Cooperative Management of Alberta Historic Lodgepole Pine Trials

Data Recovery and Management Progress Report

Thompson Nunifu, Jim Stewart and Richard Yang
5 May 2003

Table of Contents

1 Introduction

1.1 Background

1.1.1 The partners

The Canadian Forest Service (CFS) has been establishing research trials to evaluate the growth response of lodgepole pine to thinning and fertilization in western Alberta since 1938. Analysis and interpretation of the results of these trials has provided a significant contribution to our understanding of lodgepole pine growth and yield and silviculture, and this knowledge is currently used in operational forest management. Ongoing research that builds on this research legacy supports one of the major Science and Technology priorities of the Canadian Forest Service, namely to evaluate and enhance Canada's ability to practice sustainable forest management and to develop techniques to enhance timber production.

As a managing agency, the Lands and Forests Division (LFD) of Alberta Sustainable Resource Development is committed to ensuring the sustainable contribution of benefits to Albertans from Alberta's forests. Since 1960, it has maintained a system of permanent sample plots in lodgepole pine stands in the Upper and Lower Foothills, the Subalpine, and the Montane natural sub-regions. In 1980, it established a trial near Edson, Alberta, to evaluate the effects and interactions of thinning and fertilization on lodgepole pine growth.

The Foothills Growth and Yield Association (FGYA) was established in 2000 as a consortium of 9 companies holding major forest tenures in western Alberta, and administered by the Foothills Model Forest. The mandate of the Association is to continually improve the assessment of lodgepole pine growth and yield in managed stands by forecasting and monitoring responses to silvicultural treatments, facilitating the scientific development and validation of yield forecasts, and promoting knowledge, shared responsibility and cost-effective cooperation.

1.1.2 History of the cooperative

In the mid-1990s, the interest of the federal and provincial forest services in pine silviculture research was at low ebb. Most of the research trials that had been established were no longer being measured and information about the trials and data archives were becoming dispersed. Dave Preslee of Weyerhauser Canada Ltd. at Hinton was very interested in the potential for intensive management of the foothills lodgepole pine resource, and saw that the historic trials were an invaluable source of knowledge for evaluating that potential. To rejuvenate the trials, Preslee recruited Stan Lux of Northern Forestry Centre (CFS) and Stan Navratil of SilFor Consulting, to help re-locate the field plots and collect the archival material. Weyerhauser re-measured many of these trials in 1996 and 1997.

The most visible outcome of this activity was a series of field tours of the Historic Pine Trials in 1999 & 2001 for representatives of LFD, CFS and industry. The tours showcased the research and presented results from decades of measurements, including the most recent.

The tours created a great deal of interest within the industry, as well with LFD and CFS. Discussions on the third tour in 2001 raised the issue of how to protect the trials and extract the benefits of such long-term research. From these discussions arose the idea of cooperative management of the trials, involving industry, research and regulatory interests.

The newly established FGYA played a key role in bringing together industry interest and resources and focussing them on the management of the historic trials. Early in 2002, a meeting between FGYA representatives and Northern Forestry Centre management concluded with an agreement in principle to collaborate in maintaining and utilizing the trials. In a further series of meetings was initiated in the fall of 2001 between Dick Dempster and Hugh Lougheed of FGYA, and Jim Stewart of CFS to work out the details. During this process, Dave Morgan was brought in to represent LFD, along with input from other LFD staff and Richard Yang of CFS. The result was an agreement for collaborative management of the trials that came into effect in July of 2002. The agreement defined roles and activities that address the ongoing protection, maintenance, measurement, data analysis and interpretation of these trials. This document reports on some of these activities, in the area of data acquisition, analysis, and interpretation.

1.2 Project goals and objectives

1.2.1 Synthesis of trial results to date

- **Standardized analysis and presentation of trial results:** The intent here was to ensure that results of the various trials are comparable, comprehensible, and useful to forest managers. Examples of standardization are: the use of common and ecologically-referenced taper equations and site index equations; reporting of merchantable volume using applicable utilization standards; referencing of sites to the provincial ecological classification; standardized thematic presentation of results on stand density management diagrams or other frameworks facilitating comparison and management interpretation.
- **Interpretation of the implications of the results for forest managers**: This component is crucial given the interests and priorities of the FGYA membership and LFD, and the science and technology objectives of the NoFC.

1.2.2 Ongoing measurement and analysis

This task included;

- Scheduled re-measurement of the plots on a prioritized basis;
- Timely compilation, analysis, and distribution of results;
- Periodic update of the synthesis described above.

The various trials were established by different researchers to satisfy different objectives and using different treatments. Although some of these trials were meant to be for short-term studies, most have been permanently established and re-measured a number of times. Opportunities also exist to convert some of the short-term study trials into permanent sample plots with rich sources of valuable growth and yield information. However, to be able to do this, there was the need to take a closer look at these studies.

2 *Methods and activities*

2.1 Data sources and acquisition

There are many lodgepole pine research trials setup over the past years by the Canadian Forest Service. These trials were examined as possible data sources and the most valuable ones (Table 1) were selected. Selection was based on the availability of past measurement data or records. Others were selected based on their potential as sources of useful data in the future. Data from some of these trials were available in electronic formats (ASCII or MS Excel) but stored in separate files. Other trials (e.g. the Swan Lake trial) were available only on tally cards and had to be keyed into electronic form.

The electronic data files were all converted to Microsoft Excel format to facilitate easy viewing, manipulation and cleaning. The Microsoft Excel files of data from the trials identified in Table 1 were retained and are available even though all data sets have been converted into ASCII format.

Table 1. Lodgepole pine field trials

Owner/ No.	Trial Name	Type	Year
NoFC / A34	Mackay	pre-commercial thinning	1954
NoFC / A100	Gregg Burn	spacing	1963/64
NoFC / NOR-402	New Gregg Burn	spacing	1984
NoFC / NOR-405	McCardle Creek	thinning and fertilization	1984-85
NoFC	Swan Lake	mechanical thinning	1977
NoFC	Ricinus	thinning and fertilization	1975
NoFC	Clearwater	thinning and fertilization	1968
NoFC /NOR-008	Teepee Pole Creek	spacing	1967
NoFC /K-57	Kananaskis (K57)	heavy thinning	1941
NoFC	Strachan	commercial thinning	1952
LFD	Sam Takyi	fertilization and thinning	1980

2.2 Data cleaning, organization and compilation

The data cleaning exercise was aimed at examining the individual datasets to detect possible errors and to correct or flag them. The main focus was on height and diameter measurements. There are many sources of errors or problems with individual tree and stand level data. Some of these may be related to recording or data transfer from electronic data recorders or converting files from ASCII to Microsoft Excel format. Data errors can make trees appear to be shrinking (negative growth) or growing more than is biologically possible.

Although errors at the individual tree level can be assumed to average out at the stand level based on the assumption of equal chances of negative and positive errors, analysis at the individual tree level can be problematic. There was therefore the need to identify and correct errors where possible, or to flag the trees with abnormal growth rates so that future analysts can make a decision as to whether to include or eliminate such data.

Data errors were detected primarily using simple graphical plots such as tree height – diameter graphs. Graphs of some of the trials are presented in the appendices attached. Data points appearing to be far removed from the bulk of the points were selected and verified from tally cards or old records. Tree slenderness coefficients (height – diameter ratio) were also used to determine whether tree height, diameter or both were in error. Extremely low or high ratios were indicative of the fact that one or both of height or diameter measurements was in error.

The criteria above detected only measurements that had larger errors. Trees appearing to be shrinking in growth or growing at abnormally high rates but not in the extremes were not easily detected using graphical plots. For plots with multiple measurements, individual tree growth rates (height and diameter) were calculated. Trees with negative growth or extremely high positive growth rates were picked up and verified. For some trees, the errors were corrected. For others, it was not possible to corrected. Such trees were flagged with newly defined codes. The codes, named DBH growth codes and height growth codes were defined as shown in Table 2 below.

Table 2. Definitions of growth interpretive codes for all trials

Code	Definition
0	DBH or height growth looks normal
1	Tree shrinking by more than 1cm DBH or 1 m height per year
2	Tree shrinking between 0.5 and 1 cm DBH or 0.5 and 1m height per year
3	Tree shrinking by 0.5 cm DBH or 0.5 m height or less per year
4	Tree growth greater than 1 cm DBH or 1 m height per year

Data recording errors could be traced back to the tally cards for verification and subsequent correction if the error is the result of wrong keypunch. However, in most plots measured recently, electronic data recorders were used. In such circumstances, it was not possible to verify the suspected errors. Tree condition codes were used to decide if a particular data point was an error. Wherever these source of information on the data point were not available or if the correctness of a measurement could not be decided based on this criteria, a decision had to be made as to what to do with the erroneous measurements. Tree diameter measurements were much more free of errors than height measurements possibly because of the ease in measuring tree diameter.

3 Description of the individual trials

In the subsections that follow, detailed descriptions of the background, objectives, experimental design, and data collected from each trial are given. This information is based on the establishment reports of these trials obtained from the archives. The intention of the detailed description of the background, objectives and the experimental design of each trial is to make available such useful information in one document for easy accessibility.

