Oil and Gas site reforestation: Operational Trial

Annual Progress Report to March 31, 2005

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Summary of progress towards overall project objectives and deliverables:

1. **Complete the required site treatments and plot implementation. The test sites will follow the design of an operational trial to maximize information obtained. This includes planting and seeding of the sites that were treated last year.**
   Deliverable: ***Reclamation and treatment details (Test Site Summaries)***

   2nd year progress: Two sites were treated in 2004, one site from 2003 was lost due to re-entry, so a total of five mesic sites have been treated to date, with the same plot layout; five sites were planted. Installation details and comments are included in this report. Further site treatments are planned for 2005.

2. **Refine the reclamation prescription template to improve efficiency and effectiveness of future reclamation efforts.**
   Deliverable: ***Reclamation Prescription Template***

   2nd year progress: progress has been reported by Monashee

3. **Refine the pre-site assessment template to improve efficiency and effectiveness of future pre-site data collection efforts.**
   Deliverable: ***Pre-Site Assessment Template.***

   2nd year progress: progress has been reported by Monashee

4. **Monitor treatment success and soil conditions through follow-up site visits.**

   Deliverable: Monitoring of treatments and annual report detailing the findings.

   2nd year progress: Numerous field visits were made to the sites in 2004; soil samples were collected and analysis is being carried out as part of M.Sc thesis research by Trevor McConkey at UNBC; tree measurements were carried out for 3 of the 5 sites; a summary of results as of March, 2005 is provided.

Mesic Site Treatments and maintenance (year 2 - 2004)

Soil treatments in yr 2: Two mesic sites south of Dawson Creek were treated in May 2004 with excavator tillage and woodchip additions using the same methodology as was used in 2003 to treat 4 sites (see 1st year progress report for treatment details from 2003). One of the sites treated in 2003 (2-4-88-22) was lost to the study as it was slated for re-entry drilling. We were able to recover costs from the oil company involved, and this provided us with enough resources to replace the site. Sketch maps of the final plot layouts for 5 mesic sites, along with soil monitoring stations are provided in Appendix 1 of this report. The plot treatments were completed in late May, and tree planting commenced shortly after.

Tree planting in yr 2: Trees were planted on all plots in May and June of 2004. The tree planting layout consisted of 12 rows of 12 trees per row on each plot (6 plots per site). Tree spacing was 1.7 m x 1.7 m. In each row, spruce and pine seedlings were planted in an alternating pattern. The tree planting layout allows for measuring survival on 144 trees (72 of each species), and for long term growth measurements on 64 trees (32 of each species) in an inner plot. This allows for two rows of buffer trees to eliminate problems caused by edge effects at the boundary of treatment plots. Trees from the buffers can also be transplanted to the inner measurement plot if necessary to replace trees that die. Approximately 4500 trees were planted on the treated plots, evenly split between lodgepole pine (Pli seedlot number 02077) and interior spruce (Sx seedlot number 01822). Additional trees were planted on untreated portions of the wellsites.

In addition to the coniferous trees planted on the sites, a variety of approaches were used to test shrub species for their ability to establish and grow on the well sites. Willow whips were planted on untreated areas of the wellsites north of Fort St John in early spring, 2004. On two of the treatment plots (DCI and U) at each wellsite, we established several rows of shrubs and deciduous species, including trembling aspen (Populus tremuloides), Red osier dogwood (Cornus stolonifera), hedge rose (Rosa sp.), and Red elderberry (Sambucus racemosa), along with approximately 400 rooted cuttings, and 200 unrooted cuttings of Walker hybrid poplar obtained from Parkland Agroforestry in Melfort Saskatchewan. The survival and growth of these species will be assessed in spring 2005,and additional planting will also be carried out in spring 2005.

Figure 1. Planting willow whips Aitken site in May, 2004

Site maintenance in yr 2: Site visits in July 2004 revealed a significant competition problem from previously seeded cover crops on some sites, even on plots where tillage treatments, mulches and brush blankets had been applied. This was unexpected: we had anticipated competition would affect survival on the untreated plots, and had no plans to brush them as it was considered part of the raw planting treatment, and would be compared to other more costly treatments that included soil amelioration as well as brush control. However, the need for additional measures to control herbaceous cover crops was apparent, so we carried out manual vegetation control on the treated plots (B, C, D, DC, and DCI) on at least two occasions, and were thus able to minimize damage to establishing trees. Some mortality occurred however, and will be discussed in the progress report available in March, 2005.

Vegetation control involved simply pulling back the vegetation cover near the seedlings and flattening it down with foot pressure. We don't expect any changes to site (i.e. soil) characteristics to result from these treatments. No chemicals were applied, and the vegetation recovered quickly to reinvade the seedling growing space but we monitored the recovery, and pulled it back again when seedling growth appeared to be suffering. Vegetation on untreated plots was not controlled, as we want to compare the effects of doing nothing with our treatments.

We became aware of damage caused by grazing cattle on two sites (Bernadet and Blueberry) late in the growing season. This occurred despite our discussions with the rancher in the spring and summer which led us to believe that little damage would occur because the cattle were only expected to be in the area for a short period of time. The cattle, however, showed a great interest in the treated areas, and inflicted considerable damage to planted trees and the plots in a relatively short time period (2-3 weeks). For this reason, we built fences to exclude cattle from the treated areas at Bernadet and Blueberry. Although the early effects of cattle damage on seedling survival and growth are discussed in this report, the full effects of cattle trampling on establishment and growth will likely not be fully known until later in 2005 or even 2006.

Mesic Site Monitoring (year 2 - 2004)

Soil monitoring in 2004: Soil sampling was carried out to obtain information on the soil physical, chemical and nutritional factors that affect seedling performance. Activities included:

- Bulk density sampling (320 samples collected using a 0.518 l core)
- Measuring air-filled porosity using an air pycnometer (each of the 320 bulk density samples was measured following collection)
- Water retention sampling (150 samples collected using a 0.039 l core)
- Nutrient sampling (100 samples collected)
- Proctor compaction sampling (4 samples per plot = 20 samples)
- Monitoring soil mechanical resistance and water content (Sites north of Ft. St. John were monitored in May, June, July, and October, 2004; sites south of Dawson Creek were only monitored in June, July, and October due to their delayed treatment)

The following laboratory analyses are completed or in progress:

- Data analysis on soil mechanical resistance and water content for 2004 (preliminary assessments based on year 1 data are included in this report)
- Sieving bulk density samples to determine total and fine fraction bulk density, along with contribution of organic materials (preliminary assessment is included in this report)
- Mineralization of nitrogen from treated and undisturbed portions of the wellsites (results of a pilot study are included in this report)

- Proctor compaction (WSA Engineeering in Castlegar - expected 2005.04)
- Determining water retention characteristics of undisturbed core samples (MoF – Victoria; expected 2005.04)
- Nutrient sample analysis (expected 2005.10)
- Texture (expected 2005.10)
- Continuous soil strength, particle density, and (possibly) water retention characteristics of laboratory-prepared samples collected from wellsites (expected 2005.12)
- Evaluation of woodchips as a source of nutrients and available water (expected 2005.12)
- Ongoing data analysis of air pycnometer data and other factors in relation to bulk density, texture and carbon content (results will be included in final report available March 2006)

Figure 2. Collecting soil samples at Boot Lake site Sept 2004

Coniferous tree monitoring in yr 2: Trees were individually tagged for identification by placing a pin flag in the ground beside each seedling and attaching a numbered aluminium tag. Each tree in the trial has a unique identifying number. Detailed information on tree measurement techniques are provided in Appendix 2 of this report.

