THE USE OF LANDSCAPE FABRIC AND SUPPLEMENTAL IRRIGATION TO ENHANCE SURVIVAL AND GROWTH OF WOODY PERENNIALS PLANTED ON RECLAIMED SURFACE MINE LANDS[1]

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Abstract: A study was initiated to determine the effectiveness of landscape fabric and supplemental irrigation in survival and growth of woody perennials planted on reclaimed surface coal mine lands. The study compared growth and survival of nursery grown potted aspen and serviceberry planted with or without landscape fabric, and with or without biweekly supplemental irrigation. First year survival and growth indicates that the landscape fabric was particularly crucial in survival and growth of aspen trees on sites with high amount of competing vegetative cover. Supplemental irrigation appears to have provided limited advantage compared to the landscape fabric. Photosynthesis and pre-dawn moisture stress measurements on the aspen indicated that aspen trees were more stressed without landscape fabric. Soil moisture was higher under the landscape fabric. The serviceberry plants did not respond to landscape fabric or irrigation treatment during the first growing season.

Additional Key Words: Amelanchier alnifolia, aspen, competition, Populus tremuloides, re-vegetation, serviceberry, soil moisture

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Introduction

Successful re-establishment of woody vegetation on surface-mined lands in the United States is problematic. Establishment of aspen and serviceberry has been particularly difficult because these species regenerate from vegetative sprouts from parent roots in the soil which are removed in the mining process. Even when plants are established from residual parent roots, growth is commonly limited by low soil moisture conditions, particularly in the Western US. In addition, woody perennials are heavily browsed by deer and elk. Previous attempts to plant aspen seedlings on reclaimed mines have failed because transplanted root sprouts or seedlings do not have an extensive root system necessary to access water and nutrients for rapid growth. Serviceberry regeneration on reclaimed land also has been shown to be difficult. Competing with fast-growing herbaceous vegetation is an important factor in survival of planted woody perennials throughout the US. Landscape fabric has been used in plantings of woody perennials to limit surrounding vegetation that competes for moisture and nutrients. Machine planting of woody perennials using tractor-drawn equipment for planting and laying of landscape fabric on reclaimed surface mine lands can be a cost-effective method for large scale re-vegetation of reclaimed surface coal mine lands. These systems are commonly used for windbreak planting and are available from state forest nurseries or agricultural extension offices. We simulated the use of commercial machine-planting techniques with landscape fabric to establish aspen and serviceberry on reclaimed mine soils in Colorado. Our preliminary results from the first year of study suggest that this method greatly enhances survival and growth of the woody perennial aspen.

Quaking aspen (*Populus tremuloides*) and western serviceberry (*Amelanchier alnifolia*) are important native woody plants occurring throughout the western and northern United States. Of the few broad-leaved hardwood trees in many western forests, aspen is a valuable ecological component of many landscapes, occurring in pure forests as well as growing in association with many coniferous and other hardwood species. Aspen stands provide desirable scenic value, and the diversity of plants growing under aspen supply critical wildlife habitat and food, valuable grazing resources, protect soils from erosion, and help maintain water quality. These features make aspen forests a crucial component of many Western landscapes.

Although in some years aspen does produce abundant crops of viable seed (McDonough 1979), it primarily reproduces from vegetative root suckers throughout most of its range.

Occasional seedlings do establish, but seedlings require bare mineral soil and constant moisture to survive (McDonough 1979). These conditions rarely occur in many of the areas where aspen grows today. Aspen typically grows in genetically-identical groups referred to as clones. All stems in a clone sprouted from the roots of parent trees and share a common ancestor. However they do not share a common root system, as connections break down from generation to generation as new trees grow new roots.

Most aspen stands are composed of one to several clones that may persist along a continuum of successional stages, from sparsely growing individuals to apparently stable pure or near-pure groves. Although clones are often separate and distinct from one another, studies have demonstrated spatial intermingling where multiple clones are co-located (DeByle 1964; Mitton and Grant 1980; Wyman and others 2003; Hipkins and Kitzmiller 2004).

Compared to conifers, aspen ramets – individual stems, or suckers, of the same genotype from a parent root system - are relatively short lived. This is due to succession (replacement of aspen by more shade tolerant species) and/or a typical onslaught of mortality related to stem decays and diseases from ages 80 to 100 years (Baker 1925; Hinds 1985; Potter 1998; Rogers 2002). Aspen thrive where somewhat regular and frequent disturbance promotes regeneration (DeByle and Winokur 1985). Occasionally aspen stands appear to perpetuate themselves with regular low-level regeneration in multi-layer stable stands (Mueggler 1988; Cryer and Murray 1992). Aspen in the western U.S. are longer lived than elsewhere. Healthy aspen trees can live over 300 years (Personal Comm., John Shaw, Forester, USDA Forest Service, Rocky Mountain Research Station) and can attain diameters up to 38 inches (96.5 cm) diameter at breast height (dbh), however most aspen are typically much younger and smaller. Many mature stands in Colorado are currently over 120 years of age (Shepperd 1990). Tree form varies from shrubby at upper and lower forest margins to over 30.5 m (100 ft) in height in prime locations with average heights of 15 to 18 m (50 to 60 ft) (Baker 1925).

In any case, the initiation of bud growth must also be accompanied by sufficient sunlight and warmer soil temperatures to allow the new suckers to thrive (Navratil 1991, Doucet 1989). Full sunlight to the forest floor best meets these requirements. However, young aspen suckers are susceptible to competition from other understory plants and herbivory from browsing ungulates (primarily elk and deer in Colorado) even if abundant suckers are present.

Having access to a well developed parental root system gives aspen sprouts a great advantage over other plants. The parent roots supply carbohydrates and access water deep in the soil profile allowing sprouts to grow rapidly, out-compete other vegetation, and withstand frequent droughty conditions in the West.

