Effect of harvesting season, system and equipment on in-forest Pinus radiata bark removal in Australia and New Zealand

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Outline

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2. Contribution of bark to volume and weight
3. Implications of bark content in the supply chain
4. Objectives of the study
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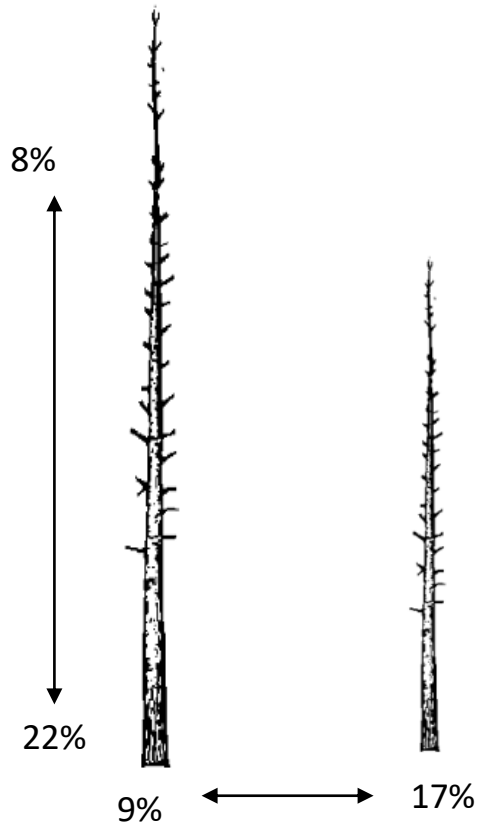
Some statistics

- Annual volume harvested in NZ = 28.7M m^3 (2016), about the same volume in Australia
- In Australia and NZ most volume is provided from industrial plantations (90%)
- 1.7 M ha of Radiata pine in NZ (90% of total forest estate), 1.1M ha in Australia (40% of total forest state)
- A big proportion of Radiata pine sawn timber and logs (>50%) are exported to Asia. In Australia domestic markets are the predominant

How much volume and weight does bark contribute?

- 10 to 30% of OB volume
- 8 to 25% of weight for pines
  - species dependent
  - site quality dependent
  - age dependent
  - tree size dependent
- Mature radiata pine:
  - 9% of weight (Webber & Madgwick 1983)
  - 10 to 12% of volume



The problem

- Bark is a low value product that adds cost from forest to customer. Eliminating it early should improve grower's profitability.

Benefits of in-forest bark removal	Issues with in-forest bark removal
- Reduced transport costs - Reduced manufacturing costs - Reduced dependency on fumigation costs - Improved storage and reduced handling costs at export shipping facilities - Reduced extraction costs for CTL harvesting systems due to improved solid wood payloads	- Additional costs for debarking - Increased in-forest storage capacity - Loss of energy and landscaping material.

Objective of the study

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- "Quantify the effects of harvesting season, system and equipment on in-forest Pinus radiata bark removal in Australia and New Zealand"
  - ✓ Improve supply chain efficiency between standing tree and delivery to the customer at the mill or export port by debarking logs in-forest
  - ✓ Understanding what factors affect bark removal will assist participants in the supply chain to manage the issues around it.
  - ✓ The results relate to harvesting operations where bark removal was a consequence of harvesting, not one of the prime objectives of harvesting.

Study data sets

Data set	Assessment purpose	Season (month/year)	# photos	# of stems or logs
AU1	Season	Spring (Aug 2015)	156	675
AU2	Season	Autumn (Mar 2016)	182	543
NZ1	Season & System effects	Winter (Jul 2015)	82	337
NZ2	Season & System effects	Spring (Oct 2015)	117	518
NZ3	Season & System effects	Summer (Feb 2016)	122	492
NZ4	Season & System effects	Autumn (Mar 2016)	162	711
NZ5	System effects	Spring (Nov 2015)	15	69
NZ6	System effects	Summer (Jan 2016)	61	143
NZ7	System effects	Autumn (Apr 2016)	15	122
NZ8	System effects	Autumn (May 2016)	11	29
NZ9	Machine effects	Winter (Jun 2016)	80	496
			1003	4135