Mesic Site Results as of March 31, 2005

Note: The results presented here should be considered preliminary as no statistical analysis was carried out as of March 31 2005. Statistical analysis of all results will be incorporated as part of the final project report available in March 2006. Interpretations and recommendations included in this report are based on the preliminary data, and may need to be refined when data analysis is completed.

Soil Bulk Density:

Bulk density values were corrected for both coarse organic and mineral fractions following sieving to 2 mm. Figure A shows data from all of the sites for individual treatments. The fine fraction bulk density appears to be lower for tilled and incorporated plots. As expected, elevated bulk densities were also observed for soil samples collected lower in the profile (10-17 cm). Figure B summarizes the average coarse fragment content determined on cores for each site based on the mineral fraction retained on a 2 mm sieve. Average coarse fragment content s ranged between 3% (Aitken) and 10% (Blackhawk).

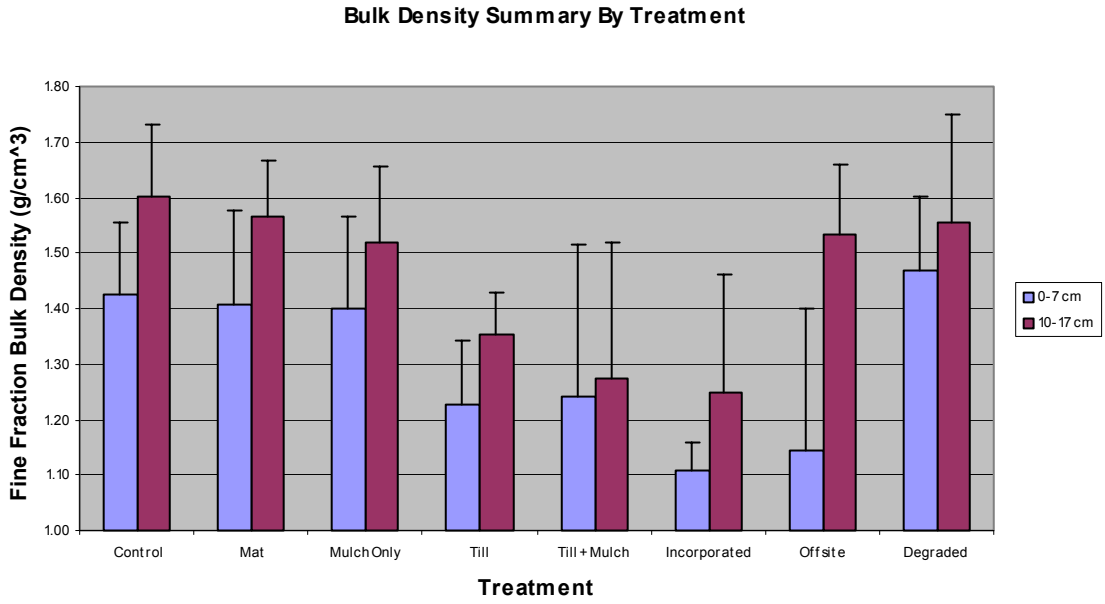


Figure A: Summary of pooled average fine fraction bulk density values by treatment

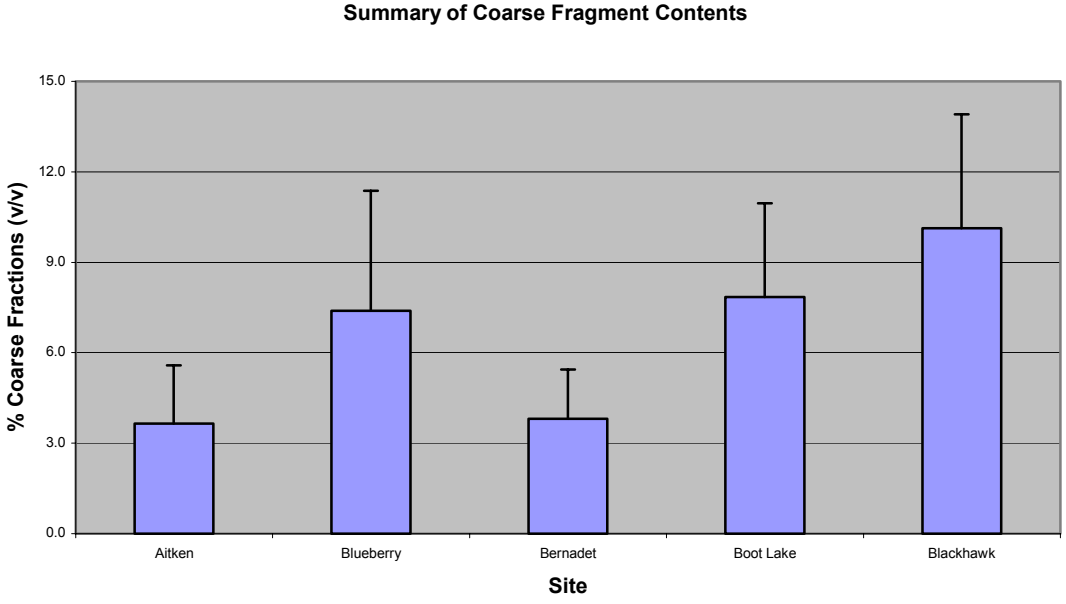


Figure B: Summary of coarse fragment determination

Soil mechanical resistance and water content:

Water content tended to be higher in spring and fall compared to summer measurements (Figure C) and the strength of this effect appears to have varied among treatments. Elevated precipitation

in the late summer was likely responsible for soils not drying as much as expected. Soil mechanical resistance determined with the minipenetrometer was lower in the spring and fall compared to summer measurements (Figure D). At Aitken, soil mechanical resistance for treated plots did not appear to reach growth limiting values at any time during the growing season, while soils on the control plots did experience growth-limiting values of soil mechanical resistance during June, which coincided with dry soils. Soil mechanical resistance and water content data indicate a correlation between soil strength and moisture content. As expected, the higher the moisture content, the weaker the soil or less resistance encountered. The relationship between the two parameters may be stronger in untilled plots, possibly due to the narrow range of soil moistures encountered throughout the season. Tables C and D show results for Aitken which in many respects are representative of all of the sites. Continuous soil strength determined with the RIMIK penetrometer was also monitored at each of the sampling stations throughout the 2004 season. Results from the RIMIK (Figure E) indicate generally stronger soils in untilled treatments, and an increase in soil strength with depth. This trend is common to each of the five sites.

