The influence of thinning on tree stability in Sitka spruce (*Picea sitchensis* (Bong.) Carr.).

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Seminar on FOREST MANAGEMENT, FORECASTING AND TIMBER QUALITY,
University College Dublin, 24 May 2017

Teagasc
Agriculture and Food Development Authority
The Irish Agriculture and Food Development Authority
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Introduction

- Windthrow one of the biggest causes of economic losses in Irish Forestry
- 10,000 ha blown (2,000 private) as a result of storm Darwin in Feb 2014
- 9% of timber sold from in 2014 for stands that were windblown
- Volume losses are expected to increase with frequency of storms
- Loss of expected revenue
- Effects all trees, especially trees planted on wet waterlogged soils (e.g. Sitka spruce, lodge pole pine): important tree species in Irish forestry

Windthrow in Irish Forestry

Direct Problems:

- Loss of timber
- Increase of costs (unscheduled thinning and clear-cutting)
- Forestry planning
- Stands blown before they reach economic potential (revenue loss)
- Downgrade of product (from sawlog to pulp)

Indirect Problems:

- Disease attacks
- Fire
- Erosion
- Landscape quality

Windthrow – Factors contributing/resisting to wind & gravitational forces

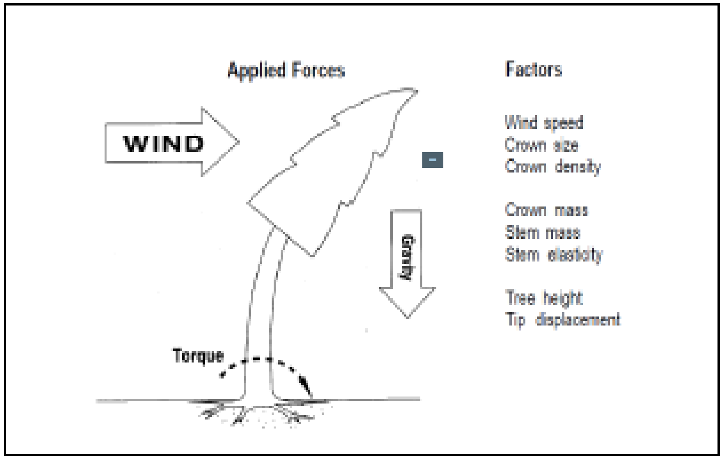


Figure 1: Factors affecting wind and gravitational forces acting on a tree.
Source: Stathers *et al.* (1994)

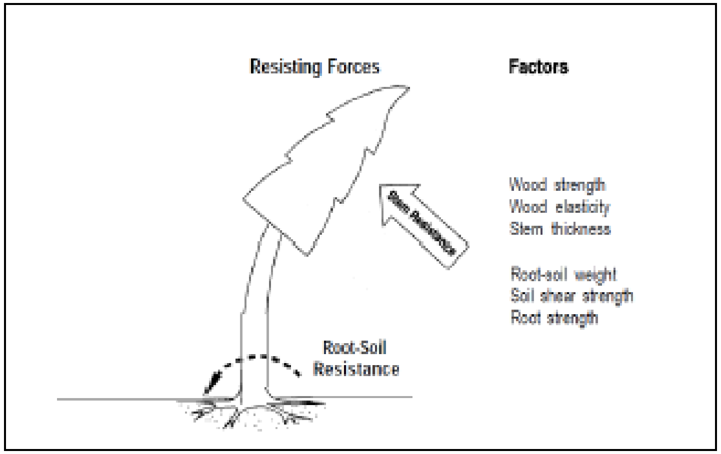


Figure 2: Factors affecting the resistance to wind and gravitational forces acting on a tree.
Source: Stathers *et al.* (1994)

Thinning & Windthrow

- thinning has been identified as a key factor in influencing windthrow risk (Gardiner *et al*., 2010).

- It is known that stands are particularly vulnerable to windthrow shortly after thinning but that the residual trees adapt to the windier environment that they are exposed to (Nicoll *et al.*, 2009).

