Analysis of direct seeding methods for establishment of native shrub and forb species on minesoils in southeastern Montana
by Joseph William Clarke III

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Land Rehabilitation
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Abstract:
Shrubs form an integral part of many semiarid and arid western ecosystems. Replacement of a diverse vegetation cover after mining consisting of shrubs, forbs and grasses is mandated by legislation in several western states. Direct seeding of shrub species has been partially successful on minesoils.

A study was initiated on topsoiled stripmine spoils in southeastern Montana during Fall, 1978 to develop methods for establishment of certain shrub species on minesoils. The major objectives of this study were to evaluate the effectiveness of high shrub seeding rates on establishment and growth with and without perennial grass competition and (for two of the shrub species seeded) to evaluate the performance of locally collected versus commercially purchased ecotypes.

Five native shrub and one forb species were selected for evaluation: big sagebrush, cudweed sagewort, Nuttall's saltbush, winterfat, rubber rabbitbrush and skunkbush sumac. Nuttall's saltbush and Winter-fat were the species for which different ecotypes were evaluated. Treatments included seeding of each shrub/forb species, both alone and with a mixture of six native perennial grass species. The locally collected ecotypes of Nuttall's saltbush and winterfat were seeded alone. Vegetation and physical monitoring took place over a two year period (1979-1980).

All species germinated and were present in 1979, but establishment and subsequent growth of the shrubs were adversely affected by below average precipitation during the 1979 and 1980 growing seasons.

Initial establishment and ultimate survival of Nuttall1s saltbush and skunkbush sumac were best when these species were seeded alone. Use of local ecotypes appeared to benefit initial establishment and ultimate survival success of Nuttall's saltbush and winterfat. Highest seedling survival after two years of drought was obtained from commercially purchased and locally collected Nuttall's saltbush, big sagebrush and locally collected winterfat seed lots. All other shrub/forb species and/or ecotypes exhibited complete drought-induced mortality at the end of this period.

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ANALYSIS OF DIRECT SEEDING METHODS FOR ESTABLISHMENT OF NATIVE SHRUB AND FORB SPECIES ON MINESOILS IN SOUTHEASTERN MONTANA

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ABSTRACT

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INTRODUCTION

Background

Shrubs form an integral part of many rangeland ecosystems. They are widely distributed and are present in most natural plant communities, many times occurring as principal constituents in arid and semiarid regions (Monsen and Christensen, 1975; Packer and Aldon, 1978).

Shrubs are important in many ways to both plant and animal communities. The various benefits they provide include: 1) substantial herbage production, hence providing forage and cover for wildlife and livestock; 2) niche diversification; and 3) ground cover for effective soil stabilization.

Many studies have shown that an association of shrubs with grasses and forbs (in proper proportions) has been more productive than shrubs or grasses/forbs alone (Robinette, 1972; Vallentine, 1971; Plummer, Christensen and Monsen, 1968; Monsen and Plummer, 1978).

Shrubs may be a valuable source of forage for both wildlife and livestock (Dietz, 1969; Julander, Robinette and Jones, 1961; Martinka, 1967; MacArthur, Plummer and Davis, 1978). This is especially true during periods of dormancy or drought. Browse species usually possess deeper root systems than grass and forb species, and tend to store food reserves in stems as well as in roots (Stoddart, Smith and Box, 1975; Coyne and Cook, 1970). Hence, protein, vitamin A and carbohy-

drates are not reduced as much in above ground portions of shrubs compared to grasses during non-growing periods (Stoddart et al., 1975; Sindelar, Hodder and Majerus, 1973). Taller growing shrubs also may constitute the only forage available for the grazing animal during periods of deep snow accumulation. Besides big game species and livestock, many species of birds and small mammals also utilize shrubs as a source of food (Robinette, 1972). Shrubs also provide wildlife with protective cover from the elements and from predators (Williamson and Wanerud, 1980). Birds and small mammals may use shrubs for nesting and/or roosting sites (Robinette, 1972; Vallentine, 1971).

The presence of shrubs in plant communities provides for greater numbers of ecological niches due to height stratification and increased plant cover. Birds are especially influenced by stratification and are often restricted to narrow vertical ranges (Odum, 1971). Thus, without shrubs many species of birds could not be present. Lack of necessary shrub cover may also preclude the presence of many small mammal species.