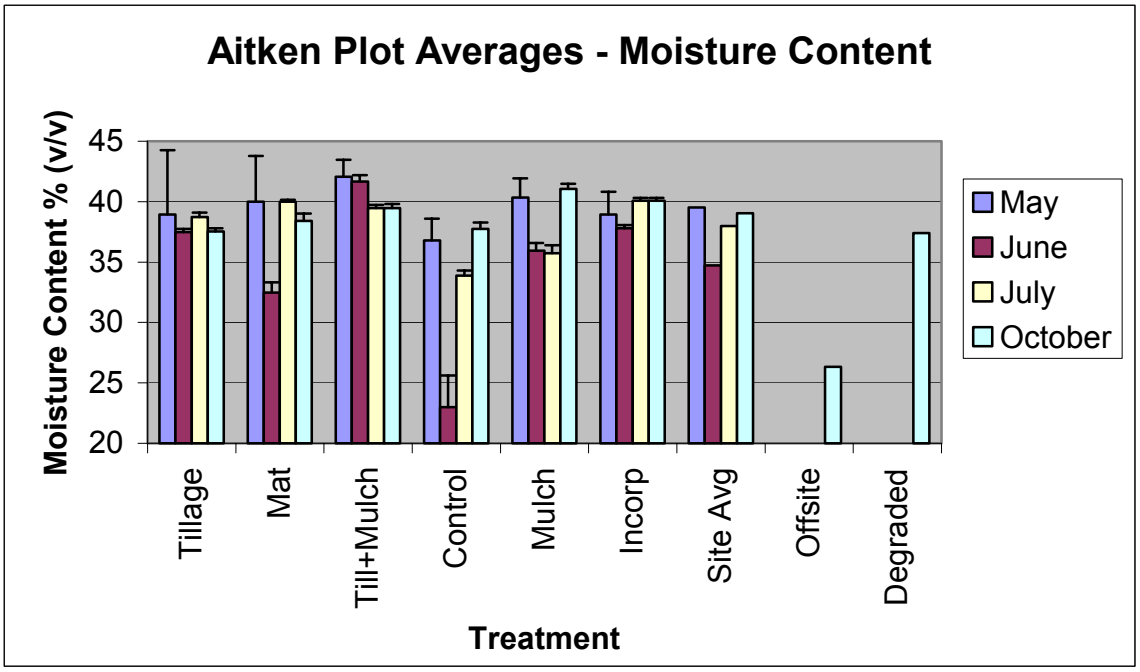


Figure C: Summary of moisture content surveys at Aitken

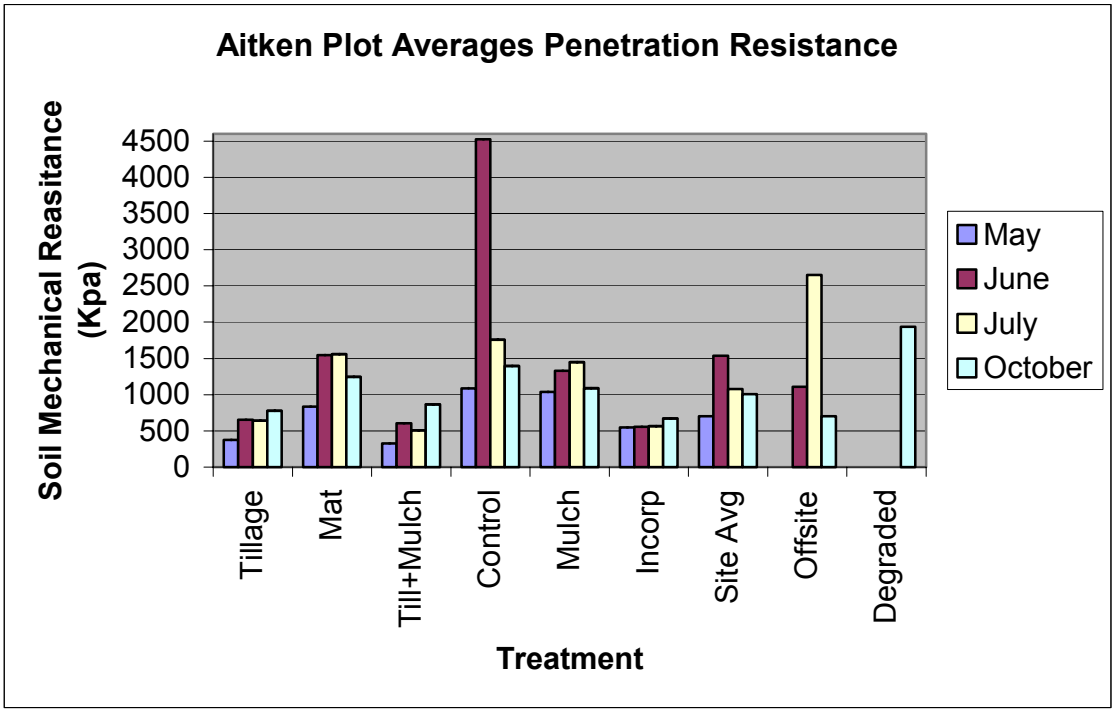


Figure D: Summary of soil mechanical resistance using hand held penetrometer

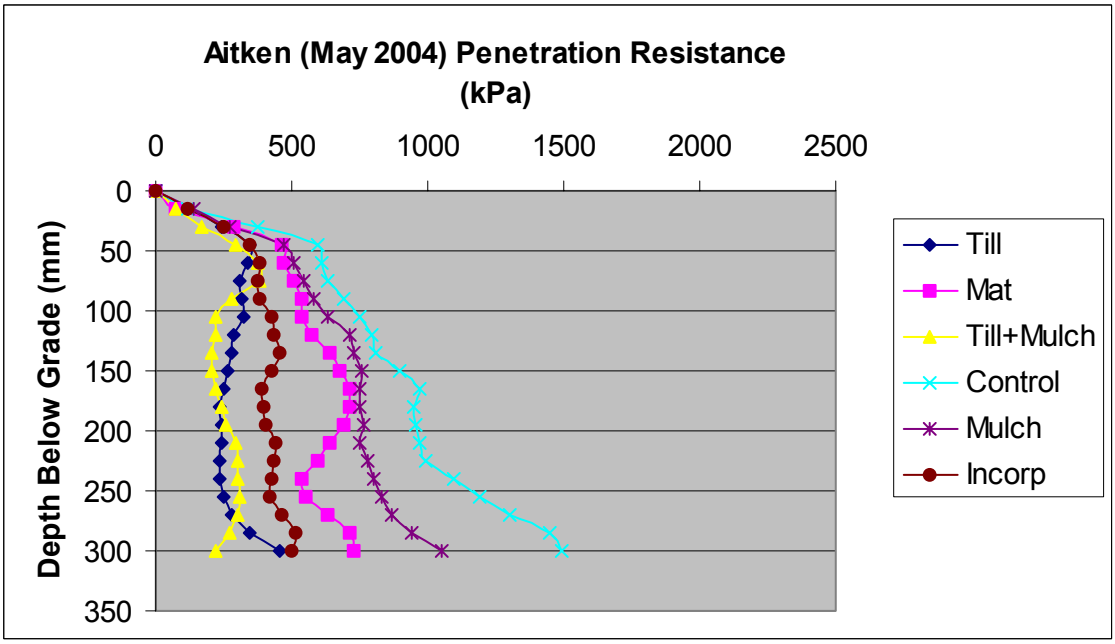


Figure E: Summary of continuous soil mechanical resistance at Aitken using Rimik Penetrometer

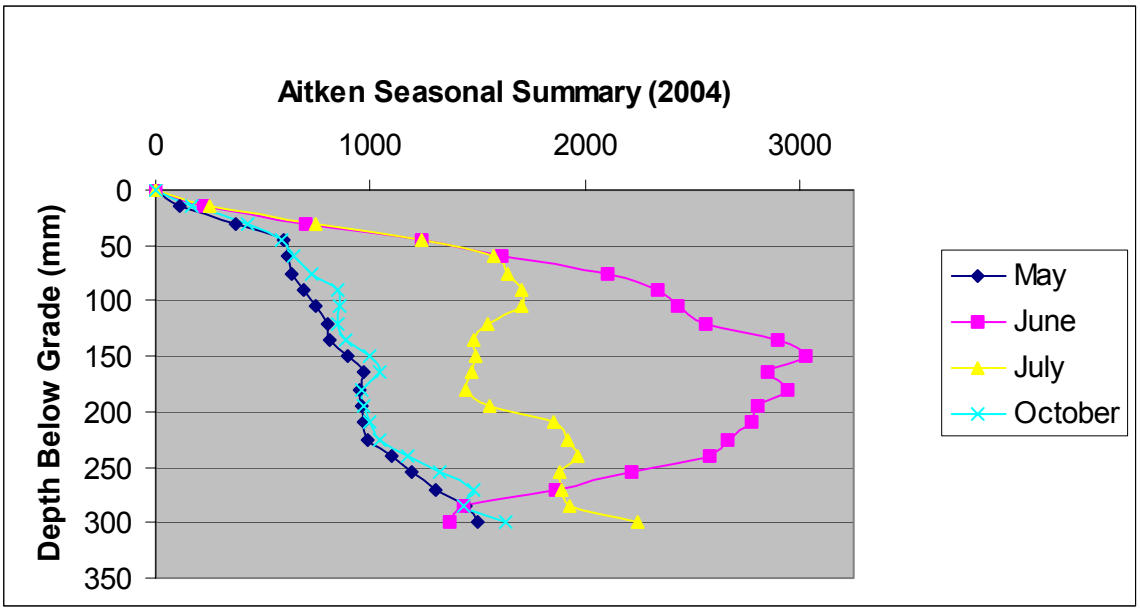


Figure F: Summary of continuous soil mechanical resistance on the control plot at Aitken over the 2004 season

Nitrogen mineralization:

N immobilization often occurs subsequent to the addition of nutrient poor residues (i.e. wood chips) as microbial populations access N during decomposition of the residues. To assess the potential need for fertilization at "incorporated" plots, mineralizable N (min N) was determined as an index of N availability following a 7-day anaerobic incubation period at 40°C. Samples were collected from Aitken for only the control and the incorporated plots. The results (summarized in Table G) indicate that there was no significant difference in mineralizable N between the two plots. Further nutrient analyses will be conducted on other samples to confirm fertilization requirements in the 2005 season.

Table G: Summary of Mineralizable N and Two Sample t-Test Results

	Control Min N (mg/kg)	**Incorporated** Min N (mg/kg)
rep 1	4.69	12.30
rep 2	12.28	10.38
rep 3	3.95	6.66
rep 4	6.65	11.27
rep 5	13.28	10.81
AVG	8.17	10.28
VAR	18.80	4.61
STDEV	4.34	2.15
T Test p-value	0.3671	-

*t-Test probability (p) determined using Microsoft Excel for two-tailed, two sample unequal variance

Tree survival and growth:

The number of survivors was determined by subtracting dead trees and unlocated trees (i.e., destroyed, dead, or missing) from the total number of pine or spruce trees planted per plot (72). Early tree growth data indicate severe competition (vigorous clover and grass cover) affected survival at Aitken. This is observed in Figure H (below) by the lower survivorship at this site, particularly in the control plot. Tree height growth was pooled between sites and summarized in Figure I below. No major trends were identified, and therefore it may be too early for treatment affects to have influenced seedling growth. Low survivorship and growth was expected in plots where cattle damage had occurred. Although not apparent given the available data, this trend may be realized during the 2005 season.

