DAVENPORT LIVING SNOW FENCE DEMONSTRATION: FIFTEEN-YEAR SURVIVAL AND GROWTH UPDATE

Introduction

This Washington State University publication discusses the Davenport Living Snow Fence, a dryland Rocky Mountain juniper (*Juniperus scopulorum*) demonstration project planted in 2003, and provides data on tree growth and survival rates during its first 15 years. The primary purpose of this planting was to demonstrate implementation. A secondary purpose was to examine tree growth, row variability, and survival. *This demonstration was not intended to measure snow catchment effectiveness, although this could be accomplished in subsequent years*. Empirical observations for snow catchment, impact of reducing snow drifting onto the state highway during periods of adverse winter weather, and wildlife uses of the Davenport Living Snow Fence are included.

Demonstration Objectives

Snow fences are common in areas subject to significant snowfall, such as the Great Plains and upper Midwest, but they are not common in eastern Washington, despite abundant snowfall and problems with drifting snow along roadways. A demonstration of living snow fence (LSF) windbreak effectiveness was needed to help landowners and the affected public, in particular motorists, visualize their utility for lessening snowdrift on roads in this region of Washington. The demonstration was done in partnership with the Washington Department of Transportation who is responsible for clearing snow from state highways. This demonstration was also done to help dispel beliefs by skeptical observers that trees will not grow in eastern Washington's arid to semi-arid ecotype climate, characterized by hot, dry summers that frequently exceed 100 degrees Fahrenheit, freezing cold winters with sub-zero temperatures, and annual precipitation patterns varying from 6 inches to 16 inches from west to east (USGS 2020). This publication will also prepare readers for seedling establishment and growth expectations. Additionally, wildlife habitat enhancement and use were documented to describe the additional potential benefits LSFs may provide in similar environmental conditions. Successful LSF demonstrations in southeastern Idaho and small-scale dryland test plantings of junipers near Ritzville, Washington, suggest LSFs could be useful for reducing snowdrift on roadways in eastern Washington, keeping roads safe and open during periods of adverse winter weather, and reducing highway maintenance expenditures.

Demonstration Design

A federal, state, county, university, utility, and landowner partnership was developed to explore the efficacy of a living snow fence windbreak in Washington by establishing a living snow fence along State Route 25, north of Davenport, Washington. Data on the ten-year survival and growth of Rocky Mountain junipers (*Juniperus scopulorum*) used to create this living snow fence were compared with the survival and growth rate through the first five years after planting, as reported by Kuhn et al. (2009).

The design applied for planting the Rocky Mountain juniper was modeled after a design commonly used throughout the Great Plains region of the United States due to its exceptional performance (R. Straight, personal communication, 2009). Evergreen trees and shrubs make excellent snow fences, reducing wind and trapping snow along roadsides and driveways where drifting snow may pose problems for drivers (Brandle and Nickerson 1996).

The project site was located approximately 14 miles north of Davenport, Washington, along State Route 25 (latitude 47.8369605, longitude -118.212447). It is a well-traveled, north–south road in which the prevailing wind is from the west and snow frequently accumulates on the road, according to Washington State Department of Transportation (WSDOT) personnel (Figure 1 and Figure 2).

The planting site can be described as having a dry cropland soil consisting of a deep silt loam (NRCS 2021). The Davenport area

Figure 1. Davenport Living Snow Fence demonstration site, 14 miles north of Davenport, WA, on State Route 25, showing the twin rows parallel to the highway. This section of highway was selected based, in part, on WSDOT snow removal personnel recommendations. (Source: Google Maps.)

Figure 2. Rocky Mountain juniper (*Juniperus scopulorum*) seedlings. (Photo by Andy Perleberg, WSU Extension.)

receives about 13.8 inches of total precipitation (30 inches of snow) annually with very little precipitation from July through September (Your Weather 2021).

Container-grown Rocky Mountain juniper seedlings of the Bridger Select province (USDA-NRCS Plant Materials Center, Bridger, Montana) were grown at the University of Idaho greenhouse for one year in the “super stock *Styro 20*” containers, under contract. Styro 20 refers to a Styrofoam block container (Figure 3) with equidistant cells that are 20 cubic inches in volume and with each cell containing a tree seedling (Landis et al. 2010; D. Regan, personal communication). The authors have extensive experience with this juniper species and stock type throughout the dryland regions of the state; thus, it was selected for the demonstration planting.