- The age at which thinning commences is also important – with early, frequent thinnings recommended in areas of high windthrow risk (Gardiner *et al*., 2010). These trends are complicated by the type of thinning used.

Overall aim of the study

- Can silvicultural practice contribute to increasing the stability of a forest crop
- Do morphological responses (i.e. in terms of root growth, dbh, and taper) increased stability and are responses dependent on the timing of the thinning.
- What is the effect of thinning type, timing of thinning and thinning intensity on stability
- Is No-Thinning the best Option for these forests?
- Does tree position (i.e. trees next to a drain or not) influence tree stability?

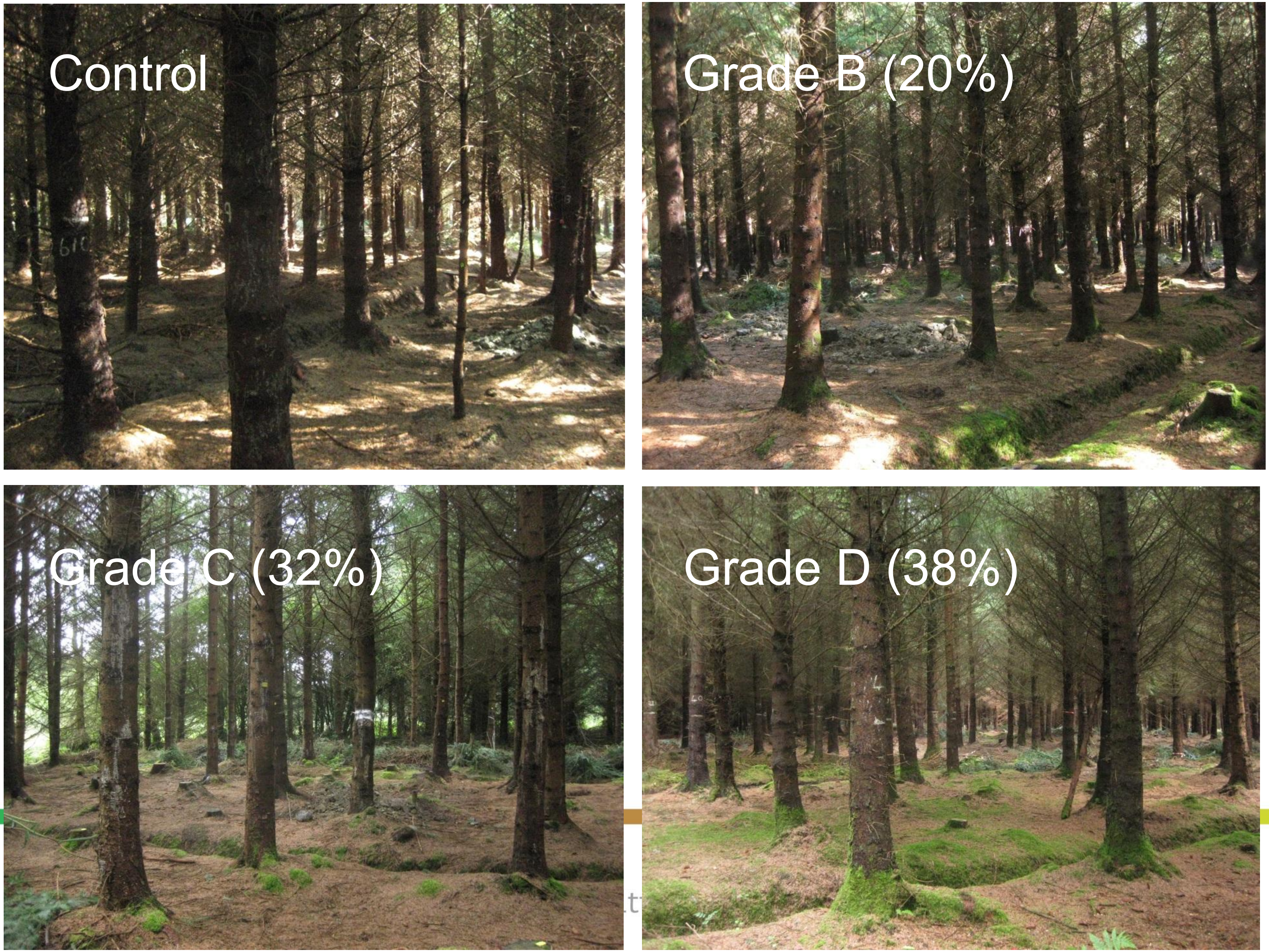
Experimental Design

- A tree pulling experiment established
- Located in Frenchpark, Co. Roscommon (1995 Sitka spruce, mounded, surface water gley surface)
- A Sitka spruce thinning experiment est. 2010
- four different treatments
- No thinning (Control)
  - Grade B (remove subdominant tree) – 20% of BA
  - Grade C (remove subdominant and some co-dominant) – 32% of BA
  - Grade D (remove subdominant and many co-dominant) – 38% of BA
- A further treatment was implemented 3 years later