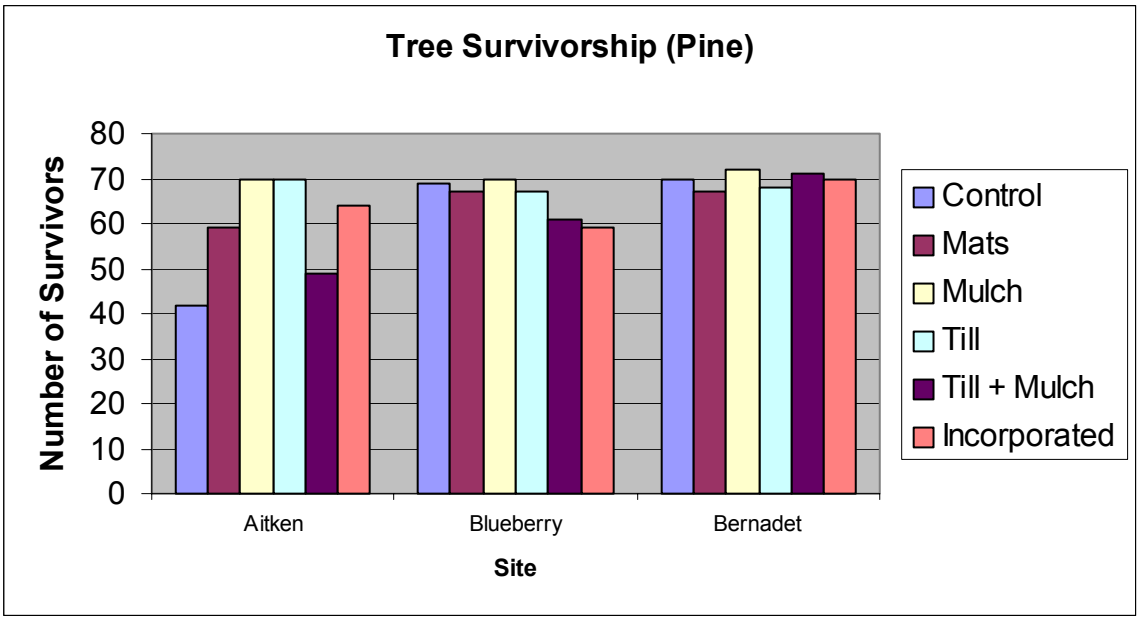


Figure Ha: Summary of pine survivorship

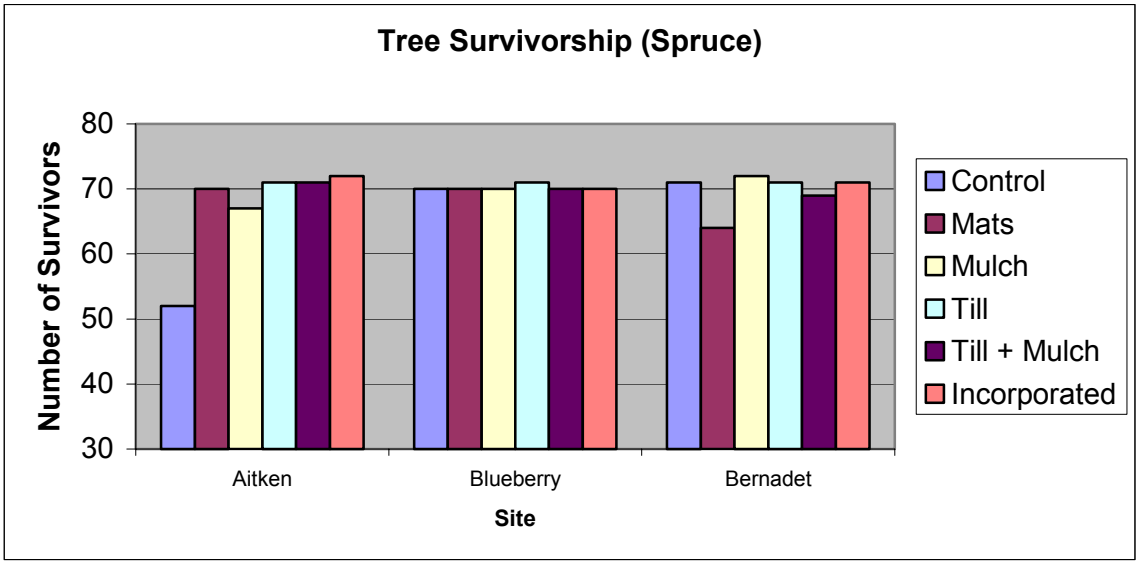


Figure Hb: Summary of spruce survivorship

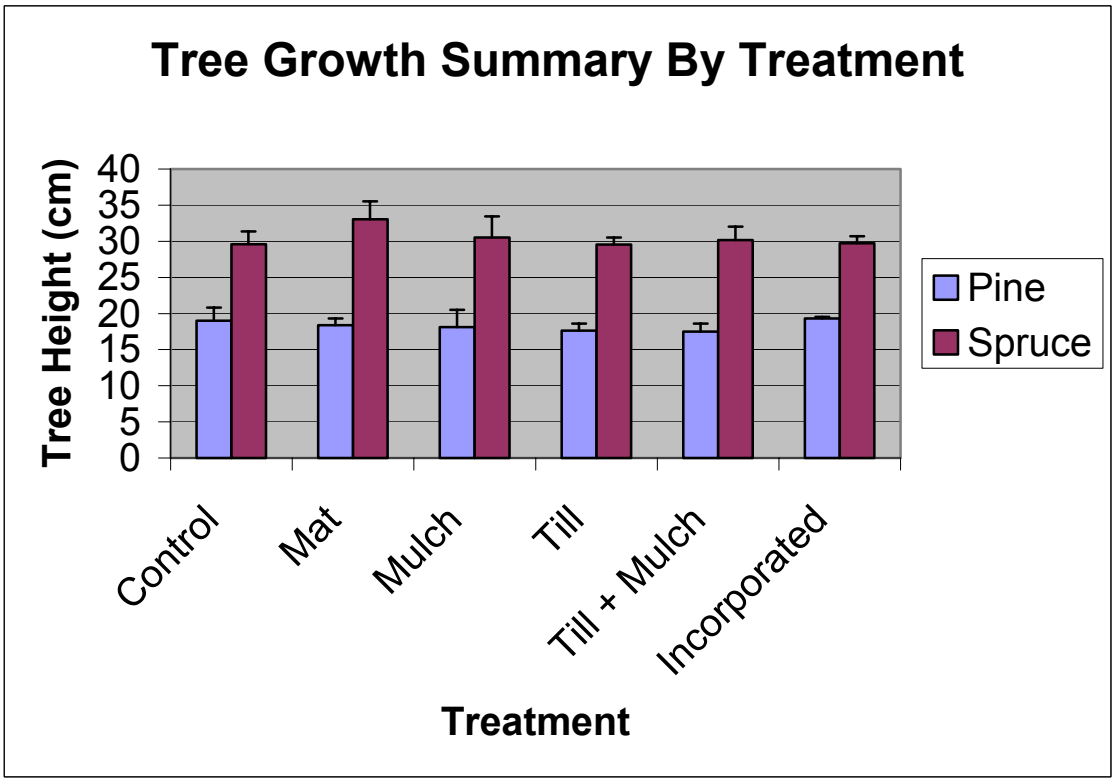


Figure Ia: Summary of pooled tree growth data by treatment for both pine and spruce