3.1 The MacKay Trial

The trial was established in 1954 by the Canadian Forest Service in cooperation with the Alberta Forest Service with the objective of determining if pre-commercial thinning of lodgepole pine can improve merchantable volume and quality at a younger age and in thereby shorten rotation and increase annual allowable cut (AAC). This was a thinning trial, setup as follows:

- Three sites were selected based on differing soil types and labeled blocks A, B, and C. These were considered as three replicates.
- Five thinning treatments were assigned to each block: control (no thinning), 5x5 ft, 6x6ft, 6x6ft with a re-thin to 70% BA 15 years later, and 8x8 ft spacing. A sixth treatment, which was established at 6x6ft spacing with the intent of re-thinning at 10 years interval, was later abandoned.
- A fourth block D was established and assigned an un-replicated treatment of 12x12 feet spacing.

Tree Data: This trial has been measured 6 times, in 1954, 1960, 1969, 1979, 1989 and 1996. All trees in the plots were permanently tagged. According to old records on this trial, a large number of tree tags were misplaced in block B, treatment 1 (5x5 feet spacing) between 1954 and 1960. Although tree numbers were reassigned, a lack of continuity exists which future users of the data should note. Though the data from this plot does not show any obvious inconsistencies in the individual tree measurements, quite a number of trees appeared as missing trees in the 1960 re-measurement year. This plot may not be suitable for individual tree level growth analysis.

Archived notes on this trial also suggest that treatment 4, block B site was disturbed prior to the 1989 measurement. This plot is no longer a valid treatment replicate to be used for analysis, even though trees continue to be measured. Old records on this trial indicate that all tree heights and diameters measurements were taken in the imperial (feet and inches) units. They were later converted into the SI units. Also, tree DBH was measured at 1.37m and not the usual 1.30m. It is however, not clear if the same standard was used in the later measurements. Nevertheless, this should not be much of a problem, as it does appear to be the same system used in the other trials such as the Gregg River and the Teepee Pole Creek trials. It should also be noted that only trees bigger than 1.54cm in diameter were retained and measured in this trial.

Tree damage code, height to live crown, crown radius, and crown class were also recorded in addition to tree height and DBH. Johnstone (1981) stated that only 30 trees were selected for height measurement for each plot in the trial. For growth analyses purposes, heights of the other trees will have to be predicted by a height-DBH function. Damage codes are available only for measurements taken from 1989 and later. These codes have been converted to the system used by the Alberta Lands and Forest Division. The definitions of these numeric codes are based on the January 2000 edition of the permanent sample plot field procedures manual.

Site Data: From information available, the eco-site of this trial is LF D1 Pine / Ledum / Corncan. There are no details as to how the eco-site classification was done. Future measurements may consider giving a little more detailed classification. Classification at a resolution less than plot level is desirable since eco-site conditions in some of the plots may not be uniform.

Plot Data: Plot level information such as legal location (legal subdivision, section, range, township and meridian) was not indicated in the data and needs to be included.

3.2 The Gregg Burn trial (1963)

The Gregg Burn trial is a spacing trial that was established in 1963 in a seven-year-old lodgepole pine stand. The stand originated from a 1956 wild fire. The objective of this trial was to evaluate the effects of spacing on early stand growth on poor, medium and high sites and develop size density and yield relationships as a basis for density management guidelines for lodgepole pine. The trial was set up in a randomized complete block design with five spacing treatments per block (200, 400, 800, 1600 and 3200 stems per acre). Two blocks were established per site (6 blocks in all). In each block a sixth treatment was established in 1996 as the control where no spacing was applied. Plots were permanently demarcated and contained 100 trees, which were tagged for re-measurements.

Tree Data: There are nine measurements taken in 1964, 1966, 1971, 1976, 1981, 1986, 1991, 1996 and 2001. According to Johnstone (1981), all trees heights and diameters were measured in the imperial units (feet and inches). They were later converted into SI units. Also, tree DBH was measured at 1.37 m and not the usual 1.30 m; however, it is not clear when this standard was abolished. It is certain that measurements taken in the past few years adopted the metric system and the standard 1.3 m as the point of measuring DBH. All plots had 100 trees at establishment; however, mortality and ingress has changed the number of

trees per plot. Only ingress trees bigger than 1.54 cm in diameter were retained and re-measured.

In addition to tree diameter and height, tree tag number, azimuth, x-coordinate, y-coordinate, height to live crown, crown width, crown class, damage codes and health status were also recorded. Tree damage codes were recorded for some of the measurement years, but not for others. Old records show that damage codes were defined differently for different years. However, the definitions of these damage codes were located and all codes were converted into the system used by the Alberta Lands and Forest Division based on their 2000 permanent sample plot procedure manual.

Site Data: Information on eco-site classification is available in the field tour guide prepared by Jim Stewart, Stan Lux and Thomas Braun. In that document, the eco-site for this trial is given as UF d1 – Pine/Ledum. There are no details at the individual plot or block levels. Ecological assessment by Ecotope Consulting (1999) did indicate some variability in eco-site types within some of the blocks. The blocks located in the low site (blocks 1 and 2) were observed to have a soil moisture rating of 4 with soil nutrients varying from poor to very poor. Soil aeration was found to be good. Blocks 5 and 6 which are classified as the medium sites have average moisture rating of 5, poor soil nutrient regime and inadequate aeration. The good sites (blocks 3 and 4) had a lot of variability both within and between blocks. Block 3 had medium to rich soil nutrient regime whilst block 4 had a poor nutrient regime. However, they were both rated 5 for moisture regime.

Plot Data: Plot location information such as legal subdivision, section, range, township and meridian were included in the data from archives. Plots in the various blocks are identified by the spacing treatments they received. In the final database, plots in each block were re-numbered in order of increase stem density, from 1 to 6.

3.3 The McCardle Creek Trial

The McCardle Creek experiment was established in 1983 southeast of Hinton in the Lower Foothills section of the boreal forest (7-5-49-22 W5). The objective of this trial was to quantify the interactive response of thinning and nitrogen fertilization in a mid-rotation lodgepole pine stand, to assess fertilization and thinning effects on stand growth and mortality and to determine the optimum fertilizer regime on the Mercoal soils. The trial was set up as a randomized complete block design (RCBD) with factorial arrangements of 8 treatments and 9 replicates. There are a total of 72 plots in this trial. The factors were thinning and fertilization. Thinning had two levels, thinning (to approximately 2000 stems per hectare) and no thinning. Fertilization had four levels, 0 kg, 180 kg, 360 kg and 540 kg of nitrogen respectively. In addition, a fixed amount of phosphorus was applied to all fertilized plots.

Tree Data: The trial has been measured four times, in 1984, 1989, 1994 and 1999. All trees were permanently tagged. All tree heights and diameters were measured in SI units. The following variables were recorded in addition to tree height and diameter at breast height (DBH); tree tag, tree species code, tree damage codes. Tree damage codes were recorded in some of the years, but not all. The system of damage or condition codes was converted to

that used by the Alberta Lands and Forest Division for their permanent sample plots measurements (ALFD 2000). The present data has no crown measurements.

Site Data: Information on eco-site classification was obtained from the field tour guide prepared by Jim Stewart, Stan Lux and Thomas Braun in 2001. In that document, the eco-site for this trial is given as LF d1 – Pl/Sb/Labrador tea/Feather moss. As with other trials, eco-site classification was done at the trial level not at the plot level. Since evidence from other trials suggest that ecosite conditions can vary within a plot, such details are important.

Plot Data: Plot data recorded for this trial include plot numbers, date of measurements and plot treatment. In the data gathering process, legal location information (to subdivision) was added.

3.4 The Swan Lake Trial

The Swan Lake trial is a mechanical thinning experiment established in the foothills of west-central Alberta in 1976 in a 9 year old dense, fire origin lodgepole pine stand. The objective of this trial was to find cheap and effective ways of reducing lodgepole pine density and accelerate individual tree growth for increased timber production. Three implements were used; anchor chains, Rome disks and shark-finned barrels. They were dragged by a D8H tractor through the study area in one or two directions (the second pass perpendicular to the first to approximate a greater thinning intensity) (Bella 1990).

The experimental design was as follows; the three primary treatments (implements) were randomly assigned to a block of plots, and within each block, treatment intensities (one- and two-pass treatments) were randomly assigned to the four plots (two replicates per treatment intensity). Three plots were established in the adjacent undisturbed area as controls. There were 15 plots in all; 12 treated and 3 untreated controls. Records from archives indicated that this trial was measured in 1988 and 1994. However, no electronic copies of these data were found. Tally cards were located and keypunched into Microsoft Excel.

Tree Data: Records from the archives indicate that this trial has been measured four times, in 1977, 1983, 1988 and 1994. The data looked quite clean and useable largely because most of the data were keypunched and verified to eliminate errors even though a few errors still exist. For this trial, only diameter, height and condition codes were recorded. Condition codes were later changed into the Alberta Lands and Forest Division system of coding (ALFS 2000). The most unfortunate aspect of the data in this trial is that only a few trees (about 25 per plot) were selected, possibly as crop trees, and tagged for re-measurements. It has been suggested that all trees in each plot should be measured starting from the next re-measurement. It is expected that the number of trees per plot will more than triple after the new trees are added. Expansion of the control plots, which were only 3 m by 3 m, has also been suggested to capture more variability.

