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Understanding silvicultural and environmental factors affecting density and stiffness of Queensland's southern pine plantations

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A Timber Queensland Growth Scholarship offers funding to Queensland based forest and timber industry professionals and workers who are in their early or mid career years. Growth Scholarships facilitate access to learning experiences and opportunities that will foster a passion for working in the forest and timber industry and enhance career pathways. This report was completed post learning project activities.

Introduction

Southern pine plantations in Queensland are the dominant source of timber for the Queensland timber industry. Density and stiffness are two key wood properties influencing the quality and value of southern pine structural timber. Silvicultural and environmental factors can significantly impact the density and stiffness of wood. The objective of this learning project was to compile, understand and analyse a dataset of various wood quality traits and factors that may impact the density and stiffness of southern pine plantation timber and improve the understanding of these impacts through site visits.

Focus of Learning Project

The primary objective of the learning project was to visit the HQPlantations Toolara forest and gather, refine, and analyse data related to different wood quality traits, as well as environmental and silvicultural information for analysis. Additionally, a secondary goal was to engage with forestry professionals at HQPlantations and researchers from the University of Sunshine Coast to gain an indepth understanding of the available data set and industrial silvicultural operations. The scholarship awarded for this project covered travel, accommodation, and expenses associated with field data collection.

Significant Learnings & Outcomes

Understanding the influence of silvicultural and environmental factors on wood quality is crucial for efficient and sustainable forest management. It can help with making informed decisions about tree specie selection and management practices, leading to improved economic viability of forest operations and appropriate resource allocation. This learning project played a crucial role in clarifying various aspects of data collection, providing meaningful insights of the data for analysis, and enhancing my knowledge in the field. Table 1 presents plot quality traits, environmental and silvicultural variables that were discussed and clarified during the site visit. The 'traits' column indicates the type of variable: wood quality trait, environmental variable, or silvicultural variable. The site visit with HQPlantations and the University of the Sunshine Coast (UniSC) proved to be highly beneficial, enhancing my understanding of various aspects of the data. This included gaining insights into the collection methods and understanding the extent and limitations of the available data.

Moreover, the site visit played a crucial role in improving the understanding of several important silvicultural factors present in the dataset. These factors encompassed essential aspects such as soil classifications, slope, depth to impediment for soil, slope positions, pre-commercial thinning, and the prior use of sites. Additionally, the visit provided clarity on various environmental factors and their derivation. Notably, aspects like the measurement of temperature, humidity, rainfall, evaporation, evapotranspiration, rain days, and the calculation of drought-related factors were all thoroughly explained during the visit. After compiling and refining the dataset, various statistical and machine learning methods to understand the effect of environmental and silvicultural factors on wood modulus of elasticity (MOE aka stiffness), density and volume production.

Table 1. description of plot quality traits, and environmental and silvicultural variables and codes

Codes	Variable description	Data type	Traits	Units
Age	Age	Continuous	Silviculture	$Years$
BA*	Basal area	Continuous	Quality*	m^2/ha
Cu_Yr0	Copper fertiliser application at year 0			
DBH*	Diameter at breast height	Continuous	Quality*	cm
Depth_Imp	Depth to impediment	Continuous	Environmental	cm
DryMonths	Average annual number of dry months with <= 30mm of rain	Continuous	Environmental	
Elev_GE	Google Earth Elevation above sea level	Continuous	Environmental	m
EstDensity	Estimated average of logs extracted density calculated from cores	Continuous	Quality	kg/m^3
Evap	Average yearly open surface evaporation	Continuous	Environmental	mm
Evapotrans	Average yearly evapotranspiration	Continuous	Environmental	mm
Ht*	Total height to highest green shoot	Continuous	Quality*	m
K_Yr0	Potassium fertiliser application at year 0			
MaxDrought	Number of consecutive drought seasons	Continuous	Environmental	
MaxT	Extreme maximum temperature for the growing period (from planting to sampling)	Continuous	Environmental	$^{\circ}C$
MinT	Extreme minimum temperature for the growing period (from planting to sampling)	Continuous	Environmental	$^{\circ}C$
Mounded	Mounded (H=high, N=no-mounding, Y=Likely High, S=spot, L=low)	Factor	Silviculture	
NumDroughts	Total number of dry months for the growing period?	Continuous	Environmental	
P_Yr0	Phosphorus fertiliser application at year 0			
pct	Pre-commercial thin completed (yes/no)	Factor (binomial)	Silviculture	
PriorUse	Prior use (2R=prior softwood rotation, P=pasture, N=native forest, U=unknown/mixture)	Factor	Silviculture	
Q	Mean daily solar radiation	Continuous	Environmental	$\frac{MJ}{m^2}$
Rain	Average yearly rainfall	Continuous	Environmental	mm
Raindays	Average yearly number of rain days	Continuous	Environmental	
Resi MOE	Predicted average MOE of logs from plots using PD400 Resitool	Continuous	Quality	GPa
ResiDensity	Average extracted density of plot of segments	Continuous	Quality	kg/m^3
RHmaxT	Mean relative humidity at Tmax	Continuous	Environmental	%
RHminT	Mean relative humidity at Tmin	Continuous	Environmental	%
SiteIndex	Site index calculated based on the height of the tallest 50 trees per hectare at age 25 years	Continuous	Silviculture/ quality	m
Slenderness*	Tree slenderness ratio (Ht/DBH)	Continuous	Quality*	m/cm
slope	Percentage of slope	Continuous	Environmental	%
Slope_Pos	Slope position (4 levels- flat, high, low, mid)	Factor	Environmental	
Soil_Class	Soil Classification (RE=red earth, YE= yellow earth, RP= red podzolic, YP= yellow podzolic, GE= grey earth, GP= grey podzolic, LP= Lat. Podzolic, P=podzol, HP= humus podzol, unknown=unknown soil class for the NSW plots)	Factor	Environmental	

