

Appendix 1: Recommendations and Directions for a Research Program to Develop and Advance Native Plant Materials for the Uncompahgre Plateau, Colorado

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INTRODUCTION

Selection and development of plant materials for use on the Uncompahgre Plateau or other regions with diverse plant communities is based on practices and procedures to retain, enhance, or restore individual communities and plant types. Attempts to change or shift the composition of species in any plant association can be accomplished through successional processes (Ellison 1959), conscientious management practices (Vallentine 1989), or active restoration measures (Plummer 1955). Seeding may not be required if changes in species composition can be attained by manipulating succession. For example, decreasing the presence and dominance of certain shrubs such as big sagebrush (*Artemisia tridentata*), and increasing the herbaceous understory may be accomplished by adjusting grazing treatments or promoting fires. The extent to which active restoration practices are accepted and used obviously affects the need of seed for native species. In most situations, site preparation and seeding are conducted if natural recovery process would not occur without some intervention (West 1984). Studies have demonstrated that certain plant communities are more vulnerable than others to disturbances, even if they are only slightly altered. Although all plant types can be disturbed, some situations require more effort and intervention to restore the complexity of species that once existed (Ellison 1954).

Investigators have found that attempts to improve disturbances in semi-arid and arid communities though natural recovery have not been successful where the number of remnant plants were moderately low and widely dispersed (Bleak and others 1965). Vallentine and others (1963) attempted to quantify numbers in the sagebrush types and suggested an index of 15 percent cover of native herbs was necessary to assure recovery. Many factors influence natural recovery and success of project seedings. Most important are the size of the land unit, proximity to natural seed sources, competition from invasive species, the extent to which soils have been altered, amount and seasonal rainfall, and post management practices. No single index is available to define disturbances that require artificial treatments to reestablish a complex of native species and initiate succession to again attain a near climax condition.

Plant communities are an assembly of related associations, and a single climax plant community does not fit the complex successional pathways of many rangeland ecosystems (West 1979; Westoby 1980). In addition, shifts or changes in species composition can be expected, creating different seral stages. Changes can often be predicated and modeled (Tausch and others 1993). However, certain impacts may create conditions or thresholds that are not reversible (Stringham and others 2003),

and once certain thresholds of disturbance are reached, the communities cannot recover without some outside intervention. State and transition models are being developed and used to define ecological processes, identify irreversible thresholds, and develop methods and practices to restore disturbances (Stringham and others 2001).

Current studies reaffirm earlier assessments that certain major plant communities that dominate the Great Basin, Colorado Plateau, and specifically the Uncompahgre Plateau are sensitive to disturbances. Tausch (1999) reported that impacts from grazing, fire management, and climate have significantly influenced the pinyon/juniper woodlands in the Great Basin creating dramatic increases in tree density and areas of occupation. (Miller and Wigand 1994; Miller and Tausch 2001) conclude that increases in tree density and presence reduce both the woody and herbaceous understory. Tausch and Tueller (1990) and Tausch and West (1994) provide predictable models defining the rate of decline and the time intervals for the loss of understory species as tree density and size increase. Tree encroachment reaches predictable transition thresholds that are not reversible without external imputes such as tree removal and seeding (Tausch and others 1993). Extensive shrub and grass communities in the West have been invaded and displaced by pinyon/ juniper (O'Brien and Woudenberg 1999). These areas will obviously require seeding to reestablish the displaced species (Plummer and others 1968).

The status of the pinyon-juniper woodlands on the Uncompahgre Plateau is certainly important to develop management practices and determine if changes may have reached thresholds where active restoration is required. Conditions will obviously be important to large areas in this region. In addition, the current ecological conditions of the woodlands determine the eventual changes that will occur and the associated thresholds that will ultimately develop. The current status and progressive changes determine if management practices may alter or reverse the direction of change and will determine if remedial treatment may be required at some particular point.

A major concern of changes that can occur and will affect remedial treatments, including tree removal and seeding, is that tree encroachment weakens and diminishes vigor and seed production of understory species. Seed production is diminished and restricted for many years as trees gain dominance. Since understory species fail to produce seeds the natural seed bank is ultimately exhausted (Poulsen and others 1999). Consequently, any attempt to reestablish the diversity of understory shrubs, herbs, and grasses must be accomplished by seeding. Natural recovery can be accomplished if tree dominance is removed before competition has effectively removed the understory species and prevented their ability to recover and reproduce (Tausch 1999). Defining progressive stages or changes that occur including irreversible transition thresholds is certainly critical in this region.

Pinyon-juniper woodlands present other important issues that influence restoration that are somewhat unique to this plant type. The lack of seed reserves of associated species is certainly a concern and is interrelated to a series of other problems. Direct competition from the trees not only diminishes survival of understory species but also prevents invasion and establishment of new species (Austin 1999). Tree competition

is so effective that few other species are able to establish and survive. Consequently, removal of the trees is required to reduce competition and assure seedling establishment (Stevens 1999). In addition, reinvasion of understory species is dependent upon creation of safe seedbeds. Natural recruitment is often hindered by poor seedbed conditions. To be successful, seeding of many species requires creation of specific seedbed conditions over extensive sites.

Other plant communities within the Uncompahgre Plateau must be carefully evaluated to determine if remedial treatments are necessary and possible. Big sagebrush communities, mountain brush shrublands, and some salt desert shrublands occur and occupy large and important sites. Many species in these communities including some dominant shrubs do not recover well particularly after excessive grazing pressure over many years. Plant density and distribution patterns are so disrupted that natural seeding is ineffective. Shrubs that are less likely to recover naturally include fourwing saltbush (*Atriplex canescens*) and common winterfat (*Ceratoides lanata*). Other shrubs including curleaf mahogany (*Cercocarpus ledifolius*), snowberry (*Symphoricarpos oreophylus*), serviceberry (*Amelanchier alnifolia*), and black sagebrush (*Artemisia nova*) occupy specific sites and loss of plants from these stands can seriously reduce the seed source. These species also require specific seedbed conditions and seed dispersal, planting, and seedling survival are directly related to climatic and biotic conditions. Natural conditions can be so altered that recruitment is not possible without some intervention.

