BIG SAGE (*ARTEMISIA TRIDENTATA VAR. WYOMINGENSIS*) : AN INITIAL COMPARISON OF SEEDLING SURVIVAL BETWEEN DIRECT SEEDING AND PLANTING CONTAINERIZED STOCK[1]

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__Abstract:__ This study investigates the cost effectiveness of three separate reclamation methods utilized in the long-term establishment of Big Sage (*Artemisia tridentata var. wyomingensis*). Direct seeding and planting with four cubic inch and ten cubic inch containerized stock were compared using five 36 square meter plots per treatment within a fenced randomized block. Seed plots were hand broadcast at a rate of 2 kilograms per hectare and mulched with certified weed-free wheat straw. Containerized stock plots were planted at a density of one per square meter. Controls with no seeding or planting were established to differentiate actual plant production/reproduction from seed bank recruitment and migration from replaced topsoil and surrounding native areas. Stem density (stem/m^2), plant height (cm), and plant reproduction (seedlings/m^2) data will be gathered every spring and fall for three years (1994-1997). Final analysis of the data will relate establishment success to cost efficiency. This initial report on the study reviews only seedling establishment based on first year data.

Additional Key Words: Big Sage, *Artemisia tridentata*, establishment, cost effectiveness, seedling, seed.

Introduction

Big Sage (*Artemisia tridentata ssp. wyomingensis*) has been difficult to establish on minelands by seed and expensive to establish utilizing container grown seedlings (DePuit 1988, Blaisdel 1949, Frichknecht 1978). Both methods of establishment have advantages and disadvantages, however. Containerized seedlings reach seed production and a size at which they can encourage the establishment of other plants more rapidly than plants from direct seeded sites (Gillis 1991). Reports indicate that sites planted with containerized seedlings grow faster than direct seeded sites in areas where moisture is limiting and unpredictable (McKell et al. 1979; Gillis 1991). The major drawback to containerized seedling use in revegetation is the cost. The goal of this three year study is to define the most cost effective method of Big Sage establishment based on planting success at Triton Coal Mine. Specifically, we will eventually determine the cost effectiveness of establishing Big Sage from seed, 4 cubic inch containerized stock, and 10 cubic inch containerized stock. Cost effectiveness will be based upon cost per surviving seedling. Within this paper, only survival rates after one year are reviewed.

The reestablishment of Big Sage is a critical component of mined land reclamation for several reasons. Of importance to the mining industry, sagebrush establishment will help to achieve shrub density requirements set by the Wyoming Department of Environmental Quality. Ecologically, shrubs ameliorate soil characteristics resulting in improved site conditions for subsequent succession toward the native climax community (which would increase biodiversity). For example, soil profiles under shrubs are deeper, pH values more alkaline (Fairchild and Brotherson 1980), and N, P, K (and other nutrients), organic matter, rate of water infiltration, and microbiological activity are all higher under shrub canopies than under the interspaces (Charley 1972, Sharma and Tongway 1973, Tiedmann and Klemmedson 1973, Blackburn 1975, West 1981, Brock et al. 1982). The increased level of microorganisms in the shrub zone is of special significance since microorganisms are responsible for improvements in the chemical and physical characteristics of the soil (Cundell 1977).

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Study Site

The study is being conducted at Triton Coal Company near Gillette, Wyoming within the Powder River Basin. Average annual precipitation ranges from 5 to 14 inches per year (Bailey 1980). Soils within the area are typically alkaline Aridisols with soil texture and composition dominated by the parent materials (Bailey 1980). Replaced soils were direct hauled to the site and hand textured as generally coarse. The study site consists of a level to slightly north facing regraded slope. The site was spread with approximately 20 to 30 inches of topsoil and ripped immediately prior to planting. The northern edge of the plot was noted as deficient in topsoil and poorly ripped which may effect seedling establishment in those areas. Due to the hilltop location of the site, soils are expected to be prone to wind erosion and desiccation.

Methods

Direct seeding and planting with four cubic inch and ten cubic inch containerized stock were compared using five 36 square meter plots per treatment within a fenced randomized block (Figure 1). Plots were established and field work completed on May 10, 1994. Four treatments included controls, seed, four cubic inch stock, and ten-cubic inch stock. Controls with no seeding or planting were established to differentiate actual plant production/reproduction from seed bank recruitment and migration from replaced topsoil or nearby undisturbed areas. Dependent variables to be measured will be stem density (stems/m^2), plant height (cm), and plant reproduction (seedlings/m^2). All containerized stock were established from seed collected on site and inoculated with site-specific mycorrhizae.

