NZ SCHOOL OF FORESTRY

ABSTRACTS OF UNDERGRADUATE DISSERTATIONS

2006 ONWARDS

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BAYLEY, MARTIN (2006)
PREDICTING RURAL FIRE IN NEW ZEALAND USING THE FIRE WEATHER INDEX

Effective rural fire management requires the correct identification of spatial fire hazards to ensure limited fire prevention and suppression resources are effectively allocated to areas of high priority. This report was written to investigate the predictive strength of the Fire Weather Index in identifying fire hazard.

Using ArcView 3.2a, monthly severity rating grids were analysed both nationally and provincially to gain an appreciation of severity ratings throughout New Zealand. Data from 783 nationwide rural fires, from July 1995 to June 2005, was then imported into ArcView 3.2a for comparison to monthly severity ratings.

Linear regressions were performed between monthly severity ratings and rural fire occurrence, areas burnt, and fire suppression costs. All three regressions produced significant results but with varied in relationship strength. It was concluded that severity ratings are a strong indicator of rural fire occurrence with a coefficient of determination of 78%. Very weak correlations were found between areas burnt, and fire suppression costs, suggesting additional influences other than severity ratings are more important in predicting these elements of rural fire.

These results of this report suggest national resource allocation should be higher in the provinces of Wellington, Tasman, Northland, and in the eastern regions of both islands.

While these results provide insight into the current situation, there is a need to consider future conditions and their implications. Global warming and climate change will have large impacts on the fire risk in New Zealand increasing fire severity, intensity, and season length. Current and predicted land use changes are forecast to increase fuel loads nationwide.

BOWEN, GARETH A. (2007)
THE EFFECT OF THINNING AGE ON STIFFNESS OF *PINUS RADIATA*, IN OMATAROA FOREST

This dissertation investigates the difference in stiffness values obtained from stands thinned at different ages. Field measures were taken in Omataroa Forest, in the Bay of Plenty. The Director ST300, an acoustic time-of-flight tool was used to measure the acoustic velocity in standing trees.

Two different treatment levels were tested: trees thinned at age 7 and trees thinned at age 13. Two stands from each treatment group were sampled, with the average current age of each treatment being 15. Mean acoustic values for the treatments were 3.95km/s when thinned at 13, and 3.84km/s when thinned at 7. A significant ($p < 0.05$) difference was found between the two treatments.

Individual tree variables measured were regressed against acoustic velocity, with fatness (DBH/height), height and DBH all proving significant ($p < 0.05$). These factors were then modelled against acoustic velocity at a treatment level. The inputs into the model were: fatness, height and a dummy variable was created for the treatment. The dummy variable for the treatment was insignificant ($p > 0.05$). This means that once fatness and height have been accounted for, there is no significant difference between the treatments.

Hypothetical rotations were run through the radiata pine calculator (PradCalc_v2.1), to determine if age at which thinning is carried out influences recoverable volume at harvest. It was found for the study site that thinning at age 7 yields 6 m^3/ha more than thinning at age 13, assuming harvest at age 30.

The distance that the Director ST300 probes were placed apart was found to have a significant ($p < 0.05$) negative effect on the acoustic velocity readings obtained.

The main finding from this report is that a significant difference was found between treatments, this was expressed by differences in fatness and height.

BUCHANAN, TODD (2009)
AN ANALYSIS OF TWO STAND EDGE SAMPLING METHODS

Pan Pac Forest Products Ltd approach to pre-harvest inventory sampling is for a plot centre that falls near a stand edge to be moved until the entire plot is within the forest stand boundary. An investigation was carried out to determine if this approach was significantly different from an alternative half plot method with the plot centre located on the boundary. The differences were analysed to gauge the effect on log output predictions. Plots were compared using a paired t-test which tested for differences in the means between each pair of plots. Significant differences were found for all stand variables tested except mean top height. Branching was significantly different between plots. Significant differences for log grade expectations were only seen for P1/P2 ($p= 0.03$) and L1/L2 ($p=<0.001$) grades, with a 40% increase in L1/L2. A stand level analysis also found that the location of edge plots had a significant impact of total recoverable volume estimated for the total stand with the impact generally increasing with the percentage of edge plots. Further investigation is needed to determine if the use of an unbiased edge plot method, such as mirage plots, would also result in significant differences from current practice.

BURNETT, SHANNON (2007)
HISTORICAL DROUGHT OCCURRENCE AND DURATION, AND ITS POTENTIAL IMPLICATIONS ON FOREST FIRES IN NELSON, KAIKOURA AND CHRISTCHURCH

Wildfires in a forest can cause major economic, environmental and ecological damage to both production and native forest. With the prospect of global warming comes a series of changes that the world is likely to experience, including changes to temperature, rainfall and more extreme weather events.

Increased drought is a possible consequence of these changes in weather conditions, and from this the likely change in fire weather conditions. An increase in drought may lead to an increased fire risk. This study considered three regions Nelson, Kaikoura and Christchurch, at the top of the South Island of New Zealand, and how drought conditions were affected; either by occurrence and duration, within and between these regions within the past 40 years.

One climatology indicator, Potential Evapotranspiration Deficit (PED), was used as a predictor of drought, and three fire weather indices (Buildup Index (BUI), Drought Code (DC) and the Duff Moisture Code (DMC)) were used as fire weather measures.

The first factor that was measured was the predictability of the fire weather indices, which are used by forest companies around New Zealand as a predictor of fire. It was found that BUI was the most strongly correlated Fire Weather Index (FWI) with PED. This meant the BUI was the best predictor of drought in the three regions considered.

When considering drought magnitude, it was found that BUI and PED indices for Kaikoura significantly increased during time. The weather variables temperature, rainfall and relative humidity were then analysed for trends.

- The results of this analysis is that the Nelson temperatures and relative humidity are increasing, these changes offset each other, which possibly explains the no change in BUI or PED.
- In Kaikoura, relative humidity and rainfall are decreasing, leading to drier weather and therefore an increase in droughts.
- Christchurch only had one significant change in weather, which was a slight decrease in temperature; this lead to no significant change in BUI or PED.

