SURVIVAL AND GROWTH OF ASPEN AND SERVICEBERRY PLANTED ON RECLAIMED SURFACE MINED LAND WITH LANDSCAPE FABRIC AND IRRIGATION[1]

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Abstract: Difficulty in re-establishing native vegetation on surface mined lands in the semi-arid western U.S. prompted this study to determine the effectiveness of landscape fabric and supplemental irrigation on survival and growth of the woody perennials aspen (*Populus tremuloides* Michx.) and serviceberry (*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roem.) at a high elevation reclaimed surface coal mine site in Colorado. The study compared growth and survival of container-grown aspen and serviceberry planted with or without landscape fabric for control of competing vegetation, and with or without biweekly supplemental irrigation during the first growing season. Response after three years indicated that the landscape fabric was particularly crucial in survival and growth of aspen on sites with heavy competing vegetative cover. Serviceberry plants grew better with landscape fabric but the fabric did not increase survival. Supplemental irrigation provided only limited advantage compared to the landscape fabric. Photosynthesis and pre-dawn moisture stress measurements on the aspen indicated that they were more stressed without landscape fabric. Soil moisture was higher under the landscape fabric.

Additional Key Words: Amelanchier alnifolia, competition, Populus tremuloides, revegetation, soil moisture

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Introduction

Successful re-establishment of the woody species aspen (*Populus tremuloides* Michx.) and serviceberry (western serviceberry *Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roem.) on surface-mined lands in the United States is problematic because these species commonly regenerate through vegetative sprouting from parent roots in the soil under natural conditions. These roots are not readily available for sprouting when removed in the mining process. 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 (Shepperd and Mata, 2005). Serviceberry regeneration on reclaimed land also has been shown to be difficult (Williams et al., 2004). Competition with fast-growing herbaceous vegetation is another important factor influencing survival of planted woody perennials throughout the US.

Quaking aspen and serviceberry 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 hardwood species. Aspen stands provide desirable scenic value, and the diversity of plants growing under aspen supplies critical wildlife habitat and food, provides valuable browsing resources, protects soils from erosion, and helps maintain water quality. These features make aspen forests a crucial component of many western U.S. landscapes (Shepperd et al., 2006).

Aspen most often reproduces by vegetative root suckers (Shepperd and Smith, 1993). 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 drought. Parent roots are not available for sprouting when topsoil has been removed by mining.

Abundant aspen seed crops are produced in some years, but natural regeneration requires bare mineral soil and adequate moisture to survive (McDonough, 1979). Although exposed mineral soil is present on freshly resurfaced mine lands, adequate soil moisture is rare on these sites, especially in the western U.S. Aspen has been considered to be somewhat tolerant of drought (Lieffers et al., 2001), but planting aspen seedlings on non-irrigated sites in Colorado has not been successful (Shepperd and Mata, 2005). Planted seedlings generally have a small root mass that is of insufficient size and extent to absorb enough of the limited moisture available to survive through summer drought periods.

Topsoil removed from previous aspen stands and placed on reclaimed sites can provide roots for adventitious shoots. For the new aspen sprouts to initiate, grow, and thrive, there must be sufficient sunlight to the forest floor and warmer soil temperatures (Doucet, 1989). However, young aspen sprouts compete with other understory plants and survival of aspen on reclaimed mined lands is reduced by herbaceous competition (Hughes et al., 1992). Aspen is a desired browse plant for cattle, deer, and elk, and aspen stems are often damaged by these animals (Shepperd and Mata 2005).

Water deficits reduce stomatal conductance, root hydraulic conductivity, shoot leaf water potential (Siemens and Zwiazek, 2003), and nutrient uptake (van den Driessche et al., 2003) in aspen, further reducing growth and survival. Irrigation might improve survival and growth of planted aspen seedlings with smaller root systems. Irrigation has increased growth of hybrid poplar (Strong and Hansen, 1991).

Serviceberry is a common and important shrub in western ecosystems, and it is an important food source for wildlife, supplying both foliage for forage and fruit for ungulate and small mammal consumption (Gruell et al., 1979). Serviceberry planted on reclaimed mine overburden had lower survival when plants were fertilized with 17-6-12 slow release plus micronutrients at planting and supplemental fertilization for the next five years (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 establish using seedlings, and has been shown to be difficult to establish on reclaimed mine lands (Agnew, 1992). Movement of topsoil containing roots for sprouting directly to the reclaimed site (live hauling), or transplanting of native plants directly from nearby forests, provided for the best establishment on reclaimed mine lands (Agnew, 1992). The influence of competing vegetation on the establishment of serviceberry on reclaimed lands has not been studied.

Previous research (Musselman et al., 2012) found that the best conditions for reproduction of aspen on reclaimed surface mined coal lands resulted when transplanted trees (about 1 m tall) obtained from local sources were replanted on freshly hauled soil removed from aspen stands. The study found that care should be taken to avoid compaction of the replaced soil, transplanted trees should be planted no deeper than the original root collar, competing vegetation should be controlled around individual trees, and fencing was necessary to prevent browsing. Natural sprouts from residual aspen roots in the freshly hauled topsoil survived if protected from competing vegetation. Few sprouts resulted from stored soils. The study suggested that irrigation with non-saline water might enhance growth and survival in years with drought conditions.

The follow-up study reported here identified factors that potentially limit re-establishment of trees and shrubs on surface-mined lands in the semi-arid west. 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. Landscape fabric has been used elsewhere in plantings of woody perennials to limit surrounding vegetation that competes for moisture and nutrients.