Planting aspen in a non-irrigated location in a Colorado study was not successful (Shepperd and Mata 2005). Transplanting greenhouse or nursery-grown aspen seedlings into the field has similar problems to those of natural seedlings, indicating that the small root mass of transplanted seedlings is insufficient to absorb enough moisture to maintain the seedlings during periods of summer drought in the wild. Re-establishing aspen and serviceberry on reclaimed surface-mined lands is therefore problematic, since the parent root systems are destroyed when topsoil is removed.

In contrast, transplanting sapling-sized aspen in irrigated urban landscapes has not been a problem, because the abundant supplies of water in lawns and landscape beds enable the transplants to thrive. Although aspen is somewhat tolerant of drought conditions (Lieffers et al. 2001), irrigation could benefit growth and survival of planted aspen stock, because moisture stress negatively affects aspen response to nutrient uptake (van den Driessche et al. 2003). Water deficit stress also reduces stomatal conductance, root hydraulic conductivity, and shoot leaf water potential in aspen (Siemens and Zwiazek 2003). Irrigation has been shown to increase growth of hybrid poplar, a closely related species (Hansen 1988; Strong and Hansen 1991). Herbaceous competition has been shown to reduce survival of aspen on reclaimed mined lands (Hughes et al. 1992).

Serviceberry is common and important shrub in western ecosystems, and is an important food source for wildlife, supplying both foliage for forage and fruit for ungulate and small mammal consumption. Serviceberry planted on reclaimed mine overburden had lower survival when plants were fertilized (Williams et al. 2004). Serviceberry planted on reclaimed mine lands in northeastern Washington survived well but growth was slow and did not respond to nutrient supply (Voeller et al. 1998).

Serviceberry, like aspen, depends on sprouting for reproduction, is difficult to start from seedlings, and has been shown to be difficult to reproduce on reclaimed mine lands (Agnew 1992). Movement of topsoil containing roots for sprouting to the reclaimed site (livehauling), or transplanting of native plants, provided for the best establishment on reclaimed mine lands

(Agnew 1992). The influence of competing vegetation on establishment of serviceberry on reclaimed lands has not been studied.

It seems reasonable to conclude that removal of competing vegetation and supplemental irrigation of trees and shrubs planted on reclaimed surface-mined lands could increase initial survival and allow the plants to grow sufficient root systems to ultimately survive without additional water on reclaimed mine lands. Planting equipment is available that can be pulled behind a tractor. The equipment plants woody perennials and lays down a weed-barrier landscape fabric. Although commonly used for windbreak planting in the Midwest and for planting crops such as strawberries in California, as far as we know this equipment has not been used for re-vegetation of reclaimed surface coal mine lands. We studied this method of planting to gain knowledge about the feasibility of adopting this method to successfully re-vegetate aspen and serviceberry on reclaimed soils. Our objective was to identify factors that potentially limit re-establishment and are crucial to reproduce trees and shrubs on surface-mined lands in the semi-arid west. The study is applicable nation-wide where competition from herbaceous vegetation limits reproduction of woody perennials on re-vegetated surface coal mine lands.

Preliminary Pilot Study

A pilot study was conducted 2005-2007 to demonstrate the effectiveness of supplemental irrigation on growth and survival of transplanted aspen sapling trees, where the experimental conditions allowed observation on several additional variables. In addition to irrigation (four levels of watering), we were able to observe growth and survival of aspen of different plant type (transplants, natural sprouts, or potted plants), soil type (soil roto-cleared [vegetation roto-tilled into the topsoil before removal] and fresh hauled to the site or soil dozer-cleared and stored for several months before moving to the site), and different levels of plant competition (hand removal of competing vegetation or no removal). Results of the preliminary study are reported here as background and rationale for the current study:

Irrigation. Best growth and survival was with low or no irrigation, but salinity of irrigation water in the first two years of the experiment reduced growth of trees receiving high and medium amounts of irrigation. Care must be taken to provide low saline water when irrigating planted aspen trees on reclaimed lands. Low level irrigation and no irrigation growth and survival were similar, suggesting that enough rainfall occurred during the initial years of this experiment so that soil moisture was adequate without irrigation.

Plant source. Transplanted trees from local sources grew best once established. Most natural suckers did not survive without removal of competing vegetation. Potted plants had a high rate of survival and seemed to grow well the first year, but growth was lower than for transplants and natural sprouts after three years. Roots of the potted aspen generally stayed in the augured potting hole.

Soil type. Best growth and survival occurred on roto-cleared/fresh soil compared to dozer cleared/stored soil. More natural sprouts from residual root segments were evident in the roto-cleared soil, likely because it was not stored before placement. The dozer cleared soil appeared to be more compacted and was less well drained than the roto-cleared soil, and it is expected that these physical characteristics and storage effects on the soil were more important to tree growth than the method of clearing.

Control of plant competition. The best growth of aspen was with trees that were hand hoed to remove all competing vegetation. This was likely related to lower water stress of the trees, since all adjacent vegetation competed with the trees for the limited water supply. This was particularly apparent on the roto-cleared soils where there was a high biomass of competing vegetation.

Root growth. Similar to top growth, root growth on the roto-cleared soil was greater in plots where competing vegetation was removed by hoeing compared to plots where competing vegetation was left intact. Effect of competing vegetation removal on root growth of dozer cleared soils was less evident, likely since amount of competing vegetation was considerably less and growth was less on the dozer cleared soils. Lateral roots in most treatments were of sufficient size but too deep to support suckering. Sucker initiation was likely inhibited by apical dominance of the growing trees. Lateral root extension was considerably slower in the plots on the dozer cleared soils. Roots of trees planted deep extended upward toward the soil surface, suggesting that care should be taken in future plantings to plant trees only to a depth of the original root collar.

Overall recommendation from pilot study. Best conditions for reproduction of aspen on reclaimed surface mined coal lands was by using transplanted saplings from local sources on freshly placed soil removed from aspen stands. Care should be taken to avoid compaction of the replaced soil. Transplanted trees should be planted no deeper than the original root collar, and competing vegetation should be controlled around individual trees. Irrigation with non-saline water might enhance growth and survival in years with drought conditions. After three full years of treatment, surviving trees were expected to thrive without further control of competing vegetation and/or irrigation. Examination of the plots in late 2008 confirmed these expectations.