Drought duration was also looked at, by a count of months that reached a certain percentile in each region. The only significant result found was that Kaikoura has a significant increase in drought occurrence. Neither Nelson nor Christchurch had any evidence of an increase in drought occurrence.

Two natural phenomena in the climate system, the El Nino-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO), have an impact of weather patterns. These weather patterns were considered and it was found that the El Nino weather pattern may have an impact on BUI and PED. These were not extensively investigated, and further research could provide more significant data.

COLES, REBECCA (2008)

THE INITIAL STAGES OF NATIVE FOREST REGENERATION UNDER MATURE SERAL *KUNZEA ERICOIDES* STANDS

The aim of this study is to assess the initial stages of woody forest regeneration under mature seral *Kunzea ericoides* stands. Environmental elements such as aspect, slope, and distance from the gully centres were assessed to determine their influence on regeneration. This study was undertaken in Tiromoana Bush, Kate Valley, North Canterbury. Data for this study was collected from five gully systems, all dominated by *Kunzea ericoides* canopy cover. The entire area has an extensive history of stock grazing (sheep and cattle), which was removed in 2005, but some native forest remnants have persisted. Tiromoana Bush is now under active conservation management.

Regeneration within the gully systems were sampled with linear transects. 2x2 metre plots were established at 15 metre intervals along each transect, with multiple transects used to sample each gully system. Mahoe was found to be the dominant seedling across all plots sampled, and there was no evidence of kanuka regeneration. There was no association

between canopy cover abundance and seedling density (R^2=0.001). Neither aspect or slope were considered key drivers of seedling distribution in this situation. Distance up the slope from the gully centre significantly influenced total seedling density for seedlings >20cm (P=0.001).

It is evident that regeneration is occurring under the seral *Kunzea ericoides* stands at Tiromoana Bush. Seedling abundance has been restricted by grazing in the past, and is now influenced by the distance from the gully centre. Environmental factors other than aspect or slope are likely to be playing a key role in variation between gullies at Tiromoana Bush. Successional processes are evident within Tiromoana Bush, and it is likely that the forest cover will continue to increase with time. Regeneration at Tiromoana Bush is likely to be representative of other native remnants scattered throughout the New Zealand landscape.

COOPER, BLAIR R. (2008)
IMPACT OF THE "WORKPLACE SAFETY MANAGEMENT PRACTICES" PROGRAMME IN THE LOGGING INDUSTRY

An investigation to determine whether or not the ACC "Workplace Safety Management Practices" (WSMP) programme is encouraging and motivating workers to be more health and safety conscious was carried out within the harvesting sector of the New Zealand forest industry. Assessment was made using the results of a survey to compare workers' perceptions, attitudes and behaviours with management systems and procedures, and the "WSMP" audit standards.

Standardised questionnaires were used to survey 39 forest harvesting workers in a person-to-person survey. This was carried out in the greater Waikato region with the sample population coming from five tertiary accredited forestry crews.

Results of this research indicate that:

- Employer commitment to safety management systems was of a high standard, with the null being rejected at $\alpha = 0.05$;
- Workers were consistently identifying, isolating and eliminating hazards, with the null being rejected at $\alpha = 0.05$;
- Information, training and supervision was occurring yet the type of training being offered was narrow and there is room for improvement;
- Incident and injury reporting, recording and investigation is consistently occurring by the workers, with the null being rejected at $\alpha = 0.05$;
- Employee participation in health and safety management is of a high standard, with the null being rejected at $\alpha = 0.05$;
- Emergency planning and readiness occurs at the workers level with 90% of the population able to explain emergency procedures;

These results demonstrate that a thorough implementation of the WSMP (indicated by tertiary accreditation of the Olsen logging gangs surveyed) does encourage and motivate harvesting workers to become more health and safety conscious.

COULMANN, MALTE (2007)
VALIDATION AND REVISION OF CANSPBL_HILLS GROWTH AND YIELD MODEL

CanSPBL_HILLS is an empirical growth and yield model for the Selwyn Plantation Board Ltd (SPBL) foothill estate. Indications were that the model was not performing to a satisfactory standard, especially at low altitudes.

A new dataset was compiled containing measurement intervals from almost all permanent sample plots in SPBL foothill forests. It consisted of 2148 entries from 99 compartments and 603 plots.

Catastrophic morality was removed from the dataset using a mortality severity index (Pinjuv 2006). Validation of CanSPBL_HILLS was conducted using residual analysis. Applied Regression including Computing and graphics (ARC) software was used. The analysis found that the stand variables basal area, mean top height and stocking were all being under predicted, especially at low altitudes. In addition it was found that the basal area model did not have an upper asymptote and predicted negative growth at ages over 30 years. As a result the models needed to be revised.

A new set of equations (CanSPBL_HILLS1.2) were created. The mortality severity index was replaced with an arbitrary cut-off for catastrophic mortality which was set at 15 stems per hectare per year. The model for basal area was a Polymorphic Schumacher III equation with an adjustment to the asymptotic parameter to include altitude in the form of a scaled power transformation. Parameters for the mean top height model were simply recalibrated using the new dataset; the equation remained the same as in CanSPBL_HILLs. The same was planned for the stocking model but it was found that altitude was not a significant predictor. Therefore altitude was removed from the asymptotic parameter of the equation.

CanSPBL_HILLS1.2 showed improved residual distributions and variation compared to CanSPBL_HILLS. It is important that these models only be applied within the range of the data used to build them.

CRONE, TIM (2008)
THE EFFECTS OF AN AUTUMN APPLICATION OF HERBICIDES ON REDWOOD SEEDLINGS

One of the biggest obstacles to establishing redwoods (*Sequoia sempervirens*) is their susceptibility to weed suppression and their sensitivity to herbicide use. There are very few chemicals that can be applied successfully over young redwood seedlings without adverse effects.

A trial was conducted at the New Zealand Redwood Company's Hundalee forest to assess the effects of an autumn application of four herbicides on the health of redwood seedlings. The objectives of the trial were to assess how the different chemicals used, and the rate applied impacted on the health of redwood seedlings.