In the spring of 2003, 532 seedlings were planted in four 880-foot-long rows using a double, twin-row, high-density design per Helwig (1983)—a design that is commonly used throughout the arid region of southern Idaho and the Great Plains with good success. The trees were planted on the windward (west) side of the highway in paired rows with trees spaced 6½ feet apart within the row, and the rows spaced eight feet apart (Figure 4). The second twin row was 42 feet from the first. Trees in the easternmost row pair were 100 feet from the highway. (While some may question the closeness to the highway for effective snow catchment, the authors selected this distance so traveling motorists would easily see the planting, and some may stop to read the descriptive project sign.)

A black-woven, polypropylene fabric, Lumite, from Shaw Fabric Products, was used for weed control and soil moisture conservation. Using a ground cloth (fabric mulch) is a common and best practice with this windbreak design in the Great Plains region. Lumite ground cloth has proven to be highly effective in windbreak establishment in the Great Plains (Geyer 2001; Atchison 2004). A couple advantages of the fabric mulch (pictured in Figure 5, spring of 2003) included no required supplemental irrigation and very little necessary weed control, except at the edges of the fabric.

Figure 3. Super stock Styro 20 containers. Seedlings are grown at University of Idaho’s Pitkin Forest Nursery for the first year. (Photo by Don Regan, University of Idaho Pitkin Forest Nursery.)

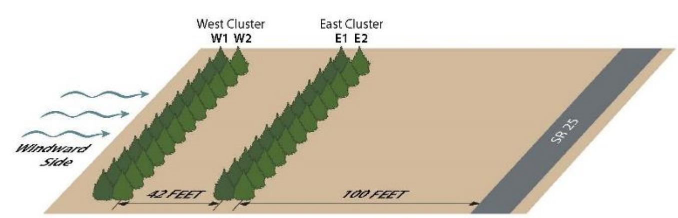

Figure 4. Davenport Living Snow Fence design (adapted from Kuhn et al., 2009). Trees were planted 6½ feet apart within the row, with twin rows 8 feet apart. Rows were 880-feet long, with 130 trees per row. Seedlings were approximately eight inches in height when planted (Figure 5).

