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Planting Aspen to Rehabilitate Riparian Areas: A Pilot Study

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Abstract—We planted 742 greenhouse-grown containerized aspen seedlings in the riparian area of Hurd Creek on the Arapaho National Forest east of Tabernash, Colorado. Objectives were to (1) determine whether aspen seedlings can be planted in an operational setting and survive in sufficient numbers to successfully establish a mature aspen stand and (2) determine the effectiveness of fencing on aspen seedling survival. Five-year survival rates were 18 percent in the fenced area and 23 percent in the unfenced area. Seedling heights were significantly taller in the fenced area than in the unfenced area.

Introduction

Aspen (*Populus tremuloides* Michx.) is a valuable part of many western landscapes, but is an especially desirable component of riparian areas where it contributes to the stability of streams, provides shade, nurtures a diverse and abundant understory community, and contributes a pleasing aesthetic component. Unfortunately, aspen has disappeared from some areas due to vegetative succession, overgrazing, and other factors (Bartos 2001). Regenerating these stands will require planting, because clonal root systems have died along with the aspen stems. However, attempts to plant aspen in upland sites such as campgrounds, mine reclamation, and highway projects has been largely unsuccessful, due to insufficient moisture to allow the transplanted seedlings to survive. Unlike natural aspen root suckers, planted seedlings do not have an extensive parental root system in place to supply moisture and nutrients. One study in interior Alaska (Zasada and others 1987) has reported success in planting aspen seedlings in a wildland environment, achieving survival rates of 40-80 percent after six years. The success of transplanting aspen for use as an ornamental in irrigated urban landscaping (Johnson and others 1985) and in irrigated nursery beds (Okafo and others 1978) indicates that aspen could be successfully transplanted in natural landscapes if sufficient moisture was available. Riparian areas may present one opportunity where moisture remains in the rooting zone long enough during the growing season to allow planted aspen seedlings to establish in the southern Rockies.

Naturally regenerated aspen sucker stands initially contain many thousands of stems per hectare. Stem densities of aspen forests do not remain stable or increase through time as in conifer forests, but follow a negative exponential decay curve as an aspen stand ages, decreasing through natural attrition to several hundred stems per hectare at maturity (Shepperd 1993). Because it is not feasible to plant thousands of aspen seedlings per hectare, protective fencing may be needed to slow the attrition process as much as possible.

The potential uncertainties associated with planting aspen in a natural setting prompted us to establish an operational test under a controlled experimental design to explore the feasibility of artificially re-establishing aspen in western landscapes. We felt that locating a test plantation in a riparian area where soil moisture is likely to remain favorable throughout the growing season and protecting the planted aspen from browsing animals would afford the best opportunity for success.

Objectives

The objective of this study was to determine whether aspen seedlings can be planted in an operational setting and survive in sufficient numbers to successfully establish a mature aspen stand. The primary hypothesis to be tested was that containerized greenhouse-grown aspen seedlings could survive for at least five years and grow into trees (>2 m tall in a single-stem growth axis) if properly planted in a carefully selected riparian environment and protected from browsing animals.

Methods

For this study, we selected a site in the riparian area along Hurd Creek, on the Arapaho National Forest, east of Tabernash, Colorado (figure 1). The site was once stocked with mistletoe and beetle-infested lodgepole pine that was removed in the 1980s. The area selected for planting

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aspen consists of an alluvial outwash plain between Hurd Creek and the toe of the adjoining slope. The planting site is nearly flat but contained some low, wet spots that could not be planted (figure 2). Soils are poorly developed gravelly sands containing many large cobblestones and are derived from upslope granitic and metamorphic rock. Associate understory plants consist of rushes, willows, alder, and chokecherry in low areas near the stream with grasses, sedges, sage, buffaloberry, and other low perennials in slightly higher (<1 m) locations. This 2,600 m site receives about 50 cm of precipitation per year and is located within 2 km of the temperature-limited lower timberline in the Fraser River Valley, in one of the coldest mountain climates in Colorado. Although no aspen are present on this site, natural aspen stands are nearby. Parts of the planting area contain standing water during spring runoff and soils remain moist much of the three-month growing season.

