Shepperd, Wayne D. 1996. Response of Aspen Root Suckers to Regeneration Methods and Post-Harvest Protection. Res. Pap. RM-RP-324. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

Abstract

A five-year study of aspen root sucker production conducted on the Routt National Forest in central Colorado indicated that bulldozer pushing consistently produced more root suckers than chain-saw felling. Fencing to protect from browsing livestock also proved beneficial but was unnecessary to achieve adequate regeneration. Leaving all downed stems on site as a substitute to fencing was not beneficial.

Keywords: Vegetative regeneration, mechanical harvest, coppice silviculture, root connections, *Populus tremuloides*, suckering

USDA Forest Service
Research Paper
RM-RP-324

June 1996

Response of Aspen Root Suckers to Regeneration Methods and Post-Harvest Protection

Wayne D. Shepperd, Silviculturist

Rocky Mountain Forest and Range Experiment Station[1]

[1]Headquarters is in Fort Collins, in cooperation with Colorado State University.

Response of Aspen Root Suckers to Regeneration Methods and Post-Harvest Protection

Wayne D. Shepperd

INTRODUCTION

Aspen (*Populus tremuloides* Michx.) is the only major hardwood tree species growing in the subalpine and montane forests of the central Rocky Mountains. Aspen is highly valued for its visual resource, wildlife habitat, and forage production capabilities. The successful regeneration of these aspen forests is critically important to maintaining healthy Rocky Mountain ecosystems. Because nearly three million acres of aspen exist in Colorado alone, managers must explore new ways to regenerate aspen stands that have not been subject to fire and other disturbances required to vegetatively regenerate these forests.

Although aspen can persist in Western landscapes for multiple generations as stable stands (Mueggler 1985), it is generally considered a seral, or early invader, species following a fire or other major disturbance (Shepperd and Engelby 1983). When overstory stems abruptly die, thousands of root suckers sprout from the lateral root system of the original stand resulting in dense populations of genetically identical stems (clones) that grow rapidly to establish a new stand. Young aspen clones quickly thin themselves as they mature (Shepperd 1993b; Schier et. al 1985a). Without periodic disturbance to kill the old stems and trigger regeneration of a new clone, seral aspen will eventually disappear from the landscape. Aspen will generally be replaced by shade tolerant conifers that establish under the aspen and eventually overtake and crowd it out. The dense conifer shade prevents aspen suckers from establishing. An aspen clone will gradually decline and die without suckering (Mueggler 1985).

Due to fire suppression within this century, many aspen stands are now mature or over mature (DeByle et. al 1987; Shepperd 1981). There are few younger stands in some ecosystems. Older stands need to be regenerated to provide a diversity of age classes within many landscapes.

Any technique used to regenerate aspen must stimulate the root system to send up new suckers and provide a suitable environment for them to establish and grow. Aspen suckers require full sunlight and are susceptible to numerous pathologic, biotic, and environmental factors during their first few years (Shepperd 1993b; Schier et. al 1985b; Crouch 1986). Browsing animals including livestock, deer, and elk eat succulent young suckers (Crouch 1986; Smith et. al 1972). Protecting suckers from browsing until the tender branch tips grow out of animals' reach may aid establishment of new stands. Suckers may also be damaged by deep snow (Crouch 1986). Stabilizing the snowpack might also aid aspen regeneration efforts.

The usual method of regenerating aspen in lieu of fire is to remove the mature stems by clear felling the stand under a commercial timber sale or firewood contract. Hand felling with chainsaws and cutting with mechanical tractor-mounted shears have been successfully used in commercial timber sales. However, in many situations the aspen wood is not marketable and other techniques must be used. Burning and herbicides have been tested and are applicable under some situations (Schier andCampbell 1978; Schier et. al 1985b; Shepperd and Engelby 1983).