Seedlings were planted with a one meter spacing in a 6x6 row arrangement (36 m^2) for each replication. Planting methods were typical of those utilized in large scale hand planting operations. A 12 inch by 12 inch area was scalped to provide a shallow bowl-like planting surface. Shrubs were planted with a Hoedad. During planting, heat damage was noticed on approximately 50 to 60 % of four cubic inch seedlings. This was due to an extended shipping period for the seedlings. The severity of this damage caused a shortage of plants and necessitated the planting of only 19 plants in one repetition.

Big Sage seed was mixed with sand and hand broadcast at a rate of 2 kilograms pure live seed per hectare. Straw was hand broadcast as a mulch to improve microclimate conditions which might encourage germination. Straw was hand broadcast over each of the seed plots at a rate to which the bare ground could barely be seen through the straw layer. Subsequent to study implementation, a seven-foot tall woven wire fence was constructed to prevent browsing by deer and antelope.

D1	B2	A4	B3	A1
A2	D5	C2	C5	D3
B4	B1	D2	A3	C3
C1	A5	D4	B5	C4

Figure 1. Randomized block design for shrub establishment experiment: A = Control; B = Seed Treatment; C = 4 Cubic Inch Treatment; D = 10 Cubic Inch Treatment.

After three years of evaluation, analysis of variance (ANOVA) will be used to determine significant differences between the treatments. Raw data will be tested for normality and homogeneity of variance with transformations conducted if necessary before using ANOVA procedures. Student residual plots will be utilized to "downweight" data that are outlier and overly influential. Within this document, only first year survival results will be discussed.

Results and Discussion

Data was collected by field personnel on August 24, 1994 to evaluate first year survival (Table). Initial observations revealed some browse damage to seedlings by rodents. Initial results of this study indicate substantially higher survival rates of 10 cubic inch containers over 4 cubic inch containers. Seed failed to produce any seedlings.

Table 1. First year establishment rates of Big Sage.

Treatment	# Planted (rate)	# Seedlings	% Survival
Control	0	0	0
Seeding	seeded (2 kg/ha)	0	0
4 in^3 stock	163	24	14.7
10 in^3 stock	180	95	52.7

Success at this point appears highly influenced by precipitation patterns. Conditions during Summer 1994 were drought-like with precipitation below normal. Although the lack of precipitation may appear to have skewed data, drought and extended dry periods are typical of the Powder River Basin climate.

Containerized shrub stock appears to offer several advantages over seeding as emphasized by preliminary results. The primary and most obvious advantage being the ability to bypass critical stages of germination and initial seedling growth under harsh field conditions. Germination requires certain vital environmental conditions be met: 1) an ample supply of water; 2) optimum soil temperature; and 3) sufficient soil aeration. Should these conditions be met and germination occur, the soil moisture environment must be maintained within set parameters to insure seedling survival through development of carbohydrate reserves and drought hardiness. Containerized stock bypasses this initial stage by allowing growth and hardening under controlled conditions.

A further advantage of the use of containerized stock is the ability to place individual plants in microsites best suited for plant survival. Although actual field placement within a grid pattern limited microsite selection, individual planting sites were prepared through the scalping of a slight depression for water retention. Such a procedure is common concern and practice by planters.

Mycorrhizal inoculation is also expected to have significantly increased seedling survival on the site. Several researchers have previously heralded the virtues of mycorrhizal inoculation (Atthowe 1993, St. John 1992). According to researchers, mycorrhizae enhance the field performance of plants through the capture and uptake of nutrients; buffering against moisture stress, root pathogens, and toxic levels of mineral elements; and improving soil structure (Atthowe 1993, St. John 1992). Survival of the containerized material during the exceptionally dry summer was most likely improved by mycorrhizal inoculation.

Ten cubic inch stock appears to have an advantage over 4 cubic inch containerized stock within these preliminary results. Of concern in this comparison was the extensive heat damage to the four cubic inch stock during shipment to the mine site. It is estimated that approximately 50 to 60 percent of the four cubic inch stock were heat damaged during shipment with extreme wilting and necrosis of topgrowth occurring. This potential damage, however, was not exhibited by ten cubic inch stock, perhaps because of box location during shipping, soil mass-heat relationships, or the physiological state of the plant. Ten cubic inch stock is expected to perform better under dry conditions due to a longer root length and the greater soil-root mass.

Conclusion

Initial results indicate a much higher establishment rate for ten cubic inch containerized stock over four cubic inch containerized stock. Seed has thus far failed to produce seedlings. These results should be treated as "initial". Adequate precipitation over the coming year may encourage germination of seed and establishment from seed. Resprouting from roots may occur from both four cubic inch and ten cubic inch stock.

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