3.5 The Clearwater Trial

The trial was established in 1968 in a 72 year-old stand of pure lodgepole pine. It was a fertilization experiment following an operational thinning of the stand. The pre-thinning density averaged 2500 trees per hectare with an average DBH of 13 cm. The estimated site

index was 17.4 m at reference age 70. Thinning was a commercial fence-post cutting operation administered in the winter of 1967-68 and supervised by the Alberta Forest Service. The objective of this trial was to redistribute growth on fewer selected trees and to eliminate mortality. Fertilization after thinning was to ensure that only future crop trees benefit from the added nutrients. Thinning reduced the number of trees by about 66%. The treatments (fertilization) were administered in a randomized incomplete block design with three factors (N, P and S) each at three levels. Treatment combinations were replicated three times. Treatment combinations are as shown in Table 3 below. Urea (45-0-0), concentrated superphosphate (0-45-0) and ammonium phosphate sulphate (16-20-0-14) were used to achieve the specified treatment levels. A total of 42 0.04-ha sample plots with 4-m buffers were established.

Table 3. Treatment combinations of the Clearwater thinning and fertilization experiment.

Treatment combination	Nutrients Added (kg/ha)		
	N	P	S
1	0	0	0
2	0	56	0
3	0	168	0
4	112	0	0
5	112	56	0
6	112	56	28
7	112	168	0
8	112	168	28
9	112	168	84
10	673	0	0
11	673	56	0
12	673	56	28
13	673	168	0
14	673	168	28

Tree Data. The data consists of only 2 measurements taken in 1975 and 1996. All trees were permanently tagged for re-measurement. However, there were more trees measured in 1996 than in 1975 possibly because of ingress. All tree heights and diameters were measured in SI

units. Variables recorded in addition to tree diameter and height were: plot number, measurement date (year, month and day), tree tag number, species code, crown length, crown radius, crown class, and damage codes. Tree damage codes were not recorded for some trees. The definitions of these damage codes were cross-checked in the archives and converted into the Alberta Lands and Forest Division system of coding.

It must be noted that although there were as many as 42 plots in the initial establishment report, only a few (15 plots) were measured in 1975 and 1996. The representation of the 14 treatment combinations by the plots relocated and measured may be poor. The data was analyzed by Bella (1978). There is no evidence of recent analysis and checking. However the data look very good. A plot of a height –diameter graphs shows the measurements are reasonable.

Site Information: Information on eco-site classification was obtained from the field tour guide prepared by Jim Stewart, Stan Lux and Thomas Braun in 2001. The eco-site for this trial is given as LF c1 – Pine/Vac-Shepcan/Corncan.

3.6 The Teepee Pole Creek trial

This trial is made up of three sites, one on the flat valley bottom site, and two on north- and south-facing slope sites. The experimental design and plot layout on the three sites are the same as in the Gregg Burn trial. There are 5 spacing treatments with a 6^{th} one established in 1996 as control. In each block (site) there are 2 replicates of each spacing treatment.

Tree Data. Data consists of 7 measurements taken in 1967, 1972, 1977, 1982, 1987, 1992 and 1996. All trees were permanently tagged. According to Johnstone (1982), all trees heights and diameters were measure in the imperial units (feet and inches), which were later converted into SI units. Also, tree DBH was measured at 1.37m and not the usual 1.30m; however, not clear if the same standard was used in the later measurements. Nevertheless, this should not be much of a problem, as it does appear to be the same system used in the other trials. The following variables were recorded for this trial: block number (1 for flat, 2 for North and 3 for South), measurement number, measurement date (year, month and day), replicate number, spacing treatment, tree tag number, tree DBH, tree height, height to live crown, crown width, crown class, species code, and damage codes. Only the 100 lodgepole pine trees per plot left after thinning were tagged and measured prior to 1996. In 1996, trees of other species in each plot were also tagged and measured resulting in more than 100 trees per plot. Tree damage codes were recorded in some of the years, but not in others. The definitions of these damage codes were similar to the codes recoded in the Gregg Burn trial and were assumed to be so. Based on that assumption, the damage codes were re-defined using the Alberta Lands and Forest Division system of classification. The data was analyzed in 1981 (Johnstone 1981). This set of data has also been checked, cleaned and analyzed and was found to be pretty much clean except the last measurement, which has now been cleaned.

Site Information: Information on eco-site classification was obtained from the field tour guide prepared by Jim Stewart, Stand Lux and Thomas Braun. In that document, the eco-site for this trial is given for the flat site only, as UF e1 – Pine/Alder/Corncan. There are no eco-

site designations for the north and south facing slope sites. There is an obvious and dramatic site change in the south-facing site that must be identified and mapped.

3.7 The New Gregg Burn trial (1984)

This trial was established in 1984 on the same sites as, and adjacent to, the 1963 Gregg Burn spacing trial. The objective was to investigate stand development following pre-commercial thinning of lodgepole pine trees at an older age. The experimental design was the same as for the 1963 trial, with some changes in the treatment levels. The levels of growing stock used were, 988, 1977, 2965, and 3954 stems/ha. The extreme levels of the previous experiment (494 and 7908 stems/ha) were omitted and another intermediate level (2965 stems/ha) was added. Thus the trial includes three sites, each containing two blocks of four treatment plots. Control plots added in the 1996 measurement are the same as for the 1963 trial.

Tree Data: The data consists of 3 measurements taken possibly in 1984, 1989 and 1996. All trees were permanently marked and tracked for re-measurement. The measurement years (particularly 1989) are not very certain as they were not indicated in the dataset itself; they were found from old records. All tree heights and diameters were measured in SI units. The following variables were recorded for this trial: block number, tree tag number, tree DBH, tree height, crown length, crown width (radius?), crown class, and damage codes (3 fields). The original damage codes ranged from 0 to 10, with code 99 added later to indicate dead trees. Tree damage codes were not recorded for some trees. In the updated dataset, the damage codes have been re-defined using the Alberta Lands and Forest Division system of classification. Information on eco-site classification for this plot is not available.

3.8 The Strachan trial

The Strachan trial is a commercial thinning experiment established in 1951 in an approximately 80-year-old lodgepole pine stand near Rocky Mountain House (NW 7-38-8-W5). The experiment consists of 9 square blocks of 10 acres size with various thinning treatments (see Table 4). The control block was located in the center of the experimental area in order to be contiguous to every treatment; all other treatments were allocated arbitrarily. Five one-fifth acre plots were established in each block as sample plots, labeled A, B, C, D and E, except the control block which had only 4 plots. There are data from only five of the nine blocks included in the database.

Tree Data: Data available for this trial are from only one measurement taken in 1996. All trees were permanently tagged and tracked for re-measurement. All tree heights and diameters were measured in SI units. The following variables were recorded for this trial: block number, treatment number, tree tag number, tree DBH, tree height, species code, crown length, crown width (most likely crown radius) and damage codes. Tree damage codes were recorded for all trees. Weldwood Canada Limited, Hinton Division provided the interpretation of these codes, which were later converted into the Alberta Lands and Forest Division system. Information on eco-site classification for this study area is not available.

Table 4. List of blocks and treatments of the Strachan experiment.

Block	Block number in database	Thinning treatment	Cut type
1	1	Heavy low thinning	Improvement cut
2	2	Heavy crown thinning	
3	3	Sanitation cut	
4	4	Diameter limit cut	Harvest cut
5		Seed tree cut	
6		Shelterwood cut	
7		Group selection cut	
8		Clear cut	
9	5	Control (no cut)	No cut

3.9 The Ricinus trial

This trial was a fertilization experiment following thinning established in 1965 in a 16-year-old stand, which originated after a 1949 fire. The site index at base age 70 was 18.3 m and the pre-treatment density averaged 12,972 stems per hectare. Thinning reduced densities to about 2125 stems per hectare. Three levels (replicated twice) of fertilization were applied to six 0.04-ha plots. The levels were; no fertilization, 146 kg/ha and 291 kg/ha ammonium nitrate (27-14-0). The adjacent unthinned area was reserved as the control.

Tree Data: Data from this trial consists of 2 measurements taken in 1975 and 1996. All trees were permanently marked and tracked for re-measurement. All tree heights and diameters were measured in SI units. In addition to tree diameter and height, the following variables were also recorded: tree tag number, species code, height to live crown, crown radius, crown class and damage codes. Tree damage codes were not recorded for some trees. The definitions of these damage codes are not known; however, they range from 0 to 19. Damage code 9 seems to indicate the tree is dead. Based on this information and evidence from the archives, the condition codes were re-defined using the Alberta Lands and Forest Division permanent sample plot (PSP) manual. A height-DBH graph of this data indicated only a very few errors.

Site Data: Information on eco-site classification for this plot is not available and should be taken if this trial remains part of the PSP system.

3.10 The Kananaskis (K57) trial

This trial was established in 1949 on a large area of lodgepole pine stands, which originated from a 1863 wildfire and was subsequently thinned in 1941 for fuel wood. The ultimate aim of the thinning was to produce poles and saw logs. In 1949, portions of the treated and untreated stands were sampled to determine the effects of the thinning on growth. An area of 17 acres (12 thinned and 5 unthinned) was selected in a stand of average age of 85 years. Individual tree size distribution indicated that the thinning was quite heavy and from above.