soil_moist	Soil moisture at time of data collection	Continuous	Environmental	
ST300MOE	Average MOE of plots using ST300 $(v^2 * 1000)$	Continuous	Quality	GPA
Stocking	Current stocking spha	Continuous	Silviculture	spha
Taxon	Taxon (PEE=*Pinus elliottii var. elliottii*; PCH =Caribbean pine (*P. caribaea var. hondurensis*) F1 & F2=a locally-developed hybrid [PEE × PCH], LBP= Loblolly pine)	Factor	Silviculture	
thinned	Commercial thinning operation (yes/no)	Factor (binomial)	Silviculture	
Tmax	Mean daily ma ximum temperature	Continuous	Environmental	$°C$
Tmin	Mean daily minimum temperature	Continuous	Environmental	$°C$
USMOE	Average estimated MOE of plot using ultrasound of core and sigmoid curve	Continuous	Quality	GPa
Volume	Volume per hectare	Continuous	Quality	m^3/ha
Wetindex	Average yearly wetness index (Rain/Evap)	Continuous	Environmental	mm

Some selected key findings from the analysis were:

- Age was a key factor associated with increase in MOE, density and volume production.
- For Taxon, PCH is associated with a decrease in average MOE and density when compared to F2.
- Stocking was positively associated with total volume production. However, it was not significantly associated with MOE or density. Note: increased volume may not translate into increased recovery of structural solid wood products.
- Higher temperature and lower elevation are associated with an increase in MOE and density.
- Prior use of site as pasture had a negative influence on MOE compared with second rotation sites.
- Site index showed a positive association with volume production and a negative association with density.

Another highlight of the visit was to visualise and compare various sites, site preparation, nursery, soil type, silviculture, harvesting, chipping operations. Site preparation is needed for effective establishment, with a focus on debris retention and minimal inputs. Harvested sites may be chopper rolled, strip-cultivated (+/- mounding) or spot mounded depending on site factors, especially drainage and erosion risks and planting access. Some areas are re-planted with no mechanical site preparation where soil and access conditions are favourable. Where possible, re-planting occurs along existing mounds or rows.

Figure 1. Chopper roller for site preparation - breaks down larger debris prior to planting, maximising debris retention.

Mounding refers to a specific silvicultural practice that involves creating raised soil mounds on the forest floor. The visits facilitated an improved understandiung of the difference between various mounding methods such as high, continuous, low and continuous mounding. Figure 2a shows example of continuous mounding.