During the summer of 1996, a 2.5 m-high hog-wire fenced enclosure was constructed around half of the planting area. Immediately following snowmelt in June of 1997 the area was planted with 742 greenhouse-grown containerized aspen seedlings that were produced by the Colorado State Forest Service nursery in Ft. Collins, CO. Local Middle Park seed sources were germinated and grown using techniques similar to those discussed in Schier and others 1986. Three-hundred-seventy-three seedlings were planted in the unfenced area and 369 in the fenced area. Seedlings were grown in large Styrofoam block containers approximately 5 cm x 5 cm x 20 cm in size and were 20-50 cm tall when planted. Planting spots were not on an evenly spaced grid but were selected to avoid rocky, dry, or excessively wet micro sites and were hand-scalped to mineral soil. Planting holes were dug using a chainsaw-powered auger. Seedlings were removed from the Styrofoam block containers and immediately inserted into the prepared hole, backfilled with mineral soil and hand-packed. Each seedling was marked with a 9-guage wire stake containing a numbered metal tag. The location of each planted seedling was mapped with a transit so they could be relocated for survival checks (figure 2).

Results

An initial survival check was completed in August 1997. Additional survival checks were completed annually for five years. Height and condition of each aspen seedling were recorded each year. Table 1 summarizes damages and seedling conditions that were noted. Browsing was the most prominent damage noted in the unfenced treatment, followed by branch stripping and rodent damage. Rodent damage was the predominant factor affecting seedlings in the fenced treatment, followed by poor growth form. A number of dead seedlings also re-sprouted from roots in subsequent years, which affected survival data (table 1).

Seedling survival over time for each treatment was estimated using the Kaplan-Meier product-limit estimator and compared using the log rank test (Lee 1992). Ending survival in 2001 was compared between treatments using Fisher's exact test, and seedling height was compared between treatments for individual years using a t-test. SPSS (2002) procedure KM was used for the Kaplan-Meier analysis, CROSSTABS for the Fisher's exact test, and T-TEST for t-test computations.

Seedling survival decreased more quickly in the fenced area than the unfenced area (log-rank test $p = 0.006$) with 18.2 and 23.1 percent of seedlings remaining alive in 2001

Figure 1—Location of plantation.

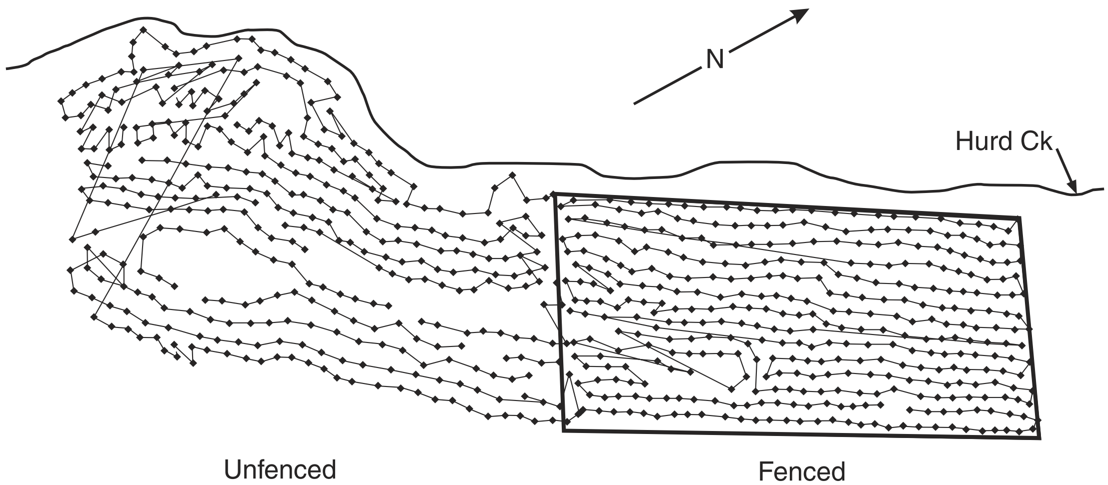

Figure 2—Map of plantation. Lines indicate numeric sequence of tagged trees to aid in relocation.