Equipment is available that can be pulled behind a tractor to plant trees and lay down weed-barrier landscape fabric. The planting equipment is commercially available in most rural forested areas throughout the U.S. and from many state forest nurseries or agricultural extension offices. 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 extensively used for revegetation of reclaimed surface coalmine lands. Machine planting of woody perennials on reclaimed surface mine lands might therefore be a cost-effective method for large-scale re-vegetation of reclaimed surface coalmine lands. These planting techniques could be used for reclamation throughout the U.S. where competition from herbaceous vegetation limits reproduction of woody perennials on revegetated surface coalmine lands.

The objective of this study was to examine effectiveness of improved operationally effective techniques on the survival and growth of replanted woody perennials for re-establishment of self-sustaining populations on reclaimed surface coalmine lands in Colorado. The study examined how landscape fabric, often applied mechanically with machine planting of trees, plus supplemental irrigation might enhance survival and growth of aspen and serviceberry on reclaimed mine lands that had sustained native trees and shrubs before mining.

Methods

Study Design

This study tested if landscape fabric that is often used with machine planting of trees for farming, conservation, and reforestation was advantageous to the growth and survival of aspen trees and serviceberry shrubs on reclaimed surface mine sites. The study examined growth and survival of aspen and serviceberry with or without control of competing vegetation using landscape fabric and with or without first year supplemental irrigation on reclaimed surface mined lands. We also measured physiological condition of the plants under the control of competing vegetation and irrigation treatments.

The experiment was conducted on reclaimed sites at about 2300 m elevation on Peabody Energy's Seneca Coal Company, Yoast and IIW surface mines, south of Hayden, CO. Mining activity had been discontinued at both mines and re-vegetation was proceeding on topsoil that had been stored and replaced after regrading. The experimental sites were not near surrounding vegetation, and the ground was bare but seeded with native and introduced grasses and forbs when our sites were laid out and planted. A large portion of both Seneca mine areas was covered with aspen, serviceberry, and other native plants prior to mining.

Aspen and serviceberry were planted using standard weed barrier landscape fabric (15 mil black woven Lumite® polypropylene, density 3 oz/sq yd, Shaw Fabric Products, Fort Collins, Colorado[3]) designed for machine planting as commonly recommend by state forest nurseries. This experiment hand planted the trees and shrubs, using the same landscape fabric (1.8 m wide) and tree/shrub spacing (1.5 m) as used with machine planting. The experiment was hand planted because the study was too small to warrant the costs of contracting for a planting machine, students were available to assist with the planting, and our plants were larger and potted compared to those commonly used in machined planting. However, the experiment was placed with the same techniques used in machine planting where trees and shrubs are planted followed by laying, slitting, and pinning the fabric around the planted trees and shrubs.

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[3]The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

The study was located on five sites or experimental plots, two within a fenced area at the IIW Mine (IIWa and IIWb, 40°21'9.31"N, 107°13'51.67"W) as shown in Fig. 1. Two more within a fenced area at the Yoast Mine (Y2a and Y2b, 40°23'30.33"N, 107°10'46.91"W), and last as a single plot located in a separate fenced area at Yoast (Y1, 40°23'51.08"N, 107°10'29.81"W). Planting within fenced areas was necessary to excluded elk, deer, and cattle browsing. Aspen and serviceberry were planted separately as two experiments, in rows randomized with or without the landscape fabric within each plot.

Figure 1. Field layout of aspen and serviceberry plantings at Seneca IIW, June 2008. Aspen and serviceberry were planted and landscape fabric was placed the previous fall. Center left is the IIWb site, center right is the IIWa site. A native aspen stand is on the horizon behind reclaimed surface coalmine land. Planted grasses and herbs are shown in the foreground.

Nursery stock aspen (3.8 l [1-gallon size] pot, 45-60 cm tall trees) and serviceberry (164 cm^3 [10 in^3] Ray Leach supercells, 21 cm depth x 3.2 cm collar, 30-45 cm tall plants) were obtained from a commercial nursery (Rocky Mountain Native Plants, Rifle, CO). Plants were 2-0 container raised using seed sources collected from the White River National Forest between Meeker Colorado and Rifle, Colorado. The nursery stock plants had already senesced and winter hardened before planting during the first two weeks of November 2007. Topsoil had been stored and placed on all sites over overburden during the summer of 2007 to a depth of 1 m.

The experiment was set up as a strip plot design where the five sites were designated as plots and treatment rows within plots designated as strips. The responses for each species were analyzed using a mixed-effects model with plot and treatment row within plot as random effects. Incorporated into each model were unstructured residual variance-covariance relationships to account for annual repeated measures. Predictors in each model included landscape fabric, first-year irrigation and year along with all second-order interactions. Growth data were not normally distributed, and therefore a Gaussian or lognormal transformation was conducted on the original data prior to statistical analysis. The repeated-measures subject was individual plant within each row. The means-separation tests are the post-hoc comparisons that were assessed using the Tukey-Kramer method (Kramer, 1956). Data are presented graphically as box-plots. SAS PROC GLIMMIX was used to analyze the experiment because of the potential presence of year-to-year residual correlation within subjects along with the presence of random effects.

Each site included 16 adjacent 1.8 m wide rows of plants, 8 rows of serviceberry then 8 rows of aspen (Table 1). Each separate landscape fabric treatment row contained 12 individual trees or shrubs planted 1.5 m apart within each row. The study was designed to follow establishment of the plants through at least three growing seasons to provide more than short-term survival and growth information. Response of perennials to treatment is often more apparent after the first year of treatment. Growth and survival were measured at the end of the 2008, 2009, and 2010 growing seasons.