Big sagebrush communities are also important and widely distributed shrublands throughout the Uncompahgre Plateau, yet when altered may require treatment to regain species diversity and areas of occupation. Disturbances that often occur in the sagebrush communities have frequently resulted in the demise of understory herbs. Sagebrush plants have increased in some situations creating serious competition that prevents natural recovery or the establishment of seeded species (Plummer and others 1955). Reduction of competition from the shrubs is essential to allow seedling establishment of associated species (Roberson and Pearse 1945). Natural recovery of understory species is particularly difficult in semi and arid situation (Bleak and others 1965). Sagebrush disturbances are also highly vulnerable to annual weed invasion, particularly of cheatgrass brome (*Bromus tectorum*). If this weed gains entry in the sagebrush and pinyon-juniper communities, its aggressive growth habit usually results in it gaining dominance (Evans and Young 1978). Annual and perennial weeds are a major factor to consider in restoring or improving shrub and tree woodlands. The presence of annual weeds in these communities is often the major factor that prevents natural recovery and the success of artificial seeding. If annual grasses gain even limited presence in these communities, thresholds are quickly reached that prevent the recovery of the natives (Young and Evans 1978). Annual weeds, particularly cheatgrass, is highly competitive and prevents seedling establish of most other species. In addition, the plants create unusual and frequent fires that weaken and eventually eliminate many native species.

It is essential that land managers recognize the feasibility and ecological practicality of restoring different plant communities by natural recovery or by a combination of plant control and seeding measures. Restoring native species by direct seeding obviously

requires an extensive plant development program. Restoration measures may be expensive and will likely require commitment over a long period. Consequently, it is essential that sites that can not be improved by natural succession are correctly identified, and effective remedial programs are developed.

SPECIES SELECTION AND DEVELOPMENT

LITERATURE REVIEWS AND COMPILATION OF EXISTING INFORMATION

Before an active and effective plant development program can be initiated, the key or principal species considered important to restore specific plant communities must be identified. Agency personnel and members of the UP committee have developed a primary list of species considered important for restoration, principally within the pinyon-juniper and big sagebrush communities, (table 1). This list of candidate plants will serve as the principal species discussed in this report. The plants included in the species list are generally climax or late serial species. These plants generally represent the plants that land managers would be desirous of re-establishing. The primary hurdles in using species and material that are native to this region are twofold. First, information about individual species is limited, and second, there are insignificant seed and plant materials to accomplish large-scale seedings. Consequently, initial research should be focused upon a thorough review of existing literature, followed by a careful compilation and assessment of this information as it relates to restoration measures. Once the information has been compiled and evaluated, subsequent research can be designed and supported. In addition, restoration projects can be initiated with greater surety of success.

Unpredicted disturbances can and will occur within the region affecting communities and sites that will require additional or different species than those currently listed for initial development. In addition, certain plants, native to the Uncompahgre Plateau, are being successfully propagated in other regions throughout the western states (McArthur and Young 1999). Sufficient information is presently available to produce and utilize a number of native species presently listed for the Plateau. Rearing and planting practices are well understood, and can be applied to species and situations in Colorado (Plummer and others 1968). Comparative studies should be conducted to determine if plant materials collected from the Uncompahgre Plateau are similar to materials from other regions.

Some research dealing with plant biology, ecology, and culture have been conducted and reported for nearly all species or genera proposed for this project. Obviously, some species has not been thoroughly investigated and considerable information is needed to consistently produce sufficient amounts of seed and successfully plant the species under wildland conditions. Some species have inherent problems that can and do limit their usefulness. Seed germination and establishment is a critical issue with many species. The potential success for artificial restoration must be recognized. Investment of resources to develop individual species must be considered. Although some species may present difficult cultural problems, they may be extremely important and may justify added attention.

Detailed Literature Review: A thorough literature review should be conducted to assemble available information of individual species proposed for restoration. Information should be compiled in the following categories:

1). Plant Identification

Individual species proposed for restoration often consist of a combination of subspecies, varieties, or ecotypes that have evolved to occur in specific environments. It is essential that differences are identified to assure that site specific species or varieties are known. The relationship of different subspecies or varieties is also important to understand the taxa, determine areas of occurrence, and identify breeding systems and means of natural reproduction. Valles and McArthur (2001) provide a useful example of techniques and practices that have evolved in determining the identity and relationship of the genus *Artemisia*. Most species would not require such exhaustive and complete investigations to facilitate use in restoration projects. Yet, it is useful to review the procedures ultimately used to understand this important group of plants. Plant classification systems were initially developed through examination of the ecology and geographical distribution of the genus. Cytogenetic and molecular biology studies were used to delineate genetic relationships and develop classification systems. The authors concluded that morphological and population biology studies can be used to better understand this genus. It is obvious that species identification will rely upon a combination of techniques and practices that will eventually evolve as information is accumulated.

2). Plant ecology

It is important to understand the different plant communities and areas of occurrence of individual species. In addition, it is necessary to know the successional or serial status of each species and the natural response of each plant to climatic and biotic influences.

3). Plant biology

Phenological and morphological information is needed to understand how plants grow and reproduce under natural conditions and in cultivated or managed situations. A variety of factors regulate plant growth and natural recruitment. It is essential to understand these influences and create conditions to favor plant growth as remedial treatments are planned. Understanding the natural growth patterns of plants provides a means to evaluate performance of reconstructed communities and predict success and perpetuation of established stands.

4). Plant rearing and culture

Attempts to manage or acquire seed of native species from wildland stands or produce seed from cultivated plantings will require

considerable information. This information is not currently available for most species. Information related to floral and seed formation is essential. In addition, seed germination features, establishment traits, rearing conditions, and seed harvesting and processing process practices are needed. Planting species under wildland conditions requires understanding of seedbed conditions, compatibility of associated plants, and influences of climatic and environmental conditions.

Information describe above has not been developed for most native species listed in (table 1). However, it is important that that the information that is available be compiled and used to determine research that is needed and should be funded. Plants proposed for restoration can be actively developed and promoted without unnecessary delays simply because some information is lacking. However, it is important that investments in the growing and production of plants are not wasted because a species is inadvertently grown in a poor environment. Some information has been compiled and can serve as a resource to initiated literature reviews, assemble or compile, and report available information (USDA Forest Service FIES Report).

Compilation and Analysis of existing information is consistently needed to revise and employ the most effective practices related to restoration. Considerable information is available but not always used as field projects are planed and administrated. Since a number of relative new species are being considered for restoration projects, including investment in extensive commercial rearing projects, it is essential that information gathered is utilized. Considerable difference and speculation currently exists of the practicality of actively restoring many plant communities. Restoration measures must be based on sound and correct information. An active part of the research program should include methods to assimilate, access, and dispense the information.

