Forest Renewal BC Research Program

Final Report

Project Details

FRBC Ref#	HQ96401-RE	**SCBC Ref#**	FR-96/97- 641
Project Leader	Mr. Timothy Conlin BC Ministry of Forests		
Project Title	Asexual Propagation of Trembling Aspen (*Populus tremuloides*)		
Project Start Date	April 1, 1996	**Project End Date**	March 31, 2001
General Topic	Forest Operations & Decision Support		
Key Words	Forest Operations & Decision Support, trembling aspen, suckering, regeneration, on-site chipping		

SCBC does not have additional copies of deliverables or products from this project. Please contact the project leader directly to obtain copies of any deliverables referenced within this report.

FOREST RENEWAL BC

Science Council of British Columbia

Project Administered by the Science Council of British Columbia
For more information, tel: 604.438.2752 fax: 604.438.6564

Revised copy!
08/08/01

FINAL REPORT

FOREST RENEWAL B.C. PROJECT HQ96401-RE

ADMINISTRATIVE SUMMARY

Forest Renewal BC Research Award: HQ96401-RE

Project Title: Asexual Propagation of Trembling Aspen (Populus tremuloides).

Project Leader and Organization: Timothy Conlin, Research Branch, Ministry of Forests.

Team Members: Timothy Conlin, David Cheyne, Robert van den Driessche.

Project Start Date: April 1, 1996.

Project End Date: March 31, 2001.

INTRODUCTION AND DISCUSSION

The concepts upon which this project were based included the lack of knowledge on how northern B.C. aspen sucker in response to soil temperature and the lack of knowledge on how harvesting practices impact aspen regeneration in cutblocks.

The overall objectives of the project were to determine:

a) The thermal time units required for effective aspen suckering and the upper and lower temperature optima for this process. This information could be used for the implementation of silvicultural management decisions for those situations involving mixedwood stands containing aspen.

b) The type of mechanical damage which prevented or reduced suckering by roots of aspen, or, alternately, promoted suckering activity. This information could help in the development of more effective logging and site preparation machinery and aspen management practices.

c) Whether residue from on-site chipping of aspen decreases the productivity of a site thorough:

i) allelopathic effects;

ii) nitrogen sequestration;

iii) or modification of soil temperature by acting as an insulating ground cover.

It was thought that a potential spin-off of this research could be the development of silviculture practices which used residue from on-site chipping to manage sites containing aspen. These practices could include rehabilitation of roads and landings, control of competing plant species (e.g. Calamagrostis canadensis), and use of residue to manage mixwood stands. This research could also determine whether it is feasible to dispose of aspen residue on-site as an acceptable operational practice.

Although items a) and c) above received considerable attention, item b) was largely ignored because of problems with the disbursement of funding until well into the field season during 1996. As a result, despite our best efforts, minimal field research was accomplished during 1996 and a decision had to be made to either concentrate on the thermal time of aspen suckering or on the effect of mechanical damage on aspen roots.

Prior to this work, the only literature on thermal time and it's effect on aspen suckering were to be found in two journal articles, one published in 1966 involving the response of one Ontario clone, and the other in 1973 involving three neighbouring clones near Fairbanks, Alaska. Despite these reports, the literature on aspen suckering is confusing and conflicting and there is a lack of quantifiable data about suckering behaviour and much of the information published appears to be more in the vein of hypothesis making than hypothesis testing.

The results of this project's research tend to eliminate some of the confusion regarding aspen suckering in response to thermal time – to a point. For example, the lower threshold for aspen suckering does appear to be around the 15 °C mark, although it is clear that suckering can occur at slightly lower temperatures. It is also clear that there is a strong relationship between the size of the suckering roots, best correlated with root surface area, and suckering potential and that this relationship would indicate that 16 °C is the more likely threshold temperature for suckering in trembling aspen.

What was innovative about the thermal time research was that we addressed the effect of season on suckering by trembling aspen. It was shown that July suckering of root cuttings was much reduced compared to late April/early May suckering at all temperature levels. This would indicate that the suckering potential of summer-logged stands would be reduced compared to winter-logged stands. Currently, the only guidelines governing summer logging on aspen stands in Forest Districts are procedures designed to minimize soil compaction, the assumption being that NSR aspen stands are the result of soil compaction. However, it would appear from our research that the guidelines for logging aspen stands in mid-summer may need to consider more than the physical effects of soil compaction on aspen regeneration. The details of the thermal time research are addressed in a manuscript which is currently undergoing review under the title "The effect of thermal time, season and clonal attributes on suckering in trembling aspen (*Populus tremuloides*) root cuttings."

