A Collaborative Program to Provide Native Plant Materials for the Great Basin

By Nancy Shaw, Mike Pellant, Matthew Fisk, and Erin Denney

The Great Basin as defined on a floristic basis[1] includes the hydrographic Great Basin plus the Owyhee Uplands and Snake River Plain of southern Idaho (Fig. 1). The region encompasses about 60 million ha, of which more than two-thirds are publicly owned. Vegetation ranges from salt desert and sagebrush shrublands in the basins to conifer forests in the more than 200 mountain ranges. Historic land management opened the environment to invasion by exotic annual grasses, primarily cheatgrass (*Bromus tectorum*). Resulting changes in fire regimes and more recent human disturbances such as energy development, mining, and recreation have combined to increase the spread of annual and perennial exotics, deplete native seed banks, simplify community structure and species associations, and reduce landscape patchiness. Ecosystem resilience declines with disruption of ecological functions such as snow or water catchment, reduction of wind velocity, and nutrient cycling. West and Young[2] described in detail the plant communities and management issues in the Great Basin and suggested that development of more effective and economical revegetation techniques should be a research priority, especially for the more arid regions.

The status of fire-intolerant sagebrush and its communities, which cover more than 43 million ha in the western United States, is threatened not only by the incursion of exotic species and altered wildfire regimes, but also by the encroachment of pinyon and juniper woodlands as a result of overgrazing, fire exclusion, and climate change. Nielson et al.[3] simulated potential climate change impacts on the future distribution of the sagebrush ecosystem. The greatest warming scenario reduced the system to 20% of its current area within the 21st century. As a result of these threats, the sagebrush ecosystem now includes about 350 species of conservation concern,[4] and 20% of the systems flora and fauna are considered imperiled.[5] Major species losses can be expected if current trends continue.

The decline in greater sage-grouse (*Centrocercus urophasianus*) in the Great Basin illustrates the complexity of managing an iconic wildlife species threatened by a loss of habitat due in large part to wildfires (Fig. 1), invasive plants, and human development. Habitat restoration has been identified as a high priority to conserve greater sage-grouse, but limitations in native seed and seeding equipment often thwart these efforts.[4] Native forbs are an important component of growing season habitats for greater sage-grouse and are often in short supply.[6] A strategic and adaptive program to provide and successfully establish native plants can help conserve greater sage-grouse and other resource and human values in the Great Basin. Given the scale of issues and the land mass of the Great Basin, collaborative efforts are essential to successfully meet these challenges.

Origin of the Great Basin Native Plant Selection and Increase Project

Rehabilitation and restoration efforts following the wildfires of 1999 and 2000 that burned more than 1 million ha in the Great Basin were limited by inadequate supplies of appropriate plant materials, especially seed of native species. To address this issue, the House of Representatives' Department of the Interior and Related Agencies Appropriations Act of FY2001 directed the Secretaries of Interior and Agriculture to prepare a plan to "supply native plant materials for emergency stabilization and longer-term rehabilitation and restoration efforts."[7] The resulting Report to Congress outlined recommendations and strategies for development of an Interagency Native Plant Materials Development Program to "ensure a stable and economical supply of native plant materials" for public lands.[7] Key emphasis areas for program success were support for federal, state, and Tribal native plant materials research, development, and production; expanded seed storage facilities; public and private sector partnerships; and education and outreach to the general public.

The 1999 and 2000 wildfires also provided the impetus for the formation of the Great Basin Restoration Initiative, an effort led by the USDI–Bureau of Land Management (BLM) to proactively address invasive species spread and