RESEARCH PROGRAMS

A number of exotic plants, principally perennial grasses, have been the primary species previously used in most wildland revegetation projects (Monsen 1975; McArthur and Young 1999). However, studies have reported that the principal introductions are not compatible with the recovery and persistence of most natives (Lusica and DeLuca 1996; Monsen and others 1996). Seeding exotic perennial grasses including smooth brome (*Bromus inermus*) and intermediate wheatgrass (*Thinopyron intermedium*) have effectively suppressed and replaced native forbs, perennial grasses, and key shrubs throughout the mountain brush and aspen parks communities in central Utah (Monsen and others 1996). Walker and others (1995) has documented that important native herbs and shrubs that initially recovered following chaining of pinyon/juniper stands were slowly eliminated by the growth of introduced grasses. Displacement of native species was closely correlated with the amount of annual precipitation received, but a shift in species composition to a dominance of a few introduced grasses continued each year over a 30-year period. Vernon and others (2001) reported that young and developing seedlings of introduced perennial grasses

had a negative influence upon the establishment and presence of native herbaceous plants following chaining and seeding of ten pinyon-juniper woodlands in Utah. Newman and Redente (2001) concluded different communities develop from seeding mixtures with and without introduced species. Seeding introduced plants had long-term implications on the richness of native species. In addition, to the suppression and replacement of native species, seeding of exotics can have negative and long-term effects on soil conditions (Domaar and others 1978).

Conversion of native plant communities to a dominance of exotic grasses does not provide the seasonal wildlife habitat required by most animals (Stevens 1999). Extensive areas throughout the Intermountain west that were once occupied by big sagebrush have been seeded to desert wheatgrass (*Agropyron desertotum*) and fairway crested wheatgrass (*Agropyron cristatum*) (Plummer and others 1955). These plantings have effectively prevented the recovery of many native broadleaf herbs and big sagebrush. Seasonal sage grouse habitats have been lost and are not likely to recover unless the introduced grasses are replaced with a native component of herbs. Carefully designed restoration measures within the pinyon/juniper woodlands, including the removal of competitive tress and re-establishment of adapted understory shrubs and herbs, have improved habitat for sage grouse (Commons and others 1999) and big game animals (Fairchild 1999). Although various introduced grasses have been successfully used to control erosion and reduce down-stream damages, re-establishment of more diverse communities are advised (Roundy and Vernon 1999).

Introduced grasses have been widely used to control annual weed invasion and spread following wildfires (Pellant and Hall 1994). Although annual weeds, principally cheatgrass, can be controlled with these species, weed invasion is an increasing and serious problem throughout the West. An increase in the number of troublesome perennial weeds and expansion of their areas of occupation continues at an alarming rate (Rees and others 1996; Sheley and others 1998). Seeding highly competitive introduced perennial grasses and repeated applications of herbicides have been effective in controlling some perennial weeds (Sheley and others 2001). These treatments have a negative effect as they eliminate other desirable species. Liao (1996) describes the reproductive features of rush skeletonweed, (*Chondrilla juncea*), which helps to explain its rapid and persistent spread in Idaho and adjacent states. Seedings of introduced grasses have not prevented the spread of this weed and other troublesome species including squarrose knapweed (*Centaurea virgata*) in central Utah. Dewey and others (1997) recognizes that prevention and containment of a new, but large group of new perennial weeds, cannot be accomplished by seedings introduced grasses, but requires the existence and maintenance of native communities.

A change in the use of native species in any regional area requires a major shift in the production of desired plants and the development of practices to plant and established the new species (Roundy and others 1997; Jones and Johnson 1998). The change affects a number of plants simultaneously. Advancement of one or two native species to replace an individual exotic species is not sufficient. The primary object is to provide a combination of native species that occur in a particular community. Consequently, a

number of species with different growth forms (grasses, broadleaf herbs, and shrubs) are needed in many situations. Developing a large number of plants requires a concentrated and long-term commitment involving studies in different but related disciplines (Monsen 1987, McArthur 1988).

Research studies in the following areas are recommended to initiate and support development of native plants for the Uncompahgre Plateau. Other related areas of study may be justified but it is important to initially understand the general ecology and biology of individual species to aid in seed propagation and wildland planting practices.

PLANT ECOLOGY

Numerous plant communities and plant associations are reported in the pinyon/juniper woodlands (Tausch and Tueller 1988), big sagebrush communities (Tiesdale 1969), and related desert shrub regions (West 1988). Changes in species presence and distribution are influenced by successional changes in the community, particularly in the pinyon/juniper types where tree encroachment is reported (Miller and others 1995, Bunting and others 1999). Consequently, knowledge of the status and adaptability of a particular species in the successional stages of plant communities is essential. It is important to understand the occurrence of individual species in a community complex, and the adaptability of plants to re-establish in reconstructed environments. Ellison (1954) reporting on subalpine communities in central Utah documented systematic recovery patterns of plants reinvading disturbance that were protected from grazing. Although secondary successional patterns likely occur in other plant communities, a majority of late serial species that occur in the pinyon/juniper and sagebrush shrublands have demonstrated the ability to establish and persist in reconstructed environments. Many species have been evaluated for their establishment and growth attributes on actual disturbances, and have performed satisfactory as early serial species. Species attributes and planting recommendations are summarized and reported by (Plummer and others 1968).

The distribution patterns and areas of occurrence of individual species must be investigated and documented. The relationship of individual plants with other species should be defined. Factors effecting plant distribution, including both physical and biological influences should be investigated. Of particular importance to species distribution and persistence are factors influencing natural spread and recruitment. This would include climatic as well as biotic influences that could influence and regulated seed formation, germination, and seedbed conditions (Meyer and others 1989).

Individual species have evolved to adapt to particular environmental conditions. Different subspecies, varieties, populations, and ecotypes have emerged, and some are restricted to specific conditions (Welch and others 1987). The genetic variation and adaptability of specific populations is essential in selecting plants for restoration plantings (Munda and Smith 1995).

Big sagebrush is a common and widely distributed shrub in Western North America and consists of five subspecies that are adapted to particular elevations and climatic zones (Rostentreder and Kelsey 1990; McArthur 1994). Although these subspecies may grow in close proximity and adjacent to one another, they do not occur beyond their natural environment. Hybrids are common among different subspecies, but their areas of occurrence are restricted to a specific hybrid zone (McArthur and others 1998). Fitzsimmons and others (1998) reported that different geographic populations of fourwing saltbush exhibit differences in growth responses which can affect plant survival. The reproductive mechanisms of many native shrubs have been reported to be directly influenced by climatic conditions (Walton 1984), and different plants populations have evolved to succeed in different environments (Meyer and McArthur 1987). Consequently, it is important to investigate the potential occurrence of different populations or ecotypes of individual species within the Plateau. As possible, it advisable to determine if difference may exist that are genetically different and may be important to the survival and use of the plant. Cytogenetic and molecular studies have been important in the identification, ecology, and distribution of big sagebrush (Valles and McArthur 2001) other large groups of plants. In addition, recent trials using metabolic heat rate and respiration to calculate growth rates and adaptability of different native species has been high successful, rapid, and repeatable procedures (Hansen and others 1994; Criddle and others 1997). Jones and others (1999) found these techniques can be used to rather quickly and accurately identify separate ecotypes of different forbs, and determine their adaptability to environmental stress. Monoco and others (1996) have used these same techniques to identify different ecotypes of select native grasses and forbs. These procedures can be used to identify different populations or ecotypes of plants collected from the Plateau. Plant phenological studies, accompanied by seed germination studies, provide useful information to assist in determining differences in plant growth as it relates to environmental conditions. Establishing and maintain receptacle field plantings is perhaps the most important procedure that can be used to conduct comparative evaluations of plant growth, reproduction, and survival over a range of conditions.