- Delayed Treatment (2013)
  - Grade C (observe if delayed thinning impacts stability)

Crop details – First Thinning/Second thinning

Treatment	Age	THT	Trees/Ha	Dbh	BA/ha	Mean Vol	Vol/Ha
Control	15	11.8	2133	16.2	44	0.10	211
Light	15	11.4	1500	17.2	35	0.11	168
Medium	15	10.5	1230	17.7	30	0.12	148
Heavy	15	11.3	1015	18.5	27	0.13	134
Medium 3 yr	18	13.4	1237	19.6	37	0.15	187

Treatment	Age	THT	Trees/Ha	Dbh	BA/ha	Mean Vol	Vol/Ha
Control	21	17.1	1990	19.9	62	0.23	452
Light	21	16.7	1163	23.2	49	0.34	368
Medium	21	16.2	938	23.9	42	0.36	3988
Heavy	21	16.9	791	24.9	38	0.40	311
Medium 3 yr	21	16.5	1058	22.6	42	0.31	329


Control
Grade B (20%)
Grade C (32%)
Grade D (38%)

Overview of Methodology

- Tree selected as representative of each treatment (mean dbh)
- Measurements taken of crop parameters
- 4 trees taken in each plot (60 trees in total)
- Utilised a winch and pull system to pulling down with load cell to measure force
- Trees pulled down in direction of the prevalent wind (SW)
- Trees located in the plot: 2 beside drain, 2 between rows

- Monitoring water table depth throughout the year
- Record data from the pulled down trees:
  - Crown size (length of live crown, width and height….etc.)
  - Root characteristics (height, width, depth, max depth….etc.)