Water for irrigation was from a nearby municipal potable water source to avoid salinity problems encountered in an earlier study at the same mine (Musselman et al., 2012). One-half of the planted aspen and serviceberry (plants 1-6 or 7-12 in each row) each received about 4 liters of water every two weeks during mid-day from mid-June until early September during the first growing season (2008) by hand watering from a bulk storage tank. The other half received no supplemental irrigation water. Water was delivered by filling a 4-liter pail with a small hole in the bottom placed at each plant to allow slow delivery and avoid runoff and transport to adjacent plants 1.5 m away. All treatments received local ambient rainfall.

Table 1. The aspen and serviceberry field layout for the landscape fabric and irrigation study at the Yoast and IIW Mines.

Site 1 - Yoast 1		Site 2 - Yoast 2a		Site 3 - Yoast 2b		Site 4 - IIWa		Site 5 - IIWb	
Row	Treatment	Row	Treatment	Row	Treatment	Row	Treatment	Row	Treatment
1	AF	1	AF	16	S	16	SF	1	AF
2	A	2	A	15	SF	15	S	2	A
3	AF	3	AF	14	SF	14	S	3	A
4	A	4	A	13	S	13	SF	4	AF
5	A	5	A	12	SF	12	SF	5	AF
6	AF	6	AF	11	S	11	S	6	A
7	A	7	AF	10	S	10	SF	7	AF
8	AF	8	A	9	SF	9	S	8	A
9	S	9	S	8	A	8	AF	9	SF
10	SF	10	SF	7	AF	7	A	10	S
11	SF	11	S	6	AF	6	AF	11	SF
12	S	12	SF	5	A	5	A	12	S
13	S	13	S	4	AF	4	A	13	S
14	SF	14	SF	3	A	3	AF	14	SF
15	S	15	SF	2	A	2	AF	15	S
16	SF	16	S	1	AF	1	A	16	SF

AF = aspen with landscape fabric, A = aspen without landscape fabric, SF = serviceberry with 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. Numbering on s 3 and 4 are in reverse order to allow numbered rows 1-8 to be aspen and numbered rows 9-16 to be serviceberry at all sites.

Field Measurements

Growth and survival. Aspen and serviceberry were measured at planting and at the end of each growing season for growth and survival. Growth measurements included leader length and stem caliper (basal diameter above the root collar). Overwinter survival was recorded in May of each year.

Physiological status. Physiological conditions may show response to stress prior to any visible leaf indications of stress and allow a better evaluation of the conditions favorable for survival and growth under specific treatments. We collected physiological measurements of aspen plants in each treatment in the first growing season, including pre-dawn leaf water potential using a Plant Water Status Console (Soilmoisture Equipment Corp, Santa Barbara, CA). These methods have been previously described (Musselman et al., 2012), and photosynthesis and stomatal conductance using a LI-COR 6400-XT (LiCor, Lincoln, NE) with a model LI-6400-40 cuvette chamber with a uniform, integrated LED light source and PAM fluorometer (2 cm^2 leaf area). Serviceberry was not monitored separately for water stress, photosynthesis, or conductance since the plants and leaves were small during their first year.

Soil and Water. Topsoil that had been placed over re-graded overburden at each planting site was analyzed for fertility (organic matter, pH, N, P, K, CEC), texture, electric conductivity, sodium adsorption ratio, and acid-base potential. Analyses were conducted by Colorado State University Soil Water and Plant Testing Laboratory (http://www.soiltestinglab.colostate.edu/) using standardized methods and protocols for those processes. Soil moisture status was determined by gravimetric analysis from a sample collected mid-day 0-10 cm depth in the non-irrigated section of each fabric and no fabric row at each site during one day in July.

Results

Results of this study found that best survival and growth for aspen were achieved with the use of landscape fabric (Table 2 and Fig. 3). Aspen showed some response to irrigation, but much less than that from landscape fabric. Landscape fabric had a significant effect on growth of serviceberry, but not serviceberry survival (Table 2). Serviceberry did not respond to irrigation treatment. Response of aspen was more visually evident in the field than was that of serviceberry. S oil chemical analyses indicated no deficiencies in N, P, or K that should limit growth of aspen or serviceberry.

Springtime soil moisture was provided by snowmelt at the site. Rainfall during the first summer season was light, but relatively frequent, with a total of 7.75 cm from July 1 – October 31. It is expected that there was sufficient ambient rainfall to provide adequate soil moisture for aspen and serviceberry to survive and grow.

Table 2. Statistical significance (P-values) for the experimental main effects of landscape fabric and interactions, for survival, terminal leader growth, and stem caliper growth after the 2010 growing season; and for 2008 aspen photosynthesis and conductance.

		Treatment Significance					
Aspen		LF	IR	YR	LF x IR	LF x YR	IR x YR
	Survival	<.0001	0.016	<.0001	0.903	0.344	0.020
	Terminal leader	<.0001	0.442	<.0001	0.606	<.0001	0.008
	Caliper growth	<.0001	0.059	<.0001	0.589	<.0001	0.475
	Photosynthesis	0.0216	0.387	---	0.944	---	---
	Conductance	0.0012	0.760	---	0.816	---	---
Serviceberry							
	Survival	0.143	0.443	<.0001	0.106	0.0001	0.126
	Terminal leader	<.0001	0.578	<.0001	0.388	<.0001	0.964
	Caliper growth	<.0001	0.608	<.0001	0.958	<.0001	0.882

Landscape Fabric (LF) and Irrigation (IR) by Year (YR)