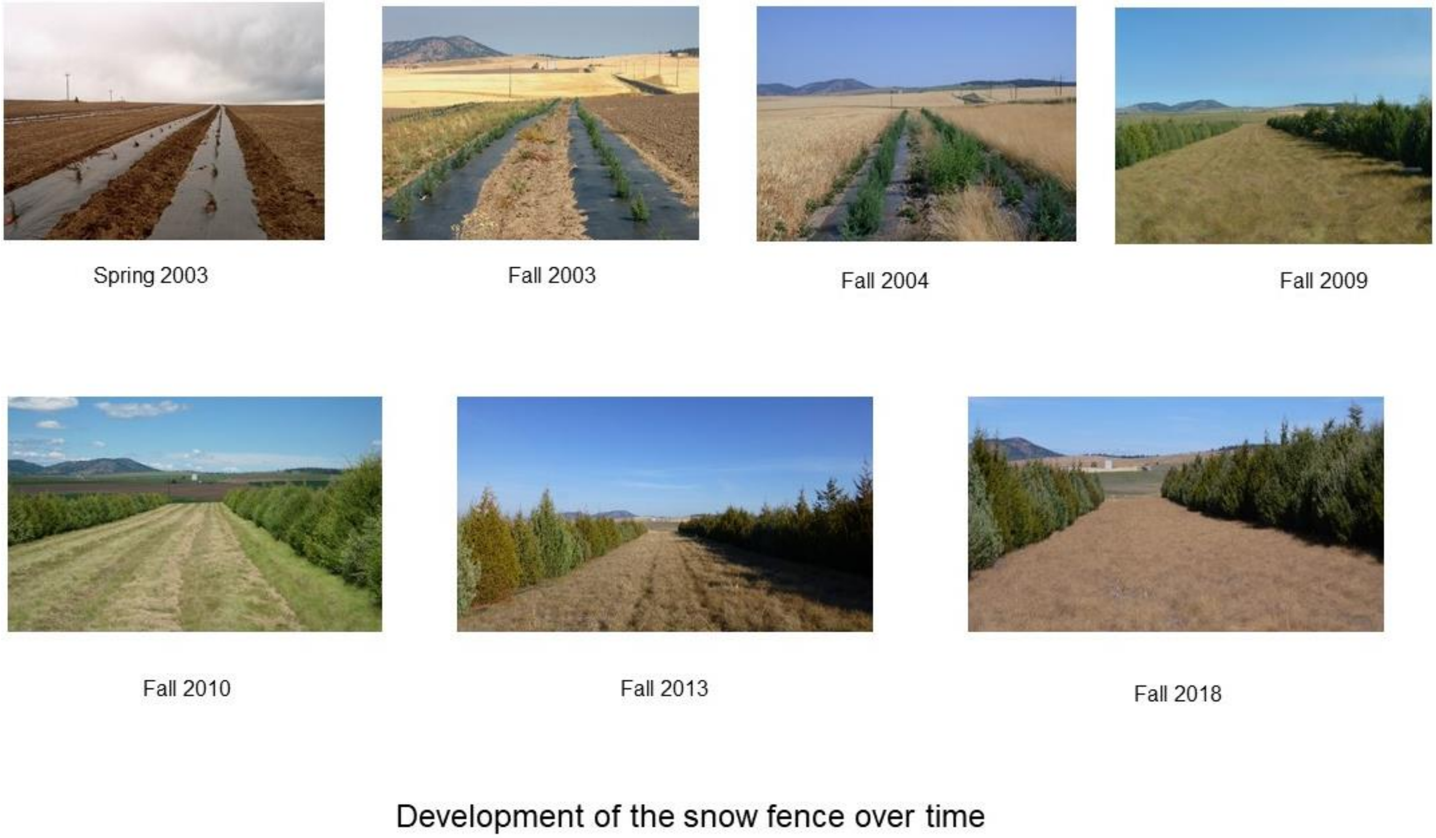

Figure 5. Time series of tree growth. (Photos from Don Hanley collection, WSU Extension.)

Periodic maintenance consisted of an annual inspection for rodent and other wildlife damage, and at year five, the fabric mulch was ripped to accommodate larger stems.

Annually, from 2003 to 2007, and then in 2013 and 2018, in a systematic sample, tree survival, height, and crown width were measured on every fifth tree in each row (Figure 6). A total of 27 trees were sampled in each of the four rows, or 108 trees overall.

Figure 6. Andy Perleberg measuring tree height and crown width after 15 growing seasons. Rows E1 and E2 are shown. (Photo by Don Hanley, WSU Extension.)

Demonstration Results

Tree Height

The trees in this demonstration not only survived at a 99% rate after 15 years but also grew significantly taller during this period (Table 1). The average tree height and crown width at the end of fifteen years was 12.1 feet and 6.8 feet, respectively. As mean tree size increased, so did the variability in individual tree size, as indicated by increasing standard errors over time (Hanley et al. 2015).

Measurements revealed that height differences between rows existed. The one-way analysis of variance (ANOVA) for tree height by row returned a statistically significant difference between rows (F=8.06, p=.00007). There was no significant difference in crown widths (F=.505, p=.68).

Further investigation (Table 2) using the Tukey Honest Significant Difference Test determined that tree height in the first row on the west side (W1) was significantly different from the first row on the east side (E1). There were significant differences between rows W1 and E1, W1 and W2, and E1 and E2. Trees in row W1 averaged 13.3 feet, and those in the first leeward row, E1, averaged 10.8 feet, a difference of 2.5 feet (Figure 7 and Figure 8).

Table 1. Mean tree height and crown width in the Davenport Living Snow Fence project after 15 years of growth. Standard errors (S.E.) are also displayed.