Destructive monotonic tree pulling arrangement

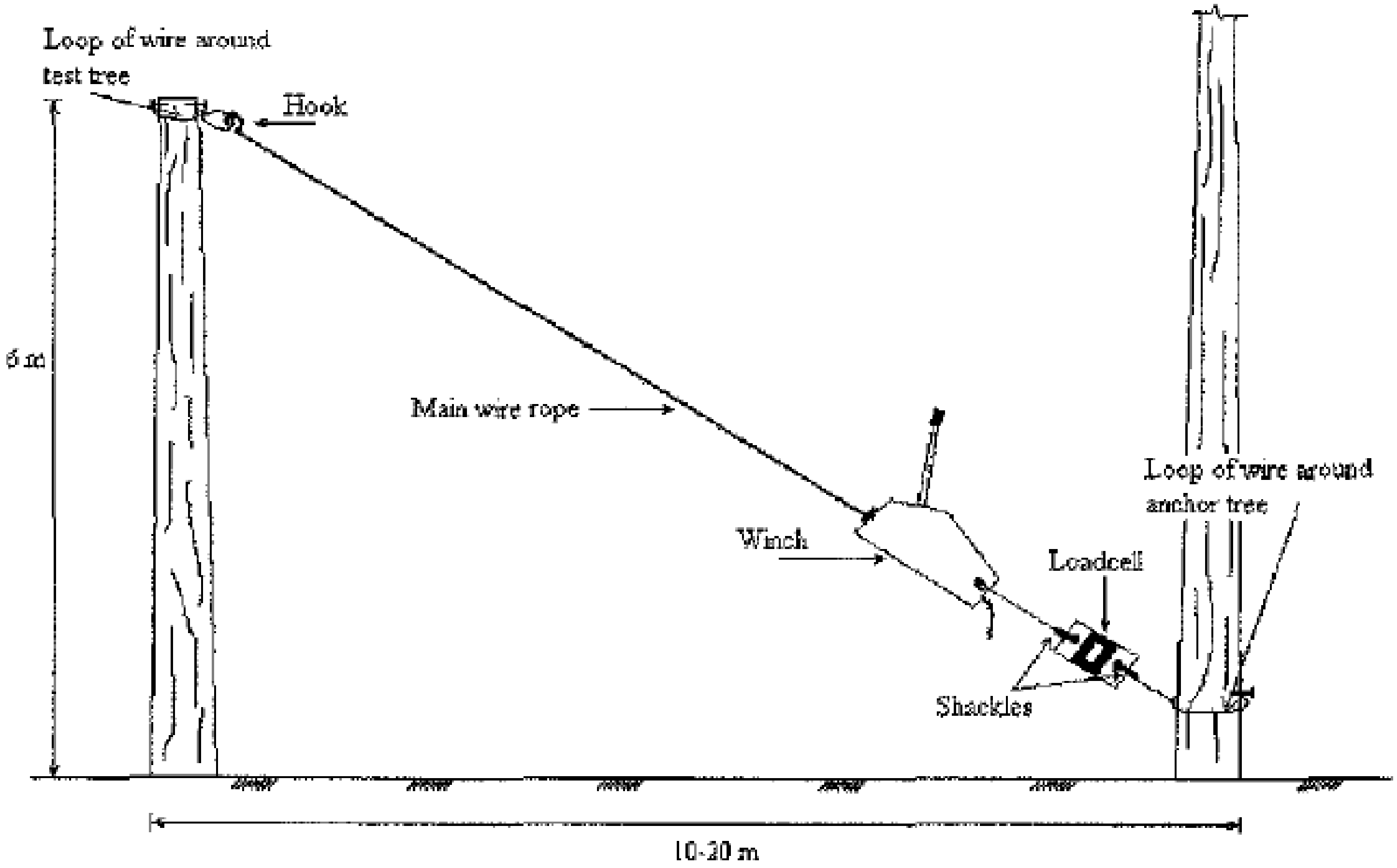


Table 4: Summary statistics for the tree and plot variables recorded.

Variable	Units	N	Mean	Standard Deviation	Minimum	Maximum
dbh	cm	60	21.04	1.55	17.60	24.60
Ø at 5 cm	cm	60	29.16	3.95	21.90	40.20
Ø at 3 m	cm	60	18.74	1.84	14.90	23.40
Ø at 6 cm	cm	60	15.52	1.97	11.70	21.50
Tree height	m	60	14.89	1.15	11.84	17.49
Stem weight	kg	60	1418.01	346.77	608.59	2454.50
Tree weight	kg	60	3478.01	954.68	1892.26	7082.94
Root plate height	m	57	1.91	0.30	1.36	2.90
Root plate width	m	57	2.25	0.53	1.10	3.80
Root depth	m	57	0.69	0.21	0.39	1.33
Maximum root depth	m	57	0.77	0.26	0.48	1.80
Root plate area	m^2	57	6.23	2.14	1.97	12.77
Root plate volume	m^3	57	4.41	2.55	1.25	13.93
Crown height	m	60	7.05	1.46	3.47	9.87
Crown width	m	60	2.97	0.51	1.80	4.10
Crown length	m	60	7.84	1.63	3.35	11.19
H/dbh ratio		60	71.02	6.20	53.33	82.42
Mound length	cm	60	58.56	8.33	40.00	78.50
Mound height	cm	60	15.41	3.63	7.25	24.00
BA small plot	m^2ha^{-1}	60	55.36	11.66	30.89	84.70
SPH small plot	$stemsha^{-1}$	60	1533.87	407.74	857.63	2682.56
BA plot	m^2ha^{-1}	60	34.67	6.00	26.60	46.10
SPH plot	$stemsha^{-1}$	60	1424.40	396.49	957.00	2198.00
Water table depth	cm	15	63.43	19.66	7.50	100.00

Results: Mode of failure

Logistic regression/Stepwise logistic regression

40% of samples snapped: Why?