PLANT BIOLOGY

Plant biology studies are important particularly of species that may be new or not previously used in restoration projects. Plant biology studies are closely related to life history studies and are directly influenced by ecological and environmental influences. It is important to investigate the effects of environmental conditions upon the growth of individual plants. Factors influencing initiation of growth and seasonal growth characteristics are obviously important as plants are grown under cultivation or in combination with other species. The ability of different plants to grow at different periods and at different rates is key to their survival under wildland conditions.

Plant biology studies can be grouped or organized into the following categories (Raven and others 1999). It is important to recognize that all species may not require similar areas of research. However, basic biological studies are required to fully understand the response and ecological adaptation of most species.

Potential Areas of Biological Studies

Biology of plant cells, Structure and Development

- The molecular composition of plant cells
- Cells and tissue of the plant body
- The root structure and development
- Shoot and structure and secondary growth

Energetics

- The flow of energy
- Respiration
- Photosynthesis

Genetics and Evolution

- Reproduction of cells
- Genetics and Heredity
- Gene expression
- The process of evolution

Physiology of Seed Plants

- Growth regulators
- External factors and plant growth
- Plant nutrients and soils
- Movement of water and solutes

A number of native plants proposed for the Uncompahgre Plateau have and are being used in restoration of other regions (table 2). Many of these taxa consist of a number of subspecies and ecotypes that differ in their growth habits. Consequently, it is advisable to establish comparative studies with a select number of species collected from the Uncompahgre Plateau with other known population to determine if similarities or differences may occur (table 2). These results can help to develop planting recommendations rather quickly.

A number of biological studies can obviously be recommended and will likely be conducted. Studies must be designed to address each individual species under question. Previous studies that focus on the initial growth on young seedlings and the ultimate development of mature plants have proven essential. Determining factors that control and regulate establishment and growth are critical to establishment of wildland plantings. Combining ecological studies with the plant growth and flowering characteristics has proven to be necessary to understand the establishment requirements of many species. A list of interrelated studies that have been essential to the development of a few representative native species is reported in (table 3). Studies of this type will be required as species are proposed for restoration. As literature reviews are completed, a better understanding of specific biological studies for individual species will emerge. It is important to develop basic information for each species, and this will require some time. University students and cooperators can be encouraged to participate and conduct specific studies that will require rather concise examinations and laboratory facilities. In addition, it is important to develop

cooperative relationships with different scientists that have the skills and facilities to pursue research in specific disciplines.

PLANT LIFE HISTORY STUDIES

Studies that relate to plant morphology, floral, and seed development are specifically important to a new group of native species. Attempts to produce seed under cultivated conditions or plant species on wildland sites requires an understanding of the seed germination features and growth stimuli. Studies have demonstrated the seed germination patterns and features are regulated, in part, by genetic constraints (Naylor 1961; Meyer and Monsen 1990; Kitchen 2001), although conditions that exist at the time of flowering and seed maturation can also affect seed dormancy and germination (Meyer and others 1990). Annual seed production, seed quality, and germination of wildland harvested seeds are highly variable and usually directly related to environmental conditions (Beckstead and others 1995).

Seed germination patterns for a number of species have evolved to match environmental conditions that prevail in the region of seed origin (Thompson 1973; Meyer and McArthur 1987). The influences are particularly important for a number of major shrubs that occur throughout the Uncompahgre Plateau, principally big sagebrush (Meyer and Monsen 1990), rubber rabbitbrush (Khan and others 1987; Meyer and McArthur 1987, and four wing saltbush (Sabo and others 1979). The geographic distribution of key native species that occur throughout the Uncompahgre plateau should be located and mapped by elevation and site conditions. Seed germination studies should be conducted of individual species to determine if germination patterns may differ among the different collection sites. If differences are recognized, additional studies should be initiated to determine if differences are regulated by genetic constraints or may be environmentally controlled.

Life history studies can obviously gather useful information of the growth sequence, longevity, and natural recruitment processes of candidate plants, but initial attention should be directed to investigating the processes of floral and seed development. Studies are required to determine timing and periods of development and the influences of environmental conditions on vegetative growth, flowers, and seed development (Venable 1984). Seed quality and germination studies should also be emphasized. Processes or vectors influencing seed pollination, development, and maturation of seed crops are of particular importance. Most species reproduce sexually although asexual reproduction can be accomplished by some plants. Species of *Poa* can produce embryos asexually, and spread by vegetative tillering is common with many species. Methods of reproduction affect population biology and ecology (Baskin and Baskin 1988), which in turn, becomes important as decisions are ultimately made in the selection and planting of specific ecotypes.

As studies influencing seed production and seed quality are completed, information will likely be obtained that would identify procedures or methods that could be employed to improve seed production, increase the quality of the seed, and regulate seed germination. A number of species will have inherent seed germination problems (Sabo and others 1979), and will require some treatment or change in rearing

conditions to stimulate and better regulate germination and growth. These problems have prevented the use and success of a number of important species. It is advisable to establish a series of screening trials to evaluate seed germination trials of all species and seed sources collected from the Uncompahgre Plateau. These studies could quickly identify problems of delayed or low seed germination. In addition, normal germination patterns and environment conditions that are required to break dormancy and stimulate growth could be identified. Species recommended for life history and specific seed production and germination studies are listed in (table 4).

SEEDBED ECOLOGY AND SEED GERMINATION REQUIREMENTS

The success associated with planting of most species is attributed to seed germination, seedbed ecology, and seedling establishment (Heit 1971; Monsen and Shaw 2001). Since seedling establishment is such an important part of restoration, defining seed germination patterns, determining the presence and influence of seed dormancy and structural barriers are studies that need to be initially developed for most species (table 4). In addition, information related to seedbed requirements and seedbed ecology is also needed for many species. Most species require somewhat specific seedbed conditions to effectively imbibe moisture, germinate, and establish (Jordan and Haferkamp 1989). A high percentage of planted seeds fail to remain viable and are able to germinate at the appropriate season. A considerable number of seeds are lost to disease, saturated soil conditions, insects, and rodents.