Year	Mean Tree Height	Mean Crown Width
	ft. (S.E.)	ft. (S.E.)
2018	12.1 (0.20)	6.8 (0.11)
2013	9.7 (0.2)	6.0 (0.1)
2007	6.6 (0.1)	4.1 (0.1)
2006	5.8 (0.1)	4.4 (0.1)
2005	4.5 (0.1)	2.7 (0.04)
2004	3.3 (0.1)	2.0 (0.035)
2003	1.9 (0.1)	1.0 (0.023)

Table 2. Sample mean and standard errors for tree height and crown width by row after 15 growing seasons.

Row	Mean Height ft. (S.E.)	Mean Crown Width ft. (S.E.)
W1	13.3 (.32)	7.0 (.17)
W2	11.7 (.47)	6.8 (.26)
E1	10.8 (.43)	6.9 (.18)
E2	12.6 (.32)	7.0 (.23)

It appears that the windy edge (the three undulating arrows of Figure 8) of both clusters (east cluster and west cluster) makes a difference (Figure 8). It also appears that the "wind shadow effect" makes a difference (differences in tree heights exist internal to the clusters). Undulating arrows show the prevailing wind direction, and yellow arcs below the rows indicate a statistically significant difference between mean tree heights. We interpreted these results to indicate that the windward most row (W1) receives and holds the most snow and moisture while all three trailing, leeward rows trap smaller amounts of snow (moisture). The fact that E2 has greater average height than E1 tells us that not all snow blows in from the direction of the prevailing wind. Nearby landowners attest that rarely, but not unusually, strong winds will come from the east. The two most inward rows (W2 and E1) are in the "wind shadow" and thus grow slower. *We speculate* that supplemental irrigation, if available, would improve these growth results, based on the fact that the trees on the windward side (row W1) trapped the most snow (measured for only one year), which provided extra soil moisture to the trees, resulting in statistically significant taller individuals.

Crown Width

There was no statistically significant difference regarding tree crown width between any rows or within any rows. However, crown closure is a good indicator for windbreak functionality, given that snow depths in the winters of 2007 and 2008 (Figure 9) averaged 35 inches behind the windbreak, while snow depths averaged less than 6 inches at the road.

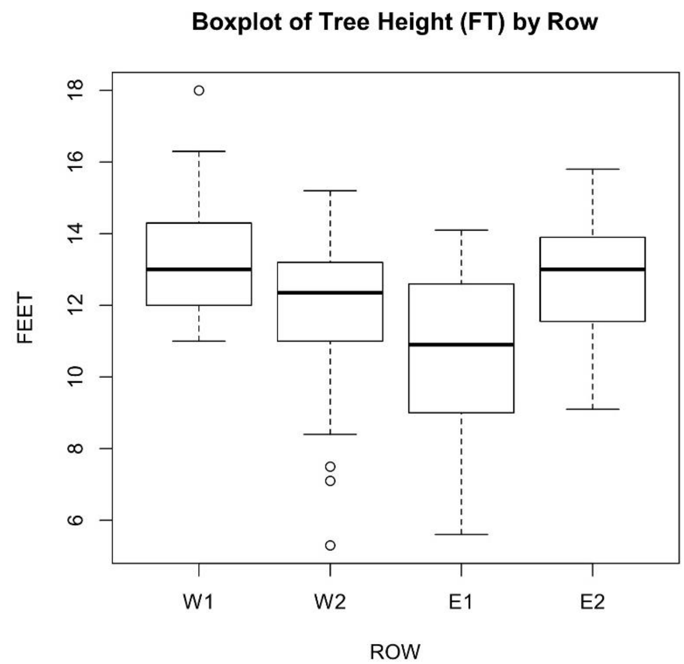

Figure 7. Box graph showing tree height (in feet) by row and mean, plus standard deviation and range values.