The field component of this research was designed to incorporate the thermal time results into the interpretation of aspen regeneration response to harvesting methods, in this case in-woods chipping operations. The working hypothesis was that the aspen residue deposited on the cut-block during winter on-site operations would act as an insulating material which would delay aspen regeneration by keeping soil temperatures below the suckering threshold. The laboratory research on thermal time provided us with quantifiable data on the lower threshold temperature for suckering, allowing us to interpret the field response in terms of suckering response to low soil temperatures, as recorded by data loggers. The field evidence, however, showed the opposite response. The residue deposited upon the aspen cutblock actually increased soil temperature levels during the growing season. These temperature increases did not encourage aspen suckering, however, and the thicker the residue layer, the fewer aspen stems suckered on the treated plots. A draft manuscript of the results of the field work has been prepared and is tentatively titled "Disposal of waste bark and wood residue from a portable chain-flail delimber-debarker-chipper in a winter–logged aspen stand: effect on soil temperature and aspen suckering." However, reviewer's recommended that more mid- to long-term data be gathered on suckering response to treatments before attempting to publish the results of the field work.

Two other aspects of the potential impact that aspen residue might have had upon aspen regeneration were examined: allelochemical interactions from the aspen leachate generated from the waste bark and wood and the possibility that the residue might sequester soil nitrogen as it decomposed, making it unavailable to aspen growth. Laboratory research demonstrated that there was indeed a potential for allelochemical interaction between the leachate generated by aspen residue and plants grown in pots. A manuscript detailing the results of this work has been published in the 2001 issue of the Forestry Chronicle, Vol. 77 No.2, pp. 345-349 ("In-woods chipping: possible evidence for allelochemical interaction of leachate generated from trembling aspen (*Populus tremuloides* Michx.) bark and wood waste").

The other aspect of the field work, the investigation that nitrogen sequestration would have an effect on aspen growth, demonstrated that this was unlikely. Although the C:N ratio's of the waste wood and bark were in the range of 92:1 to 103:1, which suggested that soil nitrogen could be sequestered by microbial activity (Brady, 1984), the results from foliage sampled from suckered shoots during mid-June and mid-July of 1999 indicates otherwise. Although there was some indication that the treated plots produced leaf nitrogen contents which were significantly lower than the controls during June, these differences were inconsistent from site to site and had disappeared by July (see the 2000 annual report for project HQ96401-RE). The foliar samples thus indicated that the evidence for differences between treatments were inconclusive. An attempt to gather foliage samples early in the summer of 2000 was thwarted by late spring leaf-out due to inclement weather and no opportunity to gather samples occurred until the end of June. These foliar samples are still undergoing chemical analysis and to date there is no information available. There is a possibility that this information will be published as a research note, although the subject area is somewhat limited.

To date, there is no published information on the effect of disposal of residue from in-woods chipping operations on aspen regeneration in winter-logged clearcuts. However, as mixedwood management and utilization progresses to a situation where both species are managed for fibre, forest mangers will look for information on the impact that this harvesting activity has on aspen regeneration and growth. I anticipate that there will be an increased demand for this information as forest companies with demands for different species (e.g. white spruce vs. trembling aspen) integrate their harvesting plans in order to utilize all the fibre on a cutblock. The eventual journal publication of results of the field research and thermal time experiments will provide a public record of our work and inform forest managers of the feasibility of alternate forest harvest practices as industry moves toward full utilization of boreal mixedwoods.

This project was linked to the Forest Renewal BC's investment priorities and Research Program priorities listed in the recent year 2000 proposal application submitted to Forest Renewal B.C. "Adaptation of in-woods chipping operations to management of British Columbia boreal and interior mixedwoods." For further information on these priorities, please see a copy of the original Forest Renewal B.C. proposal.