Follow-up study

Based on the findings of the preliminary study, a follow-up study reported here was initiated in the fall of 2007 to determine if landscape fabric could be used successfully to control competing vegetation and allow reproduction of aspen and serviceberry woody perennials on reclaimed surface coal mine lands. A detailed description of the study follows.

Objectives. The overall objective was to develop improved technologies to address environmental issues related to the reclamation of land after surface coal mining. The research was to find ways to improve the survival and quality of aspen and serviceberry planted on reclaimed mined lands. Specific objectives were to:

1. Determine growth and survival of aspen and serviceberry under different competing vegetation and irrigation conditions on reclaimed surface mined lands at a western Colorado site.

2. Quantify physiologic condition of the plants under different competing vegetation and irrigation treatments.

Experimental Procedures/Methodologies

Study Design

The goal of this research was to identify operational effective planting and control of competing vegetation techniques to reestablish self-sustaining woody perennials on reclaimed mine lands that sustained native trees and shrubs before mining. Findings from this study are applicable throughout the U.S. where planting machines are commonly available and woody perennials are grown on reclaimed surface mine lands. Our previous research found that fencing to prevent grazing, control of competing vegetation, and sufficient water availability are critical factors for insuring adequate survival and growth of planted aspen trees. This study tested the effectiveness of commercially available techniques used in high volume planting systems, adapted to account for the critical factors identified in our previous research. These questions are being investigated in experiments conducted on reclaimed Seneca Coal Company land south of Hayden, CO. A large portion of the Seneca mines was covered with aspen, serviceberry, and other native plants prior to mining. Aspen is unique in that it is a common species in the western United States, but it has not been planted successfully in wildland environments.

This experiment is examining if standard tree planting techniques and equipment used for machine planting of trees for farming, conservation, and reforestation, as recommended by the state forest nurseries, are advantageous to the growth and survival of aspen trees and serviceberry shrubs on mine reclamation sites. Tractor mounted planting equipment to replicate the techniques tested in this study are commercially available and used most US rural forested areas, and can be adapted to reclamation projects nationwide if shown to be successful here. The procedure could be used as a cost-effective method to reproduce woody perennial vegetation on large areas of reclaimed lands. The experiment is being conducted on reclaimed sites on the Seneca Coal Company Yoast and IIW coal mines (Fig. 1). Surface mining activity has been discontinued at both mines and both sites are being re-vegetated.

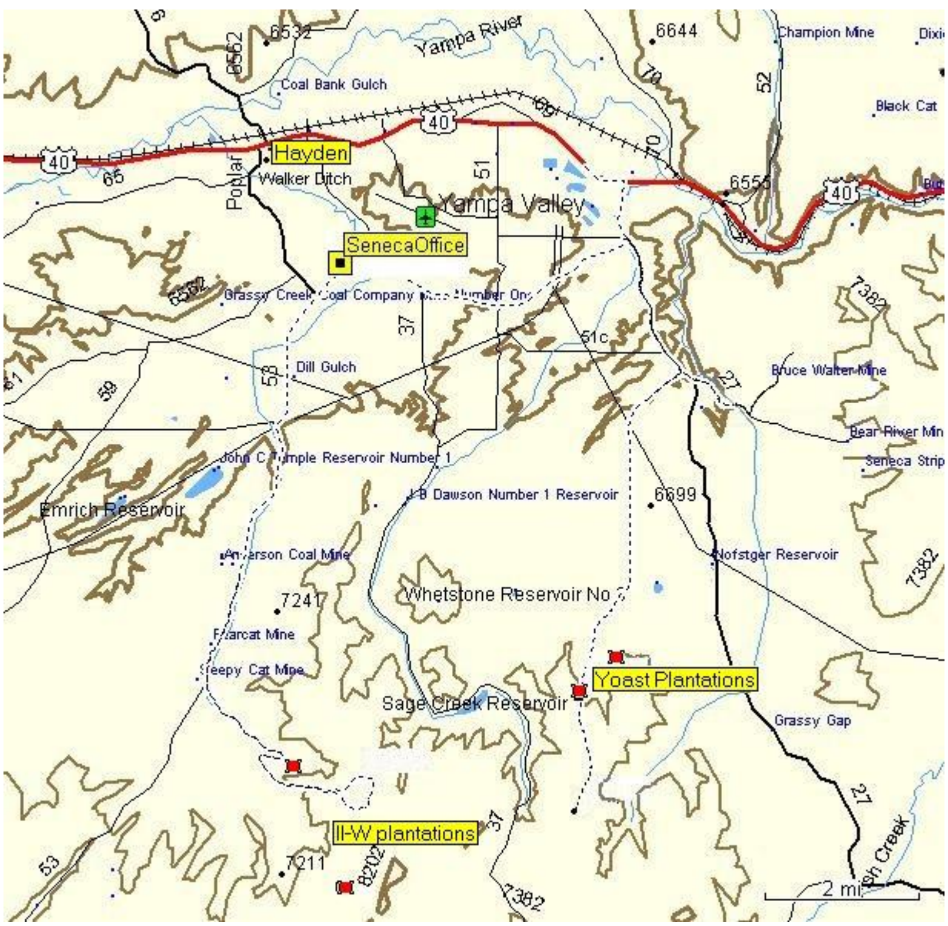

Figure 1. Map of study area, showing Seneca Coal Company IIW and Yoast plantings, south of Hayden, CO.