Data collection - Australia

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- Data gathered in Spring 2015 and Autumn 2016 at the entry of Wespine Industries sawmill in WA
- 358 photos in total were taken of bunk loads of random length logs as they arrived on truck at the mill
- Long lengths averaged 5.2 m and ranged between 3.0 and 6.7 m
- CTL systems are predominantly used in the plantations supplying Wespine sawmill

Data collection - NZ

- Data sets NZ1, NZ2, NZ3, and NZ4 were gathered at the entry to the port of Tauranga
- Full range of log grades from large butt logs to small pulp logs
- Logs lengths averaged 4.8 m (range between 3.0 and 12.0 m)
- Purpose: Determine the effect of season and harvesting system on bark removal
- Log truck loads considered to be representative of the bark removal in the region

Data collection - NZ

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- From data sets NZ1-NZ4, 483 photos from 2058 logs were taken of bunk loads of fixed length logs as they arrived on truck at the port (log length & grade from docket)
- Processing system visually assessed or determined by querying the truck driver
  - Manual chainsaw delimbing and bucking
  - Static delimbing and chainsaw bucking
  - Mechanised delimbing and bucking
- Tree length (TL) extraction to landings with delimbing and bucking on the landing is the predominant in the plantations supplying these ports

Tree length extraction to landings

Felling

Extraction

Delimbing & Bucking

Data collection - NZ

- Data sets NZ5 and NZ6 were gathered in Spring 2015 and Summer 2016 in Kaingaroa Forests
- Data set NZ5: mechanical felling, TL extraction to landing, mechanical delimbing and bucking (Woodsman PRO 800)
- Data set NZ6: mechanical felling, shovel logging to intermediate processing point, delimbing & bucking with Waratah 625C, extraction landing with forwarder
- 76 photos, 35 pre-processing & 52 post-processing, taken from 44 stems and 168 logs

Data collection - NZ

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- Data set NZ7 was gathered in Autumn 2016 in Kaingaroa forest
- CTL with a Waratah 625C processor head
- Purpose: determine the effect of CTL system on bark removal
- 15 photos and 122 logs measured in this data set
- Data set NZ8 was gathered in Autumn 2016 in Kaingaroa forest
- Mechanical felling & delimbing at the stump with Waratah 626 processor head (2-knives), extraction to landing by skidder, off-highway trucking to processing yard

Data collection - NZ

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- Data set NZ9 gathered in winter 2016 (4 crews)
- Felling at the stump, extraction of stems to landing, mechanically bucking stems into logs
- 2 crews used a Woodman PRO 800 processor head (4 delimbing knives, spiked rollers) – 34 photos & 222 logs measured
- 1 crew used a Waratah 625C processor head (4 delimbing knives, spiked rollers) – 24 photos & 146 logs measured
- 1 crews used a Waratah 626 processor head (2 delimbing knives, spiked rollers) – 22 photos & 128 logs measured