Aspen Response to Treatment

Response of aspen to irrigation was less significant than the response to landscape fabric. Survival appeared to vary by location (Fig. 2), but landscape fabric and to a lesser extent irrigation increased aspen survival (Table 3). Survival was lowest on sites Y2a and Y2b without landscape fabric, sites that had the most competing vegetation (data not shown). Additional mortality occurred each year of the study (Table 3). Terminal leader growth (Fig. 3a) and stem caliper (Fig. 3b) significantly increased with landscape fabric. The response of aspen terminal leader growth (Fig. 4a) and stem caliper (Fig. 4b) to landscape fabric increased each year. Response of aspen to irrigation was not significant for terminal leader or stem caliper growth (Table 2 and Fig. 3). There was no significant interaction between landscape fabric and irrigation for terminal leader and stem caliper. Year by irrigation interaction was significant for survival and terminal leader growth, but not for caliper growth. Senescence seemed to be delayed in aspen grown on landscape fabric but this parameter was not quantified. Trees on landscape fabric were still green in October while those without landscape fabric had senesced. Landscape fabric also appeared to increase growth and delay senescence of competing vegetation growing at the edges of the landscape fabric (Fig. 5).

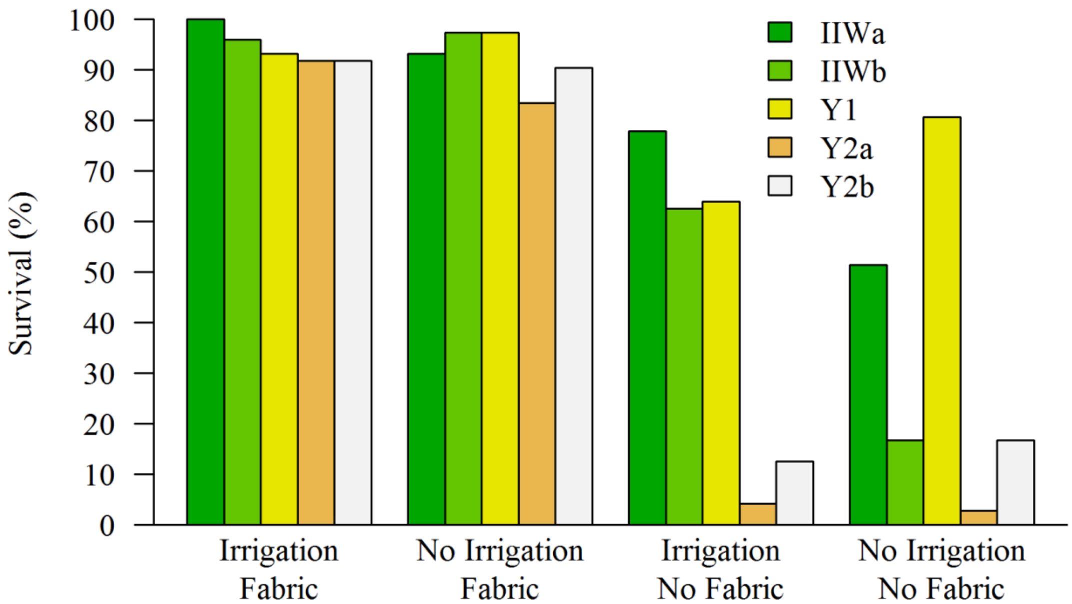
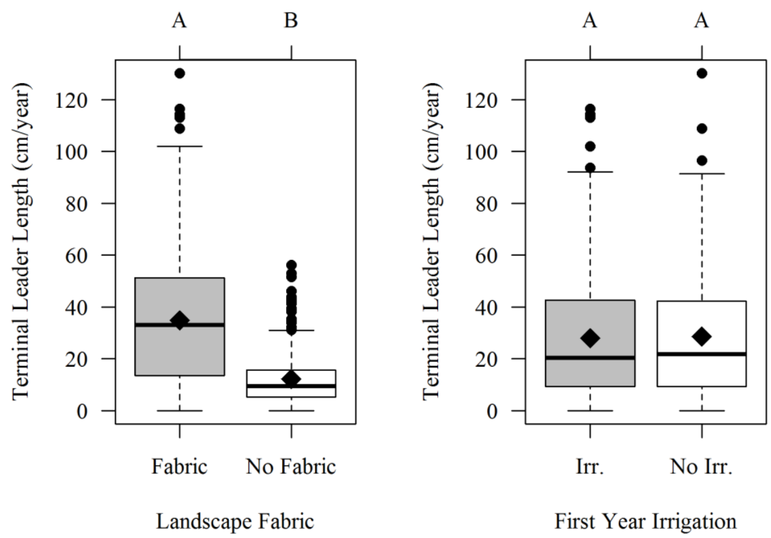


Figure 2. Aspen survival by site location in response to landscape fabric and irrigation, 2008-2010. Yoast 2a and 2b had the most competing vegetation biomass.