Aspen and serviceberry were planted using standard landscape fabric designed for machine planting as recommend by the Colorado State Forest Nursery. This experiment hand planted the trees and shrubs and hand-laid the landscape fabric, using the same 1.8 m (6 ft wide) by 91 m (300 Ft) rolls of landscape fabric, and 1.5 m (5 ft) tree/shrub spacing within the row as used with machine planting. This particular experiment was hand planted since the study is too small to warrant the economics of contracting for a planting and fabric laying machine, and students were available to assist with the planting. Trees and shrubs were planted first then fabric was laid simulating techniques used where trees and shrubs are first planted from the back of a tractor, followed by tractor-mounted rolling and laying of the fabric, then slitting and pinning the fabric around and over the planted trees. The experiment included a total of six plots, three at the Yoast Mine and three at the IIW Mine. All of the plots were located within two fenced areas at each mine to exclude elk, deer, and cattle browsing. At each mine, one of the fenced areas includes one experimental plot and the other fenced area includes two experimental plots. The single fenced plot at the IIW mine was abandoned after grasshoppers defoliated all the plants by the end of June 2008. We will re-examine this plot for survival in 2009, but it is not included in the first year growth analysis. Aspen and serviceberry were planted with or without the landscape fabric One-half of the planted aspen and serviceberry received water every other week by watering from a bulk storage tank. The other half received no supplemental irrigation water. Water supply was from a nearby potable water source to avoid salinity problems.

Nursery stock potted aspen (3.78 liter [1-gallon] size pot, 45-60 cm tall trees) and serviceberry (164 cubic cm [10 cubic inch] Ray Leach supercells, 20.1 cm depth x 3.2 cm collar, 30-45 cm tall plants) from a commercial nursery (Rocky Mountain Native Plants Company, Rifle, CO) using a Colorado Rocky Mountain seed source were planted during the first two weeks of November 2007, after senescence when the plants had winter hardened. Topsoil had been stored and placed on three of the sites over overburden during the summer of 2007 to a depth of 1 m. The fourth site (IIW single fenced plot) had topsoil placed onsite in 2005.

Re-graded overburden (spoil) and reapplied topsoil has been analyzed for pH, chemistry, texture, electric conductivity, sodium adsorption ratio, and acid-base potential. Results indicated a ‘good-rated’ suitability classification for all samples analyzed (data available from Seneca Coal Company). Soils analyses conducted for this study indicated that the topsoil at the experimental sites were not deficient in nutrients.

The first year of funding provided for data collection and analysis the first growing season following planting. The experiment was designed in consultation with the RMRS Biometrician. The experiment is fully replicated at the reclaimed experimental sites, and the study utilizes an analysis of variance (ANOVA) with sources of variation treatments consisting of landscape fabric (fabric or no fabric) and irrigation (supplement rainfall with or without irrigation). The data were analyzed using SAS GLIMMIX (mixed model) analysis.

The experiment was designed to be analyzed separately for each species. Each experimental plot or block includes 16 rows of plants, 8 rows of serviceberry and 8 rows of aspen (Tables 1 and 2). Each separate landscape fabric treatment contains 12 individual trees or shrubs; half were irrigated and half not irrigated. Plants for the experiment were selected to be of uniform size before planting. The first year growth and physiological measurements were conducted during the summer of 2008. Although the study was designed for at least three years of measurement following planting to insure more than short-term survival and growth information, and since response of perennials to treatment is often not seen until the third year of treatment, this initial report examined response only through the first (2008) growing season.

Table 1. The aspen and serviceberry field layout for the landscape fabric and irrigation study, in the two fenced areas at the Yoast Mine. AF = aspen with landscape fabric, SF = serviceberry with landscape fabric, A = aspen without landscape fabric, S = serviceberry without landscape fabric. Each row has 12 plants that was divided into two parts, where one half of the row (6) was irrigated and other half (6) was not irrigated. Blocks 1 and 2 are in fenced area 1 and Block 3 is in fenced area 2. Since positioning of aspen and serviceberry within blocks was randomized, numbering on Block 3 is in reverse order to allow rows 1-8 to be aspen and rows 9-16 to be serviceberry in all blocks.

-----Block 1------		-----Block 2-----		-----Block 3------	
Row	Treatment	Row	Treatment	Row	Treatment
1	AF	1	AF	16	S
2	A	2	A	15	SF
3	AF	3	AF	14	SF
4	A	4	A	13	S
5	A	5	A	12	SF
6	AF	6	AF	11	S
7	A	7	AF	10	S
8	AF	8	A	9	SF
9	S	9	S	8	A
10	SF	10	SF	7	AF
11	SF	11	S	6	AF
12	S	12	SF	5	A
13	S	13	S	4	AF
14	SF	14	SF	3	A
15	S	15	SF	2	A
16	SF	16	S	1	AF

Table 2. The aspen and serviceberry field layout for the landscape fabric and irrigation study, in the two fenced areas at the IIW Mine. AF = aspen with landscape fabric, SF = serviceberry with landscape fabric, A = aspen without landscape fabric, S = serviceberry without landscape fabric. Each row has 12 plants that were divided into two parts, where one half of the row (6) was irrigated and other half (6) was not irrigated. Block 4 is in fenced area 3, and Blocks 5 and 6 are in fenced area 4. Block 4 was not measured in 2008 because of defoliation by grasshoppers early in the growing season Survival will be monitored from this plot in 2009. Since positioning of aspen and serviceberry within blocks was randomized, numbering on Blocks 4 and 6 are in reverse order to allow rows 1-8 to be aspen and rows 9-16 to be serviceberry in all blocks.

-----Block 4-----		-----Block 5------		-----Block 6------	
Row	Treatment	Row	Treatment	Row	Treatment
16	SF	1	AF	16	SF
15	S	2	A	15	S
14	S	3	A	14	S
13	SF	4	AF	13	SF
12	SF	5	AF	12	SF
11	S	6	A	11	S
10	SF	7	AF	10	SF
9	S	8	A	9	S
8	AF	9	SF	8	AF
7	A	10	S	7	A
6	AF	11	SF	6	AF
5	A	12	S	5	A
4	A	13	S	4	AF
3	AF	14	SF	3	A
2	AF	15	S	2	AF
1	A	16	SF	1	A

Experimental Treatments

Vegetative Competition. Half of the trees were planted with landscape fabric and half without. This was to verify the importance of protecting plants from vegetative competition in survival of the aspen and serviceberry on reclaimed lands.

