

A STRATEGY FOR MAXIMIZING NATIVE PLANT MATERIAL DIVERSITY FOR ECOLOGICAL RESTORATION, GERMPLASM CONSERVATION AND GENECOLOGY RESEARCH

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Abstract:

One of the most important steps in planning a restoration project is careful selection of ecologically adapted native plant material. As species-specific seed zone maps are not available for most species in the *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush) ecoregion in the Great Basin, USA, we are employing a provisional seed zone map based on annual precipitation and mean maximum daily growing season (April through September) temperatures. We plotted known populations of three potential restoration species over this map to demonstrate its value as a decision support tool for identifying populations of each species that may be used individually or pooled to create restoration seed sources for immediate use or for seed increase. Provisional seed zones may also be used with other resources to identify in situ conservation sites and collection gaps for ex situ conservation or genecology research.

Keywords: *Artemisia tridentata* ssp. *wyomingensis*, climate change, common garden, provisional seed zone, sagebrush steppe

Introduction

Selection of native plant materials that are ecologically appropriate and genetically diverse is a vital element of any restoration project. Adapted materials are essential for restoring healthy, self-sustaining ecosystems with the diversity required to provide resiliency in the face of climate change and other environmental perturbations (Johnson et al. 2010). Species-specific seed zones are used to select plant materials for restoration that are best adapted to current and projected future climatic and environmental conditions (St. Clair et al. 2005). Genecology research, including common garden and reciprocal transplant studies, has long been conducted in the United States and elsewhere to develop and refine species-specific seed zones for tree species. Common garden studies aim to correlate observed intraspecific genetic variation to source environments to suggest adaptive traits determined by natural selection (Johnson et al. 2004). Adaptive genetic variation is then mapped over the area of interest to delineate species-specific seed transfer zones.

Seed harvested from within a seed zone can be planted directly, increased in agricultural seed fields or propagated in a nursery to provide seed or plants for restoration projects. Collection from at least 50 widely separated plants in each of five or more populations within a seed zone is recommended to provide genetically diverse material (Johnson et al. 2010) for restoration. In addition, species-specific seed zone maps can be used to identify collection gaps for genecology studies and strategies for in situ and ex situ germplasm conservation.

Common garden studies for development of species-specific seed zones have only recently been initiated for grasses, forbs and shrubs (Erickson et al. 2004, Johnson et al. 2012). Because emphasis on the use of native species is increasing, the number of species utilized for restoration is large, and genecology studies are costly and time-consuming, surrogate tools are required for making decisions regarding seed source selections. Provisional seed zones are one tool that can be used when genetic research is lacking (Bower et al. 2010) These zones are based on climatic and environmental variables such as precipitation and temperature that are known to influence adaptation and plant distributions.

We selected three widespread native forbs that are candidates for restoration use in the *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush) ecosystem of the northern Great Basin in the Western United States to illustrate the use of provisional seed zones. As a result of extensive exotic species invasions, altered fire regimes, climate change and other human impacts, populations of these and many other species once considered common in this vast region are frequently restricted and fragmented. Consequently, our aim is to develop strategies to meet restoration and conservation goals for these species.

Methods and Materials

We used a provisional seed zone map developed for the Great Basin by Bower et al. (2010, Fig. 1). Seed zones were delineated using mean maximum daily growing season temperatures (April through September) and annual precipitation (PRISM, <http://www.prismclimate.org>) derived from climate normals for 1971-2000. Known populations of *Penstemon acuminatus* (sharp-leaf penstemon: Scrophulariaceae), *Penstemon speciosus* (royal

Penstemon: Scrophulariaceae), and *Chaenactis douglasii* (dusty maiden: Asteraceae) were plotted over the provisional seed zone map. Location data for each population was extracted from the Great Basin Native Plant Selection and Increase Project database, which focuses on the *Artemisia tridentata* ssp. *wyomingensis* ecosystem. Maps were examined to identify gaps for future seed collection efforts for restoration and common garden studies and strategies for germplasm conservation.