Table 3. Aspen mortality in response to a) year, b) landscape fabric, or c) irrigation. Treatment differences were determined at the 5% confidence level using Tukey-Kramer Means Separation test.

a	Treatment	% Mortality (Cumulative)	Significant Differences
	Year 2008	24.8	A
	Year 2009	32.9	B
	Year 2010	44.0	C
b	**Treatment**	**% Mortality (2008-2010)**	**Significant Differences**
	Fabric	6.7	A
	No Fabric	61.6	B
c	**Treatment**	**% Mortality (2008-2010)**	**Significant Differences**
	Irrigation	30.7	A
	No Irrigation	37.1	B



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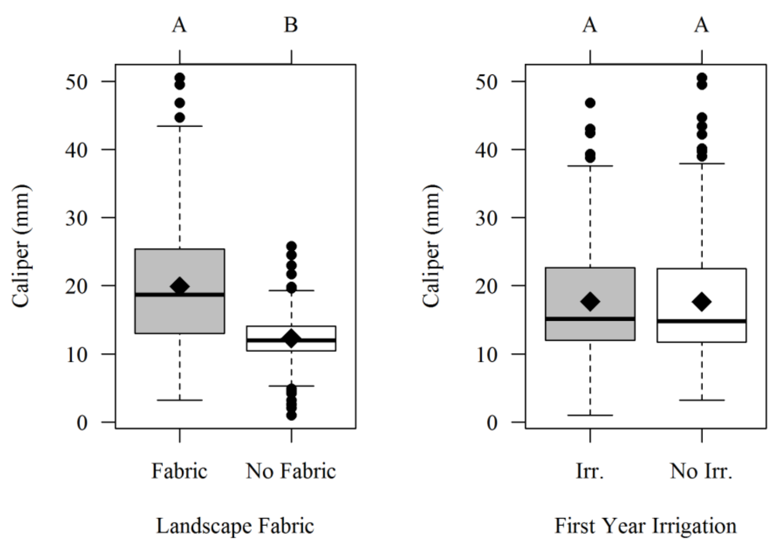

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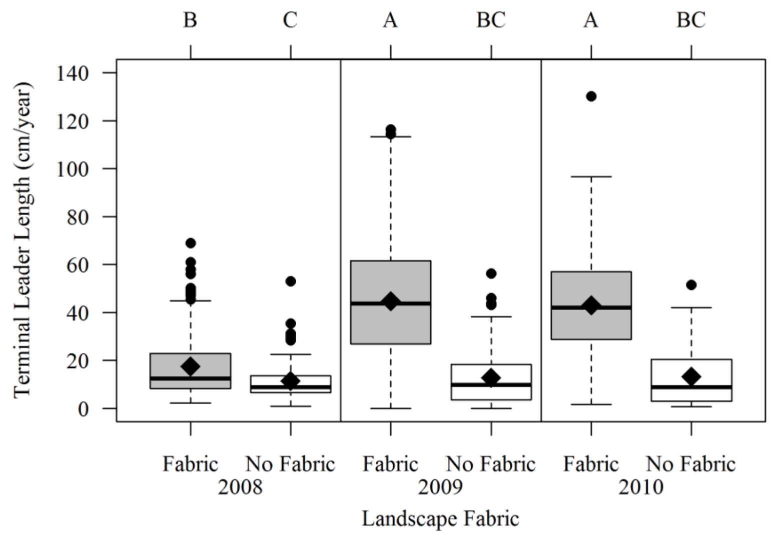
Figure 3. Aspen terminal leader (a) and stem caliper (b) growth response to landscape fabric and irrigation 2008-2010. The box plots use Tukey's recommendation to show upper and lower fences at the last points above and below 1.5*IQR (Inter Quartile Range) from the quartiles, with points beyond the fences identified as potential outliers and shown as closed circles. The horizontal line in the box is the median and the diamond is the mean. Landscape treatment was significant, but there was no significant interaction between landscape fabric and irrigation for terminal leader and stem caliper ($\alpha = 0.05$).



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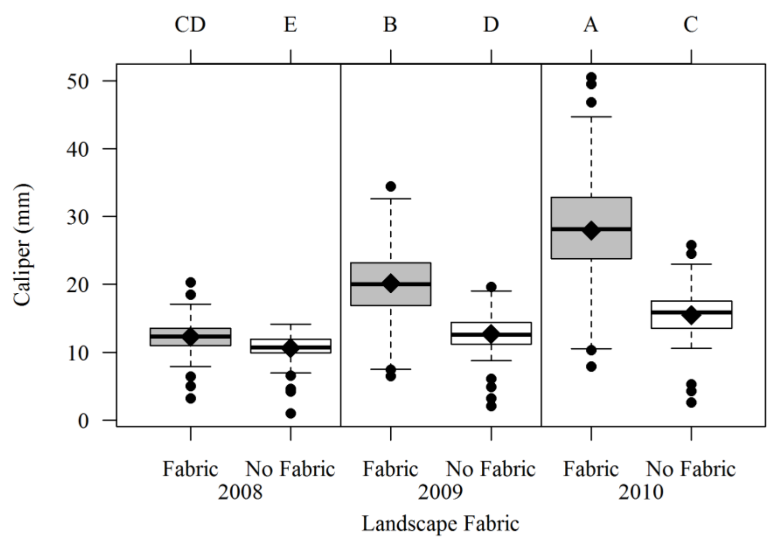

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Figure 4. Aspen leader (a) and caliper (b) growth response to landscape fabric treatment each year. There was a significant interaction between landscape fabric treatment and year for both terminal leader and caliper. Factor levels that share letters were not significantly different ($\alpha = 0.05$).

Figure 5. Competing vegetation appeared to grow more and show delayed senescence along the edges of the landscape fabric, suggesting utilization of the additional soil moisture available under the fabric, Yoast Y2a aspen site, October 2008. The non-green upper right corner of the photo shows the end of an adjacent row without fabric.