Post-treatment protective measures including fencing and leaving tree stems (slash) on the cutover areas to discourage browsing have also been tried. Fences are expensive to construct and the consequences of leaving the slash on the resultant regeneration are not well known. Leaving the stems on the ground may deter browsing animals from damaging the new suckers; however, the shading effect of the material may inhibit the sprouting and survival of the new stand (Shepperd 1986).

Another alternative to hand felling and clearing noncommercial aspen stands is to use a bulldozer to remove the original stand. Bulldozing differs from mechanical shearing and hand felling because removal of the whole tree without leaving a stump results in some disturbance to the clonal root system. The effect of the bulldozing treatment on subsequent aspen regeneration has not been documented. Bulldozing has been tried in the Lake States to remove undesirable hardwoods and promote aspen suckering in mixed stands (Botwinski and Loomans 1968). One or two attempts to use the technique in the West have been rumored, but the results were not reported in the literature. However, if bulldozing could be proven successful, it might offer some definite advantages over the high labor costs of chain saw felling noncommercial aspen stands.

The critical issue is whether or not the disturbance to the lateral root system caused by a bulldozer could be tolerated and how it would affect the number of subsequent root suckers. To be successful, any technique used to regenerate aspen should result in several thousand established suckers per hectare (Shepperd 1993b; Crouch 1986). Many factors can affect aspen regeneration success. Clonal characteristics, climate and soil conditions, microsite variability, treatment season, and time and duration of animal use can all potentially influence the numbers of root suckers that establish following a regeneration treatment. When evaluating a regeneration method, these factors should be taken into account, and the effect of post-treatment protective measures on the outcome of the treatments should be investigated.

The study described here was designed to meet these requirements in the following manner:

1. Compare aspen regeneration after bulldozing and chain-saw felling under controlled conditions.
2. Test the effect of fencing to exclude livestock on the resulting regeneration.
3. Evaluate the affect on the resulting regeneration when all cut stems are either removed or left.

METHODS

A study site was selected in 1981 in an active timber sale area on the Yampa Ranger District of the Routt National Forest in north central Colorado. The area contained several thousand hectares of aspen typical of many of the stands in western Colorado (Shepperd 1981). Choosing a study area in an active timber sale provided a feasible means of applying treatments requiring heavy equipment at minimal cost. The logging contractor agreed to bulldoze the treatment areas in return for any salvageable wood cleared from the research sites. Three 0.65 ha treatment blocks were selected adjoining the timber sale accordingto the following criteria:

- Each block was within a single clone as indicated by external stand characteristics (Shepperd 1986).
- Each block was located on a uniform slope with uniform soil characteristics and understory vegetation type.
- The stand within each block was pure aspen, mature, and uniformly spaced with no external signs of disease.
- The block was surrounded by uncut forest.

Each block was divided into eight 46.7m x 18.3m (0.08ha) units (fig. 1). Four units in each block were bulldozed, the other four cut by chain saw in August 1981. The dozer operator was instructed not to allow the dozer blade to cut into the soil but

Block Layout

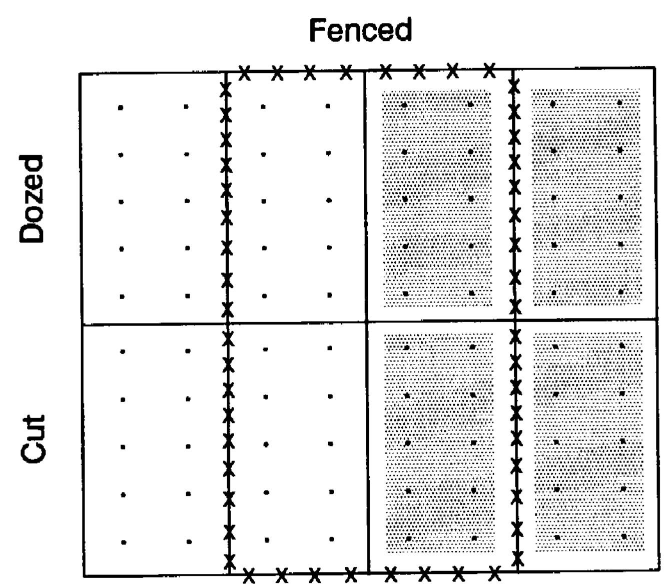

Figure 1. Diagram of the layout of a block. Each of the three blocks contained eight treatment areas. Each treatment area contained ten 4.047 m² permanent plots.