Four one-fifth-acre plots were established in the thinned area and two one-tenth-acre plots were located in the unthinned portion of the selected area. All trees on these plots were tagged and measured for height and diameter.

Tree Data: Data available consists of 3 measurements taken in 1949, 1963 and 1999. All trees were measured for diameter but only a few selected trees were measured for height. All measurements for 1949 and 1963 were made in feet and inches and later converted into SI units. The 1999 measurements were taken in SI units. The following variables were recorded for this trial: plot number, measurement date (year and month), tree tag number, tree DBH, tree height, and species code. Although tree damage codes were not recorded, dead trees have been identified. Information on eco-site classification for this trial is not available.

3.11 The Sam Takyi Trial

This trial is a thinning and fertilization experiment established by the Alberta Lands and Forest Division. The trial consists of two sites, one medium productivity and one low productivity. Stands from these sites originated from a wildfire in 1956. Treatments were applied in 1980 when the stands were 24 years old.

On the medium productivity site (labeled PSP 7008), three nitrogen fertilization rates (0 kg N, 200 kg N and 400 kg N), two nitrogen sources (urea and ammonium nitrate) and 3 thinning rates (no thinning, selective single tree to 1600 tree/ha, and strip thinning to 75% stem removal) were applied, with four replicates in a randomized complete block/split plot experimental design. Treatment units were 32 m by 16 m plots, with 6 m by 22 m (0.0132 ha) sample plots established within each plot.

On the low productivity site (labeled PSP 7009), 3 fertilization (N:0 P:0 K:0, N:250 P:150 K:200 and N:500 P:300 K:400 kg/ha) and 3 thinning rate (as above) treatment combinations were applied with four replicates in a randomized complete block design. Treatment units were 32 m by 20 m plots with 9 m by 21 m (0.0189 ha) sample plots established within each unit.

On both sites, twelve trees were initially tagged in each sample plot. However, in the later measurements all trees were tagged and measured. There was a tagged pattern that enabled the original 12 trees to be identified and numbered 1 to 12 with the numbering of the additional trees starting from 13.

Tree Data: There are about four re-measurements on the original 12 trees per plot; the other trees have been measured only once. All measurements are recorded in SI units. All trees in

this dataset are stem-mapped and measured for DBH, height, height to live crown, crown radius and crown class. Tree condition codes are based on the Alberta Lands and Forest Division condition coding system.

4 Summary, conclusions and suggestions

Data for the 11 trials were obtained from records, archives and from some of the participating members for the Foothills Growth and Yield Association. These data are very useful because of the wide variety of pine stand conditions they represent. For instance, some trials originated from juvenile stands (e.g. the Gregg Burn), and others from mature stands (e.g. Kananaskis K-57), which gives a good representation of age classes. However, in terms of site productivity and eco-site representation, there are gaps that must be considered. A superficial look at the data may suggest that most of the trials are from relatively low productivity sites.

There are some growth and yield issues that also need a closer attention. Variables related to tree mortality or tree condition codes, eco-site characteristics at the plot level, plot location, elevation and aspect need to be considered important as these variables may have significant influence on the interpretation of growth and yield results. Suggestions for adopting a standardized measurement protocol have been made already to facilitate legitimate comparison of results across different trials.

5 *Bibliography*

Anonymous. 1999. Ecological assessment of historical Canadian Forest Service silviculture trial locations. Unpublished consultant's report prepared for Weldwood of Canada, Hinton Division by Ecotope Consulting Services, Vancouver. 32 p.

Anonymous. 1999. The effects of fertilization and thinning on Lodgepole Pine. Unpublished consultant's report prepared for Weldwood of Canada, Hinton Division by The Forestry Corp, Edmonton. 77 p.

Anonymous. 2002. Permanent Sample Plot (PSP) Field Procedures Manual. Land and Forest Division Forest management Branch, Alberta Sustainable Resource Development, Edmonton. 133 p.

Anonymous. 2000. Takyi fertilization x thinning trial, low productivity (PSP 7009). *In* Remeasurement of LFS Trials. Nojack Demonstration Thinning Trials. Takyi Fertilization and Thinning Trials. Unpublished consultant's report prepared for Weldwood of Canada, Hinton Div. by The Forestry Corp, Edmonton. pp 99-101.

Anonymous. 2000. Takyi Fertilization x thinning trial, medium productivity (PSP 7008). *In* Remeasurement of LFS Trials. Nojack Demonstration Thinning Trials. Takyi Fertilization and Thinning Trials. Unpublished consultant's report prepared for Weldwood of Canada, Hinton Div. by The Forestry Corp, Edmonton. pp 22-24.

Bella, I.E. 1972. Growth of young lodgepole pine after mechanical strip thinning in Alberta, Inf. Rep. NOR-X-23. Environ. Can., Can. For. Serv., North. For. Cent., Edmonton, Alberta, 16 p.

Bella, I.E. 1978. Fertilizing after thinning 70-year-old Lodgepole Pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) in Alberta. Fish. Environ. Can., For. Serv., Bi-mon. Res. Not., 43:22-23.

Bella, I.E. 1990. Thinning Lodgepole Pine by brute force: three implements in a decade's perspective. For. Chron., 66:611-615.

Bella, I.E. 1995. Early development of Lodgepole Pine after three different mechanical thinning treatments in west-central Alberta, Unpublished internal report. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, 21 p.

Bella, I.E. and DeFranceschi, J.P. 1977. Young lodgepole pine responds to srip thinning, but . ., Inf. Rep. NOR-X-192. Environ. Can., Can. For. Serv., Edmonton, Alberta, 13 p.

Bella, I.E. and Soos, J. 1975. Early growth response of young Lodgepole Pine to thinning and fertilization in Alberta, Unpublished internal report. Canadian Forestry Service, Edmonton, 14 p.

Crossley, D.I. 1953. Management studies in a maturing Lodgepole Pine stand in the foothills region of Alberta, Unpublished establishment report. Dominion Forestry Branch, Edmonton, 60 p.

Crossley, D.I. 1955. Lodgepole Pine studies at the Strachan experimental block in Alberta, For. Res. Div. Tech. Note No. 19. Dep. North. Affairs Nat. Resour., For. Branch, Ottawa, Ontario, 13 p.

Crossley, D.I. 1955. The production and dispersal of lodgepole pine seed, Tech. Note No. 25. Dep. North. Affairs Nat. Resour., For. Branch, For. Res. Div., Ottawa, Ontario, 12 p.

Crossley, D.I. and Jewesson, R.S. 1952. Economic possibilities of thinning in an 80-year-old Lodgepole Pine stand in Alberta, Unpublished internal report. Dept. Resour. Develop., For. Br., Calgary, 12 p.

Johnstone, W.D. 1969. Thinning young and old Lodgepole Pine stands in the subalpine region of alberta, Unpublished internal report A-25. Dept. Fish. For., Can. For. Serv., For. Res. Lab., Calgary, 19 p.

Johnstone, W.D. 1981. Effects of spacing 7-year-old lodgepole pine in west-central Alberta, Inf. Rep. NOR-X-236. Environ. Can., Can. For. Serv., Edmonton, Alberta, 24 p.

Johnstone, W.D. 1981. Precommercial thinning speeds growth and development of lodgepole pine: 25-year results, Inf. Rep. NOR-X-237. Environ. Can., Can. For. Serv., Edmonton, Alberta, 36 p.

Johnstone, W.D. 1982. Heavy thinning accelerates growth of 77-year-old lodgepole pine, For. Manag. Note No. 16. Can. For. Serv., North. For. Cent., Edmonton, Alberta, 3 p.

Johnstone, W.D. 1982. Juvenile spacing of 25-year-old lodgepole pine in western Alberta, Inf. Rep. NOR-X-244. Environ. Can., Can. For. Serv., Edmonton, Alberta, 23 p.

Kolabinski, V.S. and Lux, S. 1985. Effects of spacing 25-year-old Lodgepole Pine in West-central Alberta. Unpublished establishment report. Can. For. Serv., North. For. Cent., Edmonton, 12 p.

Navratil, S. 2002. A lodgepole pine commercial thinning trial in Kananaskis, Alberta: 58-year results, Special Report. Nat. Resour. Can., Can. For. Serv., North. For. Cent., and Weldwod Can. Ltd., Hinton Division, Edmonton, 14 p.

Quaite, J. 1949. The development of a Lodgepole Pine stand following an empirical thinning together with some observations on thinning returns, Unpublished establishment report. Dominion For. Br., Kananaskis For. Exp. Sta., Calgary, 17 p.

Quaite, J. 1950. Severe thinning in an overstocked Lodgepole Pine stand, Silvicultural Leaflet no. 47. Dep. Resour. Dev., For. Br., Calgary, 2 p.

Quaite, J. 1955. The development of a 77-year-old Lodgepole Pine stand following a heavy empirical thinning, Unpublished interim report. Dominion For. Br., Calgary, 9 p.

Smithers, L.A. 1957. Thinning in Lodgepole Pine stands in Alberta, For. Res. Div. Tech. Note No. 52. Dep. North. Affairs Nat. Resour., For. Branch, Ottawa, Ontario, 26 p.