Many seeds are lost or fail to establish as they are not placed in the right location in the soil to germinate and emerge. Seeds of individual species require different periods of stratification and soil moisture to germinate. Soil surfaces dry rapidly and seeds must be properly positioned to complete germination when conditions are favorable. Many species exhibit seed dormancy and germination patterns that have evolved to coincide with specific environmental conditions. Seed germination is regulated to prevent precocious germination at periods when survival is less likely to occur. Seed germination and establishment studies must be conducted of most species proposed for restoration within the Uncompahgre Plateau.

Land managers have limited options to prepare and create seedbeds for a number of species over a large area. Seedbed preparation is usually not recognized as an important or separate practice from seeding. Planting is often conducted on surfaces that have been exposed as a result of fire or have been disturbed during extended periods of surface erosion. Planting a mixture of species on these disturbances is often conducted without any effort to prepare the seedbed. Seed bed requirements of a number of native species proposed for development and use in restoration of the Uncompahgre Plateau are not known. A series of screening trials should be established to evaluate the effects of planting depths, dates of seeding, timing of emergence, and initial growth of a number of key species (table 5). These species and studies should be given priority.

Studies should be designed to monitor and track germination and seedling emergence from the inception of fall planting dates to the end of germination in the spring or early summer months. Climatic and biotic factors that effect germination and seedling

establishment should be identified and evaluated. It is essential to determine the seedbed conditions that are required to successfully support seedling establishment. This information is required to develop and improve present equipment and planting practices.

Studies are also needed to determine the compatibility of young seedlings of different species that would likely be planted together. Many species are capable of establishing simultaneously when seeded together, yet certain plants have been reported to benefit by staggered entry patterns simulating stages of secondary succession. Creating different seedbed conditions to support planting of a number of species will require some preliminary seedbed studies.

Interseeding some select species into sites where some residual vegetation exists will be required in many situations. Evaluating and developing procedures and practices to prepare desired seedbeds without unnecessary damage to existing plants will be required. Interseedings will be required to establish shrubs and herbs in different situations.

Shrub seedlings tend to develop slower than most herbs, and differences in growth rates among ecotypes have been reported for some species. Since establishment of diverse communities is essential, designing procedures to seed and sustain species that grow at quite different rates is important. Seedling compatibility studies will be particularly important with the establishment of mountain mahogany, serviceberry, and other shrubs.

NATURAL RECRUITMENT

In most restoration projects, retention of the native plants is essential. In addition, promoting the establishment of native species by natural recruitment from seed retained in the seed bank is also important. It is important to investigate the expected recovery of native species from seeds surviving in the seed bank. Defining the influence of tree and weed encroachment on seed banks and natural recruitment is important in all communities. Some site on the Plateau could benefit by slight modifications of existing plant associations. Reduction of plant competition coupled with selective interseedings can promote natural recovery, and are viable means to restore various shrub and tree communities.

SEEDING PRACTICES

Developing seeding practices to accomplish seeding of large and irregular terrain and surfaces is desperately needed. Studies should be implemented to develop and modify equipment to improve planting success. Modification of drills to simultaneously plant a number of species in different seedbeds must be completed to improve planting success. Studies should also be developed to evaluate the seedbed conditions created by chaining, roller-chopping and other mechanical practices. Studies should also be initiated to investigate the influence of surface litter from big sagebrush and pinyon/juniper woodlands on seed banking and germination. Planting

success on burned and non-burned areas is also important as natural and controlled burns will likely occur on extensive tracts.

SPECIES ADAPTATION TRIALS

Seeds of most species considered to be important in restoration will be selectively collected from different locations throughout the Plateau and from surrounding locations. Material will be collected from areas or locations that appear to represent different ecotypes. In addition, multiple site collections will be acquired to assure that the broad germplasm of each species is obtained. The distribution and areas of occurrence of each species will be recorded and mapped. The physical and biotic conditions at each collection sites will be compiled. It is anticipated that collections will extend over 3-5 years (table 6). Collection records will be compiled and made available to other cooperators.

Genetic variability and variation among collected populations can be determined through analysis of molecular genetics DNA. Amplified fragment length polymorphism tests will be used to correlate DNA polymorphism and ecological traits of selected species. These studies can be used to assist in determining differences in plant populations and their areas of adaptation.

Comparative plantings will be established at a number of representative sites on the Plateau. Seeds collected of different populations of each species will be planted at the representative sites to record and compare survival, growth responses, recruitment, and the influences of environmental conditions on plant growth. Representative studies will be established and maintained within the sagebrush, pinyon/juniper, mountain brush, and selected salt desert communities. Plantings will be evaluated at seasonal periods to collect vegetative growth, floral formation, and seed production. These sites will also serve to support insect pollination, animal depredation and selective or grazing preference trials.

SEED REARING AND PRODUCTION

Adequate supplies of high quality seed are needed to support restoration projects. Annual production of site adapted material is needed to sustain a proactive program and to furnish seed for restoration of unexpected disturbances including wildfires. Demands for seed must be sufficiently consistent from year to year and of enough volume to sustain a commercial seed industry.

It is important to determine the amount of seed of different species expected to be used each year. This information is needed to assist seed companies and growers to develop the resources to sustain this industry.

Wildland stands of most species do not produce the amount of seed that can be harvested annually to support large restoration projects. Consequently, the majority of seed used must be grown under cultivation. Some seed may be produced by intensive management of wildland populations, but this means of production will likely be restricted to a few shrubs. A number of native species are currently grown

successfully in cultivated fields by commercial growers. However, most plants proposed for use on the Plateau have not been grown in cultivated fields and studies must be developed to investigate field production procedures (table 7). Field rearing can begin without extensive delay for a number of species. Plants that can be grown with some degree of success can be established as “foundation fields” at the Meeker Plant Center. Seed and information gathered at the Meeker center can be furnished to select growers for commercial production. Seed production studies will be conducted of each foundation field to determine seed yields and general growing requirements.

FIELD REARING

A general series of screening trials developed for each native species that has not been grown in cultivation. Separate studies will be designed depending on the anticipated problems, floral and seed features, and vegetative characteristics of each plant. The following trials may be employed for each species. In addition, comparative trials will be designed to evaluate seed yield from different populations grown in common fields.

Seedbed preparation and seeding trials. Studies will be conducted to evaluate seedling establishment of different species as influenced by planting methods, seeding rates, planting dates, and seedbed conditions.