The chemicals assessed in the trial were Versatill, Gallant, Grazon and Atrazine, each applied at three different rates. A randomised complete block method was used, with a control treatment in each block. The seedlings were assessed eight weeks after application

by being given a score of 1-5 based on the condition of the seedlings' health. Seedlings with curled tips and curved leaves were also recorded.

The analysis of the results showed that Grazon had a significant adverse effect on redwood health at all application rates. Gallant had a significant effect at a high rate, Versatill and Atrazine also may have had some impacts but they were not statistically significant. There was an apparent relationship between the rate applied and the impact on seedling health for all chemicals. However, this was stronger for Gallant and Versatill.

Based on the results of this trial, the use of a mixture of Gallant and Versatill at specified rates may be best to control grasses, broom and gorse, although the impacts of an actual mixture were not assessed. The application rate is critical as these are selective herbicides and applying too much will kill most plants. Atrazine is recommended to provide residual control of grasses and broad-leaved weeds. It is not recommended to apply Grazon to any redwood seedlings. To give an indication of the significance timing has on the impact of the chemicals, further trials should be conducted at a different time of year.

D'ATH, RYAN (2006)

MODELLING THE EFFECTS OF STAND STRUCTURAL, EDAPHIC AND CLIMATIC VARIABLES ON TRACHEID LENGTH IN *PINUS RADIATA*

Data from a nationwide set of *Pinus radiata* site quality plots established at high stand densities and grown over a period of four years were analysed to (i) determine how site, age and fertiliser influence tracheid length, (ii) determine which structural variables were most strongly related to tracheid length, and (iii) develop a simple model to predict tracheid length for New Zealand grown *Pinus radiata*.

Site had a highly significant (P<0.001) influence on tracheid length, which ranged in value from 1.11 mm to 1.79 mm for unfertilised treatments, and 1.05 mm to 1.74 mm for fertilised treatments. Fertilisation did not significantly influence tracheid length, and values of tracheid length in fertilised plots were only on average 2% lower than those in unfertilised plots (1.42 vs 1.39 mm). Age was found to significantly influence tracheid length, with average tracheid length increasing from 1.10 mm for the first two rings to 1.62 mm for rings three to four.

Using ring level data, when fertilisation was included in a model with age and site, it was found to be insignificant, as was the age by fertilisation interaction. A correlation matrix assessing the correlation of stand variables with tracheid length at the ring level found that height was the main determinant of tracheid length. Ring width was tested in conjunction with site, age and height and found to be only marginally significant (P<005), while taper and stem diameter were found to be insignificant when included in a model with site age and height.

Using site level data, a forward stepping procedure selected annual average air temperature, tree height, soil exchangeable potassium and soil carbon to nitrogen ratio as significant variables in the final model. In this model, which explained 63% of the variance in the data, tracheid length was positively correlated with annual average air temperature, tree height and soil carbon to nitrogen ratio, and negatively correlated to soil exchangeable potassium.

DOWLING, LESLIE (2008)

THE EFFECT OF LOG PRICE DISTRIBUTIONS ON FOREST VALUE: A METHOD TO INCLUDE HARVEST OPTION VALUE IN FOREST VALUATIONS

Price distributions for nine log grades were approximated with Weibull distributions in statistical software (SAS Institute, 2002). The predicted log price distributions were used to calculate expected values (by summing log prices multiplied by their probability of occurrence). The expected values were not significantly different from long term average values; showing there is no advantage in calculating expected values for risk neutral forest valuations.
The distributions found for each log grade were then used to calculate a range of values for each log grade. Values were calculated to represent log values from the worst case to the best case scenarios; different percentile ranges of predicted possible log prices were used to find values ranging from risk averse to risk taking. Using risk taking log values in existing forest valuation methods show that with a 30 year rotation an increase in value of over 16% is possible for a range of silvicultural regimes. This extra value is referred to as option value.

The best chance of capturing option value is with an unpruned regime. The log grades produced by unpruned regimes are more volatile and the regime provides a long window where discounted values are close to optimum. Export grades are the most volatile grades and provide the best chance of providing high values inside the regimes optimum value window. Although, unpruned regimes optimum option values occur between 13 and 26 years. Rotation ages greater than 26 years are considered preferable for wood quality (Walker, 2006). Where rotation ages are required to be longer than 26 years pruned regimes provide the best opportunity for option value.

The valuation method used in this study can be used by forest investors to evaluate option value available to them. To capture option value investors will need to time harvesting to correspond with high log prices. A side effect of this is inconsistent wood flow. This needs careful consideration before a commitment to inconsistent harvesting is made.

FARRELL, AMANDA (2009)

A COMPARISON OF REALISED GAIN BETWEEN COMMERCIALLY AVAILABLE GENETIC MATERIAL

Background

This trial was set up by Hancock Forest Managers in 1995 in order to compare the realised gain between 10 different seedlots which were planted on a site in Woodhill Forest, located North of Auckland. These seedlots had growth and form (GF) factors ranging from 19 to 30. The traits looked at were diameter at breast height (DBH), straightness, branch thickness and angle; the number of whorls present to a height of 6m; forks, number of ramicorns and cluster frequency; any malformations which were present, and also the height, density and velocity of selected individuals, which were representative of each plot.

Results

When data analysis was carried out on the measurements, it was found that only seven out of the total 17 traits (more traits, e.g. basal area, were calculated from the measured results) showed significant differences between seedlots at a 0.05 ANOVA level. When Tukey tests were carried out on these significant variables it was found that the DBH and number of

ramicorns were not significant, and so only the ANOVA results were taken into account for these variables. No single seedlot was found to be outperforming the others for all traits, and so tradeoffs had to be made in order to discover the best seedlot to be planted on the site.

Conclusions

Tradeoffs were made in order to find the seedlot best suited to being planted on the trial site. This was found to be seedlot 342, which has a GF rating of 27 – one of the higher ratings planted in the trial. There were, however, several limitations found with this trial, the main being that not every plot contained 66 trees, and there could be possible issues with the velocity data. These are discussed in more depth in the report.