Shrubs, especially those which are "bushy", provide excellent ground cover. According to Van Dersal (1938), the bushier the shrub and the denser its foliage, the more it will protect the soil from wind and water erosion. Many shrubs meet these criteria. Most shrubs possess deep root systems. Such root systems serve in erosion control mainly by holding the shrub in place rather than holding the topsoil

(Van Dersal, 1938). However, deep root systems may help to hold subsoil in place.

Nature of the Problem

The demand for coal as a source of relatively inexpensive energy has increased in recent years. This demand will probably continue to expand as other sources of fossil fuel become more costly and unavailable. Most of the increase in coal development will occur in the western United States, where many rich, surface mineable deposits are located (DePuit, Coenenberg and Willmuth, 1978). Montana is one state impacted by this development (Paone, Struthers and Johnson, 1978).

The need for suitable and successful means of reclaiming surface mined lands is urgent. The revegetation of such lands is a critically important facet of reclamation. The state of Montana provided strict regulations concerning revegetation in its Strip and Underground Mine Reclamation Act of 1980. This act requires that vegetation established on mined lands provide a suitable, permanent, diverse cover capable of regeneration under existing climatic conditions, and which is able to support livestock and wildlife as well as control erosion in a manner comparable to that preceding mining.

The phrase "diverse vegetative cover" is significant in many cases. A plant cover of this type should include shrubs, forbs and grasses. Although it is important to establish a cover of perennial

grass species initially to stabilize the soil, it is equally important ultimately to establish a shrub and forb association. An association of grasses, forbs and shrubs will provide a diverse habitat for many species of wildlife and livestock (DePuit and Coenenberg, 1979; Thornburg, 1974; Williamson and Wanerud, 1980).

One approach for establishing a diverse vegetation cover involves seeding mined lands with broad mixtures of grass, forb and shrub species (DePuit and Coenenberg, 1979). This technique has also been used in the renovation of deteriorated rangeland, especially winter game ranges (Plummer et al., 1968). Usually this technique has met with limited success (Monsen and Christensen, 1975; Plummer et al., 1968; Dollhopf and Majerus, 1975; Frischknecht, 1978).

There are many factors contributing to the success or failure of seeding shrubs and grasses together in a seed mixture. Only a few shrub species have seedlings which are sufficiently vigorous and aggressive to compete with concurrently establishing perennial grass seedlings. Shrub species which have sometimes successfully competed with perennial grasses include antelope bitterbrush (Purshia tridentata), sulfur eriogonum (Eriogonum umbellatum), snowbrush ceanothus (Ceanothus velutinus), rubber rabbitbrush (Chrysothamnus nauseosus), big sagebrush (Artemisia tridentata), and fourwing saltbush (Atriplex canescens) (Monsen and Christensen, 1975). Differences in competition tolerance between shrubs and grasses are related to lifeform differences

such as different seedling morphologies and growth rates. Grasses tend to mature more rapidly than shrubs and thus provide frequently stifling competition for young shrubs (Blaisdell, 1949; Frischknecht, 1978; Anderson and Brooks, 1975; Hubbard, Zusman and Sanderson, 1962; Hubbard, 1957). The growing points of shrub seedlings are usually above ground, which exposes them to spring frost and grazing animals. Conversely, grass seedlings have growing points at or below the ground, and thus have a greater tolerance to these two factors (Plummer, Christensen and Monsen, 1965). Other problems with concurrent seeding of grasses and shrubs include: 1) grasses may provide habitat for small mammals that girdle and kill shrubs; and 2) grasses may carry fire that kills susceptible shrubs (Frischknecht, 1978).

An alternative to seeding of uniformly applied grass-shrub mixtures is to seed shrubs and grasses in alternate rows, thus reducing competition between the two (Plummer et al., 1968; Frischknect, 1978). This method has proven fairly successful when seeding shrubs that possess low seedling vigor. An advantage of this technique, if successful, is the shelter belt effect of shrubs planted in this manner. Soil moisture may be increased through snow trapping (Frischknecht, 1978).

Interspecific competition will not be entirely removed when shrubs are seeded alone. Seeds of annual forbs, grasses, and other perennial and biennial species may be present in the seedbed, and may ultimately produce plants which will compete with seeded shrubs

(Holmgren, 1956; Guinta, Christensen and Monsen, 1975). This is especially true on mined lands which have been topsoiled (King, 1980).