General Field Culture. Screening trials will be established to investigate row spacing, irrigation, fertilization, herbicides, and plant diseases.

Floral and Seed Development. Surveys will be conducted to determine methods of pollination, insect associations, seed maturation processes, and viability.

Seed Features, Harvesting, and Processing. Patterns of fruit and seed development will be recorded and described. In addition, descriptions of fruit and seed structures will be compiled to assist in designing seed harvesting and cleaning processes. The effects of seed harvesting and cleaning practices on seed quality and germination will be evaluated.

Wildland Seed production Trials A number of native shrubs grow in site specific locations and do not grow well when moved to off-site locations. In addition, many species do not reach maturity for a number of years following planting. Seed production is closely correlated to climatic, insect pollination, soil conditions that are difficult to duplicate under cultivate fields. Consequently, it is advisable to manage certain wildland stands to maximize annual seed production. Certain wildland stands are of sufficient size to produce substantial seed crops if carefully managed. Stands of fourwing saltbush, winterfat, big sagebrush, low sagebrush, serviceberry, and mountain mahogany are shrubs that could be managed for seed yields. A series of treatments including pruning, thinning, control of competition, fertilization, and insect management will be investigated on select wildland stands. Flowers and seed development will be investigated of treated and control plots over a period of 2 to 5 years.

COMMERCIAL SEED PRODUCTION STUDIES AND PROGRAM

Seed production fields and studies will be established with select growers through coordination with the Colorado State Crop Improvement Association. Seed will be supplied to qualified growers using a “buy back” option, a mechanism for returning part the seed increase to the Crop Improvement Association for future increase to additional growers. Seed distributed to commercial growers will be administered by the UP steering committee and the Colorado Crop Improvement Association.

Specific seed production studies will be established with select growers to advance seed rearing research. Studies related to different methods of culture, insect pollination, and harvesting will be designed and established at select locations. Individual growers will assist with establishment, maintenance, data collecting, harvesting, and seed processing. This series of cooperative studies will aid in developing culture practices, and will train and prepare growers to produce relatively new crops. Initial seed production studies will be established at the Meeker and Colorado State Field Centers, and these centers will assist and coordinate studies with commercial growers.

RESTORATION AND DEMONSTRATION PROJECTS OF BIG SAGEBRUSH AND PINYON/JUNIPER COMMUNITIES

Representative stands of Wyoming big sagebrush, mountain big sagebrush, and pinyon/juniper that have lost their understory and may support some annual weeds will be selected for restoration. Prior to treatment, sites will be inventoried to define the composition, presence, age class, distribution, and vigor of understory herbs and shrubs. Remedial treatments will be developed to re-establish the complex of native species and plant associations that once existed. Within both sagebrush and pinyon/juniper sites, the condition of the understory and the presence of the woody vegetation will be compiled and compared with thresholds and condition classes described by other investigators (Tausch 1999). Remedial treatments will be established in areas where sufficient loss of the understory and woody plant dominance has reached thresholds that are not reversal without intervention. In addition, areas that have not have reached irreversible thresholds will be treated with measures that can reverse current plant degradation trends.

The objectives of the studies will be to:

- 1). Determine the state of stages of plant community deterioration that can be reversed without seeding to allow natural recovery.
- 2). Identify the state or condition of pinyon/juniper woodlands that require remedial treatment including seeding to restore the sites.
- 3). Develop restoration measures to restore disturbed sagebrush and pinyon/community sites. Evaluate treatment measures including burning and mechanical treatments on control of plant competition, seedbed preparation, seeding success, and recovery of existing native species.
- 4). Evaluate the effects of individual treatment on the recovery process of treated sites including areas where seeding and non-seeding measures are used.

- 5). Determine the effects of remedial treatments upon watershed stability over periods of recovery.
- 6). Evaluate the effects of treatment measures on wildlife habitat during periods of recover and late seral stages of development.
- 7). Evaluate the effects of treatments on fuel conditions, including the susceptibility of treated and non-treated sites to ignite and carry fires.
- 8). Determine the cost effectiveness of individual treatments, and develop guidelines for future projects.

Remedial treatments will require a considerable native site adapted seeds for a number of species. Seed will have to be grown from commercial fields which will require a number of years to accomplish. A series of treatments will be used to control plant competition including burning and mechanical measures. The effectiveness of these measures to reduce competition, accomplish seedings, and facilitate recovery of residual native plants will be evaluated. Treatments will also be established on comparable watersheds to facilitate large watershed scale studies. It is important to evaluate treatment effects on small watersheds to monitor effects of surface stability, channel erosion, and collective down-stream or off site resources. Secondary successional studies will be established and maintained on treated sites to evaluate and document species recovery, plant compatibility, invasion of species, and progressive stages of community development/ The rate of plant recovery and the influences of climate and biotic conditions on succession will be investigated.

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Table 1. - - Species proposed for development for the Uncompahgre Plateau Project

GRASSES

Pseudoroegneria spicata	Bluebunch wheatgrass
Bouteloua gracilis	Blue grama
Bromus marginatus	Mountain brome
Elymus elymoides	Basin wildrye
Elymus salina	Salina wildrye
Elymus trachycaulus	Slender wheatgrass
Hilaria jamesii	Galleta
Koeleria macrantha	Prairie junegrass
Oryzopsis hymenoides	Indian ricegrass
Pascopyrum smithii	Western wheatgrass
Poa fendleriana	Muttongrass
Poa secunda	Sandberg bluegrass
Sporobolus cryptandrus	Sand dropseed
Stipa comata	Needle-and-threadgrass

FORBS

Achillea millefolium lanulosa	Western yarrow
Astragalus mollissimus	Woolly milkvetch
Cryptantha flavoculata	Rough seed Cryptantha
Erigeron pumilis	Low fleabane
Eriogonum racemosum	Redroot eriogonum
Hedysarum boreale germiale	Utah sweetvetch
Linum lewisii	Lewis flax
Penstemon cyanocaulis	Bluestem penstemon
Petradoria pumila	Rock goldenrod
Senecio multilobatus	Lobe leaf groundsel
Sphaeralcea coccinea	Scarlet globemallow

SHRUBS

Amelanchier alnifolia	Saskatoon serviceberry
Artemisia nova	Black sagebrush
Artemisia tridentata ssp. tridentata	Basin big sagebrush
Artemisia tridentata spp. vaseyana	Mountain big sagebrush
Artemisia tridentata spp. Wyomingensis	Wyoming big sagebrush
Atriplex canescens	Fourwing saltbush
Cercocarpus montanus	Mountain mahogany
Chrysothamnus depressus	Dwarf rabbitbrush
Chrysothamnus nauseosus	Rubber rabbitbrush
Chrysothamnus viscidiflorus	Low rabbitbrush
Ephedra viridis	Green Ephedra
Ceratoides lanata	Winterfat
Purshia tridentata	Antelope bitterbrush
Rhus trilobata	Skunkbush sumac
Rosa woodsii	Woods rose