instead to tip trees over by pushing them above ground. This technique severed all roots attached to each aspen stem and pulled large roots from the soil a distance of 1 to 1.5m around each tree. The remaining lateral root system of the clone was not exposed.

Following the regeneration treatment, all downed woody material (slash) was removed from two dozed and two cut units in each of the three blocks. Stems and larger slash were removed using a rubber-tired skidder. Smaller stems and branches were bucked and removed by hand. All woody material was left in place on the remaining four units in each block. A completed block immediately after treatment is shown in figure 2.

Finally, a three wire barbed-wire fence was constructed around half of the eight treatment units in each block. The fence excluded livestock only and was not a barrier to elk and deer.

Treatment assignment within the split block design was determined by coin tosses that allocated dozing to the top or bottom of a block as shown in figure 1 and slash removal to the left or right. Further randomization was impossible because of the difficulty of containing heavy equipment within smaller treatment areas. Fencing treatments were clustered in all blocks as shown in figure 1 to avoid creating "cow traps" that would concentrate animals outside the exclosures.

To sample the suckering response following treatment, ten 4.047 m^2 circular plots were permanently staked in a systematic grid in each treatment unit (80 plots/block). This size and number of plots was chosen to facilitate easy counting of numerous root suckers and to accommodate microsite variability. All live aspen suckers occurring in each of the 240 plots in this study were counted at the end of the growing season each year for five years following treatment. Data reported here are sucker counts and average heights of the tallest stem in each plot from the fifth and final measurement season. Five-year data was selected for comparison to allow for the natural reduction in stocking that occurs the first few years following regeneration (Shepperd 1993b; Schier et. al 1985a). Also, it is a regulatory requirement developed from the National Forest Management Act of 1976 that the U. S. Forest Service must certify all reforested areas as either successfully regenerated or not regenerated within five years of treatment.

Figure 2. View across a block immediately following treatment. Cut areas are on the right, bulldozed on the left. Note slash in background.

RESULTS

At the end of the fifth growing season following treatment, several differences were readily observable. First, there was considerable variation in sucker stocking from plot to plot. This was most likely due to the aggregate distribution of young aspen suckers at root nodes (enlarged near-surface sections of lateral roots) (Shepperd 1993b). A histogram of average stocking by treatment (fig. 3) indicates that root suckers were more numerous on the treatment units that had been dozed than on those that had been cut, and more numerous

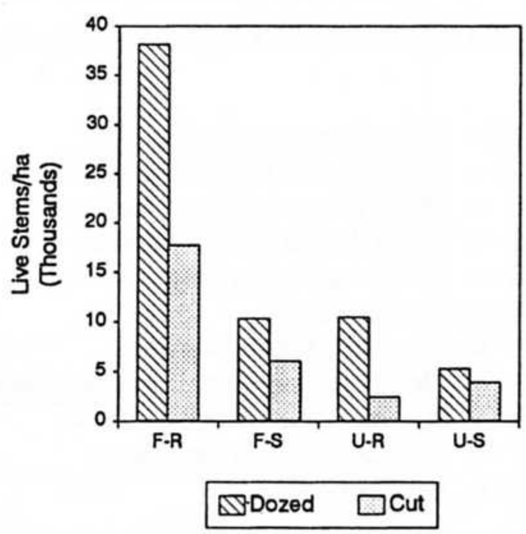

Figure 3. Histogram of average aspen sucker stocking after the completion of five growing seasons after treatment. F = fenced, U = unfenced, R = slash removed, and S = slash left.

within fenced treatments than in unfenced ones. The effect of the slash treatment on the aspen regeneration is unclear.