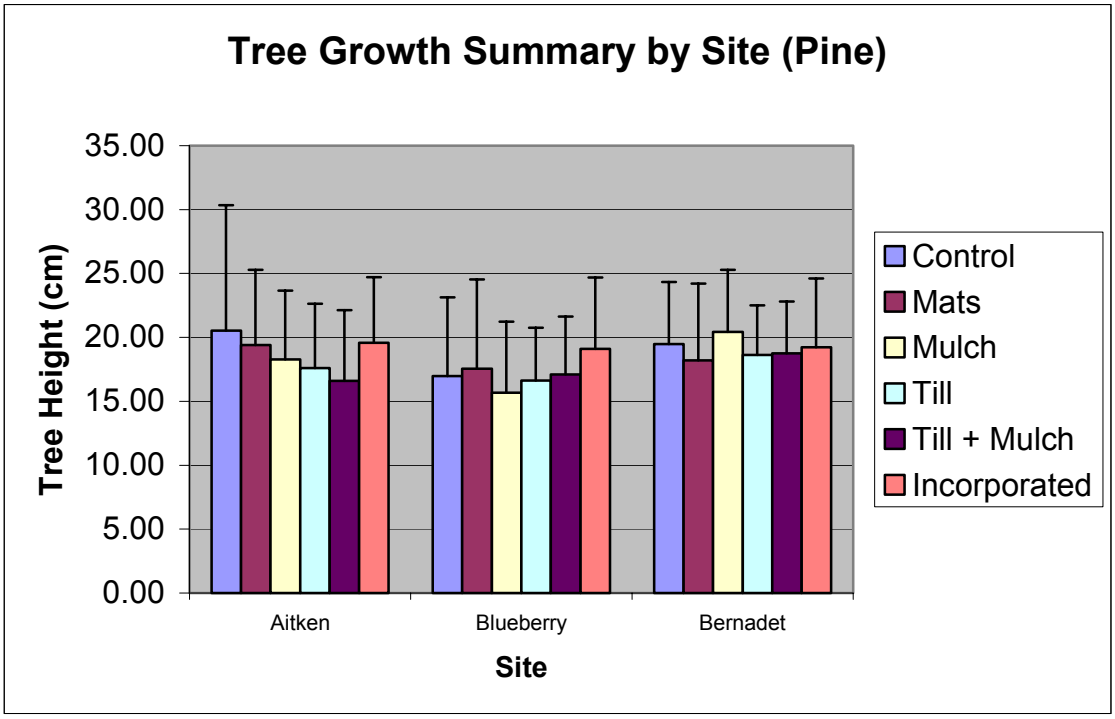


Table Ib: Summary of tree growth data by treatment for pine

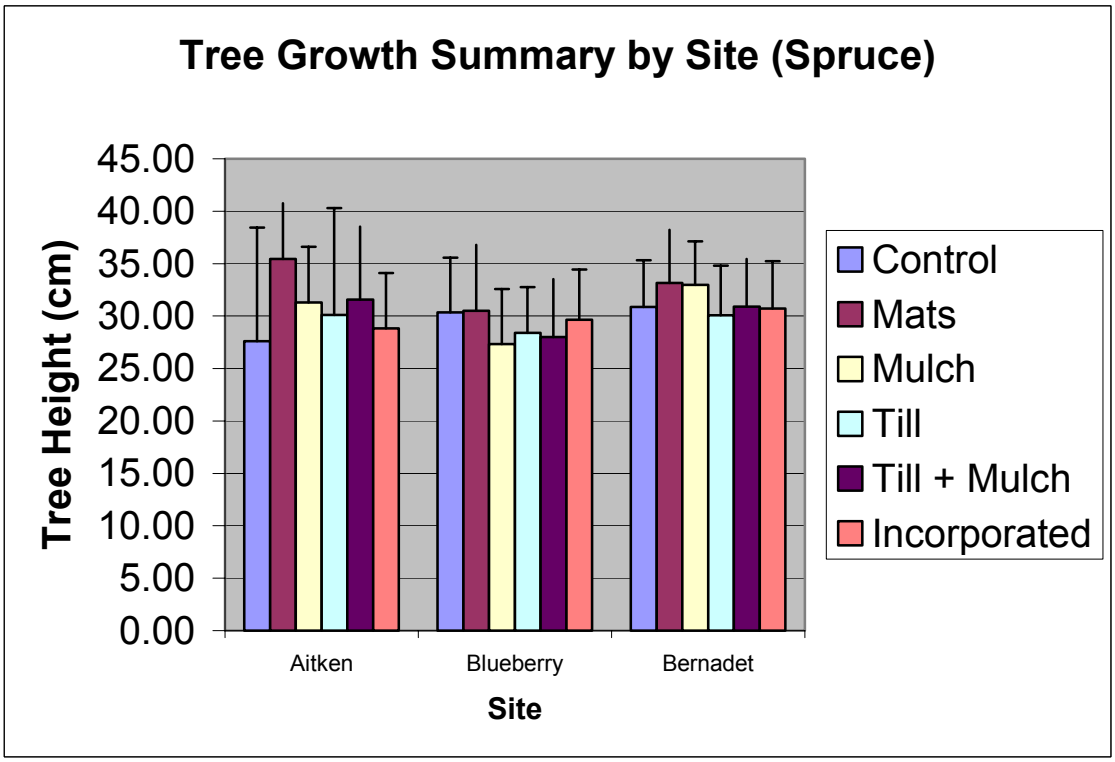


Table Ic: Summary of tree growth data by treatment for pine

Wetter sites treatments planned for 2005:

Soil treatments in 2005: Our plan is to treat wet sites in 2005. The prescription involves simple mounding to provide enhanced aeration, warmer temperatures for roots and lower water content for planted conifers. Our plan is to create approximately 150 mounds per wellsite, and to plant seedlings (Sx and Pli) on the mounds, and in adjacent portions of the lease without mounds in spring 2005. If we are able to obtain larch or black spruce seedlings, we will plant some of those as well.