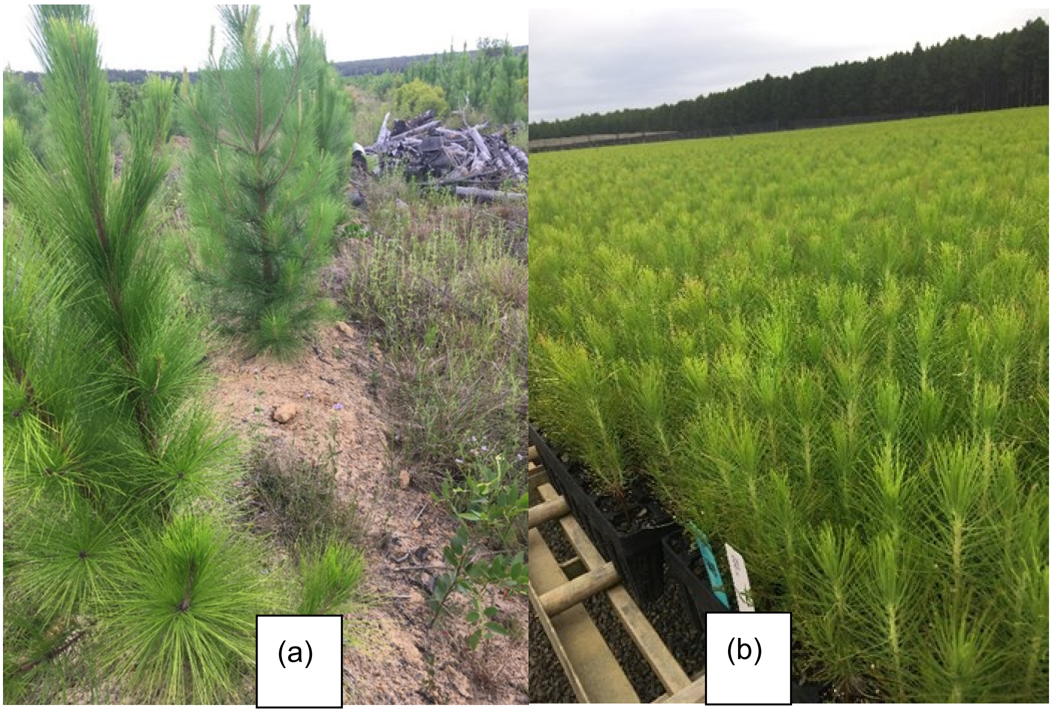

Figure 2. (a) Continuous high mounding and (b) nursery seedlings

HQPlantations obtains its Araucaria and southern pine seeds from their own seed orchards, cultivated through their extensive tree improvement programs. The Toolara nursery is responsible for producing all the planting stock for these species and holds accreditation under the Nursery Industry Accreditation Scheme, Australia (NIASA). This accreditation ensures adherence to guidelines and recommendations to maintain high-quality control and crop hygiene, including disease, pest, and weed control, as well as nursery hygiene. Occasionally, due to seasonal demands, they may also source planting stock from reputable third-party nurseries. Figure 2b shows the seedlings in Toolara nursery.

The site visits assisted in improving the understanding of the various sites having different characteristics, including thinned and unthinned sites, as well as different soil types, aiming to understand their potential impact on growth. Additionally, I observed harvesting (Figure 3a) , haulage (Figure 3b), and chipping operations to gain valuable insights into these forestry practices.

Figure 3. harvesting and haulage

This analysis I conducted with the data provided valuable insights into the influence of environmental and silvicultural factors on southern pine wood quality, specifically MOE, density, and volume production. This information may be used by forest managers to make informed decisions about tree species selection, management practices, and resource allocation to improve the economic viability of forest operations while ensuring sustainable forest management and improved recovery of high value products. The results will support critical Queensland forestry industry decision making regarding the key factors influencing growth, wood density and stiffness variation, predict density and stiffness of various sites, and suggest potential improvements in management and silviculture to maximise the value and utilisation of Queensland's southern pine resources.

Conclusion

The learning project significantly improved my understanding of data collection, analysis insights, and overall knowledge on forest management. The visit to HQPlantations sites and UniSC proved highly beneficial, providing valuable insights into data collection methods and their implications. Various statistical and machine learning methods to understand the effect of environmental and silvicultural factors on wood modulus of elasticity (MOE aka stiffness), density and volume production. The analysis yielded several key findings summarised below:

1. Age was found to be a crucial factor, with increased age leading to higher MOE, density, and volume production.
2. Taxon showed that PCH is associated with a decrease in average MOE and density compared to F2.
3. Stocking positively influenced total volume production, but no significant association was observed with MOE or density. However, it was noted that increased volume might not necessarily result in improved structural recovery of solid wood. Additionally, higher temperatures and lower elevation were linked to increased MOE and density.

4. Sites previously used as pasture had a negative impact on MOE when compared to second rotation sites.
5. Site index exhibited a positive correlation with volume production and a negative correlation with density.

The site visit included exploring various sites, site preparation, nursery, soil types, silviculture, harvesting, and chipping operations. Different sites with distinct characteristics were visited, including thinned and unthinned areas, as well as sites with different soil types. This allowed for a deeper understanding of their potential impact on growth. Valuable insights into forestry practices were also gained through the observation of harvesting, haulage, and chipping operations.

The study offered valuable insights into how environmental and silvicultural factors impact southern pine wood quality, including MOE, density, and volume production, enabling forest managers to make informed decisions for sustainable and economically viable forest operations and enhanced recovery of high-value products.

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