- **Not influenced by tree position or thinning treatment**

Key variables related to mode of failure

- **Deeper root plates ~ Influenced by water table depth**
- **Larger root heights**

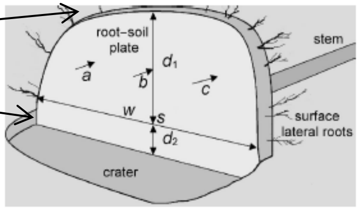
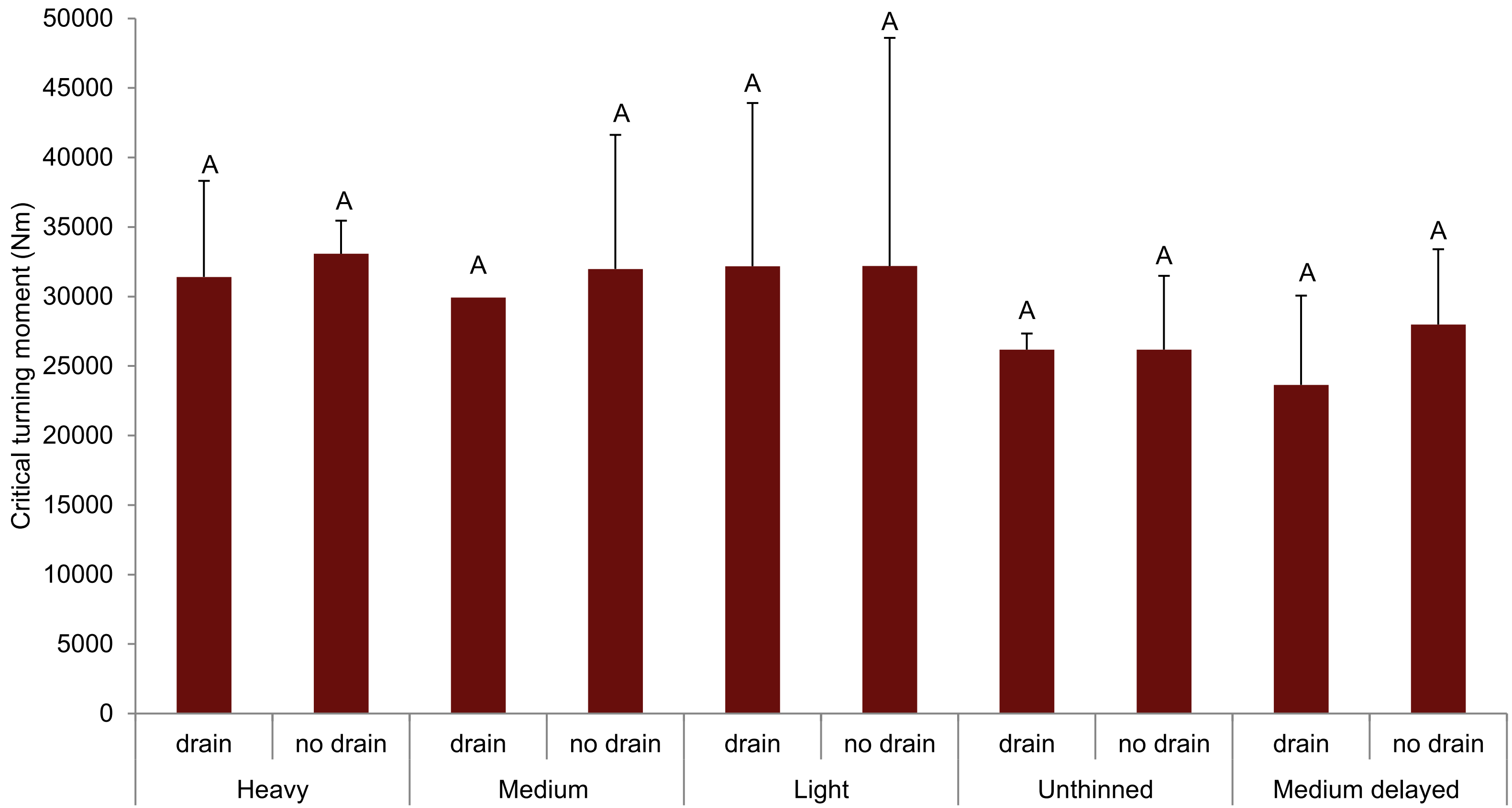
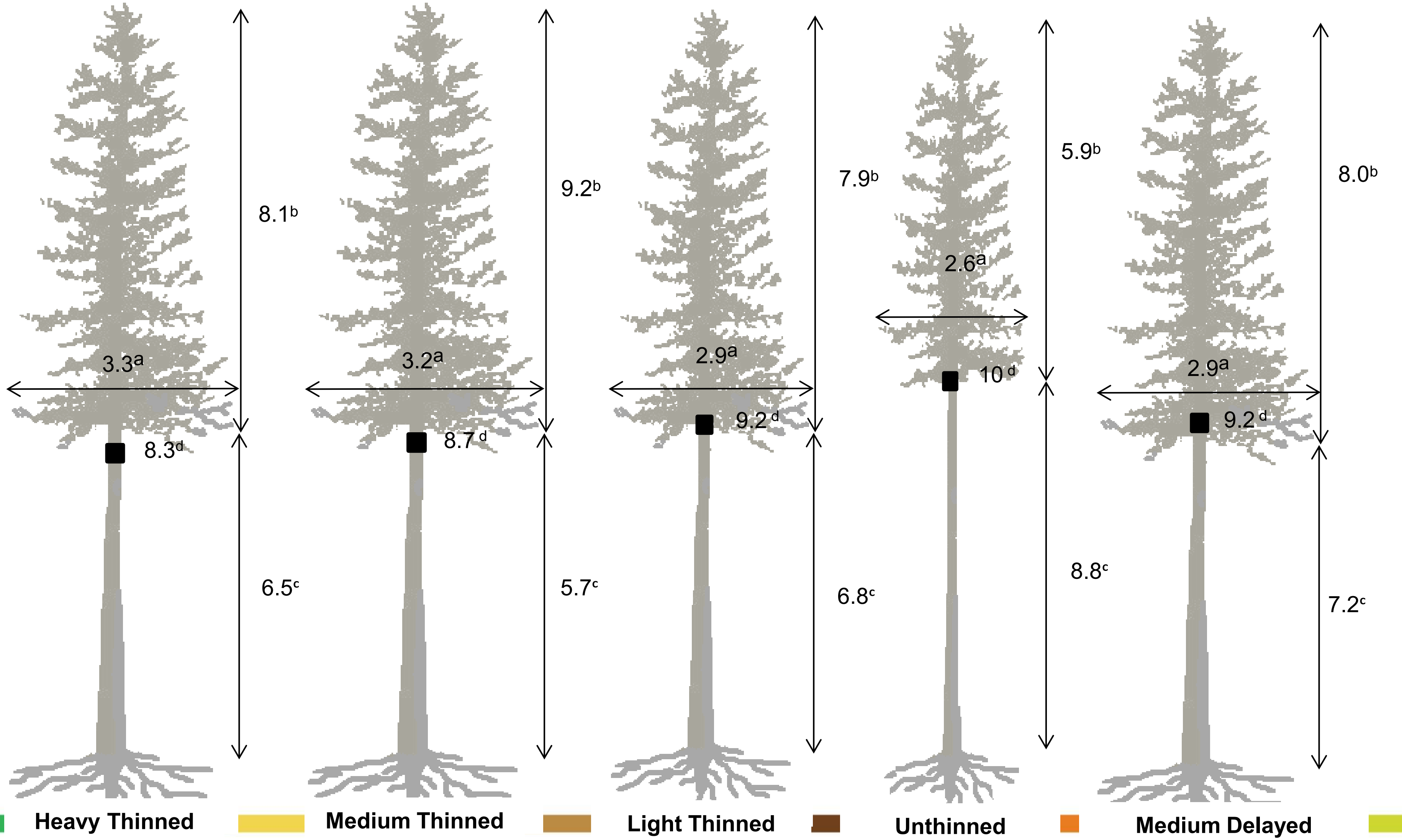