Considerable differences in root suckering response are observable in figures 4, 5, and 6 and in table 1. In each of the blocks, unfenced units and those with slash contained proportionally fewer suckers. The dozed-fenced-slash removed units in all three blocks and cut-fenced-slash removed unit in block 3 contained over 22,000 suckers/ha (fig. 4). In block 1, all other treatments contained fewer than 7,400 suckers/ha and three units (cut-unfenced-slash removed; cut-fenced-slash; and cut-unfenced-slash) contained none at all (fig. 5). In most cases, dozing produced more root suckers than cutting, especially in combination with fencing and slash removal. Heights of the tallest stems in each plot ranged from 0.21 to 3.35 m with the tallest stems in the dozed-fenced treatment.

ANALYSIS

The MANOVA procedure on the SPSS PC statistical package (Norusis 1990) was chosen for the analysis of variance of data from this study. This package was chosen because it allowed construction of a custom model for alternate pooling of error terms in the split block design of this study. The following model was used:

$$y_{ijklm} = N + D_j + F_k + S_l + B_m + (D \times B)_{jm} + (F \times B)_{km} + (S \times B)_{lm} + (D \times F)_{jk} + (D \times S)_{jl} + (F \times S)_{kl} + (D \times F \times S)_{jkl} + E_{ijklm}$$

where

N = Effect due to averaging
D = Effect due to regeneration treatment
F = Effect due to fencing treatment
S = Effect due to slash treatment
B = Effect due to blocking
E = Residual error
i = Number of plots per unit
j = Number of regeneration treatments
k = Number of fencing treatments
l = Number of slash treatments
m = Number of blocks

This model allowed an independent analysis of the effects of the regeneration treatment (D), fencing (F), and slash removal (S) across blocks

Figure 4. A bulldozed-fenced-slash-removed treatment, five growing seasons following regeneration.

Figure 5. A cut-unfenced-slash-removed treatment with no suckers, five growing seasons following regeneration.

Figure 6. A bulldozed, unfenced, slash-left treatment with sparse stocking, five growing seasons following regeneration.

Table 1. Aspen sucker counts by treatment and block. Data is from 240 circular 4.047 m^2 plots (10 plots/treatment/block) sampled five growing seasons after treatment.

Treatment combination	Block 1	Block 2	Block 3	Total count	Avg/ hectare
Dozed, fenced, no slash	90	201	169	460	37,888
Dozed, fenced, slash	31	50	42	123	10,131
Dozed, unfenced, no slash	6	16	103	125	10,297
Dozed, unfenced, slash	18	25	19	62	5,108
Cut, fenced, no slash	20	70	123	213	17,544
Cut, fenced, slash	0	3	68	71	7,038
Cut, unfenced, no slash	1	3	23	27	2,224
Cut, unfenced, slash	0	45	0	45	3,707
Total count	166	413	547	1,126	11,594

while also testing for two- and three-way interactions between the treatment factors. This AOV design also accommodated the nonrandom treatment assignment used in this study.

Root Sucker Counts

The distribution of root sucker count data from the 240 milacre plots was highly skewed because there were many plots with few or no suckers. The estimated slope of a Box-Cox Plot of the log means versus log standard deviations of the 24 treatment units indicated that a square root data transformation should be performed.

The MANOVA procedure was run twice using the above model; once with raw data and again with the data transformed. Comparison of residuals from both runs showed a reduction in the scatter in residual plots, improvement in the shape of predicted versus residuals plots, and a striking improvement in the linearity of the normalized residual plots. All indicated that the square root transformation was appropriate with the sucker count data. Results of the final AOV for the square root transformed data are in figure 7.

The number of suckers in dozed versus cut regeneration treatments were different (fig. 7) as were the number of suckers in fenced versus unfenced areas (both had an F significantly different at $p = .021$). However, the effects due to slash treatment alone were not significant at $p = .05$.