Mounding treatments are planned for the following sites:
93-P-8-d10f; 93-P-8-b37d; 93-P-1-c100k; 93P8 A-1-D; and 93P8 D-33-E,

Conclusion and summary:

In 2004, we completed site treatments on two additional mesic sites, planted five mesic sites, and carried out soil monitoring and tree growth monitoring. Our initial observations allow the following preliminary conclusions:

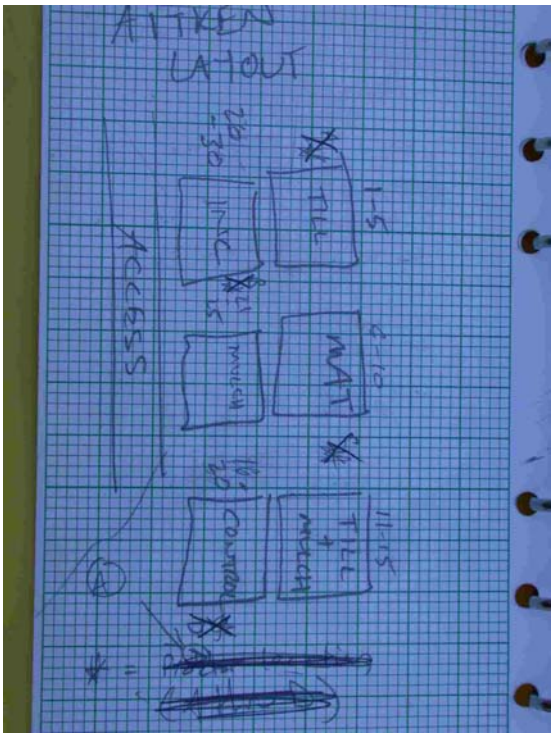
- Soil conditions indicate the sites represented a range of soil conditions for coarse fragment content and soil bulk density. Further evaluation in 2005 will indicate the extent to which these conditions reflect those observed in the previous retrospective study and also what is generally expected for abandoned and COR'd sites in the area of the Fort St John and Dawson Creek map sheets.
- A general trend towards reduced bulk density on tilled plots and those receiving organic amendments was observed. This trend is expected, and we will continue to evaluate in 2005 the extent to which this trend is reflected in other soil properties of importance for plant growth, including water retention, aeration status and mechanical resistance.
- Seedling survival was high for the three plots we measured. Vegetative competition from seeded cover crops reduced survival at the Aitken plot. The use of brush mats, combined with some manual vegetation control led to reduced mortality, as did till age treatments along with manual vegetation control. There was less evidence that vegetation competition reduced survival at the Bernadet and Blueberry sites.
- Although significant cow damage was observed on the plots at Blueberry and Bernadet in the fall of 2004, the impact on first year survival and growth of pine and spruce appears to be small. The effect on subsequent survival and growth will be evaluated in future years.

In addition to completing site treatments and planting on wetter sites, our monitoring plans for 2005 include:

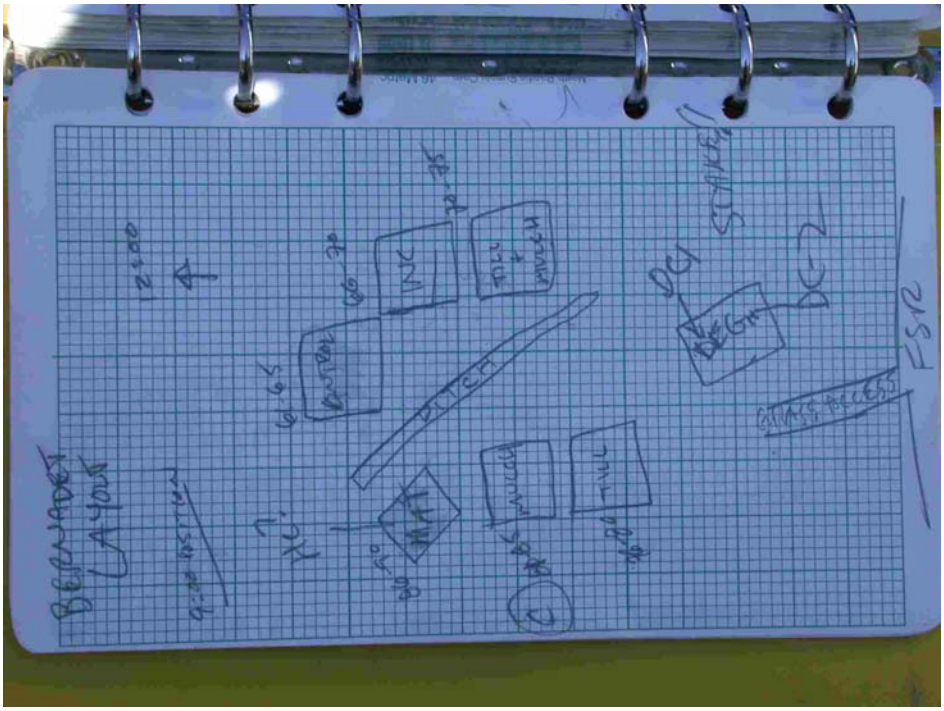
- Continue with monitoring of soil physical conditions and their variation throughout the growing season
- Collect bulk density and water retention samples from remaining plots at Blackhawk and Boot Lake sites
- Complete laboratory analysis of samples collected in 2004
- Monitor tree growth and survival after 2 growing seasons
- Carry out data analysis on all data, and prepare a final report
- Present a poster at the BC Reclamation Symposium in Abbotsford in September.