Figure 5: Measurement of the root–soil plate: root width (*w*), distance from the stem centre (*s*) to the windward edge (*d1*), distance from *s* to the hinge (*d2*), and plate thickness at 3 points (indicated by arrows *a–c*) across the plate.
Source: Nicoll *et al.* (2005)

Results: Critical turning moment



Results: Impact of thinning on crown development and COG



critical turning moment: most important tree and plot variables

- Stepwise regression analysis
- Most important variables
- Tree Weight
- Root plate width

$R2 = 0.46$

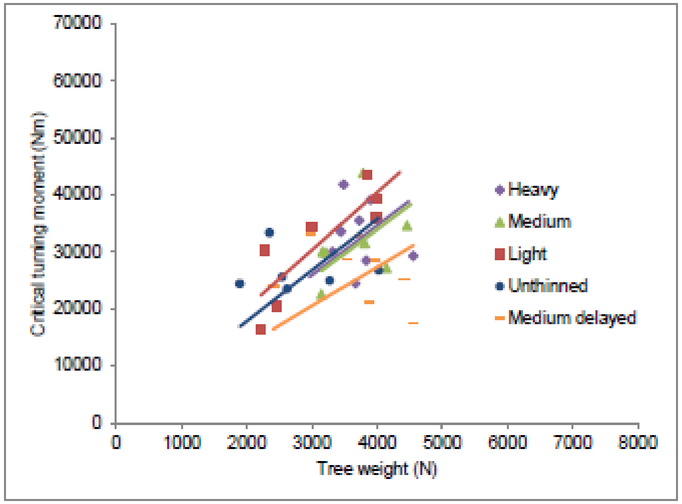


Figure 9: Critical turning moment against tree weight for all thinning treatments.

- Other important variables
- Dbh
- d@ 0.5, 3, 6 m


Root plate in unthinned plot

Root plate in heavy thinned plot

Factors affecting tree weight and root plate

- Tree Weight and Root plate significantly positively related to
- crown width
- crown length

- Tree Weight and Root plate significantly negatively related to
- SPH
- BA/Ha

Root Depth

- Maximum root depth key variable influencing mode of failure

Maximum root depth related to tree height and the autumn water table depth (these collectively explained 17.9% of the variability)