Irrigation. Based on findings from the 2005-2007 preliminary study, we applied clean water (low-saline) or no water (control treatment) every other week. All plots received local ambient rainfall. Four liters of water were applied to each irrigated plant by hand from a bulk tank during mid-day once every two weeks from mid-June until early September. Water was delivered from a pail with a small hole in the bottom placed at each plant to allow slower watering than possible directly from the hose attached to the tank. The pail also allowed for closer monitoring of the volume of water to be delivered to each plant. Soil moisture status was determined from gravimetric soil moisture measurements and plant water status measurements were obtained from a plant water status console.

Field Measurements

Growth. Aspen and serviceberry were measured at planting and at the end of the summer growing season for height and basal caliper (diameter) growth and survival. Observations on leaf size and chlorosis were also noted. Terminal leader growth and stem diameter (caliper) data were not normally distributed, and therefore a Gaussian or lognormal transformation was conducted on the original data prior to statistical analysis.

Physiological status. Physiological conditions, such as stomatal conductance, photosynthesis, and respiration, may show response to drought or other stress prior to any indications of leaf stress. These physiological measurements may provide an early indication of which plants are stressed and not likely to survive. We collected physiological measurements of the plants in each treatment, including leaf water potential, photosynthesis, respiration, and transpiration. This allows a better evaluation of the physiological stress conditions occurring under specific treatments; and the physiological conditions favorable for survival. Serviceberry was not monitored for physiological status since the plants and leaves were too small.

Soil and Water. At each planting site soil samples from within the topsoil down to overburden were collected for analysis for texture and fertility (organic matter, pH, N, P, K, CEC) by a contract soils testing laboratory using standardized methods and protocols for those processes. Root zone soil samples were collected during the growing season for gravimetric soil moisture determination. Soil samples were also submitted to the soils testing laboratory for determination of other chemical constituents.

Results

Results of this study confirm our hypothesis that best survival and growth were achieved with the use of landscape fabric for aspen. Irrigation of aspen also increased some growth parameters, but the response was less from irrigation than that from landscape fabric. Serviceberry did not respond to landscape fabric or to irrigation treatment. It is likely that the aspen responded more to treatment since these plants were larger and less subject to transplant shock than the smaller serviceberry. Very little growth was evident on the serviceberry plants, and it expected that first year response may have been concentrated in survival and root growth. Soil chemical analyses indicated no deficiencies in nutrients that should limit growth of aspen or serviceberry.

Response of aspen to irrigation was less than the response to landscape fabric. Rainfall during the growing season was light, but relatively frequent (Fig 2). It is expected that there was sufficient ambient rainfall to provide adequate soil moisture for aspen to survive and grow. However, the amount of survival and growth was dependent on the amount of soil moisture remaining after removal by competing vegetation.

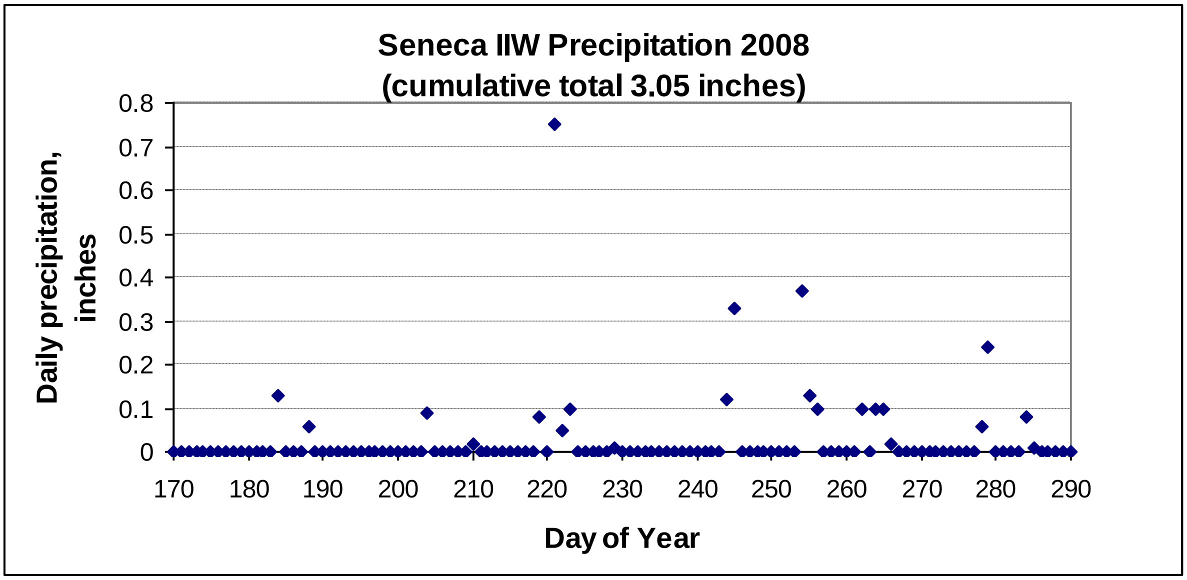

Figure 2. Ambient rainfall at the IIW study site.

Survival was related to biomass of competing vegetation for aspen, but not for serviceberry (Fig. 3). Mortality averaged about 20% for serviceberry, regardless of treatment. Mortality of aspen varied from about 10% to 45% and was highly related to biomass of competing vegetation. The response varied greatly by site (Fig. 4), and was apparently related to surrounding vegetation that competed with aspen for water and this affected survival. Yoast plots had the highest biomass of competing vegetation, and highest biomass and aspen mortality was in Yoast Blocks 1 and 2 that were in the same fenced area. Serviceberry plants were smaller, suggesting it took less water for them to survive.