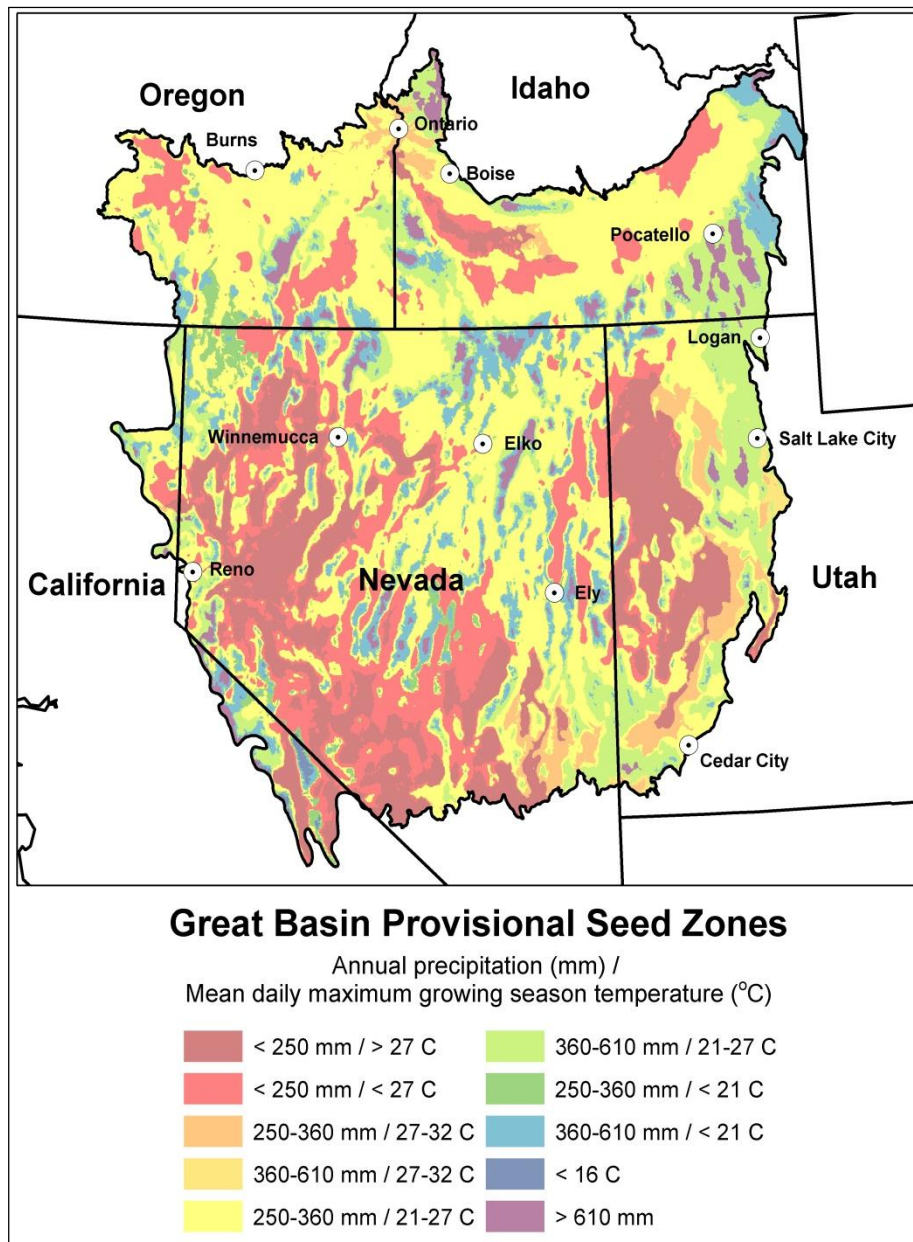


Figure 1. Great Basin Provisional Seed Zone Map (Bower et al. 2010).