Processing heads

Waratah 626 – 2 knives

Waratah 625C – 4 knives

Woodsman 800 – 4 knives

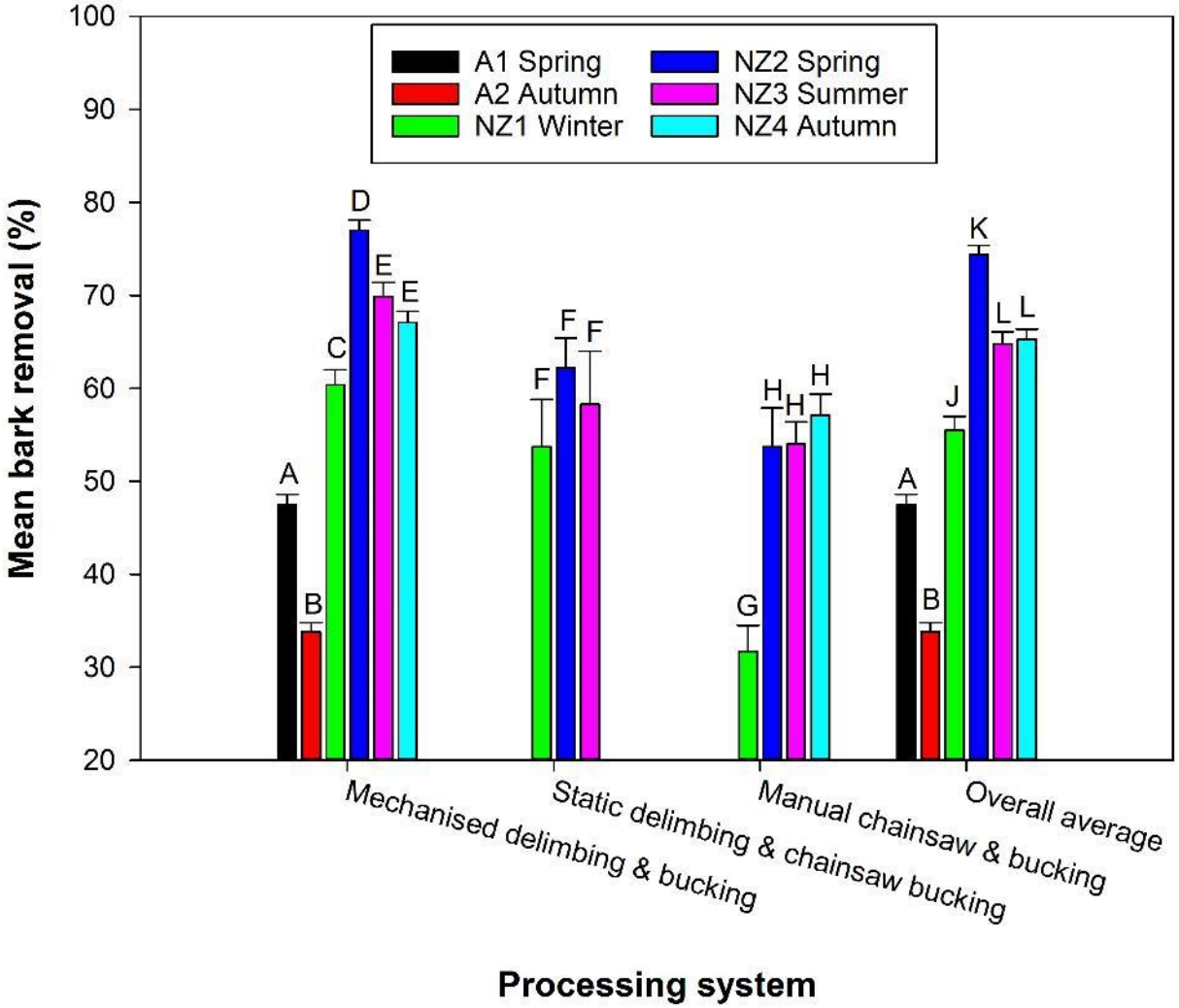
Line interception method

1003 photographs, processed with Photoshop and ImageJ software

Callipers or metallic tape used to do the scaling

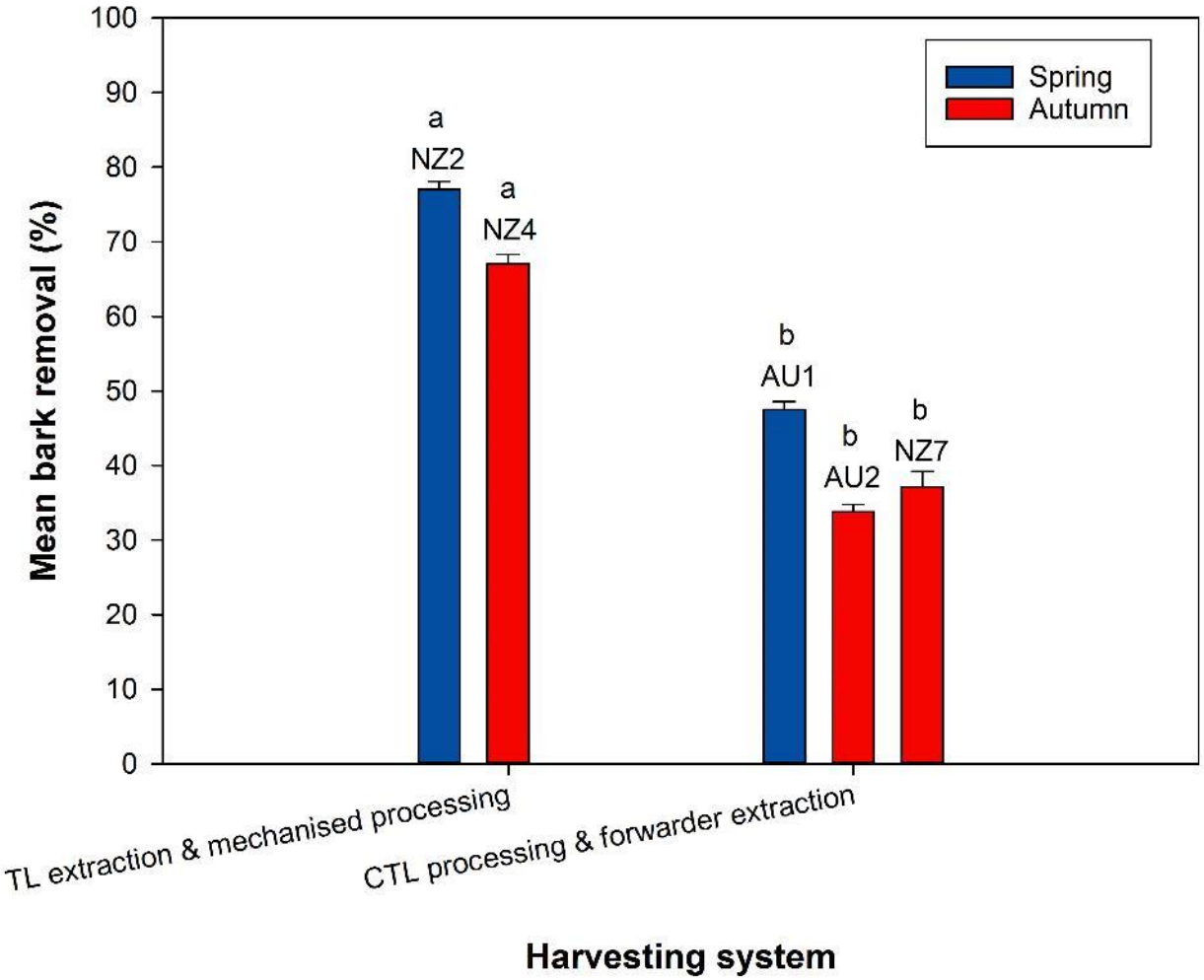
- Introduced by Canfield (1941) for determining the aerial coverage of terrestrial plant species.
- Other uses: coverage of marine plants, soil disturbance, volume of logging slash on harvesting sites
- Harris and Nash (1973) use the LIM for determining bark lost during extraction of radiata pine in NZ.
- Murphy and Pilkerton (2011) found that bark loss estimates were not sensitive to transect location on the log