FLANNERY, BRAYDEN (2009)

INFLUENCES OF SILVICULTURE AND GENOTYPE ON COREWOOD ACOUSTIC VELOCITY OF RADIATA PINE

The joint influences of stocking, grass control, fertilisation, genotype and wind sway on the corewood acoustic velocity of 4-year-old *P. radiata* D. Don were investigated in an experimental plot at Rolleston, Canterbury, New Zealand. Acoustic velocity was determined on standing trees using both the Fakopp Ultrasonic Timer and the TreeTap time of flight tools.

Stocking significantly ($P = 0.0098$) influenced TreeTap acoustic velocity measurements, with an increase of 1.44 to 1.51 km/s as stocking increased from 625 to 2500 stems/ha. Genotype had a significant ($P < 0.0001$) effect on TreeTap acoustic velocity measurements, ranging from 1.41 to 1.52 km/s between the 2 extreme clones.

Stocking significantly ($P < 0.0001$) influenced acoustic velocity measurements from the Fakopp Ultrasonic Timer. Acoustic velocity increased from 1.58 to 1.67 km/s with an increase in stocking of 625 to 2500 stems/ha. There was a significant ($P < 0.0001$) interaction between genotype and Fakopp acoustic velocity measurements, ranging from 1.56 to 1.69 km/s between the 2 extreme clones. A significant ($P < 0.0110$) relationship was found between Fakopp acoustic velocity and grass control treatment, where trees that had no grass control had higher velocity than trees with treatment.
Fertiliser and restraining trees from wind sway had no significant ($P > 0.05$) interaction with acoustic velocity measurements.

A comparison of tools found that the Fakopp measurements explained a relatively weak proportion ($R^2 = 0.3648$) of the TreeTap measurements. Reconciliation of measurements found the Fakopp measurements to be highly variable ($R^2 = 0.3409$), compared to TreeTap measurements which were more consistent with an R^2 of 0.9847. Therefore, it is recommended that only the TreeTap tool be employed for reliable acoustic measurements of trees of similar age and size to this study.

The influence of stocking and genotype on acoustic velocity corroborates other research and indicates the potential for the incorporation of these factors into silvicultural regimes and models to help improve the corewood stiffness of radiata pine.

HADDON, SALLY (2008)
HABITAT UTILISATION BY GPS-COLLARED SHEEP, OTEMATATA STATION, NEW ZEALAND

Habitat use by sheep *Ovis aries* will impact upon natural ecosystem functions. Building a better understanding of the relationship between habitat use and environmental patterns will aid in applying sustainable land management practices. This dissertation quantifies the summer habitat use of four merino wethers on Otematata Station, Waitaki Valley.

Four merino wethers were fitted with Televilt GPS collars and left to graze on a 5332 ha alpine grassland block from December 2005 to April 2006. The collars were programmed to record the animal location every 20 minutes, with 34 000 locations logged.

Using ArcMap 9.2, each sheep's home range was determined from the GPS locations and was summarised in terms of landcover, aspect, altitude and slope. The distribution of each of habitat parameter class was represented as a proportion of each home range, representing the expected utilisation of each habitat parameter. The incidence of sheep locations falling on each habitat parameter class was then summarised. The proportion of locations that fell on each class was represented as the actual observed utilization of each habitat parameter.

Landcover was not utilised differently to its proportion in the landscape. The sheep did show a preference for higher altitude (>1500 m.a.s.l.) and flat slopes, however these two parameters may be spatially correlated. Northerly aspects were also preferentially selected for, with a distinct avoidance of southerly aspects. Northerly aspects are warmer than southerly, thus possess higher vegetation growth and better forage.

It is likely that the detrimental effects of grazing sheep within high country ecosystems will be disproportionately concentrated in preferred areas. Sheep can impact on native biodiversity, accelerate erosion, and contribute to nutrient concentration. Land managers may be able to mitigate these impacts through practical measures, and encourage sustainable land use.

MCCALLUM, DANIEL (2007)
THE INFLUENCE OF WIND EXPOSURE ON *PINUS RADIATA* WOOD QUALITY, TREE FORM, AND VALUE IN NELSON AND MARLBOROUGH, NEW ZEALAND

The aim of this study was to test whether exposure to wind (topographic exposure, and altitude) is correlated to a number of *Pinus radiata* tree form, wood quality and value, measures in complex topography. These relationships were assessed as topographic exposure (topex) or altitude may be used as a variable for estimating wood quality and value gradients within a stand (or within a harvesting setting). Furthermore, topex or altitude may be useful in determining the best regime for a particular site.

Two sites were studied, one in the Nelson region and the other in the Marlborough region, New Zealand, both sites were located within Weyerhaeuser New Zealand Inc forest estate. Standing tree stiffness measurements were recorded in 30 plots within each study site capturing a range of different topex scores and altitudes. 2006 pre-harvest inventory data was analysed within each site to test tree form and value relationships.

Significant ($p<0.001$) relationships were found between altitude and wood quality (stiffness), tree form and value variables in both sites. However these relationships differed markedly between sites. Significant relationships ($p<0.001$) were found between variations of topex and stiffness, in both sites, again relationships differed markedly between sites. These relationships were generally weak ($R^2<0.10$). However, stronger relationships (r^2 0.23-0.32) were found between variations of topex and tree form variables in the Nelson site, suggesting a influence of wind exposure variables on ranch size, sweep severity and taper.

MCEWAN, MARIA (2007)
EXPLORING THE RELATIONSHIP BETWEEN FIRE DANGER AND FIRE OCCURRENCE

The New Zealand Fire Danger Rating System (NZFDRS) is used by rural fire managers as an effective tool for preventing and controlling forest, grass and scrub fires. The five fire danger classes display the potential for a fire to develop and spread over a given time. This report was written to provide fire managers with a useful evaluation of the NZFDRS and its ability to determine fire conditions by comparing fire occurrence and the annual area burned with the fire danger class at the time.

Department of Conservation's electronic database of fires for the Canterbury region from 1997 to 2007 and their fire reporting form were used to create two databases that contained the raw weather values and Fire Weather Index System's indices obtained from the National Rural Fire Authority.