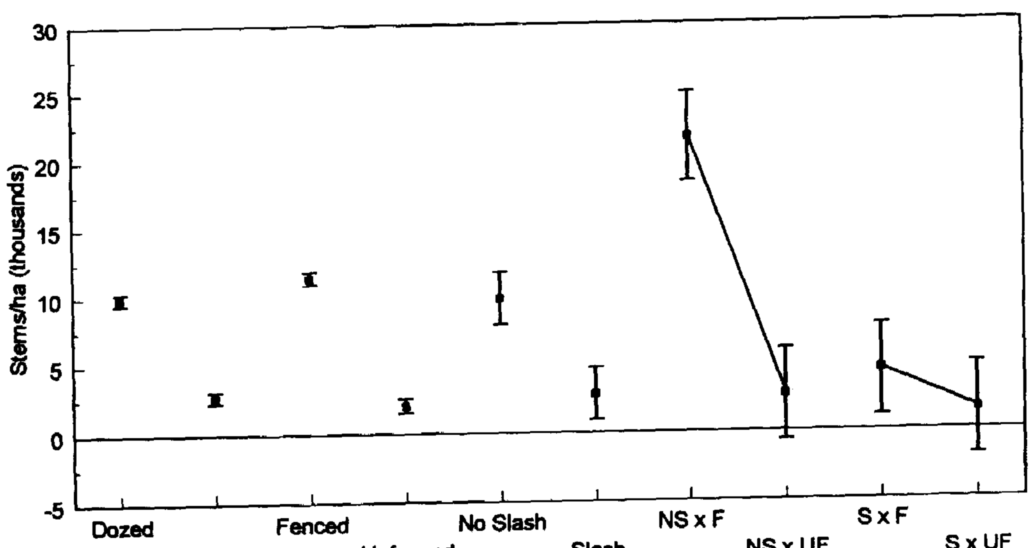

Figure 7. Comparison of average sucker stocking in dozed versus cut treatments, fenced versus unfenced treatments, and interaction of average sucker stocking by combinations of fencing and slash treatments, with standard error bars.

While slash appeared to have a drastic affect on suckering in some areas (fig. 6), overall, slash treatment had only a marginal affect on the numbers of suckers existing on the sites five years after treatment.

The analysis of interactions revealed one significant interaction, which occurred between fencing and slash treatments (F significant at p = .10) (fig. 7). This indicates that the effects of fencing and slash treatment were nonadditive or counteracted each other under some combinations (e.g., sucker counts were only significantly increased by fencing if slash was removed).

Finally, differences in the numbers of suckers between blocks was also highly significant (p = .0001), confirming initial observations. Block 1 contained an average of 1,733 stems/ha, block 2 had 6,505 stems/ha, and block 3 averaged 10,800 stems/ha (SE ± 259 stems/ha).

Stem Heights

The stem heights of the tallest aspen suckers in each plot were analyzed using the same model design as above, but without transformation. Heights of the five-year-old suckers were significantly taller in the dozed areas than in the cut areas (1.29 m versus 0.63 m, SE = ±0.29 m, p = .0001). The analysis of sucker heights produced no significant interactions between any combination of treatments. However, sucker height differences between blocks were highly significant (p = .0001). In a pattern similar to that of sucker density, the tallest suckers in block 1 averaged 0.53 m in height, those in block 2 averaged 0.85 m, and those in block 3 averaged 1.51 m (SE ± 0.21 m).

DISCUSSION

These data show that bulldozing will generally produce more root suckering in Rocky Mountain aspen than chain saw felling. Although both techniques produced adequate numbers of suckers when combined with fencing, bulldozing appeared to provide an extra stimulus in block 1 where other treatment combinations failed or resulted in marginal stocking.