Serviceberry Response to Treatment

Serviceberry survival was not related to landscape fabric or irrigation (Tables 2 and 4). Mortality significantly increased after the first year of the study (Table 4), but the increase was small. Landscape fabric significantly increased terminal leader (Table 2 and Fig. 6a) and stem caliper growth (Fig. 6b), but the growth increase was much less evident for serviceberry than for aspen. Serviceberry terminal leader growth (Fig. 7a) and stem caliper (Fig. 7b) response to landscape fabric was most evident after three years of treatment, but there was no growth response to first year irrigation evident after three years (Table 2).

Table 4. Serviceberry mortality in response to a) year, b) landscape fabric, or c) irrigation. Treatment differences were determined at the 5% confidence level using Tukey-Kramer Means Separation test.

a	Treatment	% Mortality (Cumulative)	Significant Differences
	Year 2008	21.5	A
	Year 2009	25.0	B
	Year 2010	27.1	C

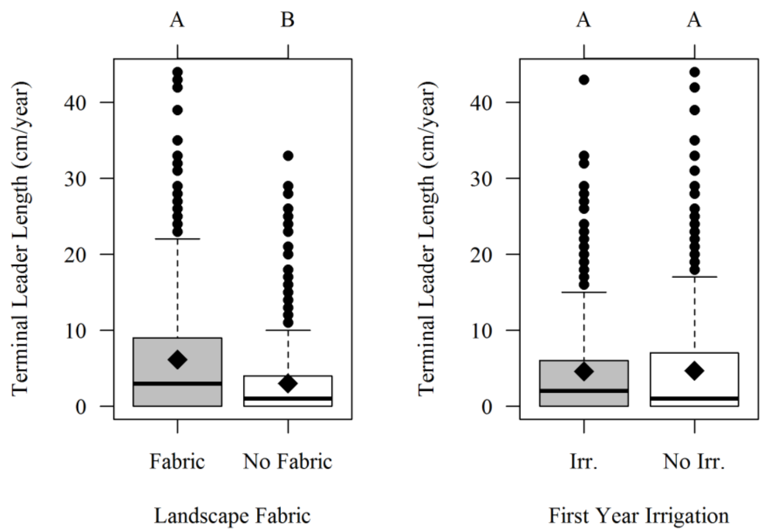
b	Treatment	% Mortality (2008-2010)	Significant Differences
	Fabric	21.8	A
	No Fabric	27.2	A

c	Treatment	% Mortality (2008-2010)	Significant Differences
	Irrigation	23.1	A
	No Irrigation	26.0	A

Growth and Survival and Competition

The apparent delay in senescence of aspen grown on landscape fabric and competing vegetation near the edge of the fabric (Fig. 5) may have resulted from increased soil moisture supply from under the fabric (Fig. 8 and 9). Soil moisture was 29% higher under the landscape fabric compared to no fabric. The increased moisture provided more favorable leaf water potential (Fig. 10) and subsequently increased stomatal conductance and photosynthesis of aspen (Fig. 11), likely contributing to increased growth.

It appears that aspen mortality occurring after 2008 may have been higher on the landscape fabric. Some plants that were dead aboveground at the end of the 2008 growing season, primarily those without fabric, re-sprouted from live roots in 2009. These factors combined to lessen the difference between survival with or without the landscape fabric after the first year of treatment.



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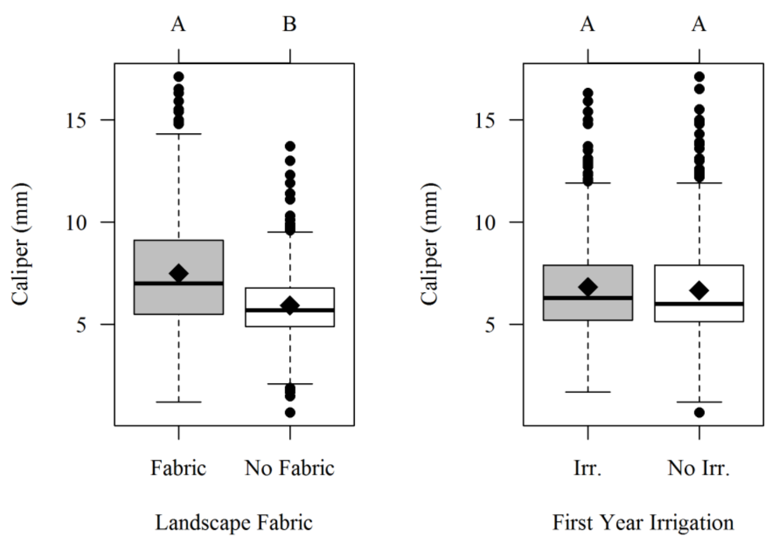
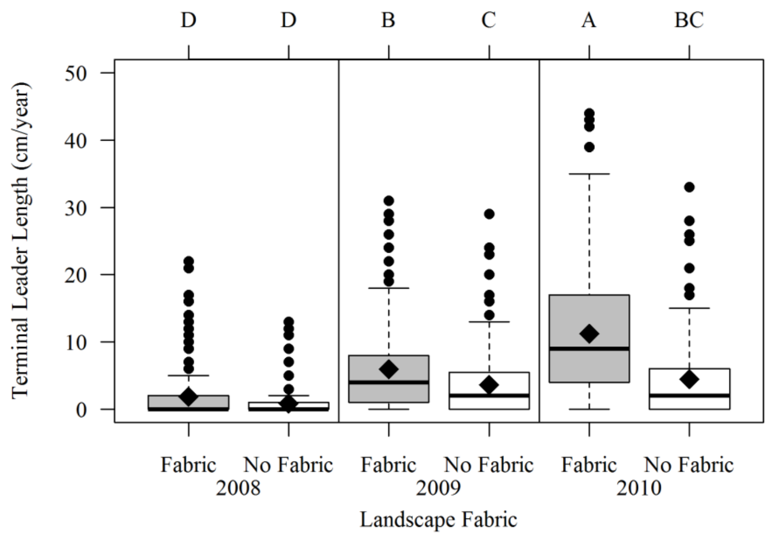


b

Figure 6. Relationship of terminal leader (a) and stem caliper (b) growth of serviceberry to landscape fabric and irrigation 2008-2010. For terminal leader or stem caliper growth the landscape fabric treatment was significant but there was no significant interaction between landscape fabric and irrigation (α = 0.05).