Significant analysis of variance and contingency tables showed that within forest and grassland fuels, more frequent and larger fires are occurring when the fire danger is Moderate or Low. Within scrubland fuels, fires were more frequent and larger when fire danger was Extreme. While the NZFDRS only appears to be functioning as expected for scrubland fuels, there are many factors not considered in this research that may explain the discrepancies for grassland and forest fuels. The causes of fires over the ten-year period were also analysed and showed that fires of unknown causes made up 30% and landowners burning off land accounted for 24% of all fires. The results indicated that fire managers may be less prepared in Low conditions and fire danger awareness among the public may be an issue.

Further analysis into the location of fires in regards to access difficulties and response is required to better understand the NZDFRS.

This report has emphasised the issue of data quality affecting analyses. Improved methods of reporting and recording data are necessary for better future analyses.

MCGREGOR, ROB (2009)
DEVELOPMENT OF A CORRELATION EQUATION FOR CLEGG IMPACT SOIL TESTER CBR EQUIVALENT VALUES ON EAST CAPE FOREST ROADS

Forestry road construction in New Zealand varies widely across regions, where each region faces their own unique set of issues, problems and benefits. The East Cape of New Zealand is an area where road building is problematic, with the transport cost of aggregate being the

major issue. The cost of aggregate can be reduced by improving the subgrade, so that less aggregate is required. Improvement can be achieved through many methods, such as chemical stabilisation, compaction and water content management; however, subgrade improvement requires an effective method of testing subgrade strength in the field. A test method widely used for low volume roads is the Clegg Hammer (CIST) – a rapid infield subgrade soil tester.

The purpose of this dissertation was to develop a correlation equation for Clegg Impact Soil Tester - CBR equivalent values on East Cape forest roads. The study was carried out in two phases where 1) a correlation equation was developed between CIV and CBR for subgrades from the East Cape, and 2) the soil type and soil moisture content were assessed to determine whether they had a significant impact on the relationship. Seventeen soil samples were collected from six different forests in the East Cape region. These samples were analysed using the following tests: particle size distribution, dry density/water content relationship, liquid limit, plastic limit, plastic index, CBR test and the CIST test.

The analysis has shown that CBR and CIV correlate well for Gisborne soils. Soil types lean clay and silty clay as well as moisture content type WET had a significant ($P<0.05$) impact on the CBR/ CIV equation. The practicality of the equation is essential for a forestry situation where time and technical expertise in road construction are limited, which is why only the WET variable was included in the equation to predict CBR:

$$\mathbf{CBR = 0.92\ CIV - 3.26\ WET + 0.31}$$

The CIST is not a highly accurate device, but the speed at which you can gain results and the level of simplicity of the tool makes it a great entry level tool to promote a higher understanding of subgrade bearing strength. Through averaging multiple readings, greater accuracy can be achieved.

MARSHALL, WILLIAM (2008)

ENSURING A STEM ACOUSTIC VELOCITY READING CAN BE USED AS A CUT OFF TO ENSURE STRUCTURAL LOGS WILL MEET MILL REQUIREMENTS

This dissertation project explores the relationship between stem and log sonic measures in *Pinus radiata* stems for forests managed by New Zealand Forest Managers (NZFM). The stands studied were in both the Lake Taupo and the Tongariro Prison Farm Forests within the Central North Island in which after statistical analysis, were pooled together. Acoustic velocities were determined to determine structural logs within a stem for three variables. The three variables being (a) 2nd logs, (b) 3rd logs and (c) 2nd and 3rd logs combined.

For this study the hypothesis was: it is possible to use a stem acoustic velocity reading as a cut off to ensure that 80% of NZFM's 2nd and 3rd logs that are delivered to mill customers achieve a 3.0km/sec threshold.

Data collection from both forests required gathering sonic readings for stem and logs. The pattern of sonic velocity up the stem was explored. The focus was on the 2nd and 3rd logs which are typically structural logs. Statistical analysis was conducted to determine if there were relationships between stem and log velocities and whether there were differences between (a) LTAU and TPF forest and (b) 2nd and 3rd logs.

Analysing both forests' pooled 2nd and 3rd logs highlights that when using a stem velocity of 2.96km/sec as a velocity cut off, greater than 80% of the 2nd and 3rd logs will meet a 3.0km/sec threshold.

This dissertation project provided the necessary information to highlight that a stem velocity reading can in fact be used to determine the probability of structural logs within a stem meeting structural specifications. Choosing a practical stem cut off reading will result in a trade off with the major focus being on the percent of logs incorrectly allocated. To meet NZFM's mill customer's requirements, there is currently a leeway of 80% correct allocation for structural logs. It is important to note that being able to cut a structural log, the cut off applies to the 2nd and 3rd logs only.

ORTON, SARAH (2008)
NEEDLE RETENTION AND TREE TRANSPARENCY MEASUREMENT METHODS AND THEIR RELATIONSHIPS WITH TREE GROWTH, TREE HEALTH AND ENVIRONMENTAL VARIABLES FOR USE IN CONDITION MONITORING PLOTS IN TIMBERLANDS LIMITED'S ESTATE, ROTORUA, NEW ZEALAND

This paper explores the significance and strengths of relationships between new measurement variables of needle retention and tree transparency with forest growth (height and diameter), forest health (*Dothistroma* Health Scores) and environmental (site index and LENZ) variables in permanent sample plots in Timberlands Limited's estate in Rotorua, New Zealand. Needle retention is the number of years worth of needles present in the bottom third of the green crown and is measured using a four value scoring system. Tree transparency is measured as the percentage of needles remaining on a tree out of a possible 100%. Two readings are made per tree (whole tree and top half) to minimise the effect of suppression. Scoring is in 5% increments for both readings.

This report found few significant (p-value >0.05) relationships between the variables tested. Of those relationships that were significant, all of them produced weak relationships ($R^2 > 0.56$). Due to the weak nature of the relationships, no attempt was made to model needle retention or tree transparency. The tree transparency measurement methods were found to be subjective and hard to measure in overcast conditions. Also the two readings produced very similar results, which did not fully counter the effect of suppression created by high stocking. Unless a less subjective way (not using an assessor) can be found to measure tree transparency, it is recommended that this measurement method be used.