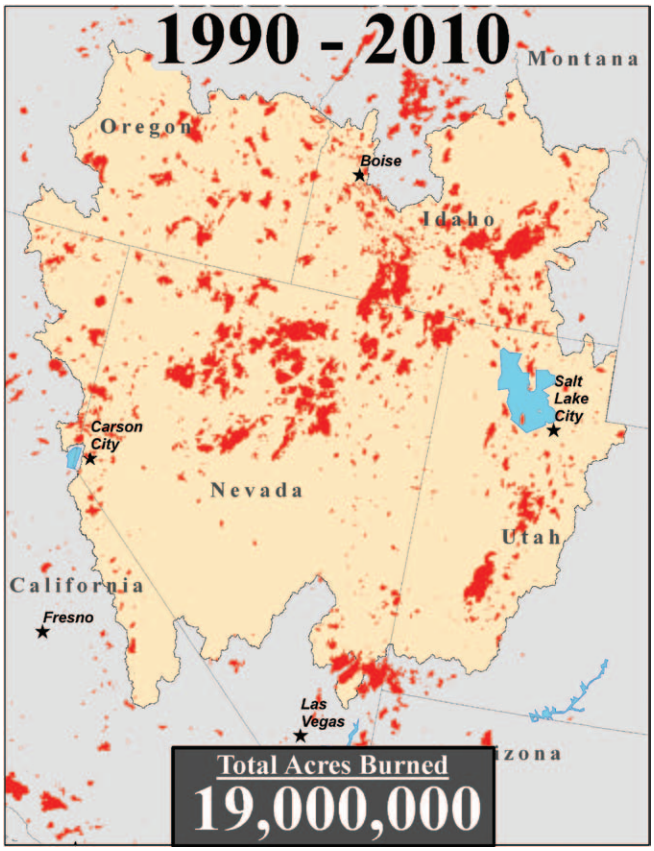

Figure 1. Map generally depicting the floristic Great Basin[i] showing areas burned from 1900 to 2012.

altered fire regimes, issues largely responsible for declining ecosystem resiliency.[8] The goals of the Great Basin Restoration Initiative are to maintain high-value native plant communities and to strategically restore degraded areas, thereby reducing the impact of annual grasses and noxious weeds and to reverse the destructive cycle of wildland fires.

The Great Basin Native Plant Selection and Increase Project (GBNPSIP) was organized by the Great Basin Restoration Initiative in 2001 in collaboration with the USFS Rocky Mountain Research Station and with funding provided by BLM's National Native Plant Materials Development Program.[6,8] Founding partners in the GBNPSIP included the Utah Division of Wildlife Resources, Great Basin Research Center, Ephraim, Utah; USDA-NRCS Aberdeen Plant Materials Center, Aberdeen, Idaho; USDA-ARS Forage and Range Research Laboratory, Logan, Utah; and the Utah Crop Improvement Association, Logan, Utah.[6,8]

Overarching objectives of this program are to 1) work with land managers to select native species appropriate for restoring successional processes that will contribute to the recovery of degraded ecosystems; 2) increase commercial seed availability of genetically diverse, regionally adapted native plant materials, particularly native forbs; 3) develop cultural practices for producing seed and seedlings of these materials; 4) devise strategies and equipment for reestablishing healthy, diverse ecosystems at the landscape scale; and 5) provide tools for selection of plant materials and restoration strategies for reestablishing healthy, resilient native communities in light of continued human impacts, climate change, and potential changes in plant distributions.[9] Science delivery is an essential component of each objective.

Over the last decade the GBNPSIP has expanded to include federal, state, and university research partners. Scientists in fields such as botany, genecology, agronomy, horticulture, entomology, climate change, ecological restoration, and related fields have been sought out as new areas of research are initiated or when problems requiring specific areas of expertise are encountered. In most years there are more than 20 collaborative research projects in progress. Along the way the project has supported numerous undergraduate students and interns, more than 20 MS and PhD students, and three postdoctoral researchers.[9] Integral to the program is interaction with state seed regulatory agencies, the native seed industry, and equipment developers.

Species Needs Assessment, Native Seed Collection, and Research and Development

The first step in meeting the project objectives described above was to select priority species to meet restoration needs. Although several native grasses are included in the research, native forbs were emphasized because of the limited availability of forb seed and their value in increasing and supporting community diversity and resilience. Species lists were generated through surveys of ecologists, botanists, and other resource specialists to identify "workhorse" species, those that are widely distributed and in demand for restoration, fire rehabilitation, or other revegetation efforts. An additional major priority was to identify native forbs that might have narrower distributions, but that are locally important for improving land health and more specific needs such as habitat for wildlife. The list of target species has been adjusted over time in response to evolving priorities and progress in advancing production of key species.