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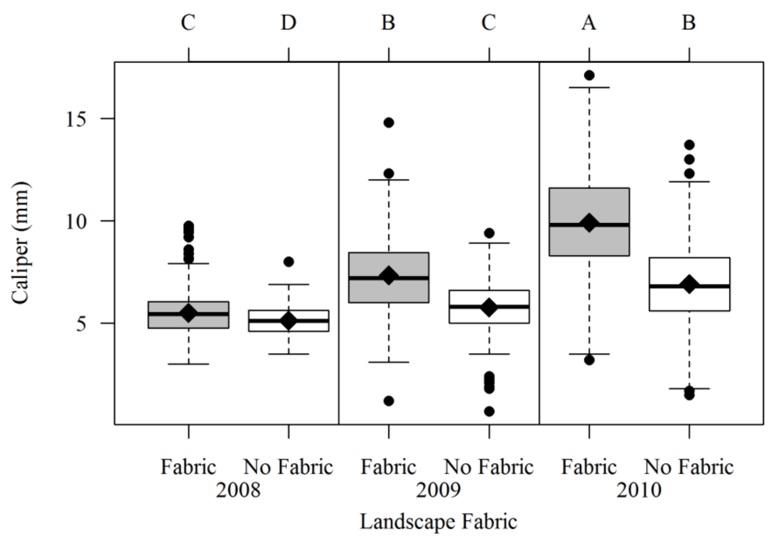

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Figure 7. Serviceberry terminal leader (a) and stem caliper (b) growth response to landscape fabric treatment each year. There was a significant interaction between landscape fabric treatment and year for both leader and caliper growth. Factor levels that share the same letters were not significantly different ($\alpha = 0.05$).

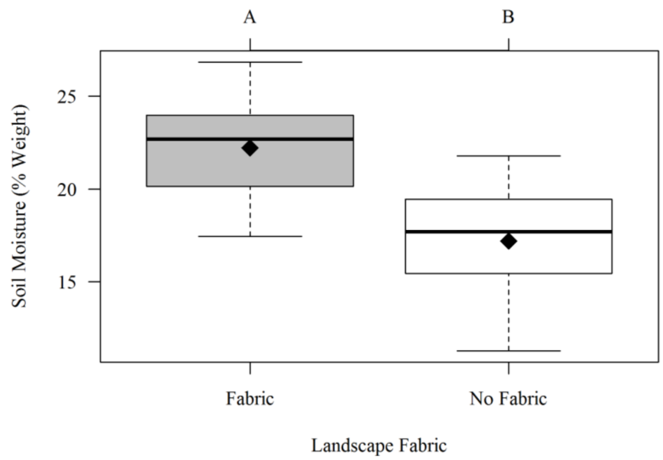


Figure 8. Soil moisture with or without landscape fabric, mid-July 2008. Soil moisture was significantly higher with landscape fabric (α = 0.05).

Figure 9. Landscape fabric and/or lack of competing vegetation increased soil moisture under the fabric.

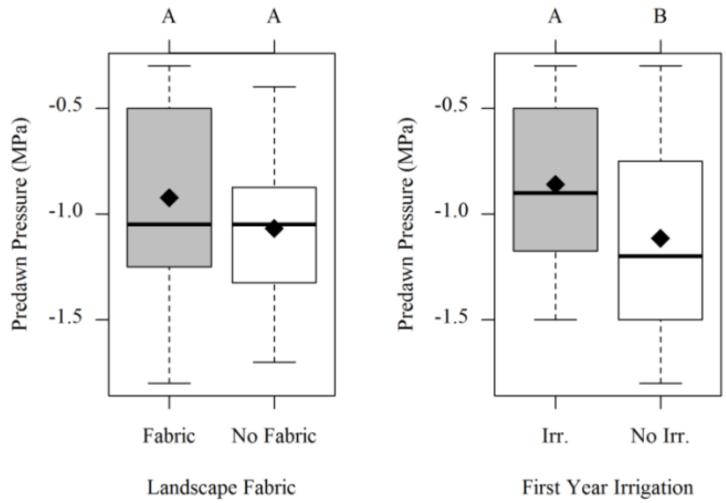
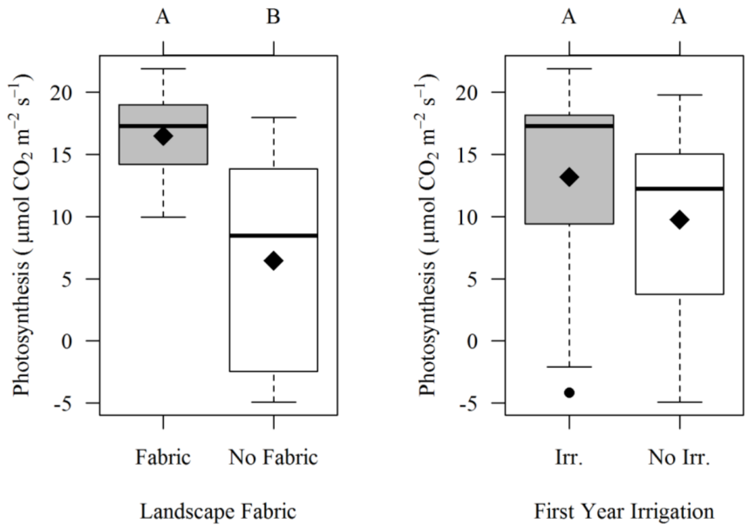


Figure 10. Pre-dawn leaf water potential of aspen in response to landscape fabric and irrigation, 2008. Irrigation had a significant ($\alpha = 0.05$) effect on pre-dawn pressure, but landscape fabric did not.