for fenced an unfenced treatments, respectively (table 1, figure 3). However, ending survival was not different between treatments (fisher's exact test p = 0.103). In contrast, seedlings were significantly taller in the fenced treatment compared to the unfenced treatment ($p < 0.05$) in 1999, 2000, and 2001 by 8.5 cm, 9.4 cm, and 11.6 cm respectively (figure 4). However, mean heights actually decreased between 1999 and 2001 in both fenced and unfenced treatments (figure 4), indicating that dieback of shoots was occurring. Although seedlings inside the enclosure were protected from deer and elk browsing, they were not protected from similar damage by rodents. Rodent damage to live seedlings was higher in the fenced treatment area than in the unfenced treatment area (table 1), which may indicate that rodents were protected from predators within the fenced enclosure.

Discussion

Although about a fifth of the original planted seedlings survived for five years, it is not likely that any of these trees will survive to maturity. Heights of surviving seedlings had increased only marginally since planting and were much shorter than those observed in natural sucker populations (Shepperd 1993). Seedling heights were significantly taller inside the fence, but none of the seedlings were tall enough to be above competing vegetation or browsing animals and thus could not be considered to be established. Ironically, the fence appeared to have adversely affected seedling survival, most likely by exposing seedlings to rodents which had been protected from predation by the fenced enclosure.

The re-sprouting of new shoots from the roots of seedlings that had previously been declared dead was notable (table 1). This phenomenon demonstrates that root systems of the containerized seedlings were still viable after death of the original shoots and indicates that sufficient moisture was available in the riparian soils to keep the roots alive in spite of below average precipitation for some of the study period (figure 5).

In conclusion, the limited success of this study illustrates the difficulties of planting aspen in wildland environments. Use of containerized seedlings, fencing, and planting in a moist riparian area did not result in success in this case. Further investigation of other possible methods of planting aspen is needed to investigate how soil type, physiographic conditions, associate vegetation, type of planting stock, and other factors might affect success.

Table 1—Frequency distribution of damage condition codes of aspen sprouts planted at Hurd Creek.

	Unfenced					Fenced				
Seedling conditions	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
OK	201	192	126	55	52	205	140	95	66	41
Browsing	1	16	7	26	8	0	0	0		
Branches stripped				9	3					
Poor form									1	2
Rodents			2	1	1	3	9	3	3	6
Cumulative mortality	171	165	238	272	287	161	220	271	294	302
Resprouted				10	22				5	18
Total planted	373	373	373	373	373	369	369	369	369	369
Surviving	202	208	135	101	86	208	149	98	75	67