Results

Penstemon acuminatus: Known populations are largely restricted to sandy and sandy loam soils in two provisional seed zones (< 250 mm/< 27°C and < 250 mm/> 27°C; Fig.2). Northern populations in each zone are adequate in number and distribution to provide seed collections that can be pooled to prepare restoration plant materials. Northern populations can also be selected for in situ conservation or for common garden studies or ex situ conservation. Although the species is not known from Utah, it is widely distributed in Nevada (USDA, NRCS 2012) where currently identified sites are confined to locations along a single highway corridor. Further reconnaissance and collection in Nevada may be facilitated by use of the provisional seed zone map combined

with examination of floras, herbarium databases, soil surveys, ecological site descriptions, and consultation with local authorities.

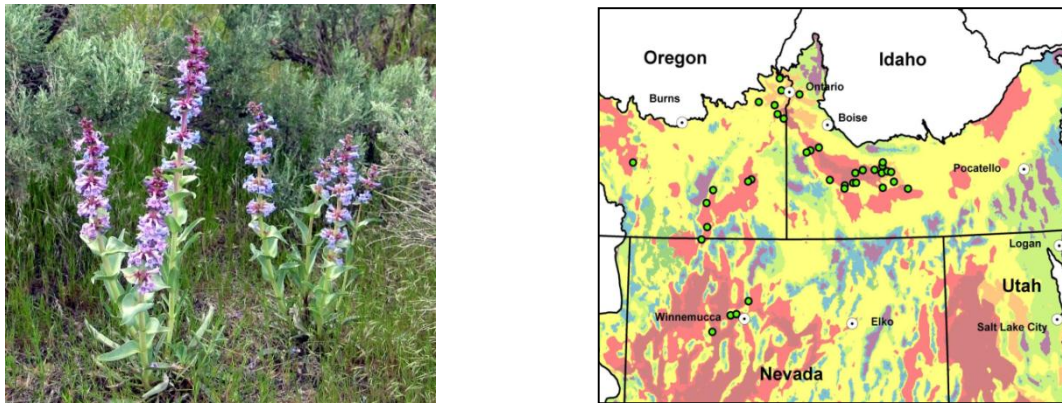


Figure 2. *Penstemon acuminatus* plant and known collections sites, northern Great Basin.

Penstemon speciosus: Identified populations are widespread within the *Artemisia tridentata* ssp. *wyomingensis* ecosystem. They are located primarily within the 250-366 mm/21-27°C seed zone on loam to fine sandy loam soils (Fig. 3). Known collection sites may be selected for in situ or ex situ germplasm conservation. However, location of additional populations is desirable to provide a better distribution of populations if accessions are to be pooled to prepare restoration plant materials. A larger number of populations from the *Artemisia tridentata* ssp. *wyomingensis* ecosystem plus populations from higher elevation plant communities where the species also occurs would be essential for genecological research to develop a species-specific seed zone map for the northern Great Basin.

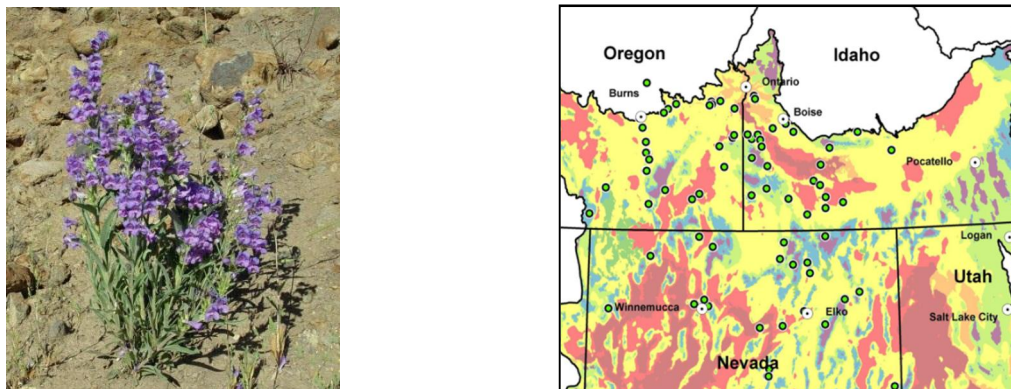


Figure 3. *Penstemon speciosus* plant and known collection sites, northern Great Basin.