Table 2. - - Species proposed for the Uncompahgre area that will require comparative studies with similar plants from other geographic regions

SPECIES	AREAS OF COMPARATIVE STUDIES				
	Ecological	Genetics	Phenological	Morphology	Seed
<u>Grasses</u>					
<i>Pseudoroegneria spicata</i>	X	X	X	X	X
<i>Bouteloua gracilis</i>	X	X	X	X	
<i>Bromus marginatus</i>	X		X		
<i>Elymus elymoides</i>			X		
<i>Elymus salina</i>					
<i>Elymus trachycaulus</i>	X		X		
<i>Hilaria jamesii</i>	X				
<i>Koeleria macrantha</i>					
<i>Oryzopsis hymenoides</i>	X		X		X
<i>Pascopyrum smithii</i>	X	X	X	X	
<i>Poa fendleriana</i>					
<i>Poa secunda</i>		X			
<i>Sporobolus cryptandrus</i> X					
<i>Stipa comata</i>			X		
<u>Forbs</u>					
<i>Achillea millefolium lanulosa</i>	X				X
<i>Astragalus mollissimus</i>					
<i>Cryptantha flavoculata</i>					
<i>Erigeron pumilis</i>					
<i>Eriogonum racemosum</i>					
<i>Hedysarum boreale germiale</i>	X	X	X	X	
<i>Linum lewisii</i>	X	X	X	X	X
<i>Penstemon cyanocaulis</i>					
<i>Petradoria pumila</i>					
<i>Senecio multilobatus</i>					
<i>Sphaeralcea coccinea</i>	X	X	X	X	X
<u>Shrubs</u>					
<i>Amelanchier alnifolia</i>	X				
<i>Artemisia nova</i>	X	X	X	X	
<i>A. tridentata</i> ssp. <i>Tridentata</i>	X	X	X	X	X
<i>A. tridentata</i> spp. <i>Vaseyana</i>	X	X	X	X	X
<i>A. tri.</i> spp. <i>Wyomingensis</i>	X	X	X	X	X
<i>Atriplex canescens</i>	X	X	X	X	X
<i>Cercocarpus montanus</i>					X
<i>Chrysothamnus depressus</i>					
<i>Chrysothamnus nauseosus</i>	X	X	X	X	X
<i>Chrysothamnus visidiflorus</i>					
<i>Ephedra viridis</i>					
<i>Ceratoides lanata</i>	X	X	X	X	X
<i>Purshia tridentata</i>	X	X	X	X	X
<i>Rhus trilobata</i>					X
<i>Rosa woodsii</i>					

Table 3 – Representative studies conducted of select native species that have been important in the plant development programs

SPECIES	STUDIES
<u>Grasses</u>	
<i>Bromus marginatus</i>	Plant longevity and smut tolerance
<i>Poa secunda</i>	Seasonal period of growth and reproductive mechanisms
<i>Pseudoroegneria spicata</i>	Drought tolerance and seedling vigor
<i>Stipa thurberiana</i>	Flowering morphology and abscission of awns
<u>Broadleaf Herbs</u>	
<i>Balsamorhiza sagittata</i>	Floral parts, maturation, and insect resistance
<i>Hedysarum boreale utahensis</i>	Ecological presence, floral development
<i>Lomatium nuttallii</i>	Seed retention and pollination
<i>Lupinus sericeus</i>	Seed quality, resistance to seed-born diseases
<u>Shrubs</u>	
<i>Ceanothus martini</i>	Seedling growth, site adaptability
<i>Cercocarpus ledifolius</i>	Seed germination, seedling establishment
<i>Ephedra viridis</i>	Flowering patterns, seedling root development
<i>Eriogonum umbellatum</i>	Seed maturation, plant longevity
<i>Sambucus cerulean</i>	Vegetative and floral development relationships

Table 4. - - Selected species proposed for life history studies

SPECIES	Ranking by Priority of Importance
<u>Grasses</u>	
<i>Pseudoroegneria spicata</i>	1
<i>Bouteloua gracilis</i>	2
<i>Bromus marginatus</i>	2
<i>Elymus elymoides</i>	2
<i>Elymus salina</i>	3
<i>Elymus trachycaulus</i>	2
<i>Hilaria jamesii</i>	2
<i>Koeleria macrantha</i>	5
<i>Oryzopsis hymenoides</i>	2
<i>Pascopyrum smithii</i>	2
<i>Poa fendleriana</i>	5
<i>Poa secunda</i>	4
<i>Sporobolus cryptandrus</i>	3
<i>Stipa comata</i>	4
<u>Forbs</u>	
<i>Achillea millefolium lanulosa</i>	4
<i>Astragalus mollissimus</i>	4
<i>Cryptantha flavoculata</i>	4
<i>Erigeron pumilis</i>	4
<i>Eriogonum racemosum</i>	4
<i>Hedysarum boreale germiale</i>	3
<i>Linum lewisii</i>	2
<i>Penstemon cyanocaulis</i>	5
<i>Petradoria pumila</i>	4
<i>Senecio multilobatus</i>	5
<i>Sphaeralcea coccinea</i>	4
<u>Shrubs</u>	
<i>Amelanchier alnifolia</i>	3
<i>Artemisia nova</i>	3
<i>A. tridentata</i> ssp. <i>Tridentata</i>	2
<i>A. tridentata</i> spp. <i>Vaseyana</i>	2
<i>A. tri.</i> spp. <i>Wyomingensis</i>	2
<i>Atriplex canescens</i>	2
<i>Cercocarpus montanus</i>	4
<i>Chrysothamnus depressus</i>	3
<i>Chrysothamnus nauseosus</i>	2
<i>Chrysothamnus visidiflorus</i>	4
<i>Ephedra viridis</i>	3
<i>Ceratoides lanata</i>	3
<i>Purshia tridentata</i>	2
<i>Rhus trilobata</i>	4
<i>Rosa woodsii</i>	3

Rankings: 1 = Not Important 2 = Little Importance 3 = Moderately Important 4 = Highly Important 5 = Extremely Important
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Table 5. - - Species proposed for germination, seedbed ecology, and seedling competitions studies

