seed zone guidelines for transfer of sagebrush seeds across the landscape.

The direct management application is to aid in two key decisions as they affect sagebrush recovery following fire: 1) how should the herb layer be treated, in light of prospects for sagebrush establishment, and 2) which sagebrush seed should be used? Sagebrush from a warmer climate, sagebrush (eg, basin big sagebrush) that might have a better ability to compete with cheatgrass. Furthermore, we will provide a critical test to the prevailing assumption that "local is better" in seed sources. Considerable climate shifts have occurred since the establishment of sagebrush stands as they would influence the designation of an Ecological Site Description and suggested native vegetation.

This project will leverage an existing Joint Fire Sciences project (led by Doug Shinneman, USGS, in collaboration with Anne Halford, BLM) that established landscape-scale management treatments and sustains background data collection such as herb species and cover and microclimate (described below). The combined JFSP, USGS, and BLM investments are over $200K thus far. Additionally, the Great Basin Native Plant Selection and Increase project supported the collection, genotyping, rearing, and outplanting of seedlings into the treatment plots. Large volunteer crews have been instrumental in the outplanting.

Methods:

Nearly 1800 seedlings of sagebrush have been (or continue to be as of 27 MArch 2013) outplanted into the JFSP plots at the Birds of Prey (BOP) NCA. The seedligs are from 11 different provenances of all three subspecies of big sagebrush (mountain, basin, and Wyoming Big Sagebrush). We planted the most local seed sources possible for each subspecies. For the remaining 8 subspecies, we selected a wide range of genetics, and so both diploid and tetraploid basin and mountain sagebrush are included. Ploidy is hypothesized to affect growth rate and stress response in plants, but this is less clear for sagebrush. We also selected carefully to obtain other provenances from relatively warm or cool areas, with one warm site almost having no winter (from near Mojave in CA). Lastly, we selected relatively fast-growing provenance that appear to have deep rooting, as well as genotypes that appear more slow-growing and stress-adapted. This latter selection criteria was based on data from adult plants in each provenance from existing common gardens.

Seeds were germinated onto cone-tainers (8" depth) having native soils in August 2012, were watered, overwintered (Jan-Mar) at Lucky Peak Nursery's cold storage facility, and outplanted into small holes dug with picks in a high-throughput planting pattern.

Whereas most outplanting efforts tend to concentrate seedlings into relatively small areas, both the treatments and our outplanting are relatively expansive. The site in the BOP NCA for this experiment consisted of a mixed cheatgrass and Sandberg's Bluegrass community, on relatively flat terrain with loam soils. Sagebrush was not present in plots due to historic fire. Three replicate blocks have all of the following treatments in a randomized array: grazing, seeding, herbicide application, mowing, and all combinations of each treatment. Plot sizes are 1 hectare and a hectare of untreated area separates each plot, resulting in a very large experimental area. Treatments (except grazing) were implemented in fall 2012, and grazing will begin in 2013. Cover is measured annually, and microcliate and soil water content is recorded with dataloggers. Each treatment combination occurs along a gradient of herb abundance (and type), ranging from low cover in plots that have the combination of herbicide, no seeding, and are grazed, compared to plots that have the opposite condition. In each of the 30 hectare-sized plots are 9 sampling circles that are each 25 m in diameter. Seedlings were planted in each of the cardinal directions of these circles, resulting in very large separation of plants.

The seed sources represent a very large geographic extent of influence - effectively the entire Great Basin and several seed provenances are beyond the boundaries. The use of a wide range of genotypes across a wide range of herb conditions created by experimental management treatments, and the disperal of these over a large area (several square miles) should all aid in promoting the robustness and transferability of the findings. The most transferable aspect of the information will be to show effects of management treatments or genotypes, and illustrating that these need to be considered although precise information for other sites may not be available.

The main activity that funding is requested for is to collect data on the responses of the seedlings. Because these seedlings are numerous, small and hidden in the herb layers (albeit in flagged locations), and spread out over a very large areas (~ 10 m, or 30 feet between seedlings), many days of sampling effort are required to visit each seedling. Measurements will include survivorship, growth (height), herb (and crust) cover in neighborhood, and a portion will have measurements of water status (pressure chamber) and isotopic assessment of water-use efficiency (using USGS instruments). The relationships of these variables to temperature, precipitation, and soil moisture will be evaluated across the treatments, as well. This assemblage of variables will inform us on seedling performance, point us to possible factors affecting performance, and indicate key ways that seedlings may differ in growth strategy that make or break survivorship under the various settings we will assess.

Anne Halford facilitates access to the site and informs the researchers on the how the activities and science relates to management. She contributed local seed and provided key leadership, labor, and volunteer recruitment in the planting of the subject seedligns. Beth Newingham also aids in recuiting students to assist. Nancy Shaw provides consultation in restoration relevance, helping link our project to end users and she provides key advice on technical problems of the planting, and Bryce Richardson provided the genetic analyses and will perform the seed zone guidelines and mapping (this latter activity not funded by the current proposal).

Timeline of Schedules, Products and Outcomes:

Start: August 2013

Data collections: Quarterly
Presentation to Great Basin Consortium: Fall 2013
Data analysis: Summer 2014
Final project report: August 2014

Budget:

Funds are requested to support the student and assistant on this project, there is essentially a full year of effort required of data collection, processing, analysis, and reporting. The graduate student has been only partially funded thus far and we have been working with volunteers. The project was started without proper funding because the opportunity to embark on it was a rare one.

Salary for a student and assistant (each $13/h): $24,000
Field travel (50 miles one-way): $40/trip x 20 trips = $800
Meeting travel: flight, hotel, registration = $1000
Publication costs: $1000

Subtotal direct costs: $26,800
Overhead (17% of direct costs): $4556
TOTAL REQUEST: $31,356

Matching funds have been materialized already to get the treatments in place, seeds collected and mother plants genotyped, seedlings reared, and outplanting underway. Combined with the project director's salary and use of lab and physiological instrumentation (~$15K) the effective match is in excess of several hundred thousand dollars. This can be itemized if necessary.

Disclaimer regarding Data Sharing:
N.A. – we will share data in its preliminary form and it will be available openly following completion of the project.

Briefly describe any known restrictions on sharing of the data expected to be generated by this project:
NA.