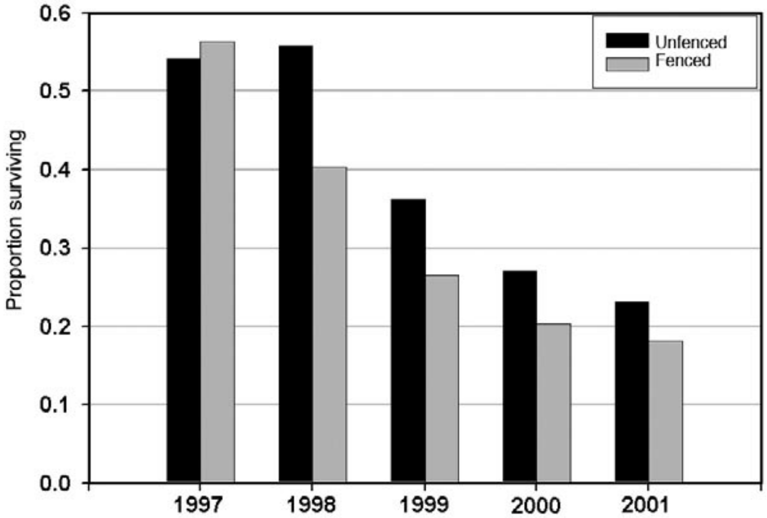

Figure 3—Proportion of planted aspen seedlings surviving in successive years by fencing treatment.

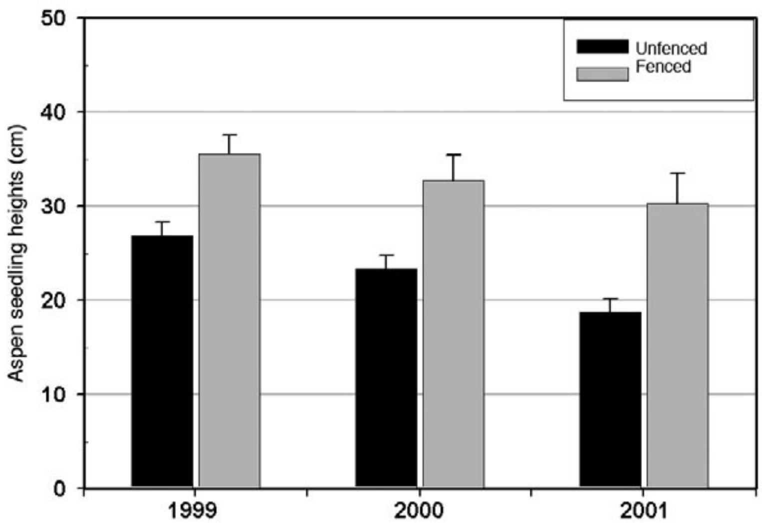

Figure 4—Average planted aspen seedling heights in successive years by fencing treatment (with 95% SE bars).

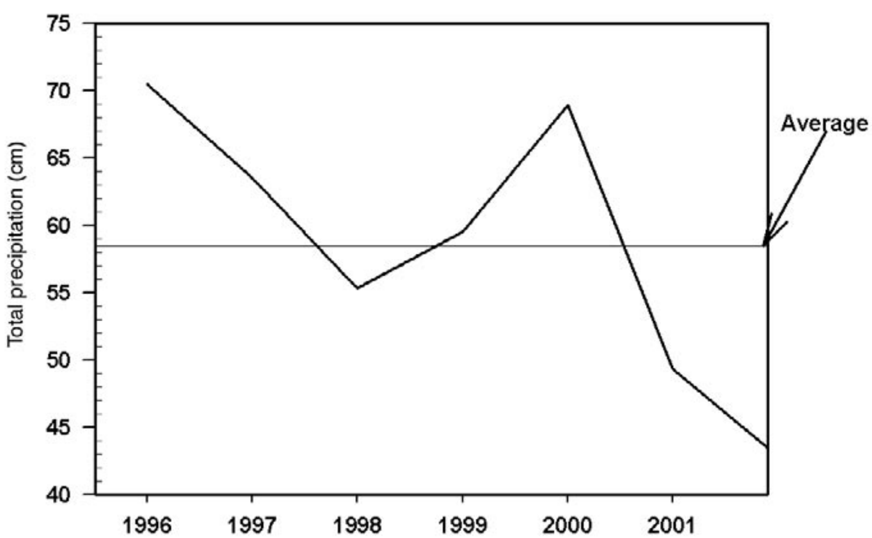

Figure 5—Annual precipitation for years 1996 to 2001 from Fraser Experimental Forest, headquarters weather station, 19 km southwest of the Hurd creek planting site, the closest weather station in similar terrain.

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