Low germination of seed is another factor which makes establishment of shrubs difficult from direct seeding (Sindelar et al., 1974; Monsen and Christensen, 1975). Research has also shown that low seeding rates of shrubs in comparison to perennial grasses has resulted in poor shrub establishment (DePuit and Dollhopf, 1978; Dollhopf and Majerus, 1975; Plummer et al., 1968).

Monsen and Christensen (1975) utilized three criteria in the selection of shrub species for restoration of disturbed range sites: 1) The species must be adapted to the site; 2) The species must provide forage, ground cover and protection to animals; and 3) The seedlings must be able to establish and reach maturity under existing site conditions. They believed that species adaptability was the most important criterion and that locally collected seed of species native to the area best met this criterion. Other authors have also stressed the importance of locally collected ecotypes of plant species for revegetation of disturbed areas (Plummer et al., 1968; Vallentine, 1971; Thornburg and Fuchs, 1978). Thornburg and Fuchs (1978) for example, believed that selection of the proper ecotype is as important as selection of proper species.

Another method used to establish shrubs on disturbed sites, besides direct seeding, is transplantation of bareroot, containerized

stock, and stem and root cuttings (Monsen and Christensen, 1975). Transplantation, although sometimes successful, is usually considered unfeasible as a practical approach to extensive shrub establishment due to its excessive cost (Monsen and Christensen, 1975; Stevens, 1980).

Objectives

The general goal of this study was to develop methods for establishment of several shrub and forb species on topsoiled stripmine spoils by direct seeding.

Specific Objectives included:

1) Evaluation of effectiveness of high seeding rates in promotion of shrub and forb establishment and growth.
2) Determination of effects of presence and absence of competition from concurrently seeded perennial grasses on shrub and forb establishment and growth.
3) Comparison of responses of five selected shrub and one forb species seeded to above treatments (presence and absence of competition from concurrently seeded perennial grasses) in terms of establishment and growth.
4) Evaluation of the performance of locally collected versus commercially purchased seed of two species.

STUDY AREA

The study area was located in southeastern Montana near Colstrip (Figure 1). This town is approximately 48 kilometers south of Forsyth, Montana in Rosebud County.

This area overlies rich deposits of sub-bituminous coal within the Fort Union geologic formation (DePuit, Coenenberg and Skilbred, 1980). Stripmining of this area to extract coal is practical, and is being conducted by both the Peabody Coal Company and Western Energy Company.

The pre-mining topography of the Colstrip area consists of gently rolling hills and valleys, with scattered sandstone and porcelainite outcrops (Wyatt, Dollhopf and Schafer, 1980). Most of the streams present are intermittent in nature and dissect the hills and valleys (Sindelar, Hodder and Majerus, 1973). The elevation ranges between 1100 and 1833 meters (Gomm, 1974). Soils in this area are usually poorly developed and have sandy or loamy textures (DePuit et al., 1980). Major soil sub-groups include Ustic Torriorthents, Borollic Camborthids and Aridic Haploborolls (Schafer, Nielsen and Dollhopf, 1977).

Vegetation is primarily characteristic of the Eastern Montana Ponderosa Pine Savannah Type, with ponderosa pine (Pinus ponderosa) on the ridgetops grading into mixed prairie grassland below (Payne, 1973;