SPECIES	PROPOSED AREAS OF STUDY			
	Seed Formation	Seed Germination	Seedbed Ecology	Seedling Competition
<u>Grasses</u>				
<i>Pseudoroegneria spicata</i>			X	X
<i>Bouteloua gracilis</i>		X	X	X
<i>Bromus marginatus</i>			X	X
<i>Elymus elymoides</i>	X	X	X	X
<i>Elymus salina</i>	X	X	X	X
<i>Elymus trachycaulus</i>			X	X
<i>Hilaria jamesii</i>		X	X	X
<i>Koeleria macrantha</i>	X	X	X	X
<i>Oryzopsis hymenoides</i>	X	X	X	X
<i>Pascopyrum smithii</i>		X	X	X
<i>Poa fendleriana</i>	X	X	X	X
<i>Poa secunda</i>	X	X	X	X
<i>Sporobolus cryptandrus</i>	X	X	X	X
<i>Stipa comata</i>	X	X	X	X
<u>Forbs</u>				
<i>Achillea millefolium lanulosa</i>	X			X
<i>Astragalus mollissimus</i>	X	X	X	X
<i>Cryptantha flavoculata</i>	X	X	X	X
<i>Erigeron pumilis</i>	X	X	X	X
<i>Eriogonum racemosum</i>	X	X	X	X
<i>Hedysarum boreale germiale</i>	X	X	X	X
<i>Linum lewisii</i>	X	X	X	X
<i>Penstemon cyanocaulis</i>	X	X	X	X
<i>Petradoria pumila</i>	X	X	X	X
<i>Senecio multilobatus</i>	X	X	X	X
<i>Sphaeralcea coccinea</i>	X	X	X	X
<u>Shrubs</u>				
<i>Amelanchier alnifolia</i>	X	X	X	X
<i>Artemisia nova</i>	X	X	X	X
<i>A. tridentata</i> ssp. <i>Tridentata</i>	X	X	X	X
<i>A. tridentata</i> spp. <i>Vaseyana</i>	X	X	X	X
<i>A. tri.</i> spp. <i>Wyomingensis</i>	X	X	X	X
<i>Atriplex canescens</i>	X	X	X	X
<i>Cercocarpus montanus</i>	X	X	X	X
<i>Chrysothamnus depressus</i>	X	X	X	X
<i>Chrysothamnus nauseosus</i>	X	X	X	X
<i>Chrysothamnus visidiflorus</i>	X	X	X	X
<i>Ephedra viridis</i>	X		X	X
<i>Ceratoides lanata</i>	X		X	X
<i>Purshia tridentata</i>				X
<i>Rhus trilobata</i>	X	X	X	X
<i>Rosa woodsii</i>	X	X	X	X

Table 6. - - Yearly schedule of seed collection for all species

SPECIES	YEARS OF SEED COLLECTIONS			
	2003	2004	2005	2006
Grasses				
<i>Pseudoroegneria spicata</i>	X	X		
<i>Bouteloua gracilis</i>			X	X
<i>Bromus marginatus</i>	X	X		
<i>Elymus elymoides</i>	X	X		
<i>Elymus salina</i>		X	X	
<i>Elymus trachycaulus</i>	X	X		
<i>Hilaria jamesii</i>			X	X
<i>Koeleria macrantha</i>		X	X	
<i>Oryzopsis hymenoides</i>	X	X		
<i>Pascopyrum smithii</i>	X	X		
<i>Poa fendleriana</i>	X	X		
<i>Poa secunda</i>		X		
<i>Sporobolus cryptandrus</i>		X	X	
<i>Stipa comata</i>		X	X	
Forbs				
<i>Achillea millefolium lanulosa</i>	X	X		
<i>Astragalus mollissimus</i>			X	X
<i>Cryptantha flavoculata</i>			X	X
<i>Erigeron pumilis</i>		X	X	
<i>Eriogonum racemosum</i>		X	X	
<i>Hedysarum boreale germiale</i>	X	X		
<i>Linum lewisii</i>	X	X		
<i>Penstemon cyanocaulis</i>	X	X		
<i>Petradoria pumila</i>			X	X
<i>Senecio multilobatus</i>	X	X		
<i>Sphaeralcea coccinea</i>			X	X
Shrubs				
<i>Amelanchier alnifolia</i>	X	X		
<i>Artemisia nova</i>	X	X		
<i>A. tridentata</i> ssp. <i>tridentata</i>	X	X		
<i>A. tridentata</i> spp. <i>vaseyana</i>	X	X		
<i>A. tri.</i> spp. <i>wyomingensis</i>	X	X		
<i>Atriplex canescens</i>	X	X		
<i>Cercocarpus montanus</i>	X	X		
<i>Chrysothamnus depressus</i>	X	X		
<i>Chrysothamnus nauseosus</i>	X	X		
<i>Chrysothamnus visidiflorus</i>	X	X		
<i>Ephedra viridis</i>	X	X		
<i>Ceratoides lanata</i>	X	X		
<i>Purshia tridentata</i>	X	X		
<i>Rhus trilobata</i>	X	X		
<i>Rosa woodsii</i>	X	X		

Table 7. -- Species proposed for the initial establishment of foundation fields, and subsequent field rearing studies

SPECIES	Establishment Foundation Fields			Establishment of Seed Rearing Studies		
	Dates of Establishment					
	2003	2004	2005	2004	2005	2006
<u>Grasses</u>						
<i>Pseudoroegneria spicata</i>	X				X	
<i>Bouteloua gracilis</i>						
<i>Bromus marginatus</i>	X				X	
<i>Elymus elymoides</i>	X				X	X
<i>Elymus salina</i>						
<i>Elymus trachycaulus</i>	X				X	
<i>Hilaria jamesii</i>			X			
<i>Koeleria macrantha</i>		X				
<i>Leymus cinereus</i>		X	X		X	X
<i>Oryzopsis hymenoides</i>	X					X
<i>Pascopyrum smithii</i>		X				X
<i>Poa fendleriana</i>	X				X	
<i>Poa secunda</i>		X			X	
<i>Sporobolus cryptandrus</i>			X			X
<i>Stipa comata</i>		X				X
<u>Forbs</u>						
<i>Achillea millefolium lanulosa</i>	X					X
<i>Astragalus mollissimus</i>						
<i>Cryptantha flavoculata</i>						
<i>Erigeron pumilis</i>						
<i>Eriogonum racemosum</i>						
<i>Hedysarum boreale germiale</i>	X			X		
<i>Linum lewisii</i>		X			X	
<i>Penstemon cyanocaulis</i>	X				X	
<i>Petrorhiza pumila</i>						
<i>Senecio multilobatus</i>		X				X
<i>Sphaeralcea coccinea</i>						