METHODS

Thermal Time:

Three locations along a latitudinal gradient where aspen is abundant in northeastern B.C. were selected for the gathering of aspen root cuttings during the 1997 and 1998 growing seasons. The two higher latitude locations, the northern-most 317 Bridge clone (Ft. Nelson) and the mid-point Del Reo and Kiskatinwa clones (Peace River), were chosen for clone selection because they were each located in a distinct boreal biogeoclimatic subzone (DeLong et al., 1990). The Salmon River clones (Prince George) were chosen because they were located in a different biogeoclimatic zone (MacKinnon et al, 1990) separated by the intervening Rocky Mountain Range. Clones that appeared to be stressed were avoided as sources of root cutting material. Attempts were made to identify two adjacent clones in mature closed-canopied stands based on gender. However, sexing clones was made more difficult than anticipated because springtime flowering events in each location were irregular. This resulted in the selection of smaller than desired clones or clones of indeterminate sex. As a consequence during 1998, root cuttings had to be collected from new sources on the Salmon Forest Road because the supply of cuttings from the 1997 female clone had been exhausted.

The dates of collection for all clones were in late April to early May and and mid to late July during 1997 and 1998. A minimum of 50 segments were collected from each clone. Root cuttings from each clone were divided into two replicates for each temperature. Measurements were taken of the length and diameter of each root cutting (diameter was based upon the mean of two measurements of diameter taken at both ends and at the middle of the cutting). Each root cutting was then bagged with moist peat in 11 cm diameter plastic tubing sealed at both ends and slit down one side to facilitate removal of the cutting during the course of each experiment.

Ten growth chambers and incubation cabinets were used to incubate the cutting. Each replicate of chamber or cabinets was randomly assigned one of five temperature levels (14, 16, 18, 20 and 22 °C). Harvest of suckered material in each experiment was scheduled for 36 days after the start of incubation to minimize sampling error brought about by the onset of sucker mortality due to, Venturia spp. infestation.

Bagged root cuttings were incubated in the dark (Maini and Horton, 1966; Zasada and Schier 1973). Each cutting was inspected every two to three days for the development of adventitious shoot buds. Adventitious buds on each cutting were marked with 0.1% Safranin O dye and tallied as they appeared until the onset of sucker height growth. Following the initiation of height growth, cuttings were left in the growth chamber until the end of the 36 day incubation period. At the end of the incubation period, all suckered shoots over three mm were measured for height, harvested, dried and weighed.

Statistical analysis

Data was analysed using a multi-level mixed model analysis of variance using SAS® (Littell et al., 1996). Temperature levels and time of root cutting harvest were treated as fixed treatment factors, while clone location and it's interactions were considered random treatment factors. It should be borne in mind that for some clones slightly more cuttings were collected and as a result some temperature x time x clone cells contained one or two extra cuttings. Because some of the clones harvested in 1997 were not the same clones harvested in 1998, these yearly data sets were analyzed separately.

Sucker dry weight and height, adventitious bud numbers, sucker numbers and sucker:bud ratios were used to quantify suckering response by root cuttings. Variability in the mean length and diameter of root cuttings occurred during collection. This was due to a number of factors, including the unpredictability in the size and quantity of harvestable lateral roots for each clone and a small amount of damage inflicted upon the cuttings during harvest which meant that the cuttings had to be trimmed in order to facilitate callus development and avoid rot infestations. However, this was not considered a problem since the variability in length, as well as cutting diameter, was compensated for by an analysis of covariance using cutting length or total lateral surface area as a covariate.

Root cutting surface area was estimated using the formula for cylinder lateral surface area (lsa):

$$lsa = 2\pi(\text{radius})(\text{length}).$$

Radius of each root cutting was calculated by dividing the cutting length by three and assigning each mean diameter to its corresponding section. The sum of lateral surface area's from each of the three sections, along with a cutting's length, were used to calculate total lateral surface area of each root cutting. This was the most satisfactory method of dealing with the variability, from one end to the next, in each root cutting's diameter.

Allelochemistry:

Plant Seedlings and Experimental Design

Aspen were sown into sand-filled pots, allowed to germinate, and later thinned to one plant per pot. Paper birch and Calamagrostis canadensis seeds were pricked into sand-filled pots one week after germination. White spruce and lodgepole pine were germinated in flats over a two-week period and then transplanted to sand-filled pots. White spruce 415B 2+0 white spruce plugs were also planted in pots filled with sand. Sand from a local gardening supplier was used as a rooting medium to ameliorate uncontrollable stochastic responses which might have occurred if natural mineral soils were used. Two-gallon pot sizes were used in all experiments. Prior to treatment each species group was divided into two replicate samples and the sample to be treated with leachate was then randomly selected using a coin toss. Seedlings within each treatment were watered twice daily using tap water or aspen leachate applied directly to the soil. A 1% solution of 20-20-20 fertilizer was substituted for one regular watering every second day. The watering schedule was occasionally supplemented with 20 minute misting periods on dry, hot days.