Bulldozer pushing appears to be a viable regeneration technique for Rocky Mountain aspen and may sometimes be the method of choice. It is important to note that technique application is critical. As in this study, the lateral root system of the parent clone should be left as undisturbed as possible by always keeping the dozer blade clear of the ground. Gouging the blade into the soil surface with the machine or disturbing or compacting the lateral roots may result in regeneration failure (Shepperd 1993a).

Because bulldozing damages tree boles and leaves root collars and severed roots attached to the boles, it is undesirable to use this technique in commercial timber sales. The method does, however, offer managers a cost-effective means of regenerating poor quality or inaccessible aspen stands. In this study the dozer was able to down stems about five times as fast as a six person saw crew.

Although no physiologic tests were conducted on any tissue in this study, the stimulating effect of bulldozing on aspen suckering and growth was probably due to the abrupt interruption of growth suppressing auxin to the roots (Schier et. al 1985a) when entire stems (including stumps) were removed. Apparently, suppression of suckering is not totally eliminated by cutting a stem and leaving a stump. This may be because auxin is produced by activated dormant buds in the stump, or occasionally, by subsequent stump sprouts. It is also possible that root movement that occurs when aspen stems are torn from their root systems during bulldozing causes a stress or injury that stimulates suckers (author's communication with G. Schier, U.S. Forest Service, Forestry Sciences Lab, Delaware, OH, 1994).

The effect of the dozing treatment suggests other methods that might be used to regenerate aspen. Provided that sufficient light is available, severing roots around the perimeter of isolated clones or within open, sparsely-stocked clones may trigger suckering without having to remove parent trees. Therefore, it may be possible to rejuvenate or expand some clones without sacrificing the critical attributes provided by the existing aspen overstory. Initial results of studies underway in Arizona indicate that this may be the case (data on file with the author, Rocky Mountain Forest and Range Experimentation, Fort Collins, CO).

This study has also demonstrated that fencing treated areas following regeneration can improve aspen root sucker establishment. While not always necessary to achieve a fully stocked sucker stand, fencing clearly benefited both dozing and cut regeneration treatments. Although expensive and time consuming to construct and maintain, fencing hard-to-regenerate sites or areas of heavy animal use should be considered.

Leaving slash on sites to discourage animal use and provide protection from snow does not appear to be beneficial. The interaction between fencing and slash treatments in this study indicates that root suckering is inhibited by the shading effect of large amounts of slash left after a regeneration treatment. These results suggest avoiding concentrations of logging slash but complete slash cleanup following aspen harvest is not a mandate. The effect of slash treatment was marginal in this study even though slash concentrations were intentionally heavier than what would normally be left on site following logging or firewood cutting.

The block differences apparent in this study were expected, because each of the three blocks was located in a separate clone. Clonal variation in sucker production has often been demonstrated (Schier et al. 1985a). A number of factors might be responsible. For example, differences in the ability of the three clones to sucker or unforeseen root diseases could have resulted in the lower stocking in block 1. However, differences in local animal-use patterns or preference of one clone over another might be eliminated here because sucker numbers were lower both inside and outside the fenced areas in block 1. At any rate, the difference does point out the variability in the number of suckers that establish following regeneration of aspen stands in the Rocky Mountains. The fact that treatment differences were apparent, in spite of the block effect, enforces the applicability of these results over a wide range of circumstances.

MANAGEMENT IMPLICATIONS

This five-year study of aspen root sucker production conducted on the Routt National Forest in central Colorado indicates that bulldozer pushing is superior to chain saw felling as a regeneration method in pure aspen stands, producing significantly greater numbers of aspen suckers and significantly taller suckers. The apparent root stimulation effect of bulldozing may have application in other circumstances to promote suckering while retaining attributes of the existing clone. For example, isolated clones could be expanded in size by severing roots growing out from the edges or ripping around trees in sparsely stocked stands could initiate a new sucker understory.

Fencing to protect suckers from browsing livestock is also beneficial, but may not always be necessary. Local evaluation of the potential browsing impact should determine whether fencing is needed.

Leaving slash in high concentrations as a substitute to fencing may inhibit root suckering. Further research into identifying optimal slash concentrations is needed.