Stewart, J.D., Lux, S. and Braun, T. 2001. The historic Alberta Lodgepole Pine trials tour, August 28-31, 2001. Field tour guide and information manual. Presented by The Foothills Model Forest, Canadian Forest Service, and Weldwood of Canada Ltd.

Yang, R.C. 1985. Effects of fertilization on growth of 30-year-old lodgepole pine in west-central Alberta, Inf. Rep. NOR-X-268. Can. For. Serv., North. For. Cent., Edmonton, Alberta, 15 p.

Yang, R.C. 1985. Fertilization and thinning of semi-mature Lodgepole Pine, Unpublished establishment report, Dec 1985. Northern Forestry Centre, Edmonton, 11 p.

Yang, R.C. 1986. Growth of 25-year-old lodgepole pine after juvenile spacing in western Alberta, For. Manag. Note No. 38. Can. For. Serv., North. For. Cent., Edmonton, Alberta, 8 p.

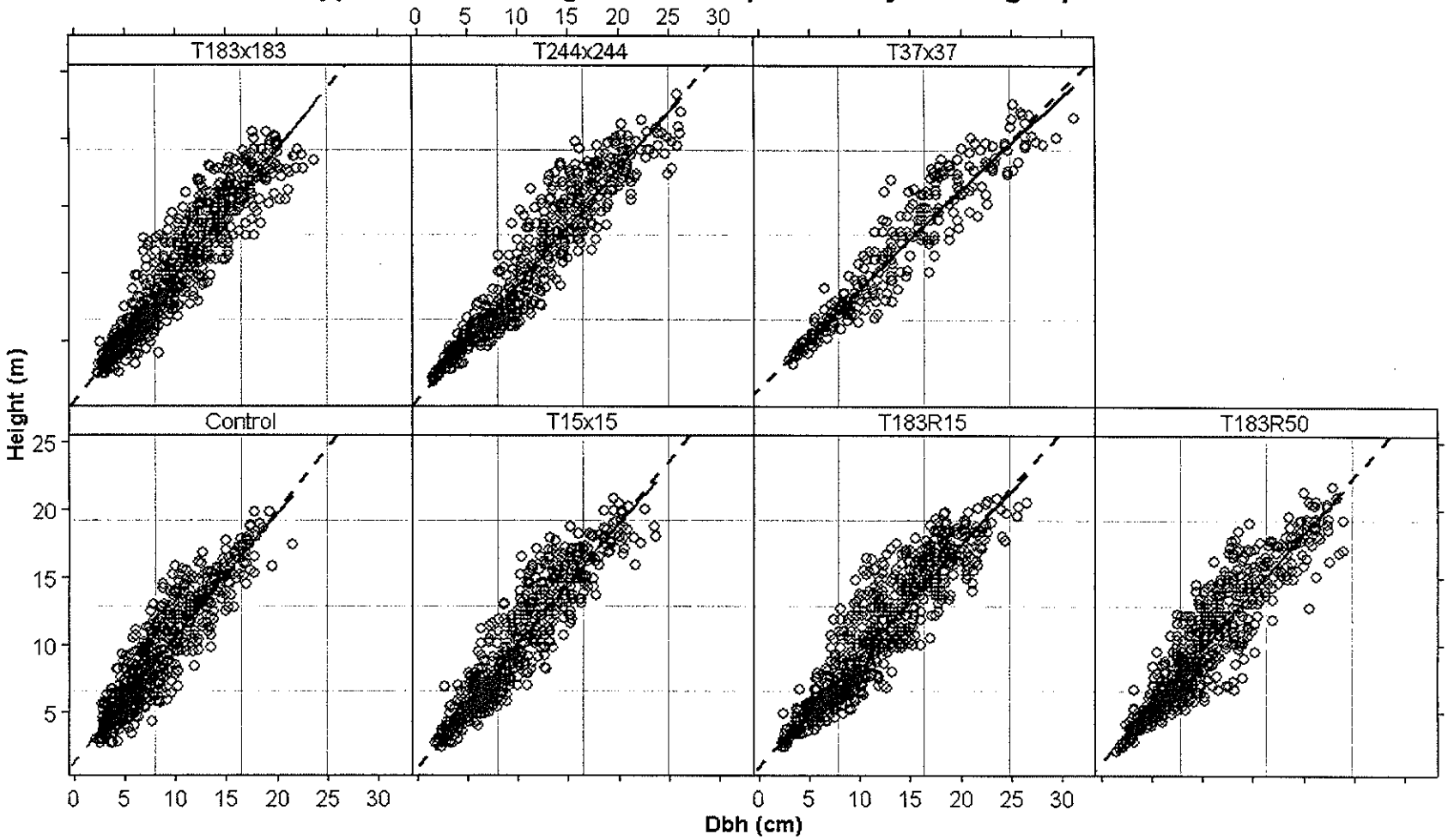
Yang, R.C. 1991. Early stand development of lodgepole pine spaced at age 7 in west-central Alberta, Inf. Rep. NOR-X-322. For. Can., North. For. Cent., Edmonton, Alberta, 18 p.

Yang, R.C. 1998. Foliage and stand growth responses of semimature lodgepole to thinning and fertilization. Can. J. For. Res., 28:1794-1804.

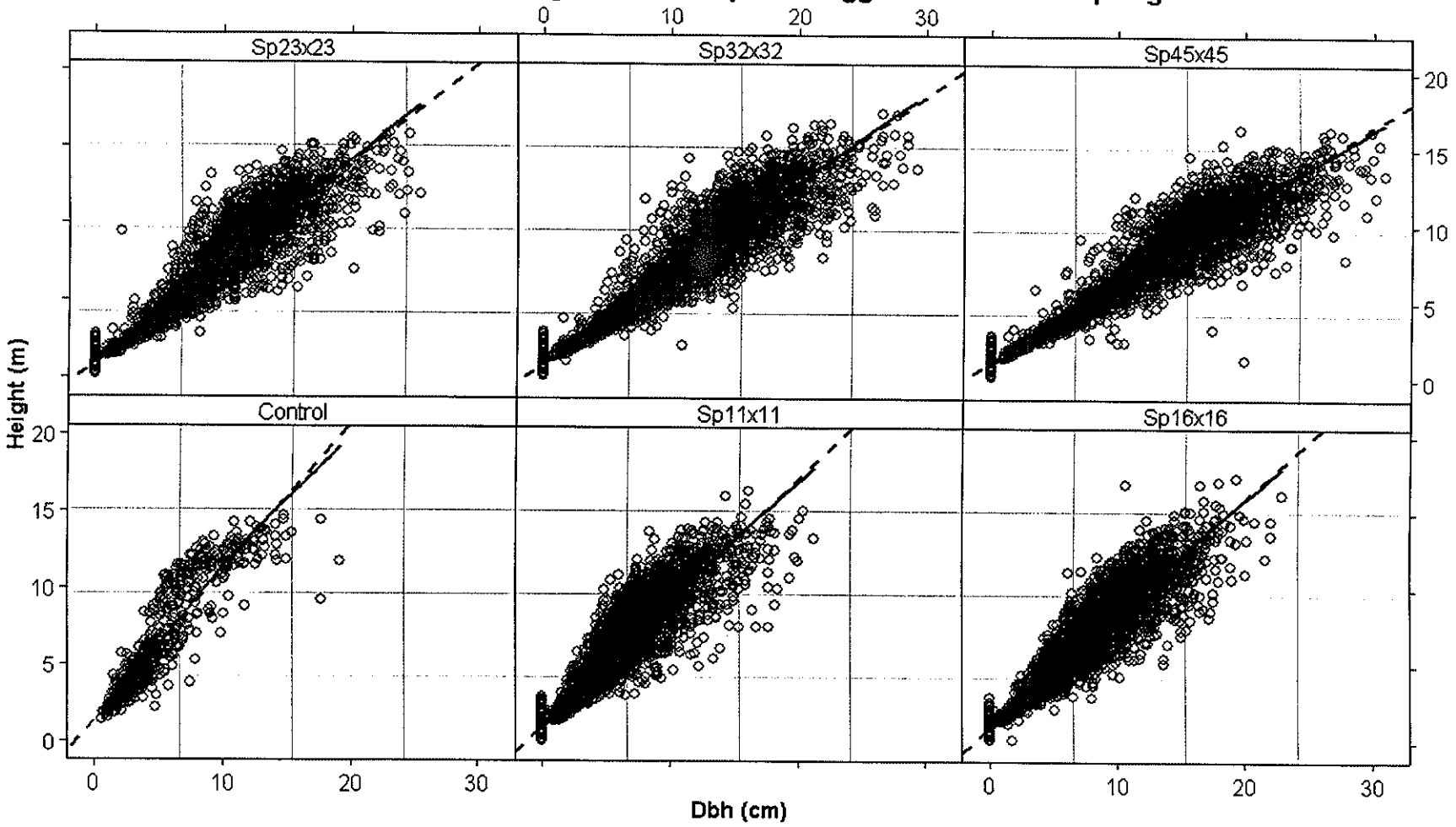
6 *Appendices*

The following are height-diameter graphs from the trials.