PARK, DA WOON (2009)
DOCUMENTATION AND ANALYSIS OF CATASTROPHIC WIND DAMAGE IN NEW ZEALAND RADIATA PINE PLANTATIONS

This study had two purposes. The first was to provide an update of historical wind damage records of all regions in New Zealand, and the second was to describe any spatial and chronological patterns of the damage. Over 60 000 ha of damage on large owners' radiata pine forests was collected through a literature review along with a survey.

Average annual % damage was estimated for each region. Four regions had over 40 years of records. Canterbury has the highest average annual % damage followed by Nelson and CNI with Otago at a lower level. The ranking is the same as that found by Somerville (1995) except that Nelson and CNI are reversed although still at similar levels.

There has been a decrease in wind damage in the CNI and Canterbury regions where there have been no wind events causing over 1000 ha of damage during the last 20 years. The reduction in damage in CNI and Canterbury corresponds with a reduction in extreme winds at weather stations at both Rotorua Aero and Christchurch Aero. A more extensive analysis of weather station data is required before wind speed trends can be generalised for the CNI and Canterbury regions.

The majority (50 out of 59) of the recorded events caused damage in a single region. Only one event caused damage in more than two regions. Eight events caused damage in two regions that were usually adjacent. Risk against wind damage can be diversified through establishing a portfolio of forests across different regions.

POULSON, ERIN (2009)
EFFECTS OF SITE PREPARATION ON ESTABLISHMENT AND GROWTH OF NATIVE WOODY SPECIES IN A DIRECT SEEDING TRIAL, TIROMOANA BUSH, NORTH CANTERBURY

The aim of this study is to assess the success of different pre-sowing cultivation methods on the establishment of native woody plants from seed. There were three different cultivation components using a standard plough, a bush bog plough and tyne harrows. Establishment success, average height and maximum height were used as indicators to assess the success of different pre-sowing cultivation methods. This study was undertaken in Tiromoana Bush, North Canterbury. The data was collected from an existing trial set up by SCION in 2007. Historically, the site had been extensively grazed by both sheep and cattle but grazing ceased in 2005. The removal of grazing pressure led to the development of extremely long rank grass swards. Tiromoana Bush is now under active conservation management.

The existing trial was 54 m x 36 m and consisted of six different treatments with three replicates of each. 1x7 metre plots were established in each of the replicates, and seedlings were identified and their attributes were measured. It was found that no seedlings established in any of the treatments apart from those that used a standard plough as the cultivation method. The only significant difference between the treatments that used a standard plough was found to be in the establishment rate of poroporo between the treatment that was mown, had herbicide sprayed then ploughed and the treatment that was just ploughed ($p = 0.037$).

It is obvious that pre-sowing cultivation effects the establishment and growth of native woody plants from seed. Results suggest that under the conditions at Tiromoana Bush (strong summer soil moisture deficits), a cultivation method that turns over and exposes a large amount of bare soil is required for direct seeding to be successful. However, given the small data set further research is required to fully validate the results.

ROSE, KIM (2007)
ANALYSES OF SHIFT PATTERN EFFECTS ON PRODUCTIVITY AND VALUE AT THE KAINGAROA PROCESSING PLANT (KPP)

The Kaingaroa Processing Plant (KPP) is a mechanised central processing yard located in the central North Island of New Zealand. The KP processes over 1 million m^3 of stem length radiata pine into 70 to 80 different log grades annually. The KP operates 24 hours a day, 6 days a week. There are four crews of five operators who work a four day on/four day off shift pattern constructed of two day shifts followed by two night shifts. Each shift is 12 hours long and separated by scheduled stoppages or 'smoko' into three distinct work periods. Shift design and pattern can potentially affect performance of operators. The main purpose of this study is to analyse the effect of shift pattern on productivity and value at the KPP.

Software captures details about every stem that is processed at the KPP and it is this data which was uplifted for the use in this study. The study period was 10th January 2006 to 30th June 2006. The performance indicators assessed were productivity, value, pruned grade production, and chip/industrial grade production. These performance indicators were assessed across week in study period, day in week, shift in day (day/night), period in shift, and consecutively worked days. Piece size is known to have a significant effect on production and therefore was assessed for its relationship with the performance indicators and its variation across the study period.

It was found that all the performance indicators were significantly different across week in study period. However, these indicators all had a significant relationship with piece size and are thought to be a reflection of the increasing piece size across the study period. Night shift was found to be more productive than day shift, however there was no different in piece size to explain this. The night shift was found to be more productive given larger piece sizes and this is thought to drive the difference in overall production across the day and night shifts.

SCOTT, LAWRIE (2008)
SUITABILITY OF NATURALLY REGENERATED *PINUS RADIATA* FOR RE-ESTABLISHMENT IN THE NELSON REGION

The aim of this study is to test whether natural regeneration of *Pinus radiata* densities are significantly correlated with cone count, and other site and management factors. In doing so a regeneration and cone model was developed that can help forest managers predict natural regeneration and cone densities. It is realized that cone counting may not always be feasible, so a model was also developed without a cone variable.

317 plots were assessed over two areas in Nelson Forests Ltd. State. The first was in Golden Downs Forest and the second in Rai Valley/Marlborough Forests. Transect plots representing 0.005 of hectare were used with regeneration, cone counts, and site and management factors being recorded on pot sheets.

Cone frequencies were found to significantly increase with decreasing rainfall, increasing percentages of bare round, decreasing gorse and broom densities, non granite soil types, and decreasing altitude. Regeneration frequencies, when using a model with cone count, were found to significantly increase with the number of cones counted, increasing site index,

decreasing altitude, and decreasing blackberry and bracken height. Regeneration frequencies, when using a model without cone count, were found to significantly increase, increasing site index, decreasing blackberry and bracken height, decreasing broom density, and non granite soil type. The R^2 for the regeneration model with and without cone count was 0.35 and 0.14 respectively. This proved that cone count was the variable that explained the most variation in natural regeneration densities.