Successful vegetative regeneration of aspen depends on obtaining as many root suckers as possible following the regeneration treatment. Unlike conifer regeneration, aspen sucker populations follow a negative exponential decay curve over time (i.e., sucker densities rapidly drop the first few years after regeneration and continue to decline throughout their lifetime) (Shepperd 1993b). Initial sucker numbers must be sufficient to sustain normal mortality and still have adequate stocking at maturity. Poorly stocked, widely spaced sucker populations are subject to continued deformity from browsing and snow damage (Shepperd 1993b). Based on data from this and other studies, a successfully regenerated aspen stand should have several thousand stems per hectare at least 2 m tall at the end of the fifth growing season after regeneration.

LITERATURE CITED

Botwinski, C.A.; Loomans, Arlyn. 1968. Made-to-order deer range. Wisconsin Conservation Bull. Sept/Oct: 10-12.

DeByle, N.V.; Bevins, C.D.; Fischer, W.C. 1987. Wildfire occurrence in aspen in the interior western United States. West. J. Appl. For. 2(3): 73-76.

Crouch, Glenn L. 1986. Aspen regeneration in 6- to 10-year-old clearcuts in southwestern Colorado. Res. Note RM-467. Fort Collins, CO: U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station. 4p.

Mueggler, W.F. 1985. Vegetation associations. In: DeByle, Norbert V.; Winokur, Robert P., eds.

Aspen: Ecology and management in the western United States. Gen. Tech. Rep. RM-119. Fort Collins, CO: U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station: 45-55.

Norusis, Marija J. 1990 SPSS/PC+ Advanced Statistics 4.0 for the IBM PC/XT/AT and PS/2. Chicago, IL. SPSS Inc. 372p.

Schier, G.A.; Campbell, R.B. 1978. Aspen sucker regeneration following burning and clearcutting on two sites in the Rocky Mountains. Forest Science. 24(2):303-312.

Schier, George A.; Jones, John R.; Winokur, Robert P. 1985a. Vegetative regeneration In: DeByle, Norbert V.; Winokur, Robert P., eds. Aspen: Ecology and management in the western United States. Gen. Tech. Rep. RM-119. Fort Collins, CO: U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station: 29-33.

Schier, George A.; Shepperd, Wayne D.; Jones, John R. 1985b. Regeneration In: DeByle, Norbert V.; Winokur, Robert P., eds. Aspen: Ecology and management in the western United States. Gen. Tech. Rep. RM-119. Fort Collins, CO: U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station: 197-208.

Shepperd, Wayne D. 1993a. The effect of harvesting activities on soil compaction, root damage, and suckering in Colorado aspen. West. J. Appl. For. 8(2):62-66.

Shepperd, Wayne D. 1993b. Initial growth, development, and clonal dynamics of regenerated aspen in the Rocky Mountains. Res. Pap. RM-312. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8p.

Shepperd, Wayne D. 1986. Silviculture of aspen forests in the Rocky Mountains and Southwest. Publication RMTT-7. Fort Collins, CO. U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station. 38p.

Shepperd, Wayne D. 1981. Stand characteristics of Rocky Mountain aspen. In: DeByle,N.V., ed. Situation management of two intermountain species: Aspen and coyotes. Symposium proceedings. Volume I, Aspen; 1981 April 23-24; Logan, UT. Logan, UT: Utah State University: 22-30.

Shepperd, Wayne D.; Engelby, Orville. 1983. Rocky Mountain aspen. In: Silvicultural systems for the major forest types of the United States. Agric. Handbook 445. U.S. Department of Agriculture, Washington D.C.: 77-79.

Smith, Arthur D.; Lucas, Paul A.; Baker, Calvin O.; Scotter, George W. 1972. The effects of deer and domestic livestock on aspen regeneration in Utah. Pub. No. 72-1. Logan UT. Utah Division of Wildlife Resources. 32 p.