All plants were grown in a greenhouse environment during the summer growing season. With the exception of the white spruce plugs, each experiment with each species was repeated at least once in a subsequent year with a different batch of aspen residue. This was to ensure that seedling responses to the leachate treatments were not specific to aspen from particular stand. Following harvest, each individual plant was divided into shoot and roots, dried, and weighed. Spruce plug roots were further subdivided into the old plug root mass and new root growth, the latter based on succulent white roots growing outside the parameters of the plug root mass composed of peat and fibrous brown roots. The old plug roots were washed free of peat rooting media, and dried along with excised new roots and shoot material. Dry weights and root:shoot ratio's of the control and treatment samples were compared using a two-sample Student's t-test.

Production and Application of Leachate

Leachate was produced by sprinkling tap water over a hopper filled aspen residue. The residue originated from recent winter-logged aspen stems, which had their crowns removed prior to processing with a Peterson Portable Flail Delimber-Debarker-Chipper™. Prior to experimentation in each year, the old lot of residue was replaced with a load of new, fresh residue, which was then used to generate all batches of leachate during a growing season. A fresh carboy was produced every three to four days, which was used for leachate treatment application to seedlings. Watering the treated plants with leachate commenced at the four- and two-leaf stages for aspen and birch respectively; after approximately three weeks for C. canadensis and the white spruce plugs; and after 9 weeks for pine and spruce seedlings. Leachate was applied to all treated species over a six week period for broadleaf seedlings and over eight weeks for conifer seedlings. Harvest occurred immediately after the cessation of leachate application for each species. Each time a 54 L carboy of leachate was produced, a sample was frozen and stored until it could be chemically analyzed at the end of each growing season.

Field Experiments:

Three aspen cutblocks, selected by the Dawson Creek District office, B.C. Ministry of Forests under the Small Business Forest Enterprise Program, were clearcut in late winter during one of three years (1996 through to 1999). The sites were all located in the Boreal White and Black Spruce biogeoclimatic zone, Peace moist warm variant (BWBSmw1) (Delong et al., 1990). Two sites are located on Brunisolic Gray Luvisols in the Del Reo south of the Moberly River while the third is located on Dark Gray Luvisols north of the Kiskatinwa River (Lord and Green, 1986). All contained mature, close canopied aspen stands approximately 100 years of age with Site Indices range of between 16 and 18 m at 50 years of age (Prince George Regional Research Section, B.C. Ministry of Forests).

In the fall prior to logging operations, 10 x 10 m plots were located amongst healthy aspen clones within a pure stand of mature aspen in each cutblock and their corners marked with 30 cm sections of iron rebar driven into the soil. Each plot was systematically sub-sampled for soil and forest floor bulk density and chemistry for the purpose of characterizing the sites for future reference. Immediately following winter logging operations, plot corners were relocated under the snow using a metal detector and re-flagged. Thermocouples were placed into the mineral soil 5 cm below the organic-mineral soil interface within each plot. This depth was chosen because it was the median depth of lateral roots involved in suckering (Kemperman, 1978). Once the thermocouple was in place, the soil wedge was replaced in its original position. Thermocouple wires were run back to a data logger station via a trench in the snow dug to ground level.

The hog residue was supplied by a local business (North Peace Timber Ltd., Taylor, B.C.), which used a Peterson Portable Flail Delimber-Debarker-Chipper™ (DDC) to manufacture pulp chips from tree-length logs, and was trucked into each site using chip vans. Residue was applied using a front-end loader with a 4.5 m^3 bucket. The treatments used at each site consisted of three levels of residue application, 34, 68, 102 kg m^{-2}, and a control plot. Initial planning called for each treatment to be replicated three times. However, due to extra time and material, a fourth plot without a datalogger station was added at one site, while spring breakup prevented the complete application of the third replicate of the 68 and 102 kg m^2 treatments at another site.