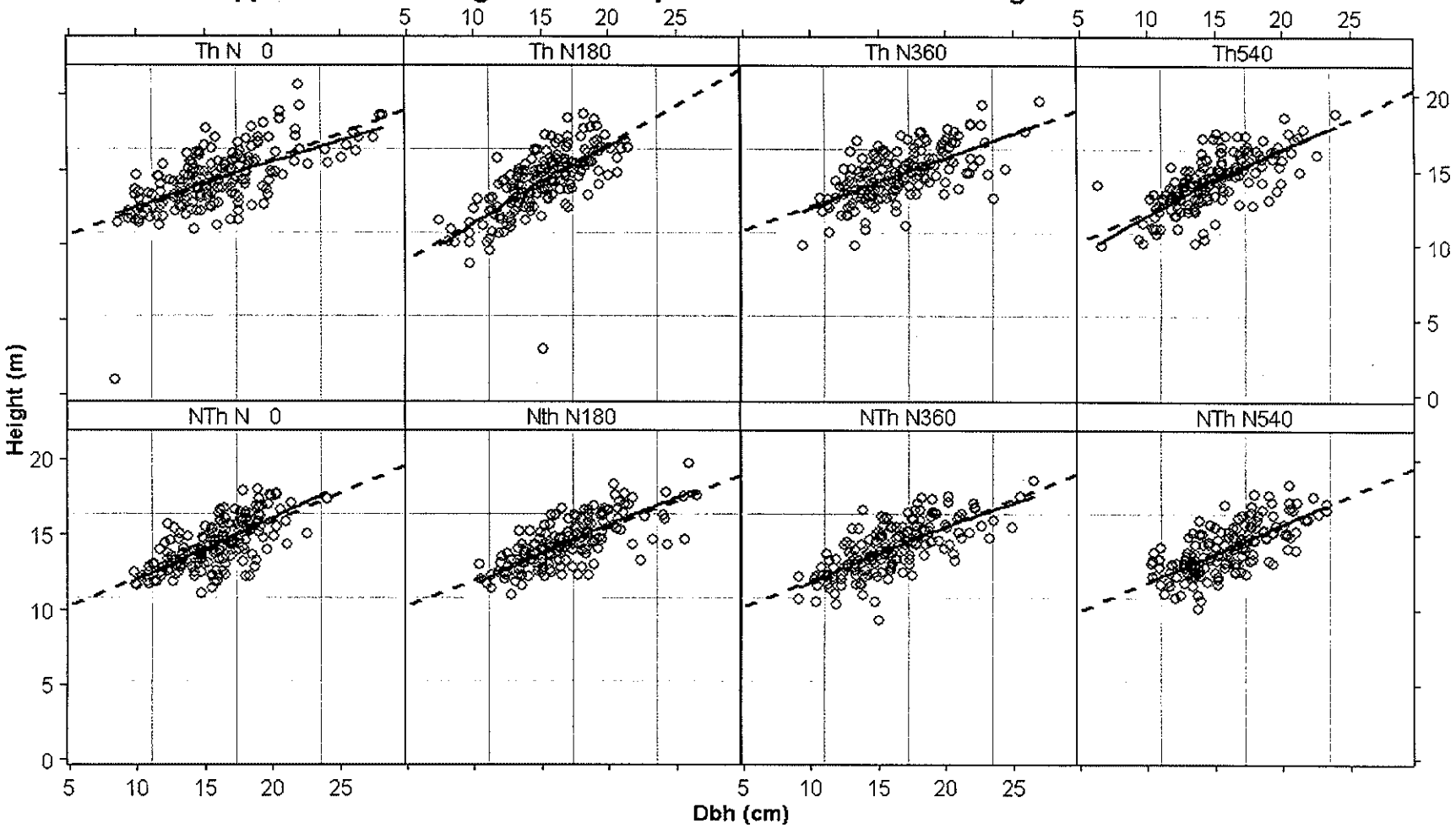
Appendix 1. Dbh-Height relationship -- MacKay Thinning Experiment



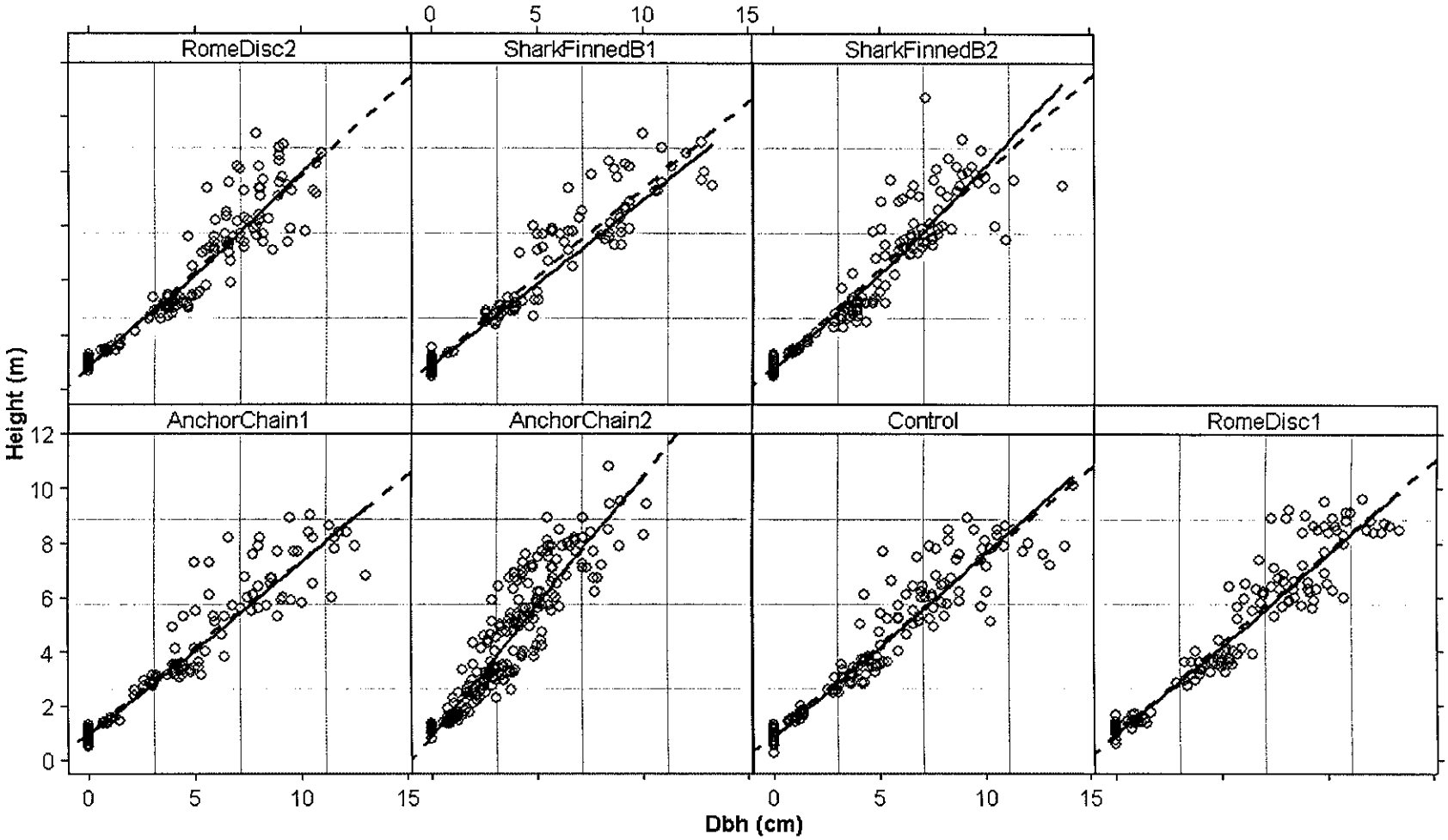
Appendix 2. Dbh-Height relationship -- Greegg Burn Juvenile Sapcing