To date, cooperators have made seed collections of 58 forb, six grass, and three shrub species from more than 2,500 wildland sites in five states for use in plant materials development and other research studies (Fig. 2, Step 1). Exchange of seed collected by researchers located at diverse locations in the Great Basin has aided in reducing travel costs for collecting, particularly as the seed-harvesting window for many species is narrow. In addition to researchers working with individual species, private consultants such as Eastern Oregon Stewardship Services, interns from the Bureau of Land Management Seeds of Success Program, and volunteers have assisted in seed collection. This major effort, which includes collection of vouchers and preparation of detailed site descriptions, provides researchers with material representing the range of genetic variation of each species within the Great Basin. It has also increased our knowledge of species' distributions, adaptation, and stressors.

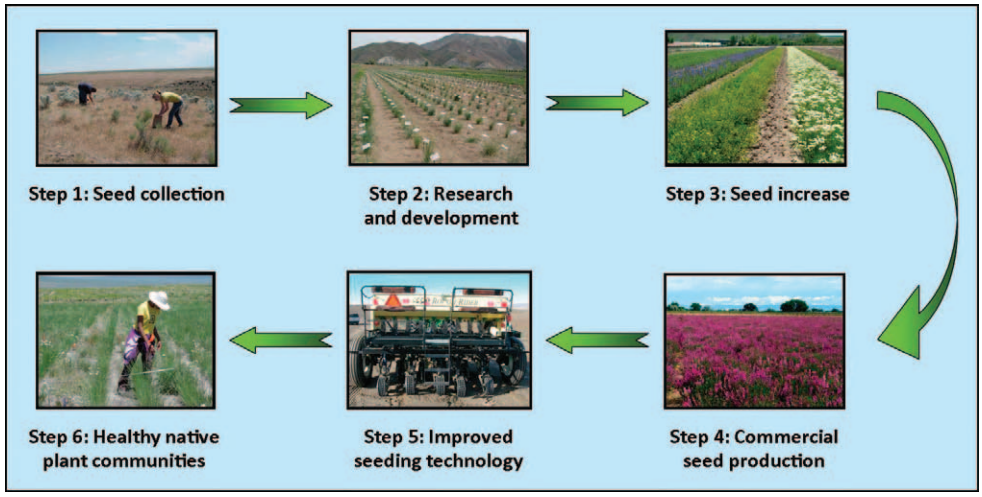

Figure 2. Steps in development and use of native plant materials for wildland restoration. Photos courtesy of USFS and J. Cane, USDA-ARS.

Some late-successional species, such as narrowleaf hawksbeard (*Crepis acuminatus*), an important species for greater sage-grouse habitat restoration, were initially given high priority as potential restoration species. However, several forbs in this category have not proven amenable to production in seed fields, and some do not flower for several years following seeding. Early successional species, including short-lived perennial forbs (e.g., hoary aster [*Machaeranthera canescens*]) and annuals such as fiddleneck (*Amsinckia* spp.) are now being given increased emphasis as they are adapted to disturbed conditions and they flower in the first growing season. From a practical standpoint, seed growers find these species more attractive economically as they begin to reap income in the first year post-seeding. To improve research efficiency, researchers at the USFS Rocky Mountain Research Station and Utah Division of Wildlife Resources have begun screening prospective revegetation species by growing them under agricultural conditions and noting potential bottlenecks to seed production and use.

For the widespread "workhorse" species, researchers are developing empirical or species-specific seed zones by examining genetic variation across the landscape[10] and its relationship to environmental variation using a common garden approach (Fig. 2, Step 2). Genetic variation among populations that correlates with climatic conditions at the seed source locations is likely to represent adaptive traits. This adaptive genetic diversity is then mapped using GIS to provide species-specific seed zone maps. Collaboration among federal researchers at the USFS Rocky Mountain and Pacific Northwest Research Stations, the USDA-ARS and USDA-NRCS Aberdeen Plant Materials Center, and the University of Nevada–Reno has facilitated establishment and monitoring of common gardens at multiple locations. This permits observation of variation among populations when planted in different environments and distributes the considerable time commitment required to conduct these studies. Variations on the approach described above are then applied to guide development of seed zones and plant materials.