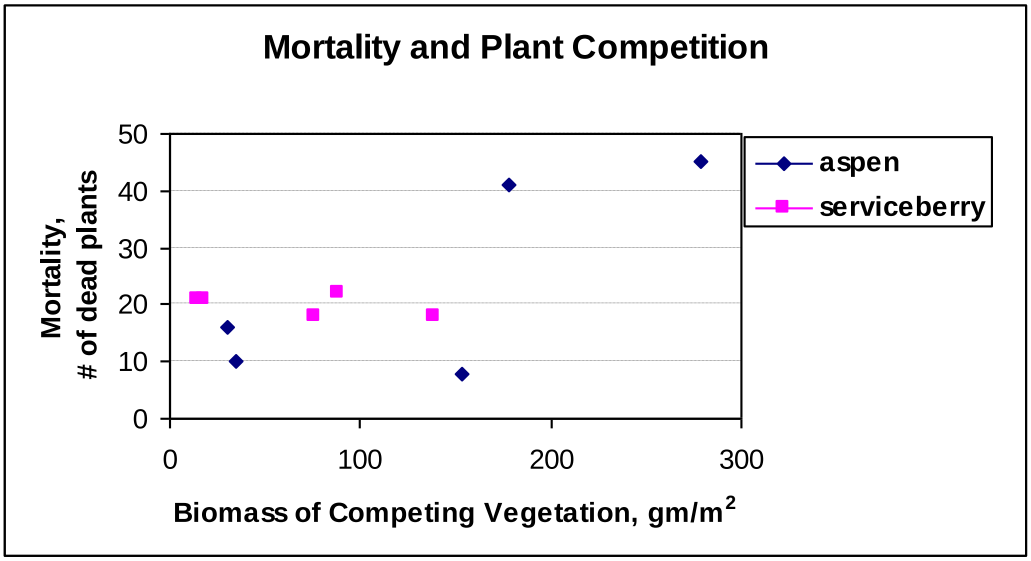

Figure 3. Relationship of plant mortality to biomass of competing vegetation. Plots with the highest aspen mortality were from the Yoast site.

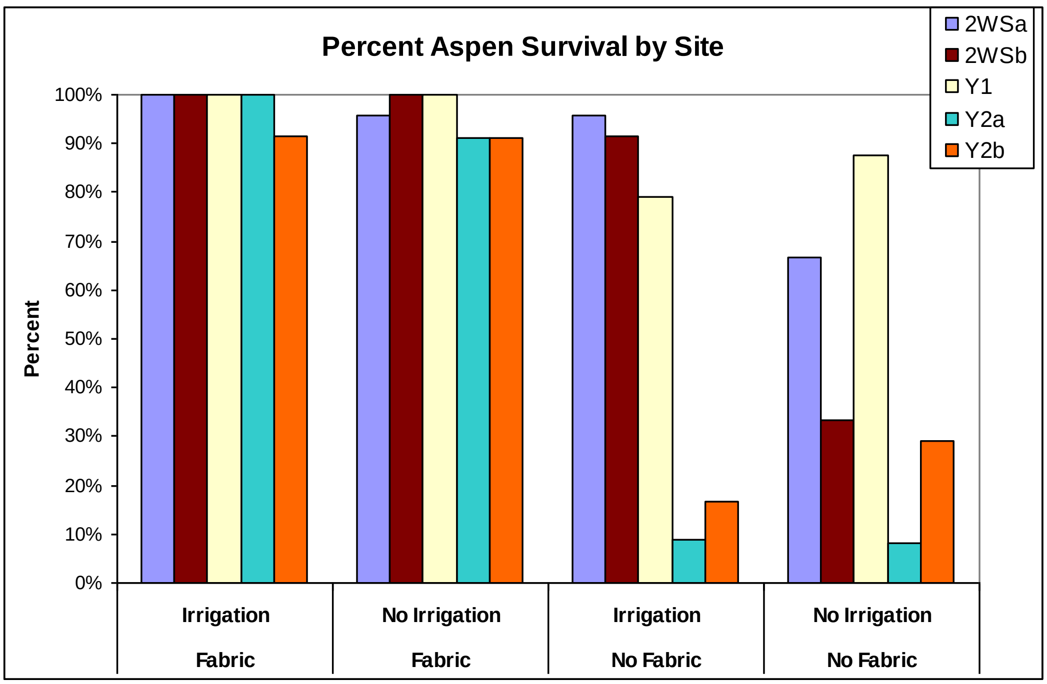

Figure 4. Aspen survival by site location in response to landscape fabric and irrigation. Note Yoast 2a and 2b had the most competing vegetation biomass.

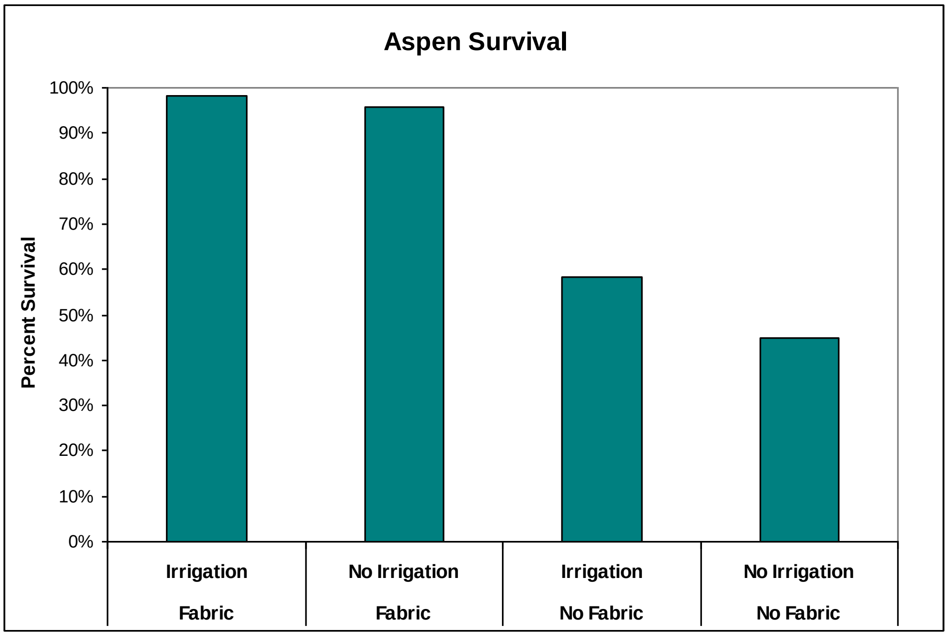

Figure 5. Survival of aspen in response to landscape fabric and irrigation.