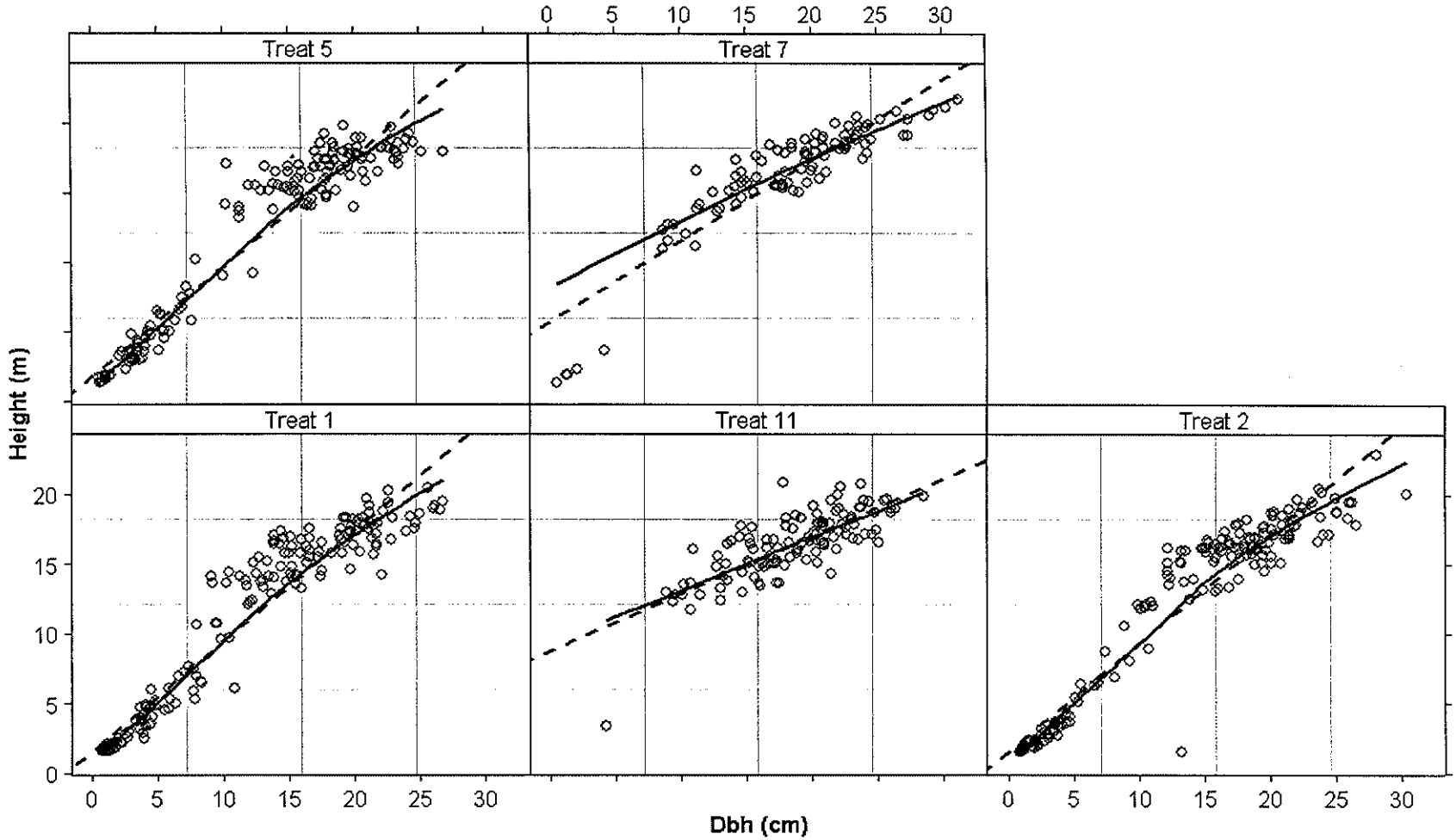
Appendix 3. Dbh-Height relationship -- McCardle Creek Thinning and Fertilization



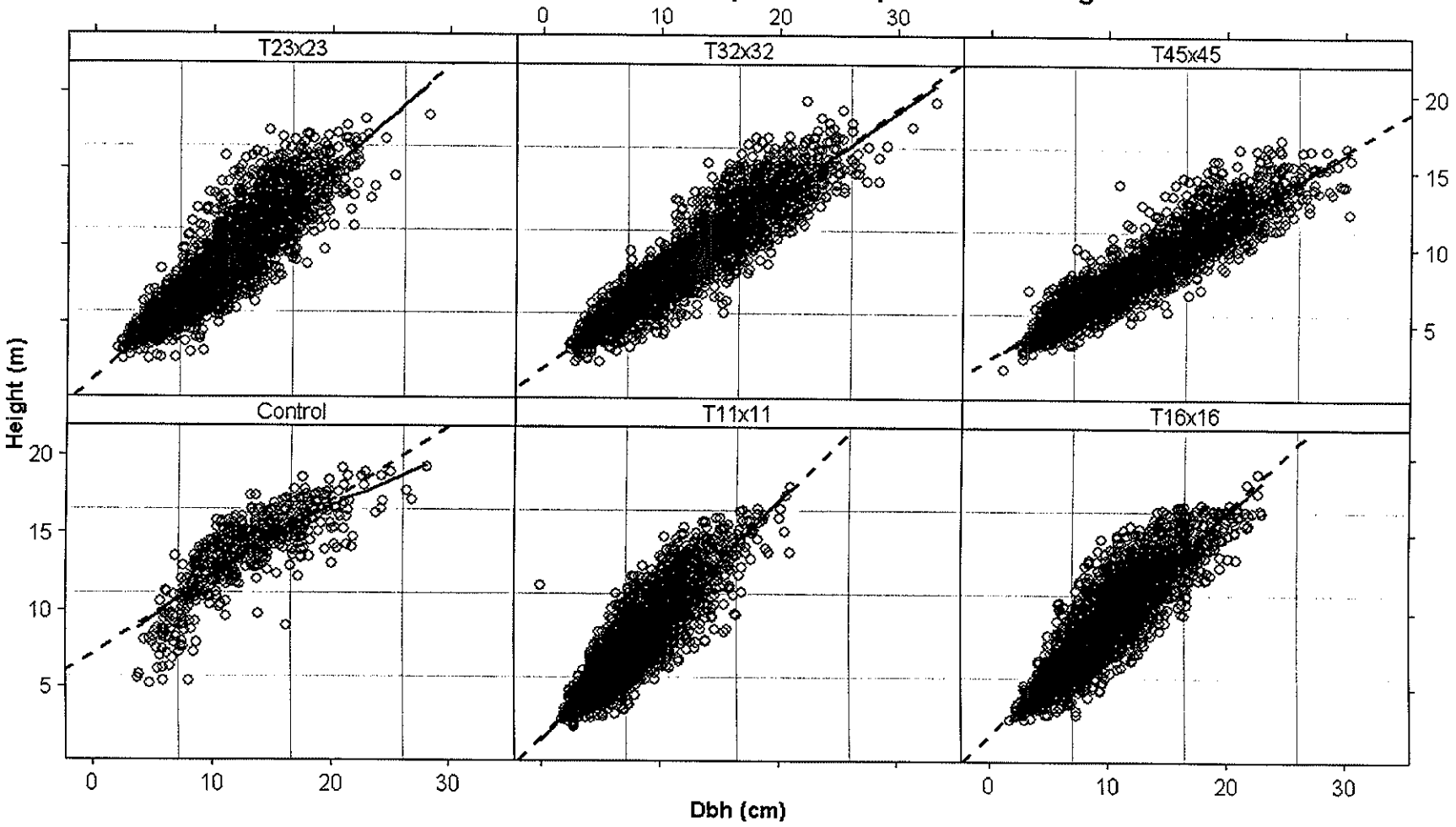
Appendix 4. Dbh-Height relationship -- Swan Lake Trial



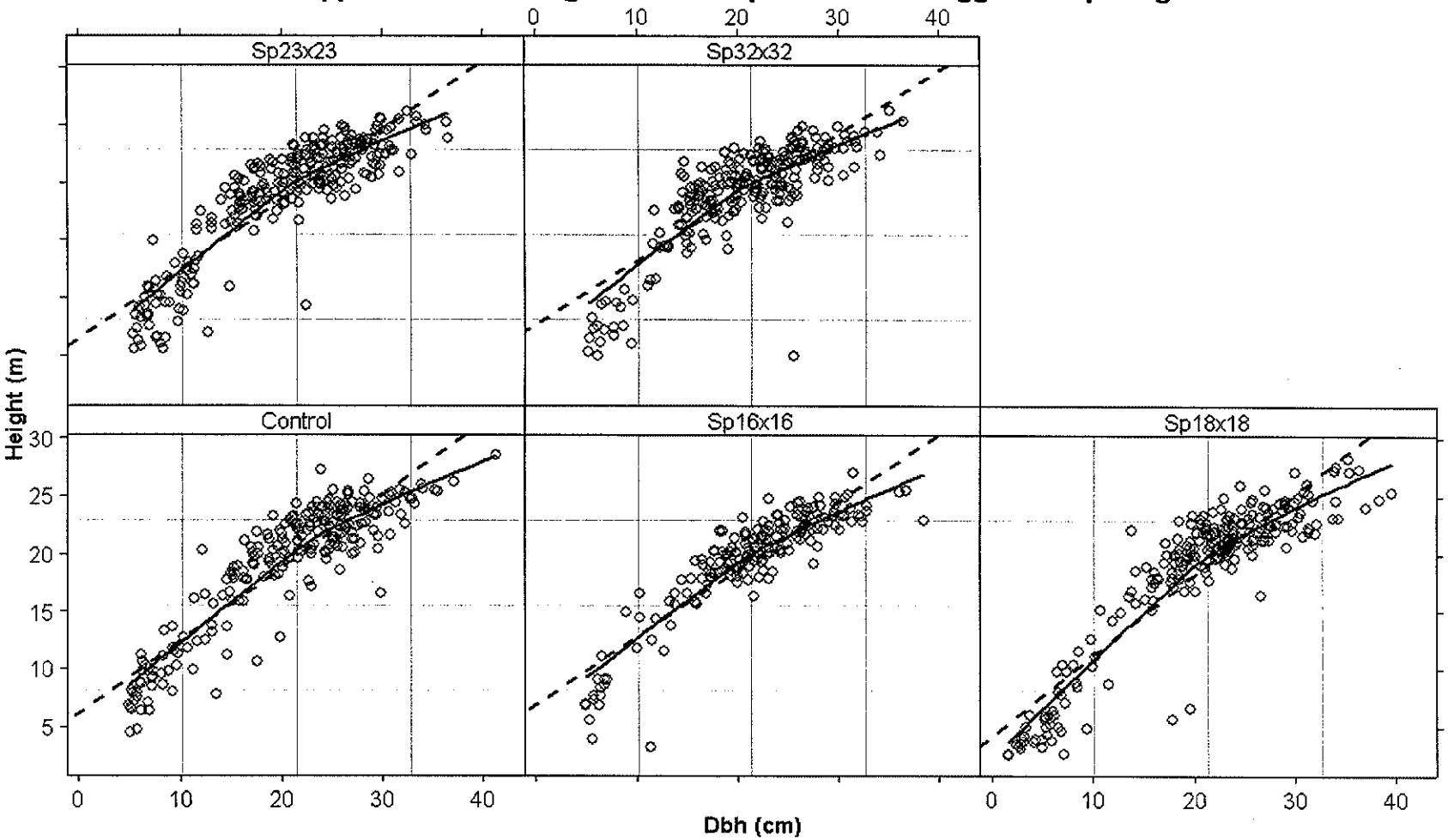
Appendix 5. Dbh-Height relationship -- the Clearwater Trial