Appendix1. Final plot layout sketches and soil sampling locations

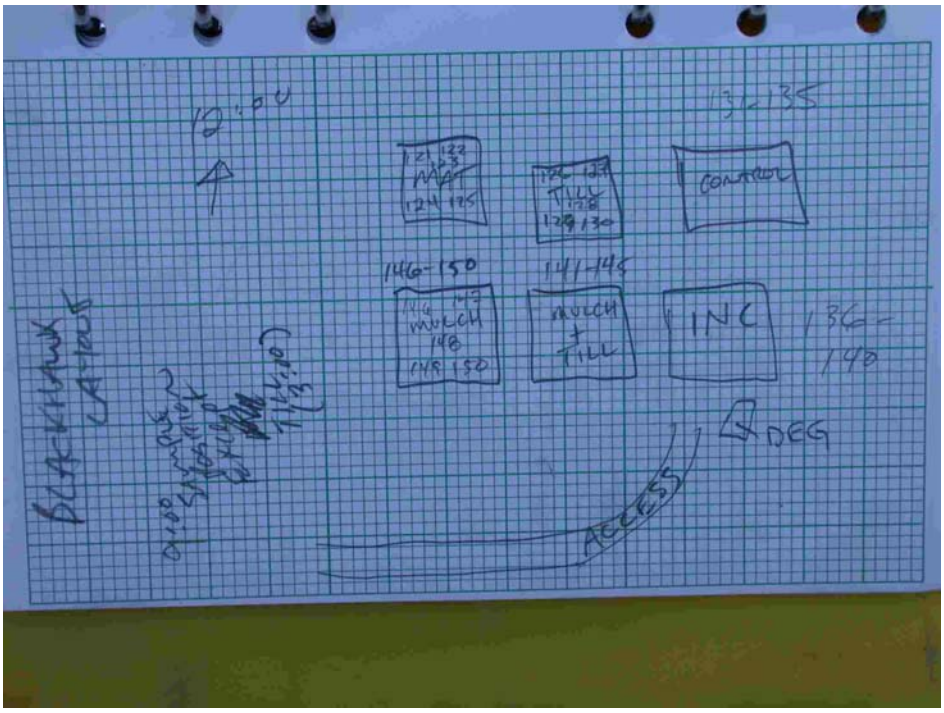
Aitken



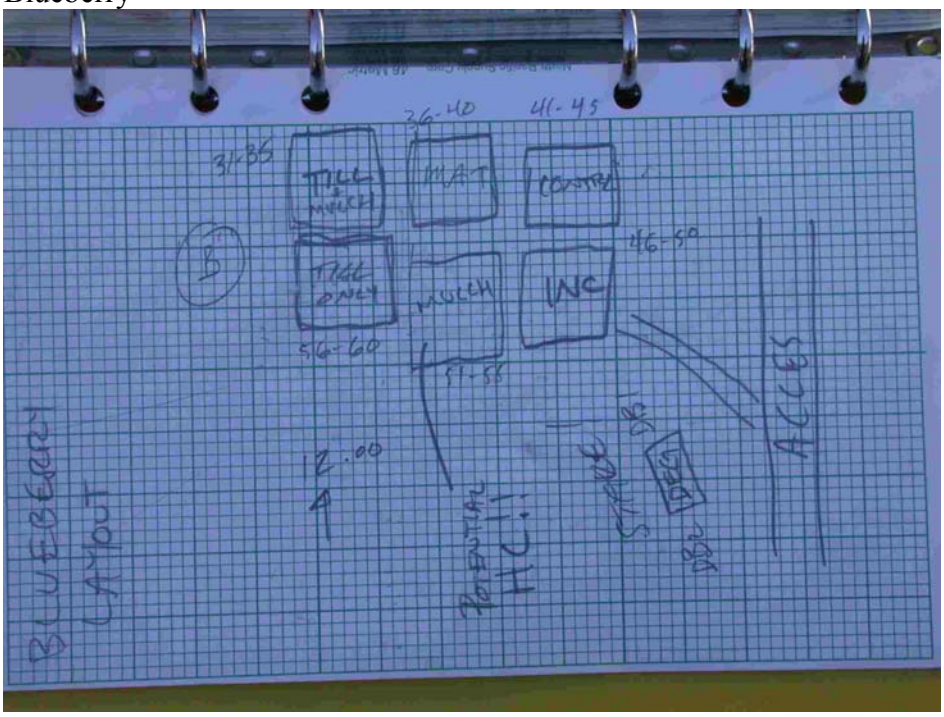
Bernadet



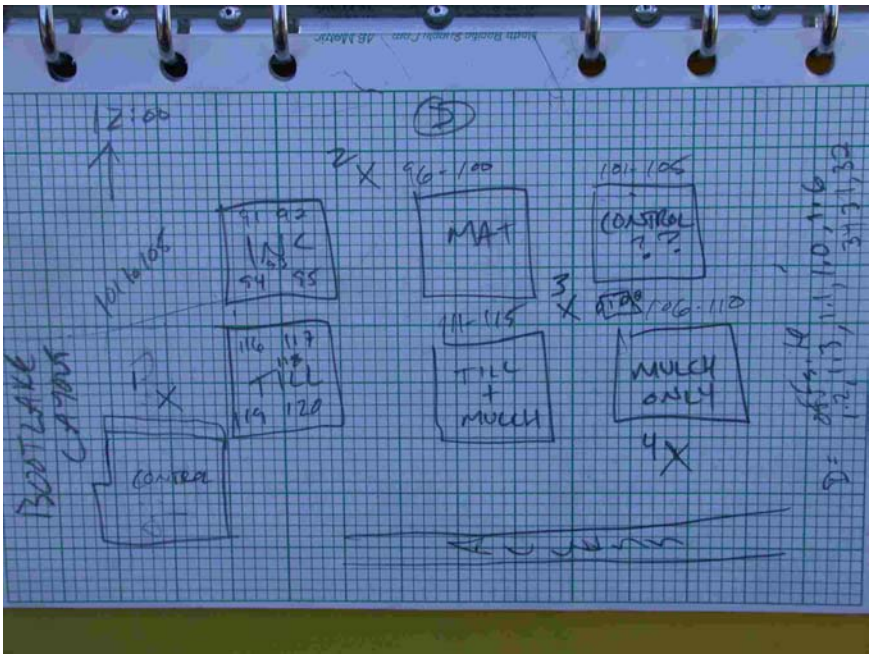
Blackhawk



Blueberry



Boot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Appendix 2. Measurement methods

Tree measurement methods:
Trees were measured in the fall after shoot growth had stopped. Height was measured from the base of the root collar to top of bud to the nearest cm. Tree condition was recorded (poor / medium / good / no tree / dead), competition staus (high / medium / low), wildlife presence (high / medium / low), wildlife type comments, etc.

Odd numbered tags were used for pine, even for spruce, in the following pattern:

Location:

Aitken (16-4-88-22)	1-1000
Blueberry(10-14-88-25)	1001-2000
Bernadette (8-36-87-25)	2001-3000
Boot Lake (a-1-D)	3001-4000
Blackhawk Lake (d-33-E)	4001-5000

Treatment:

Untreated	1-150
Untreated with Brush Mats	151-300
Untreated With Chips	301-450
Ripped	451-600
Ripped With Chips	601-750
Ripped With Chips Incorporated	751-900

Soil measurement methods:
In the Spring of 2004, five sampling stations (denoted as "soil pit" in Figure A2.1) were laid out on each plot where all samples and measurements would be taken over the course of the season. Prior to recording soil mechanical resistance (using hand held penetrometer) and volumetric water content (using a Theta probe) at each station, a fresh face of the soil would be exposed to facilitate measurement at a depth of 10 cm. Further excavation was then completed to a depth of 18 cm where soil water content was again measured. Continuous soil mechanical resistance was also measured using a Rimik Penetrometer from 0 cm to 30 cm at each station. Prior to recording each reading, care was taken to avoid areas that had been previously measured. Soil mechanical resistance and water content were measured in May, June, July, and October at Aitken, Blueberry, and Bernadet. Due to delayed treatment, the Boot Lake and Blackhawk sites were only measured in June, July, and October.

In October, 2004, bulk density and water retention characteristic cores were collected at all of the plots. Cores were collected adjacent to the stations at their prescribed depths for bulk density cores (0-7 cm and 10-17 cm) and water retention characteristic cores (2-4 cm and 12-14 cm). It should be noted that due to a delay in site treatments for the Blackhawk and Boot Lake sites, the "tilled", "till + mulch", and "incorporated" plots will not be sampled for bulk density, water retention characteristics, and nutrients until May 2005.

Figure A2.1. Tree planting and soil monitoring plot layout for mesic sites