SEWELL, ADAM (2009)
EVALUATING VELOCITY VERSUS STOCKING, PHYSIOLOGICAL AGE AND SPECIES IN A NELDER EXPERIMENT

The aim of this study was to evaluate how initial stocking, physiological age of pine parents and species influenced velocity in wood (as an indicator of wood stiffness) in a Nelder experiment located at Rolleston, Canterbury. Velocity and physical characteristics including diameter, height and stem slenderness were investigated for 456 *Pinus radiata* trees two years after planting and 399 *Eucalyptus nitens* trees one year after planting. Regression analysis was performed using the statistical package R, with velocity as the dependent variable, and stocking, physiological age of pine parents and species as the independent variables. Stocking and stem slenderness significantly influenced velocity for radiata pine, although both variables were highly correlated and therefore only one could be included in the model. Stem slenderness was a more powerful variable for predicting velocity. Stocking and height significantly influenced velocity for *E. nitens*. Species had a significant influence on velocity with *E. nitens* producing wood with velocities that were significantly higher than those of radiata pine.

The Fakopp USV tool was relatively impractical for field measurements of young trees. It was difficult to maintain consistent probe angle, depth, and distance between probes, and the presence of branches reduced the accuracy of the measurements. In addition, it was difficult to obtain accurate measurements of very small trees.

SMITH, AARON (2008)
PREDICTING CANOPY COVER IN NEW ZEALAND GROWN DOUGLAS-FIR

This study investigates the relationships between measured stand variables and leaf area index (LAI) with the objective of developing a canopy closure model for predicting LAI of New Zealand grown Douglas-fir.

The LiCOR LAI 2000 was used to measure LAI in 181 permanent sample plots (PSPs) throughout the South Island of New Zealand during the summer of 2007/208. Data analysis was broken into three steps: initial basic analysis followed by multivariate analysis and multiple regression.

Initial analysis found the most likely stand variables to have a significant relationship with LAI are: BA, MTH, Vol, Stocking, Green crown length (GC), height ratio (HtRat) and Crown height (CrHt). DBH performed poorly in this initial analysis was not considered in further analysis. Multivariate analysis in SAS found a significant interaction between BA and MTH. The linear form of this interaction was: Square root (Sqrt) BA * MTH. Multiple regression analysis found crown measurements to be insignificant in predicting LAI. The

best model was found to be a linear relationship including the variables Sqrt BA, stocking (SPH) and the interaction term (INT). Age slightly improved the model but was left out due to autocorrelation with MTH. The developed model has the following form:

$$LAI = 1.77013 + Sqrt\ BA * (0.60119) + INT * (-0.01330) + SPH * (0.00179)$$

Error in LAI prediction from the developed model may be explained by stand variables that were not considered in this study and could include: site productivity, altitude, and climate. A clumping factor also needs to be applied to the LAI predicted in this study. An additional side study needs to be carried out to determine this adjustment factor.

SOUTAR, JOHN (2006)
THE EFFCTS OF BIOSOLIDS ON *PINUS RADIATA* WOOD QUALITY, FOLIAGE AND TREE VOLUME IN CANTERBURY

Municipal biosolids have been applied to a 22 year old stand of *Pinus radiata* (D. Don) on the Canterbury Plains. Applications were made in two treatments in 2000 and 2004 at two differing rates: control (0 kg/N/ha) and high (800kg/N/ha).

The aim of this study was to assess the effects of the biosolids on the nitrogen content in the foliage, tree volume growth and the modulus of elasticity. There was a significant response in the nitrogen levels in the foliage as a result of the biosolid application with a 0.37% N content increase. Tree volume was not significantly affected. The modulus of elasticity decreased significantly as a result of the biosolids by an average of 22%.

The results indicate that biosolids negatively affect wood quality in terms of stiffness on the Canterbury Plains with no significant volume growth to offset the loss in potential value. However, the social and environmental benefits in disposing of the biosolids in a forest rather than alternative methods such as disposal in landfills and incineration may outweigh the potential loss in wood quality.

Thus, disposal of biosolids in plantation forests in Canterbury may be a viable disposal method if non-financial benefits are taken into account.

TAN, BOON KHIANG (2009)
A STUDY ON THE USAGE OF WOODEN POLES AND CROSSARMS IN THE NEW ZEALAND ELECTRICITY NETWORK INDUSTRY

Electricity network companies utilise poles and crossarms to support electricity lines in their distribution networks. Various materials are used for poles and crossarms, and this study specifically looks at the total current and potential future demand for wooden poles and crossarms in the New Zealand electricity network industry. In total, there are 27 electricity network companies in the country.

5 companies were initially visited to gather the necessary data and gain industry knowledge, and then the remaining 22 companies were surveyed by phone. The survey was designed to gather both qualitative and quantitative data. The qualitative survey was carried out in a 30 minute phone interview to gather information on trends in pole and crossarm utilisation, and

a total of 23 companies provided information. 19 companies responded to the quantitative survey, which provided data on current stock and annual consumption of poles and crossarms, and product prices and specifications. Estimation of current stock and consumption of poles and crossarms was carried out for the entire industry using these data, and other data from published sources. The annual pole consumption preference is dominated by concrete poles (63%), followed by Softwood (21%), hardwood (14%), steel (0.21%) and other (1.61%). The estimated annual volume consumed by the industry is 1,812 m^3 for hardwood poles, and 2,108 m^3 for softwood poles. Significant portion of wooden poles are used in the South Island (81% of total annual wood consumption). This is mainly related to the ability of wooden poles to withstand dynamic load in snow loading areas. Annual crossarm consumption is dominated by hardwood (97%), and followed by steel (3%). The estimated annual volume requirements for hardwood crossarms is 740 m3. Wooden pole consumption is expected by industry participants to decline in the near future (especially hardwood), with the increasing competition from concrete poles. However, hardwood poles will likely remain competitive for special applications, and an increase in company confidence in softwood poles is required for it to be used more widely. Hardwood timber is expected to remain the preferred material for crossarms in the future.