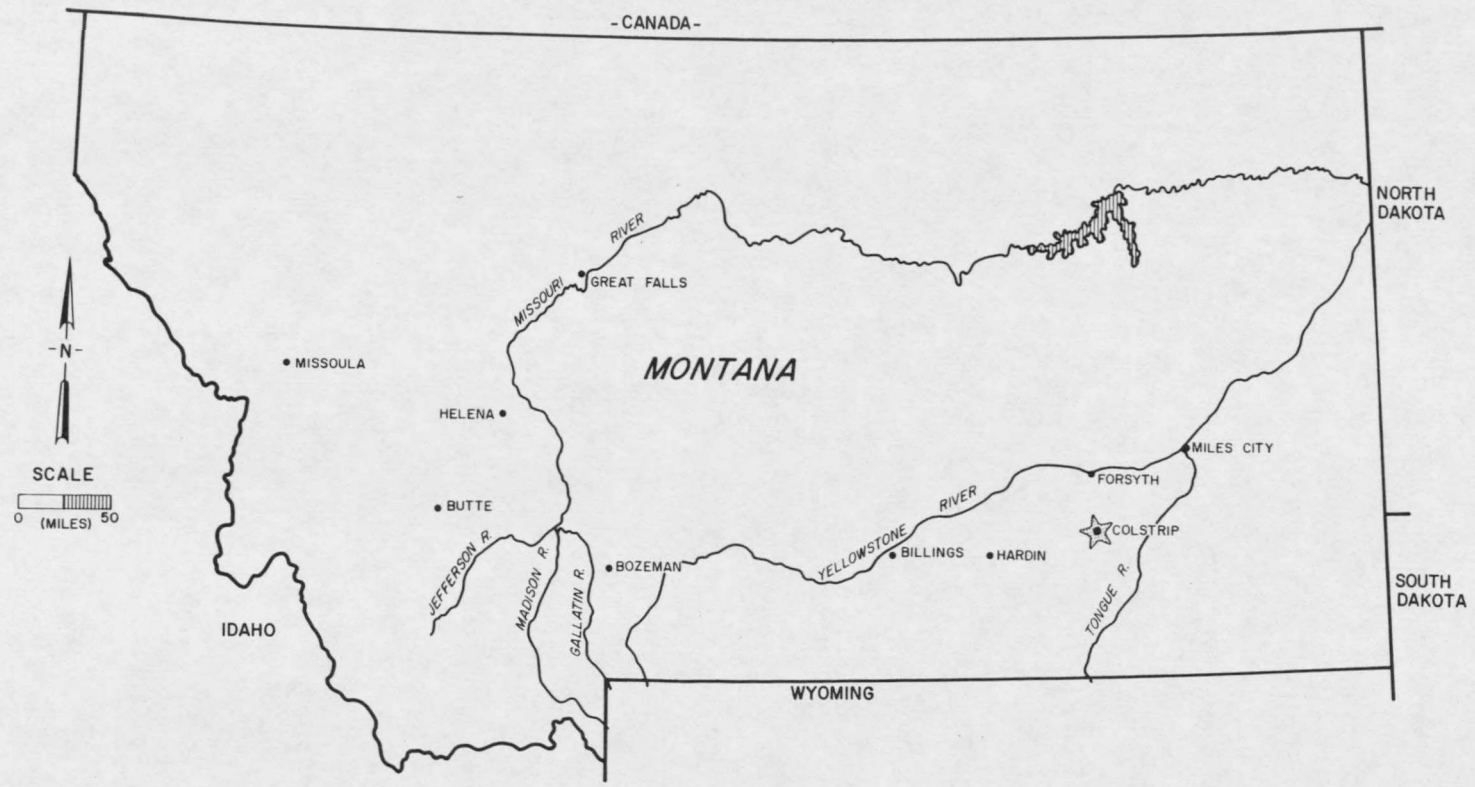

Figure 1. Location of Colstrip, Montana

Wyatt et al., 1980; Sindelar et al., 1973). Dominant understory grass species on the ridgetops include bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), and little bluestem (Schizachyrium scoparium). Important grass species of the mixed prairie grassland community include western wheatgrass (Agropyron smithii), thickspike wheatgrass (Agropyron dasystachyum), green needlegrass (Stipa viridula), needle-and-thread (Stipa comata), Sandberg bluegrass (Poa sandbergii), prairie junegrass (Koeleria cristata) and blue grama (Bouteloua gracilis). Other common plant species include the shrubs, skunkbush sumac (Rhus trilobata) and western snowberry (Symphoricarpos occidentalis), needleleaf and threadleaf sedges (Carex eleocharis and C. filifolia, respectively) and the forbs, phlox (Phlox spp.), wild buckwheat (Eriogonum spp.) and lupine (Lupinus spp.). Overgrazed and otherwise degraded sites are characterized by a predominance of increaser and invader plant species such as cheatgrass brome (Bromus tectorum), Japanese brome (Bromus japonicus), lupine, big sagebrush and silver sagebrush (Artemisia cana).

The climate of the Colstrip area is continental, characterized by warm summers and cold winters (NOAA, n.d.). Mean temperatures during July (typically the warmest month) and January (typically the coldest month) are 23.9 C and -6.7 C, respectively (Munshower and DePuit, 1976). Average annual precipitation is 40.12 cm, three-fourths

of which falls as rain from April through September (NOAA, n.d.). The frost-free growing season varies from 95 to 135 days (Sindelar et al., 1973).