Chaenactis douglasii: This species occurs widely across the Great Basin on dry, sandy, gravelly, and rocky sites and on recent disturbances in communities ranging from salt desert shrublands on basin floors to alpine ridges (Morefield 2006). Collection efforts in the *Artemisia tridentata* ssp. *wyomingensis* ecosystem were only recently initiated (Fig. 4). Site descriptions for known populations, the provisional seed zone map and other available resources should be consulted to guide future surveys. Because of the species's wide distribution, areas where the species is most abundant and restoration needs greatest should be defined and targeted for development of restoration seed sources.

Unlike the two penstemon species, *Chaenactis douglasii* includes overlapping subspecific taxa, *C. d. douglasii* and *C. d. alpina* (Morefield 2006). Furthermore, polyploid populations occur at lower elevations of the species's range and on Pleistocene disturbances (Mooring 1980). These factors impose additional restrictions on seed transfer.

Conclusions

The Great Basin provisional seed zone map provides a valuable decision support tool that can aid in making germplasm collection and conservation decisions when genetic research is lacking. Local knowledge of physiography and plant ecology can be used to adjust provisional seed zone boundaries. Knowledge of a species's biology and edaphic and biotic factors influencing its distribution should direct surveys and deployment of restoration material within each zone. As is the case for species-specific seed zones, climate change models may be used to predict future changes in provisional seed zones.

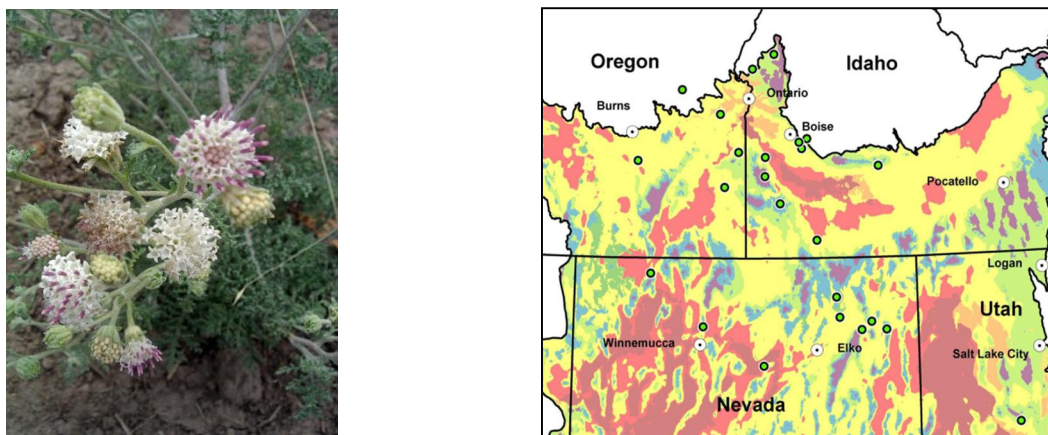


Figure 4. *Chaenactis douglasii* plant and known collection sites, northern Great Basin, USA.

Most restoration species do not occur in all seed zones. In addition, the scale of restoration occurring in each zone varies. Thus it may be possible to limit initial survey efforts to priority areas and zones to expedite development of urgently needed plant materials.

Provisional seed zone maps for the United States and completed species-specific seed zone maps and associated literature are available on the USDA Forest Service Western Wildlands Environmental Threat Assessment Center website: http://www.fs.fed.us/wwetac/threat_mapIntro.html Mapping applications are available in formats ranging from geobrowser to ArcGIS ArcMap to facilitate user applications.

Acknowledgements

Funding for this research was provided by the USDA Forest Service, Great Basin Native Plant Selection and Increase Project and the USDI Bureau of Land Management, Great Basin Restoration Initiative. We thank Erin Denney, Jan Gurr, and Alexis Malcomb for their assistance.

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