For the many species yet lacking species-specific seed zones, a Provisional Seed Zone Map for the Great Basin was developed by the USFS Region 6, based on annual precipitation and average daily maximum summer temperature.[11] Provisional Seed Zones provide a tool that can be used along with Ecological Site Descriptions, Soil Survey data, professional knowledge, and other resources to inform seed collection and deployment. Pooled collections made from within a species-specific or Provisional Seed Zone provide genetically diverse material for seed increase and subsequent commercial production that will help to improve the adaptability and sustainability of outplanted material, while reducing negative impacts on remnant native populations of the same species.[10]

Maps of species-specific seed zones and the Provisional Seed Zone Map for the Great Basin and other regions are available in several formats on the USFS Western Wildlands Environmental Threat Asssessment Center's (WWETAC) Seed Mapper Website[12] along with pertinent literature. WWETAC is posting these maps in several formats (WWETAC Geobrowser, Google Earth, KML, MXD) and will place additional maps on their website as research is completed to aid in planning for research and operational-scale restoration.

Cultural Practices for Seed Increase and Production

Development of cultural practices for seed increase of native plant materials is essential to resolve difficulties encountered when producing seed of individual species under agricultural conditions and to provide guidelines for growers (Fig. 2, Step 2). Native seed growers are primarily small businesses and are reluctant to take on new restoration species, especially native forbs, which often present production problems when field grow-outs are first attempted. Grower's caution is accentu-

ated by market uncertainty as purchases of native seed in the Great Basin fluctuate widely from year to year depending on the number of acres that burn. Production issues vary among species, but the major areas of research required to address these challenges are seed biology and technology, stand establishment, and stand maintenance and harvesting. The USFS National Seed Laboratory collaborates in this effort by developing seed technology and standardized seed germination testing procedures that can be used by seed laboratories to provide data required for marketing and seeding rate determinations. Factors that affect seedling emergence and stand establishment are being examined by university, USDA-ARS, USDA-NRCS, and Forest Service cooperators who work with individual species. These include such factors as soil requirements, seed pretreatments, seedbed preparation, and appropriate planting dates, seeding rates, and seeding depths.

Stand maintenance research examines irrigation, weed control, and nutrient requirements for maintaining healthy seed production fields. The Oregon State University Malheur Experiment Station has taken the lead on this research for a number of forb species. Although irrigation requirements are low for most rangeland species, timing and amounts of added water can be critical in dry years, and requirements vary among species with differing phenologies and growth habits. Subsurface drip irrigation offers the advantage of reducing the availability of irrigation water to weeds developing between rows. These scientists have also tackled specific stand establishment challenges identified by other researchers. Use of row cover has increased emergence and initial establishment of most forb species and has also reduced bird predation of seedlings. Results of this research, including emergence dates, phenological development, and seed yields are made available at annual field days and in detailed annual reports posted online.[13]

Other concerns related to seed production are pollinator requirements, insect pests, and plant diseases. Breeding systems and pollinator requirements for a number of forbs have been examined by a USDA-ARS scientist and his colleagues. Results of this work are used to provide recommendations and cautions regarding potential availability and management of appropriate pollinators in farmland settings.[14] Insect pests and plant diseases can become serious problems when wild species are grown in cultivated monocultures. Colorado State University Cooperative Extension, Tri-River Area, and University of Idaho Parma Research and Extension Center scientists have assisted other researchers and seed growers by identifying insect pests and diseases and recommending appropriate control measures.

Results of research on cultural practices are published as Plant Production Protocols, USDA-NRCS Plant Guides, and online reports for use by growers, nurserymen, and other researchers.[15] These guidelines aid growers in producing native forb seed more reliably, which increases seed availability and growers' willingness to try additional species, while reducing costs for both growers and buyers. The next step in adding to the roster of restoration materials is fostering initial seed increase at public facilities or with private growers (Fig. 2, Step 3) to the point that adequate amounts of seed are available for commercial production (Fig. 2, Step 4).

Wildland collection of shrub seed is often variable because of low seed production in closed shrub stands, excessive browsing or grazing, competitive exotic understories, weather conditions, and other factors. Researchers at Brigham Young University have examined treatments to reduce intershrub competition in Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and antelope bitterbrush (*Purshia tridentata*) and increase seed production.[16] Successful treatments could be used along with appropriate protection from wildfire to manage critical seed production areas as sources of local, site-adapted seed.