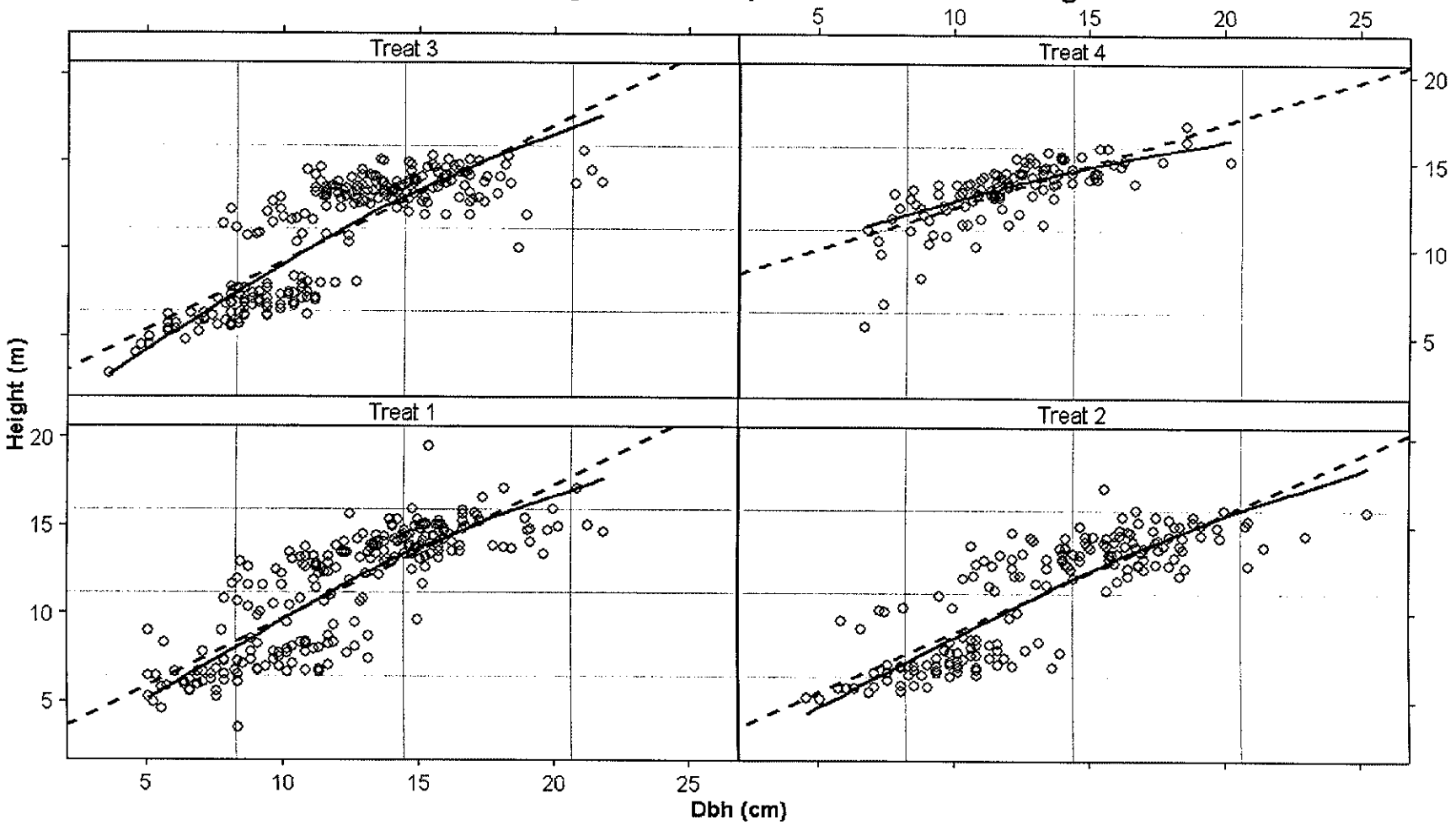
Appendix 6. Dbh-Height relationship -- the Teepee Pole thinning Trial



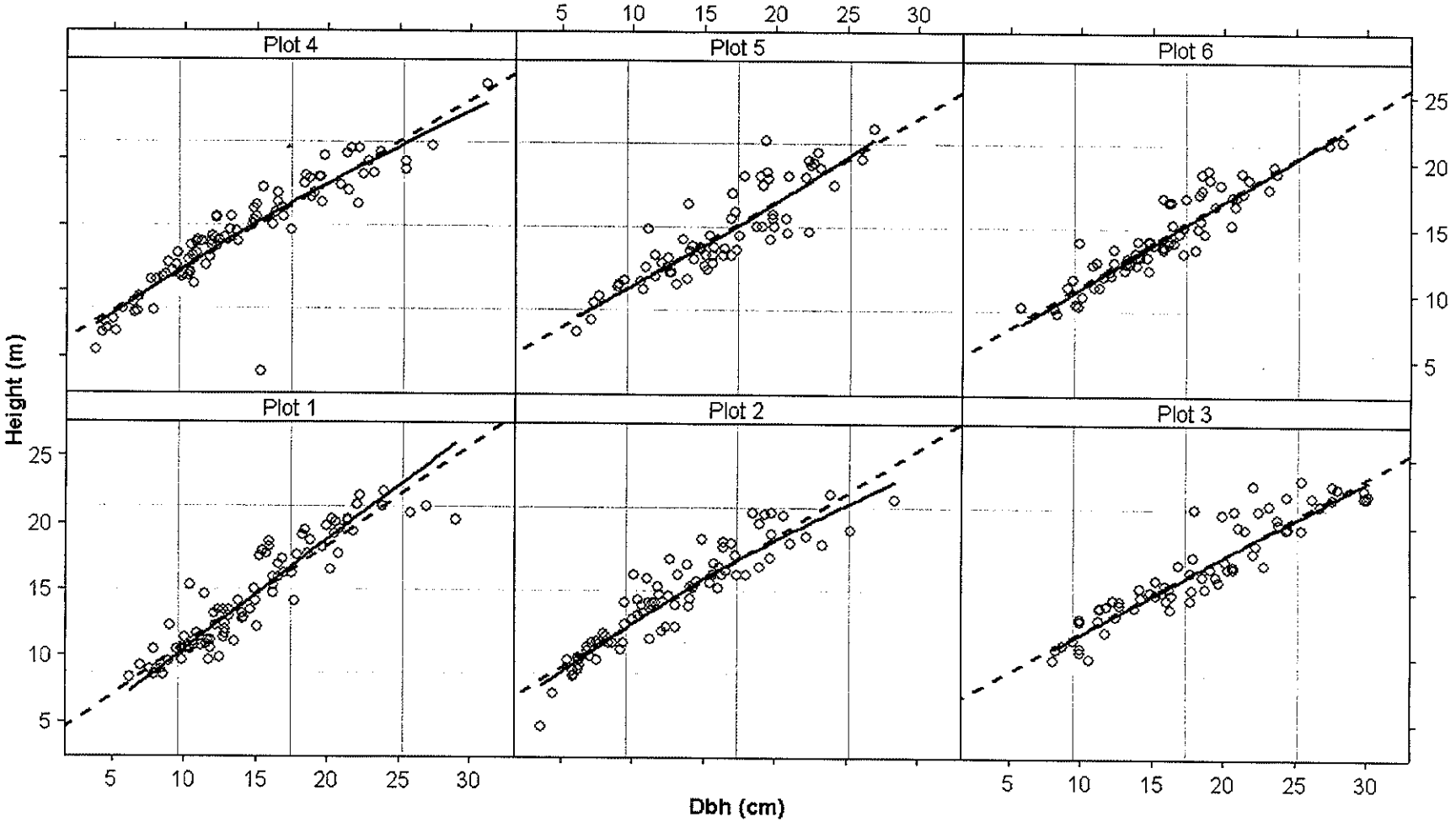
Appendix 7. Dbh-Height relationship -- the new Gregg Burn Spacing



Appendix 8. Dbh-Height relationship -- the Strachan Thinning Trial



Appendix 9. Dbh-Height relationship -- the Ricinus Fertilization Trial



Appendix 10. Dbh-Height relationship -- the Kananaskis Thinning Trial