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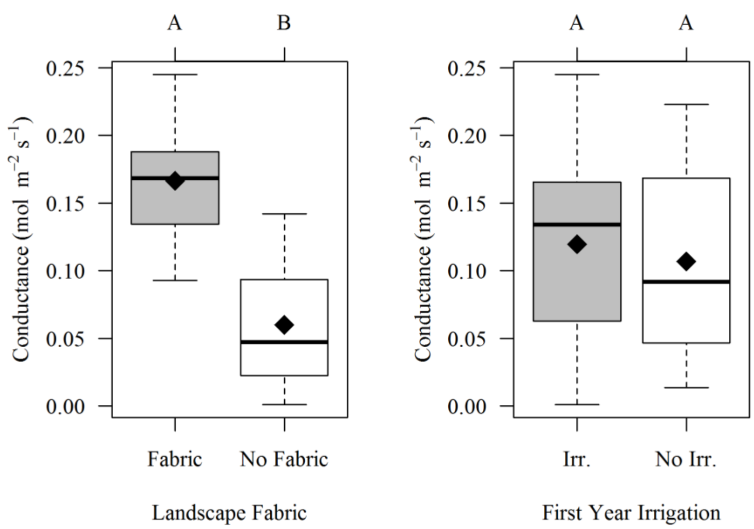

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Figure 11. Net photosynthetic rate (a) and stomatal conductance (b) of aspen in response to landscape fabric and irrigation, 2008. The landscape fabric had a significant ($\alpha = 0.05$) effect on both photosynthesis and conductance but irrigation did not. There was no significant interaction between landscape fabric and irrigation for either photosynthesis or stomatal conductance.

Discussion and Conclusions

This study specifically addressed how one can successfully establish aspen and serviceberry on reclaimed surface mines in high altitude semi-arid environments in Colorado, but the experiment should be applicable for reclamation throughout the range of these two species. Aspen and serviceberry had occupied many surface coalmine sites in the western US prior to mining operations. Aspen and serviceberry reproduce primarily by root suckering (Shepperd and Smith 1993) and parent roots are removed in the mining process, therefore sites must be reclaimed using container-grown plants or transplants (Musselman et al. 2012). Container-grown seedlings or transplanted root sprouts do not have an extensive root system to access water and nutrients needed for establishment and rapid growth and to compete against native or planted vegetation. We conducted this experiment to test the use of commercially available tree and shrub planting techniques to establish planted aspen and serviceberry on reclaimed coalmine soils, and to compare growth and survival of the plants under irrigation and landscape fabric treatments. We used commercial weed-barrier landscape fabric commonly placed on the ground by tractor-drawn machine. The method could be used as a cost-effective way to reproduce woody perennial vegetation on large areas of reclaimed lands.

It was apparent after the first growing season of this experiment, that survival of aspen was increased by use of the landscape fabric, but serviceberry was not. The presence of the fabric significantly increased growth of both species. The increased growth of aspen seemed to be related to increased soil moisture and the resultant decrease in leaf water stress and increase in 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 loss of moisture from the site because of less vegetative cover.

Additional problems not evaluated in this study also limited establishment of aspen and serviceberry at the mine sites. We observed (data not presented) that the lowest survival was on rows without fabric that had the greatest amount of competing vegetation. One site planted with aspen and serviceberry was initially abandoned after both species were defoliated by grasshoppers and few plants survived regardless of fabric or irrigation treatment. Rabbits within the fenced areas also damaged some of our plantings by girdling the aspen and heavily browsing the serviceberry. Care must be taken to control these additional threats to perennial establishment on reclaimed surface coalmine lands. We recognize that the use of landscape fabric could cause additional problems such as additional costs, habitat for small mammals, and increased rhizosphere temperatures.

The results of this experiment suggest that the use of landscape fabric for control of competing vegetation can be beneficial to the establishment of aspen and serviceberry on reclaimed surface coalmine lands. Growth measurement of the plants in the fall of 2010 after three growing seasons suggests that both aspen and serviceberry are responding well to landscape fabric treatment. We also observed that aspen trees growing with landscape fabric were senescing later than those plants growing without landscape fabric. There was a small response of aspen to irrigation but serviceberry did not respond to irrigation. Since irrigation occurred only during the first year of the study, supplemental irrigation for additional years could have increased response to that treatment. The establishment methods used successfully on reclaimed surface coalmine lands in Colorado could be useful under similar conditions elsewhere, and allow revegetation of surface mines where previous attempt have failed.

Summary

- The woody perennials aspen and serviceberry can be established on reclaimed surface coalmine lands.
- Growth of aspen and serviceberry was greater using landscape fabric for control of competing vegetation.
- Landscape fabric resulted in increased soil moisture available to the plants; and physiological measurement indicated that aspen grown with landscape fabric were less stressed.
- Supplemental irrigation was marginally helpful for establishment compared to landscape fabric.

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