WARREN, EDWARD (2006)
THE EFFECT OF STOCKING ON STIFFNESS FOR THREE *EUCALYPTUS* SPECIES IN THE COFFS HARBOUR DISTRICT, NEW SOUTH WALES

Studies of ways in which stocking regulates wood stiffness (modulus of elasticity – MOE) for three *Eucalyptus* species (*E. dunnii, E. pilularis* and *E. cloeziana*) have never been undertaken. This dissertation quantifies the effect of stocking on wood stiffness for these three species, using a 5 year-old trial established by Forests New South Wales (NSW) in the Coffs Harbour district, NSW. An acoustic time-of-flight tool, TreeTap, was used to measure the stiffness on the standing trees.

Four different stocking levels (714, 1000, 1667 and 3333 sph) were examined. Stiffness varied significantly ($p < 0.05$) with stocking for *E. dunnii* ($p = 0.0086$), mean stiffness 11.3 GPa) and *E. pilularis* ($p = 0.0388$, mean stiffness 12.5 GPa), but not for *E. cloeziana* ($P = 0.2545$, mean stiffness 14.4 GPa). However, stiffness varied significantly only between the two lowest stocking levels for *E. dunnii* and *E. pilularis* (714 sph and 1000 sph): stockings above 1000 sph did not significantly increase tree stiffness in any species. These findings have implications for managers establishing plantations of these species. Where stiffness is a high priority then forest managers could reduce establishment costs by planting with low stockings (i.e. 1000 sph or less).

High mortality at a young age (from heavy frosting) in 5 of the twelve *E. cloeziana* plots is the likely reason for the lack of significant differences in stiffness between stockings for *E. cloeziana*. This high mortality confounds the 'true' plot stocking, affecting tree stiffness and hence the validity of these results.

The secondary objective was to investigate the relationship between four growth variables (dbh, height, green crown height and tape) and wood stiffness for these three species. Here the main finding is that there is a high degree of inter-correlation between growth variables, which confounds their effects on tree stiffness.

WIGNALL, GREER (2006)

A CLONAL FORESTRY TRIAL LOOKING AT IMPROVING CANKER RESISTANCE WITHIN *CUPRESSUS MACROCARPA*

A trial aimed at tracking canker resistance in *Cupressus macrocarpa* (macrocarpa) and *C. lusitanica* (lusitanica) was conducted at the Forest Research Institute, Rotorua, New Zealand. The goal of the trial was primarily to improve the breeding population of these cypress species, while keeping a genetic base a broad as possible.

Early analysis of the lusitanica data found unusually high rates of death and infection. With results too difficult to successfully interpret, the following report was based on data derived from the macrocarpa clones only.

Each stem was subjected to eight different inoculations of agar carrying one of two canker strains under observation, either *Seiridium unicorne* (unicorne) or *S. cardinale* (cardinale). One of the inoculations was a control (simply agar only).

The analysis of this report investigated whether or not there was a significant difference between the effects of the two canker strains on the macrocarpa inoculations. Also analysed was the presence of any differences in canker tolerance between tree families and within trial replicates.

Results from analysis showed that 2030 of the macrocarpa inoculations because diseased with canker, and 867 remained healthy. A significant difference was found between the effects of the two canker strains, with more inoculations becoming diseased with cardinale than unicorne. There was much variation in canker tolerance found to exist between tree families, and to a lesser extent, between the trial replicates.

Management implications are discussed, as is the design of the trial and the consequential influence on the results it has. Possible improvements to the trial include increasing the number of families under observation, maintaining consistency between inoculation runs and reducing microsite differences. A less severe method of inoculation has also been suggested to improve the quality of the data.

XU, CONG (VEGA) (2008)

USE OF A HYDROTHERMAL TIME MODEL TO PREDICT SEED GERMINATION UNDER VARIABLE CONDITIONS FOR *BUDDLEIA DAVIDII*

Buddleia davidii is an invasive weed in New Zealand *Pinus radiata* plantations. Understanding the germinati0n pattern of this weed would assist the scheduling of spray operations. Temperature and water potential are two primary factors that determine seed germination. The hydrothermal time (HTT) model combines the effect of temperature (T) and water potential (ψ) on germination and has been widely used to model seed germination. A recent study by Watt *et al*. (submitted, see Appendix) modelled *B. davidii* germination pattern under a range of constant sub-optimal temperatures and water potential using a HTT model. The objectives of this study were to (i) determine the accuracy of this model under variable temperatures and water potentials, and (ii) determine if priming occurs for *B. davidii*.

Buddleia davidii seeds were collected from Rotorua, New Zealand. Seeds were germinated at laboratory under prescribed water potentials using polyethylene glycol 6000 (PEG) solution, and at controlled temperatures in growth cabinets. This study assessed the accuracy of the HTT mode to predict germination at 21°C under both constant and variable water potentials (0 to -1.0 MPa), as well as at alternating temperatures 25/12°C under both constant and variable water potentials (0 to -1.0 MPa). An experiment was set up to determine if priming occurred by exposing seed to water potentials below the base water potential of -1.8 MPa (-2.1 to -5.0 MPa) for 14 days, and then germinating these seed at 0 MPa. The presence of priming would be indicated by germination for these treated seeds occurring more rapidly than untreated controls.

The model accurately fitted the germination data at 1°C under constant condition, explaining 96% of the variation in germination data. The germination at 21°C under variable water potential was also well estimated except for underestimation for the driest treatment. At alternating temperatures 25/12°C, the model predicted germination reasonably well under constant water potentials, but the model appeared to underestimate the germination under variable temperature and variable water potentials. Priming of *B. davidii* was found to occur above -2.64 MPa.

YANG, CHEN (2008)
VARIABILITY OF WOOD QUALITY IN VERY YOUNG UNIMPROVED *EUCALYPTUS NITENS*

The variation in twenty-five very young unimproved *Eucalyptus nitens* at 16 months was evaluated for wood properties including green density, green stiffness, growth stress and basic wood density for different positions up the stem. Correlations between green stiffness before and after debarking, growth stress, and basic wood density were estimated. There were statistical differences within and between each stem-section. Some bottom stem-section showed good correlations between the wood properties. There was no correlation between stiffness and basic density. The variabilities in wood properties were large. Thus this scoping study indicates that very early selection for better wood quality properties is an achievable and desirable objective.