Ecological Restoration–The End Product

Commercial production and increased availability of native seed, although the major objective of the GBNPSIP, are not its ultimate goal. Improved technology, equipment, and appropriate seeding strategies are required to successfully restore native forbs and grasses (Fig. 2, Step 5), leading to the desired endpoint of restored, healthy native plant communities (Fig. 2, Step 6). By shifting away from exotic grass monocultures and increasing the use of native species where feasible, land managers can improve ecosystem diversity, structure, and function on degraded or fire-damaged rangelands. However, reestablishing communities of native grasses, forbs, and shrubs on semiarid and arid lands remains challenging and is a priority for GBNPSIP and other Great Basin research collaborations. As native forbs have not been widely used in Great Basin restoration efforts, GBNPSIP researchers have focused their studies on the functional traits, competitive abilities, and establishment requirements of forbs that might be added to restoration mixes in order to provide guidelines for their use.[17,18]

Cooperating scientists from the USFS Rocky Mountain Research Station, USGS, University of Idaho, USDI-BLM, North Dakota State University, and the USDA-NRCS Aberdeen Plant Materials Center have established seeding trials at six locations in four states, primarily on Wyoming big sagebrush sites, to identify strategies for reestablishing diverse, functional communities following wildfire. Comparisons of the standard rangeland drill with the minimum-till Truax RoughRider drill are being conducted to evaluate planting techniques, and the degree of soil disturbance created by each drill. Practices being evaluated include separating species with different seed sizes, surface seeding versus furrow seeding, imprinting small forb seeds on the soil surface, and seeding rates and dates. Seeding treatments are being examined for their effects on subsequent community development, resistance to exotic species, dust emissions, and soil physical and chemical characteristics. Preliminary results indicate that both pieces of seeding equipment result in similar native grass

establishment, while the minimum-till drill with imprinters improves forb establishment. As part of this research, scientists are conducting long-term evaluation of protocols for monitoring post-fire seedings and the impacts of livestock grazing on native seedings.

USDA-ARS, Brigham Young University, and University of Nevada–Reno scientists are conducting studies in four states to examine the feasibility of applying a strategy termed "assisted succession" to restore natives following disturbance. This entails seeding species such as crested wheatgrass to preclude establishment of cheatgrass, then applying techniques to reduce crested wheatgrass competition prior to restoring native plant diversity. Results indicate multiple treatments with herbicides and/or disking are required to lower competition sufficiently to establish and maintain the seeded native species.[19,20]

Science Delivery and Conclusions

The magnitude of ecological issues in the Great Basin requires an integrated and highly collaborative effort to effectively restore degraded ecosystems. Wildfires and invasive species are largely to blame for this degradation, and restoration with native plants offers our best opportunity to a return to a more natural fire regime and landscapes dominated by native rather than invasive species. Substantial progress has been made in designing and implementing a research program to aid managers in obtaining adapted native plant materials and growers in producing them. This program also provides economic benefit to the native seed industry by developing cultural practices for growing native seed and seedlings appropriate not only for disturbed public and private lands, but also for low-maintenance landscaping and horticultural applications. The recent research on successional processes, plant interactions, and technology for successfully establishing native communities is providing new insight and strategies that will improve restoration outcomes.

The success of this project is also measured in sharing the results of the studies and plant material development with the restoration and native seed industry community. A number of venues have been utilized to disseminate this information, including publications, workshops, field days, a dedicated website, and the annual GBNPSIP researcher/manager meetings. Our website[i] is a source of one-stop shopping for all project results, including annual progress reports, scientific papers, technical notes, graduate theses and dissertations, cooperator contact information, and other project-related materials. A web-based Revegetation Equipment Catalog[21] sponsored and maintained by GBNPSIP has received more than 100,000 visits in some years.

Collaboration among this diverse group of researchers has been the key to the growth and productivity of this project since its inception. The 2012 Joint Bureau of Land Management/Forest Service Conservation Project Award was presented to the GBNPSIP at the 77th North American Wildlife and Natural Resources Conference in recognition of the long-term partnership and its accomplishments. This partnership is just part of the success story for GBNPSIP. Just as important are the contributions of the more than 40 federal and state agency, university, and private sector scientists that have greatly increased both the availability of native plant materials and the science and technology required to restore native communities. The accomplishments of this project truly reflect the contributions of all of the cooperators and their dedication and efforts to restore the health of Great Basin lands.

[i] http://www.fs.fed.us/rm/boise/research/shrub/greatbasin.shtml.

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