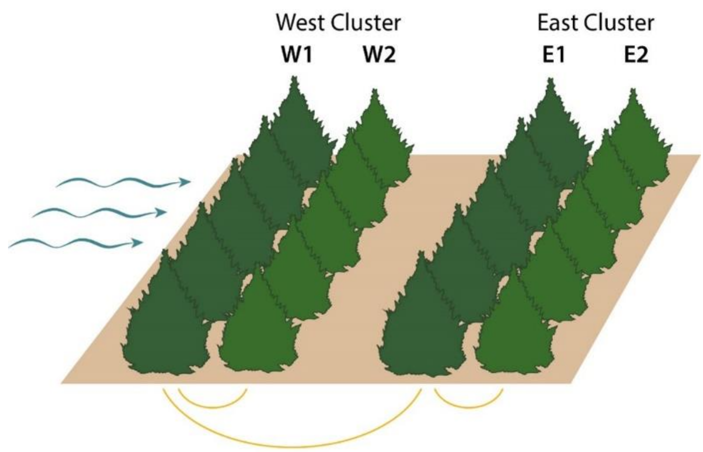

Figure 8. Graphical Interpretation of the statistically significant differences concerning tree height between rows.

Twelve extra trees were planted at the north end of the rows, but without Lumite fabric mulch. These extra trees were half the height and had less than half the crown width as those planted with fabric mulch. In addition, only 60% of them had survived at ten years (Kuhn et al. 2009). No statistical analysis was done to verify these differences.

The Davenport demonstration planting results support those from the Great Plains, showing that fabric mulch is excellent for survival, growth, and vigor of trees without supplementary irrigation. The fabric mulch has been on the ground for 17 years and is starting to show signs of deterioration. The crowns are large enough now to completely cover the fabric in most cases. It is not known how long the fabric will last in this area's dry climate, or if the trees will require its benefits as the roots grow deeper into the soil.

Figure 9. Five-year-old Davenport Living Snow Fence capturing 35 inches of snow in January 2008. (Photo by Andy Perleberg, WSU Extension.)

Living fences are agroforestry practices used worldwide to increase aesthetic, social, ecological, and economic benefits (Hanley and Kuhn 2003). The Davenport Living Snow Fence provided new habitat forage and cover, as tracks, pellets, and scat were observed along with direct sightings by the authors and the landowner (Figure 10). Ring-neck pheasant (*Phasianus colchicus*), chukar (*Alectoris chukar*), snowshoe hare (*Lepus americanus*), white-tailed deer (*Odocoileus virginianus*) were seen utilizing the living snow fence. Red-tailed hawks (*Buteo jamaicensis*) and rough-legged hawks (*Buteo lagopus*) were observed using the perch poles built and erected by Inland Power and Light (Figure 11).

Figure 10. Ring-necked pheasant (*Phasianus colchicus*) tracks (left photo) and scat (right photo) using the living snow fence for cover. (Photos by Andy Perleberg, WSU Extension.)

Conclusion

This 15-year-old Rocky Mountain juniper living snow fence demonstration, in dryland conditions, has shown that excellent tree height and crown width growth, coupled with very high survival rates, can be achieved in arid and semi-arid eastern Washington conditions. Using this design, complete crown closure can be expected between the fifth and tenth growing seasons (Figure 12 and Figure 13). The high survival rate (99%) can be attributed to good site preparation, high quality nursery stock of a hardy species, proper planting technique, and the use of a high quality Lumite groundcover requiring minimal periodic maintenance.

Figure 11. Roost pole to attract predatory raptors was contributed and erected by Inland Power and Light. (Photo by Andy Perleberg, WSU Extension.)

Living snow fences show great promise in providing windbreak services in eastern Washington (Figure 14). Living snow fences can also provide habitat for wildlife. Citing the successful growth and establishment of the living snow fence in Davenport, Washington, other organizations have invested in the development of living snow fences, specifically in Anatone, Washington, and Athena, Oregon.

Figure 12. Crown closure was achieved between the fifth and tenth growing seasons, and the trees had intertwined crowns at the 15-year measurement. (Photo by Don Hanley, WSU Extension.)

Figure 13. Rows W2 and E1, looking north, after ten growing seasons. (Photo by Andy Perleberg.)

Figure 14. Gary Kuhn and Dennis Robinson, NRCS state foresters (retired), survey the excellent growth of the trees after one growing season, in 2004. (Photo by Don Hanley, WSU Extension.)

No attempt was made to financially quantify the economic impact of this demonstration planting as it is not replicated elsewhere. However, the relatively small planting area compared to the implied benefits provides great interest among WSDOT road maintenance personnel and the general motoring public.

Acknowledgements

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