

**Strategies for Establishment of Big Sagebrush (*Artemisia tridentata* ssp. *wyomingensis*)
on Wyoming Mined Lands**

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A. Abstract

Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) is one of the dominant shrubs on native rangeland in this region but reestablishing it on reclaimed mined lands has been difficult. Therefore, we initiated this project to investigate the cultural and ecological factors affecting sagebrush reestablishment. The research was comprised of four substudies: the Establishment study, the Arbuscular Mycorrhizae (AM) study, Pioneer Plant study, and the Survey study. The research was designed to evaluate several cultural methods to define effective strategies for establishing big sagebrush, to evaluate the role of a “pioneer” species on sagebrush establishment, to assess the role of AM in sagebrush seedling drought stress tolerance, and to evaluate the success of shrub establishment using pre-1985 reclamation technology.

The research has shown that mulching and elimination of herbaceous plant competition significantly enhance early sagebrush establishment. Direct-placed topsoil improved first year sagebrush seedling establishment over that of 5-year old stockpiled topsoil in the Establishment Study but had little effect in the Pioneer Study. Arbuscular-mycorrhizae infection was found to improve drought tolerance of sagebrush seedlings. Older sagebrush seedlings (>120 days old) exhibited a greater dependency on AM than younger seedlings. Seeding fourwing saltbush (*Atriplex canescens*) 1 year before seeding sagebrush did not show any benefits nor did it significantly reduce sagebrush establishment compared to other seeding treatments. A survey of 14 pre-1985 reclamation sites at 8 mines showed the reclamation technology used to establish shrubs provided limited densities of shrubs and they did not meet the new shrub standard. Shrub density was directly related to shrub seeding rates (up to 1000 seeds/m²) and diversity. When the observed shrub densities were compared to an extrapolation of the new Wyoming shrub density standard established in 1996 only 8 of the 14 sites had shrub densities in excess of 0.2 shrubs/m² on 100% of the land area sampled. The shrub communities established using pre-1985 technology resulted in suboptimum wildlife habitat as defined by shrub density, cover, or species diversity.

The research has identified cultural practices that can be utilized by reclamationists to enhance shrub establishment and achieve the desired shrub densities under near normal or optimum climatic conditions. Climatic conditions, particularly precipitation and temperature, significantly influence sagebrush germination and seedling establishment; however, the negative effects of environmental stress can be reduced using the cultural practices described.

B. Introduction

Xerophytic shrubs are a conspicuous component of rangelands throughout Wyoming and much of the arid/semiarid West and they provide manifold benefits to the function and utility of rangeland ecosystems (McKell and Goodin 1973). Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) is one of the most widely distributed and adapted shrub species in Wyoming and the region (Beetle and Johnson 1982). However, reestablishment on mined lands has generally proven difficult because of low seedling vigor, an inability to compete with herbaceous species, and altered edaphic conditions (Harniss and McDonough 1976, Young and Evans 1989, Schuman et al. 1998). Reduced levels of arbuscular mycorrhizae in disturbed soils has been postulated as a factor limiting the success of reestablishment of big sagebrush on disturbed lands (Call and McKell 1982, Stahl et al. 1988). This perceived limitation is based on the fact that arbuscular mycorrhizae can improve a host plant's ability to extract nutrients and water from the soil and observations that sagebrush appears to be particularly dependent upon mycorrhizal symbiosis to reach full growth potential (Allen 1984). Indirect evidence also indicates that soil water availability is one of the most critical factors involved in big sagebrush seedling establishment (Jones 1991). The use of "pioneer" plants to prepare reclaimed sites for later seral species has been postulated by Booth (1985) and Meyer (1990). Booth (1985) suggested that fourwing saltbush (*Atriplex canescens*) could function in this role and noted that fourwing saltbush was easily established using conventional seeding methods. Although considerable debate has surrounded sagebrush value and use in mined land reclamation (Tessman and Kleinman 1989, Colbert and Colbert 1983), the fact remains that the Wyoming Department of Environmental Quality, Land Quality Division and the Office of Surface Mining have recently enacted rules to require the reestablishment of shrubs (those species dominant prior to mining) on mined land. The findings of this research will greatly aid in the reestablishment of Wyoming big sagebrush and will enhance the mining industry's ability to meet these new regulations where sagebrush is an important predisturbance shrub species.

C. Research Objectives

This research was designed to integrate several shrub establishment approaches in a manner to define effective strategies for establishment of big sagebrush. Specific objectives included: (1) determine the efficacy of direct-applied topsoil for enhanced sagebrush establishment, (2) determine the value of an annual grain stubble mulch for increasing sagebrush establishment through enhanced moisture conservation and microsite modification as compared to superficially applied straw mulch, (3) determine the effect of competition from concurrently seeded grasses on establishment of big sagebrush, (4) determine the effect of establishing fourwing saltbush as a