Landscape fabric resulted in significant increases in the aspen survival (Fig. 5), terminal leader growth (Fig. 6), and stem caliper (Fig. 7). Irrigation significantly increase stem caliper, but not terminal leader growth. The relationship of terminal leader growth and basal caliper in relation to landscape fabric was dramatic and significant. The response of aspen to irrigation was statistically significant only for caliper growth, and the response was considerably less to irrigation than to landscape fabric.

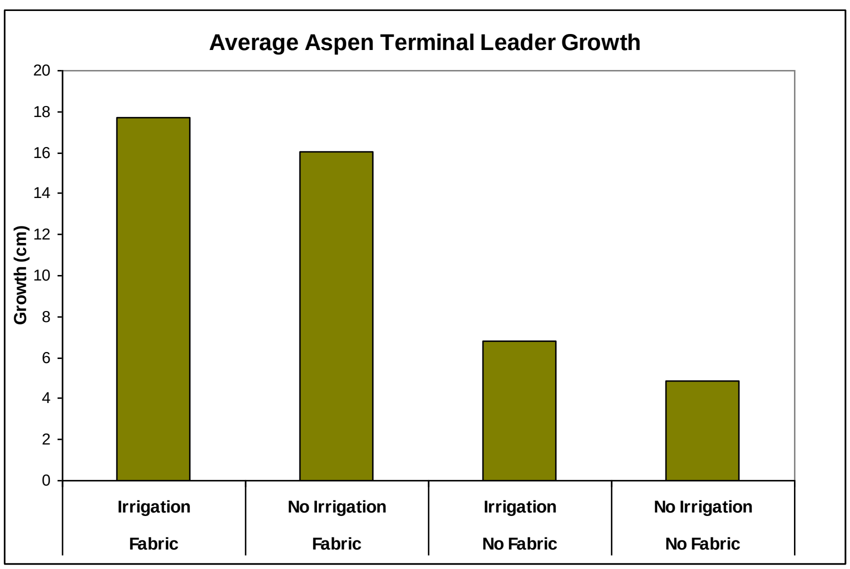

Figure 6. Relationship of terminal leader growth of aspen to landscape fabric and irrigation.

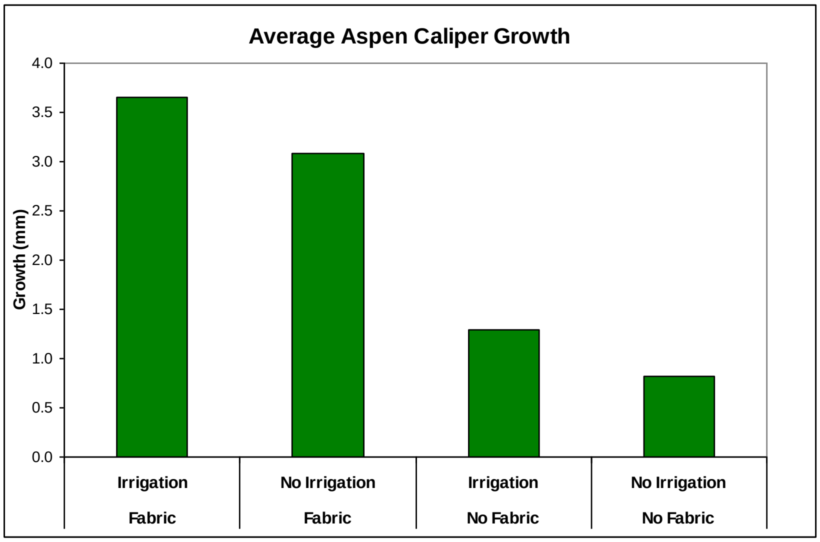

Figure 7. Relationship of stem caliper growth of aspen to landscape fabric and irrigation.

Landscape fabric increased the amount of soil moisture available to the plants (Fig. 8), which in turn provided more favorable leaf water potential (Fig. 9) and subsequent increased photosynthesis and growth of aspen. Soil moisture was 29% higher under the landscape fabric compared to no fabric. Photosynthesis and conductance were higher in aspen trees grown with landscape fabric, but showed less of a response to irrigation treatment (Figure 10).

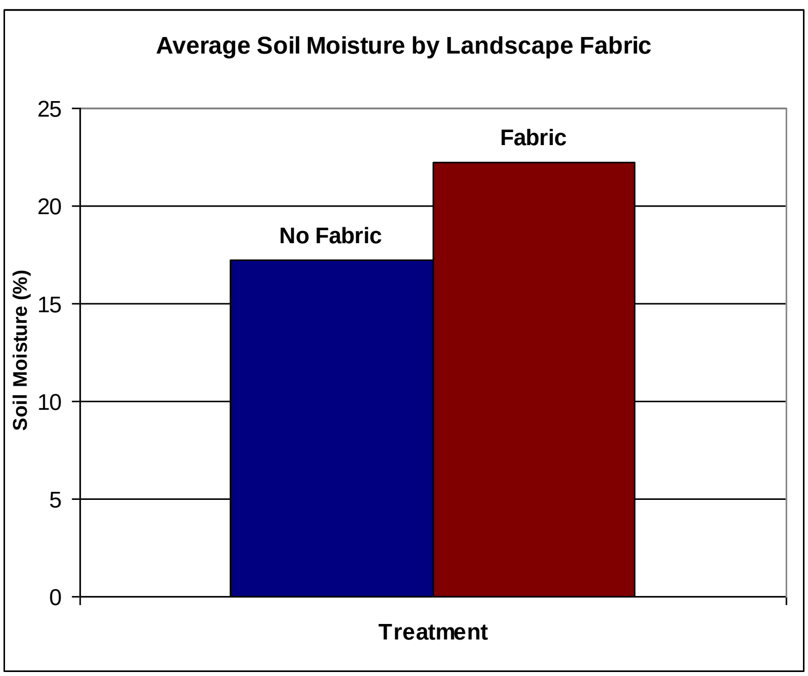

Figure 8. Soil moisture with or without landscape fabric.