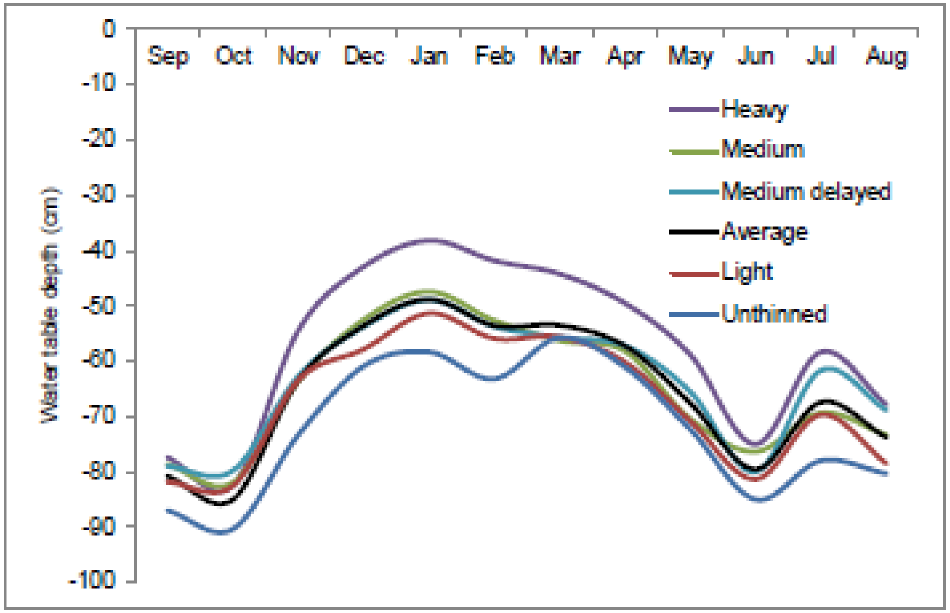


Figure 12: Water table depth for the different thinning treatments and the average for the studied period of time.

Conclusions

Despite no significant differences on critical turning moment:

- **Trees in thinned plots had greater critical turning moment than unthinned**
- **Critical turning moment increased with thinning intensity**
- **Trees thinned earlier had greater critical turning moment**
- **Tree position had no effect**

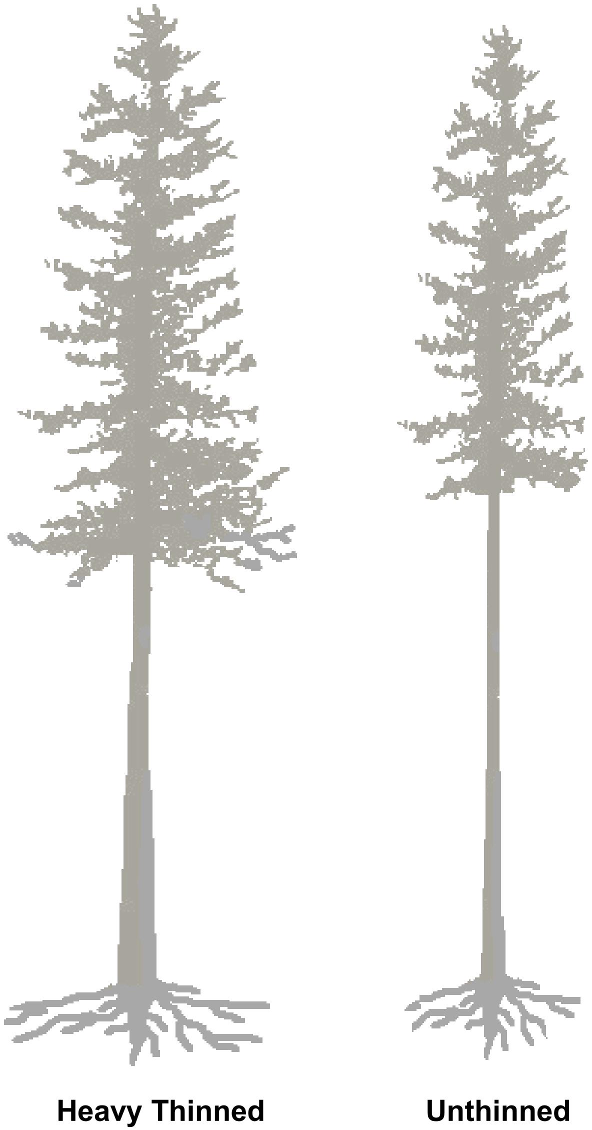
- **Will this trend continue? Further research is necessary, time & age???**
- **Critical wind speed or kinetic energy transfer not accounted**
- **Brown edge – Forest edge stripping for timber stacking/roading - planning**

Conclusions

Some tree attributes were already significant:

- **Diameters at different heights**
- **Crown parameters**
- **H/dbh ratio**
- **Centre of gravity**

Stability predictors (H/dbh ratio, Centre of gravity)



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Thank you for your attention!