Following snowmelt, the thermocouple leads were attached to data loggers and soil temperatures recorded over the growing season. Datalogger information was downloaded in September of each year and the number and height of all suckers on the 10 x 10 m hog treatment plots were recorded. Sucker number and height on the control treatment plots were recorded randomly using five 1 x 1 m quadrat measurements per 10 x 10 m plot because of high stem numbers on these plots. Sucker numbers for each plot were extrapolated upward to reflect stem ha^{-1} and means and standard errors were calculated for each treatment.

Foliar samples were collected at two sites in the summer of 1999 and 2000 for the purpose of sampling for foliar chemistry, including nitrogen content. Ten plants in each treated plot were chosen at random and three full-sized leaves from the top, mid and bottom crown levels were sampled. All leaves from the top -, mid – and bottom - positions were composited for each plot. The results of the analysis were analyzed using a one-way analysis of variance with blocking.

Extension:

The target audience for this project were forest mangers who work in areas where aspen is considered to be a commercial fibre species. The extension method will be mainly based on journal publications with feedback through journal citations and requests for reprints. Although plans were made to present to the results to such organizations as the Poplar Council and the Boreal Aspen Co-op, the meetings that these organizations have had recently with regard to aspen have occurred in Alberta. In order to travel to Alberta as a provincial government employee, I need to seek travel approval from management and I have not been very successful lately in obtaining this approval. Although I would have liked to have attended the meeting of the Northern Silviculture Committee last January, the meeting date occurred during my vacation. Perhaps I will get a chance to present the results to NSC in January, 2002.

SUMMARY

The benefits achieved were:

- quantification of suckering response by trembling aspen in northeastern B.C. to temperature and season. This is important information for those foresters managing aspen on summer and winter-logged sites.
- quantification of aspen regeneration in response to the on-block disposal of waste bark and wood from in-woods chipping of aspen. The results show that application of progressively thicker layers of waste residue resulted in decreasing numbers of regenerated aspen stems. Greenhouse studies indicated that leachate generated from waste residue may cause allelochemical depression of seedling growth on cutblocks and that this might be a cause of decreased aspen stems in plots treated with waste bark and wood. However, without further information on the composition or residence time of the allelochemical materials in soils, it is impossible to determine the impact that leachate might have had on regeneration on these cutblocks. The results of foliar analysis showed no conclusive evidence that nitrogen sequestration occurred in response to the deposition of waste material on these cutblocks. Finally, disposal of waste residue on aspen cut-blocks appears to increase rather than decrease soil temperatures. This soil temperature increase, however, did not appear to stimulate suckering.

LITERATURE CITED

Brady, N.C. 1984. The nature and properties of soils. MacMillan Pub. Co., New York. pp. 269-272.

DeLong, C., MacKinnon, A. and L. Jang. 1990. A field guide for identification and interpretation of ecosystems of the northeast portion of the Prince George Forest Region. Land Mangt. Handbook No. 22, Research Branch, B.C. Ministry of Forests, Prov. of B.C. 116 pp.

Littell, R.C., Milliken, G.A., Stroup, W.W. and Wolfinger, R.D. 1996. SAS® system for mixed models. SAS Institute Inc., Cary, NC. 633 pp.

Kemperman, J.A. 1978. Sucker-root relationships in aspen. Ontario Forest Research Centre, Ministry of Natural Resources, Forest Res. Note No. 12. 4 pp.

Lord, T.M. and Green, A.J. 1986. Soils of the Fort St. John - Dawson Creek Area, British Columbia. Land Resource Research Centre, Contribution No. 85-27, Report No. 42. Agriculture Canada. 130 pp.

MacKinnon, A., DeLong, C. and Meidinger, D. 1990. A field guide for identification and interpretation of ecosystems of the northwest portion of the Prince George Forest Region. Land Mangt. Handbook No. 22, Research Branch, B.C. Ministry of Forests, Prov. of B.C. 116 pp.

Maini, J.S. and Horton, K.W. 1966. Vegetative propagation of Populus spp. I. Influence of temperature on formation and initial growth of aspen suckers. Can. J. Bot., 44:1183 - 1189.

Zasada, J.C. and Schier, G.A. 1973. Aspen root suckering in Alaska: Effect of clone, collection date, and temperature. Northwest Sci., 47:100-104.