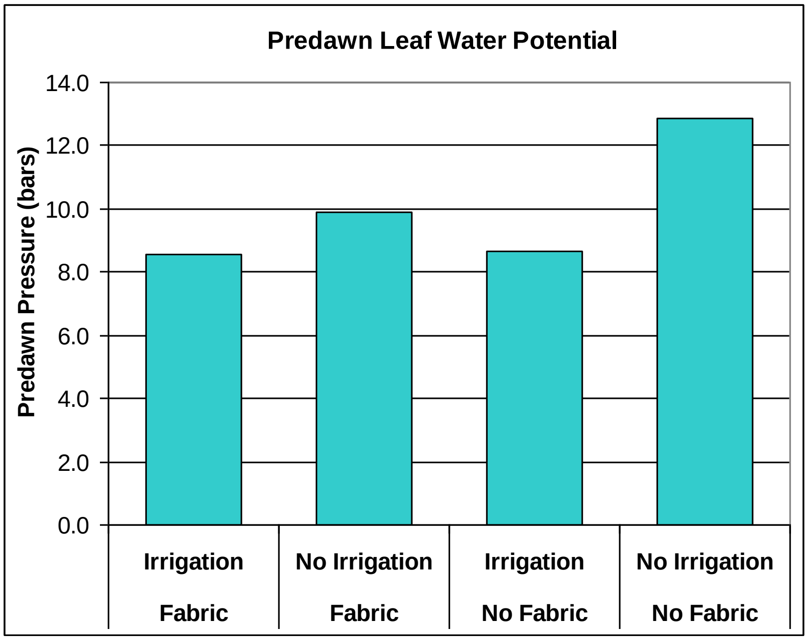

Figure 9. Predawn leaf water potential of aspen in response to landscape fabric and irrigation.

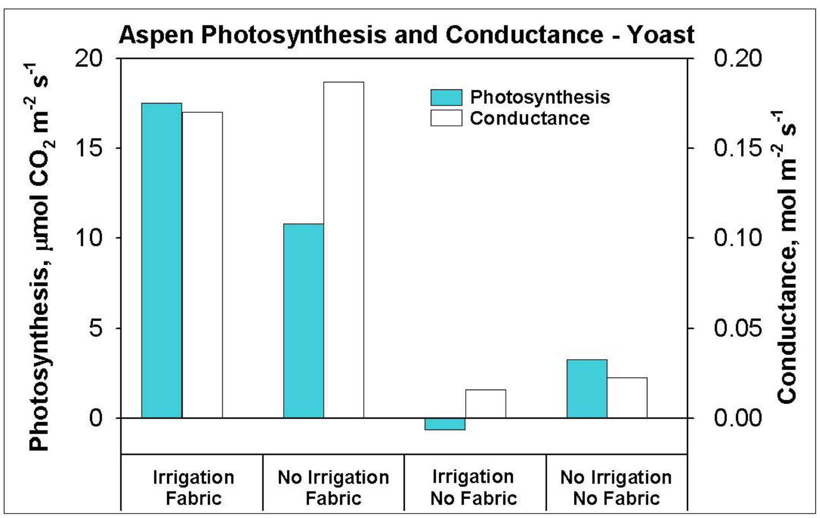

Figure 10. Photosynthesis and conductance of apsen at the Yoast site in response to landscape fabric and irrigation.

Discussion and Conclusions

This study specifically addressed the issue of finding ways to successfully plant aspen and serviceberry on reclaimed surface mines in high altitude semi-arid environments in the western United States, but the experiment is applicable for reclamation nationwide. Aspen and serviceberry have occupied many surface coal mine sites in the Western US prior to mining operations. Because aspen and serviceberry reproduce by root suckering and parent roots are disturbed in the mining process, sites must be reclaimed using potted plants or transplants. Potted seedlings or transplanted root sprouts do not have an extensive root system to access water and nutrients needed for establishment and rapid growth. We conducted an experiment to test the use of commercially available tree and shrub planting techniques to establish planted aspen and serviceberry on reclaimed coal mine soils, and to compare growth and survival of the plants under the different irrigation and landscape fabric treatments. We used commercial weed barrier landscape fabric commonly placed on the ground by tractor-drawn machine.

It is apparent that after the first growing season of this experiment that survival and growth of aspen was highly dependent on use of the landscape fabric, with the presence of the fabric significantly increasing growth and survival. The increases seemed to be related to increased soil moisture and resultant decreased leaf water stress and increased photosynthesis. The increased soil moisture may have been related to less water evaporation from the soil having a landscape fabric cover or from less transpiration from the site because of less vegetative cover.

We have shown that control of competing vegetation is important in survival and growth of aspen. The landscape fabric was particularly important in the sites with the most competing vegetation. The first year results of this experiment confirm the hypothesis that landscape fabric will increase growth and survival of aspen, particularly where amounts of competing vegetation are high. The ability of the plants to successfully re-establish will require lateral root growth necessary for sprouting. This could not be determined after one year of growth. The irrigation and landscape fabric treatments had no significant effect on serviceberry, likely a result of the small initial size of the serviceberry plants. We expect a response of serviceberry is more likely to appear in the second and third years after treatment.

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