Results: Effect of season & Processing system



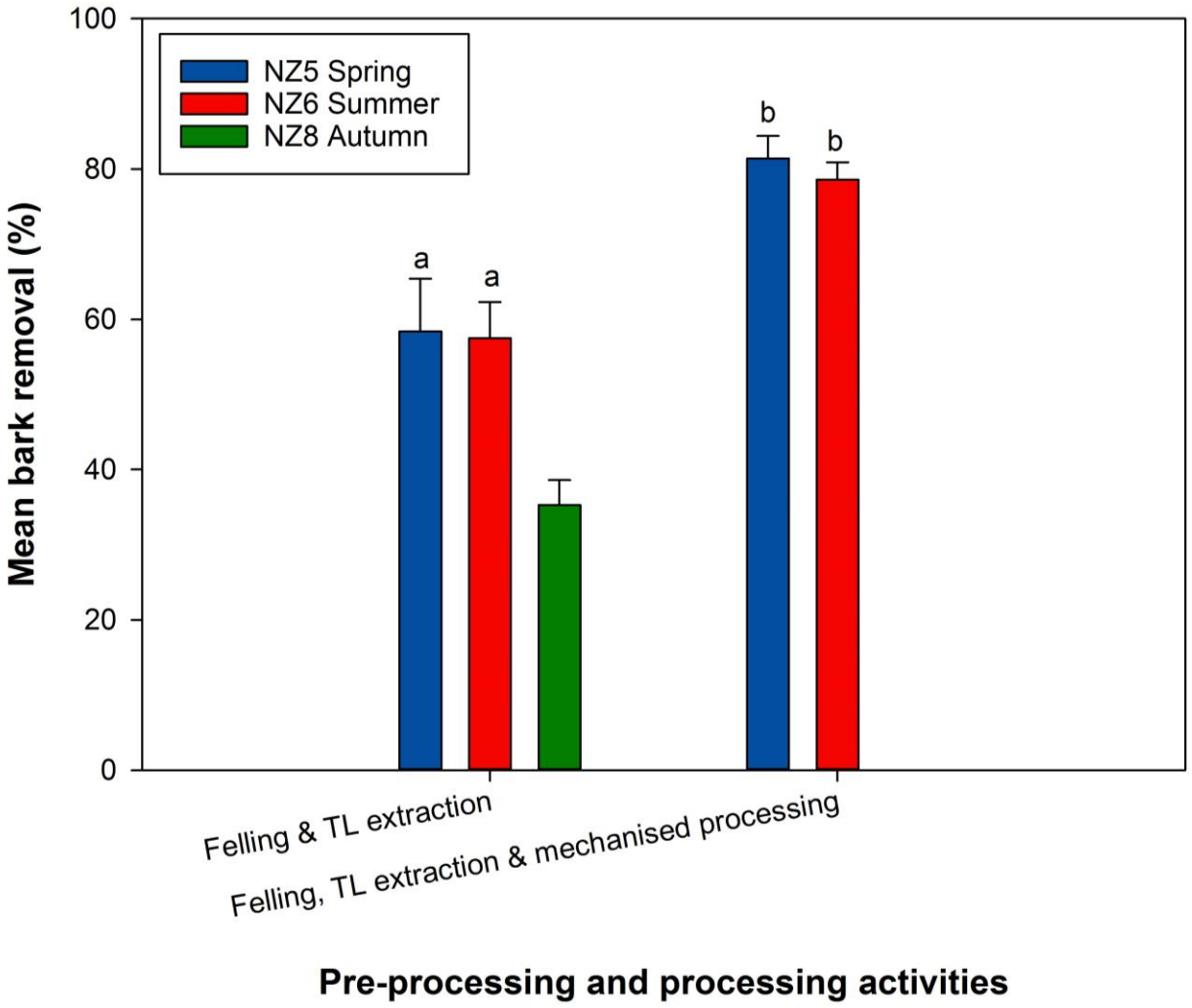
- On average, a little over 40% of bark was removed in Australia. Bark loss was 65% in NZ.
- Processing system affected the amount of bark removed.
- Manual delimbing and bucking with a chainsaw resulted in less bark removal (49%) than mechanized delimbing and bucking with a processor (69%).
- Greater differences in winter.

Results: Comparison of harvesting systems



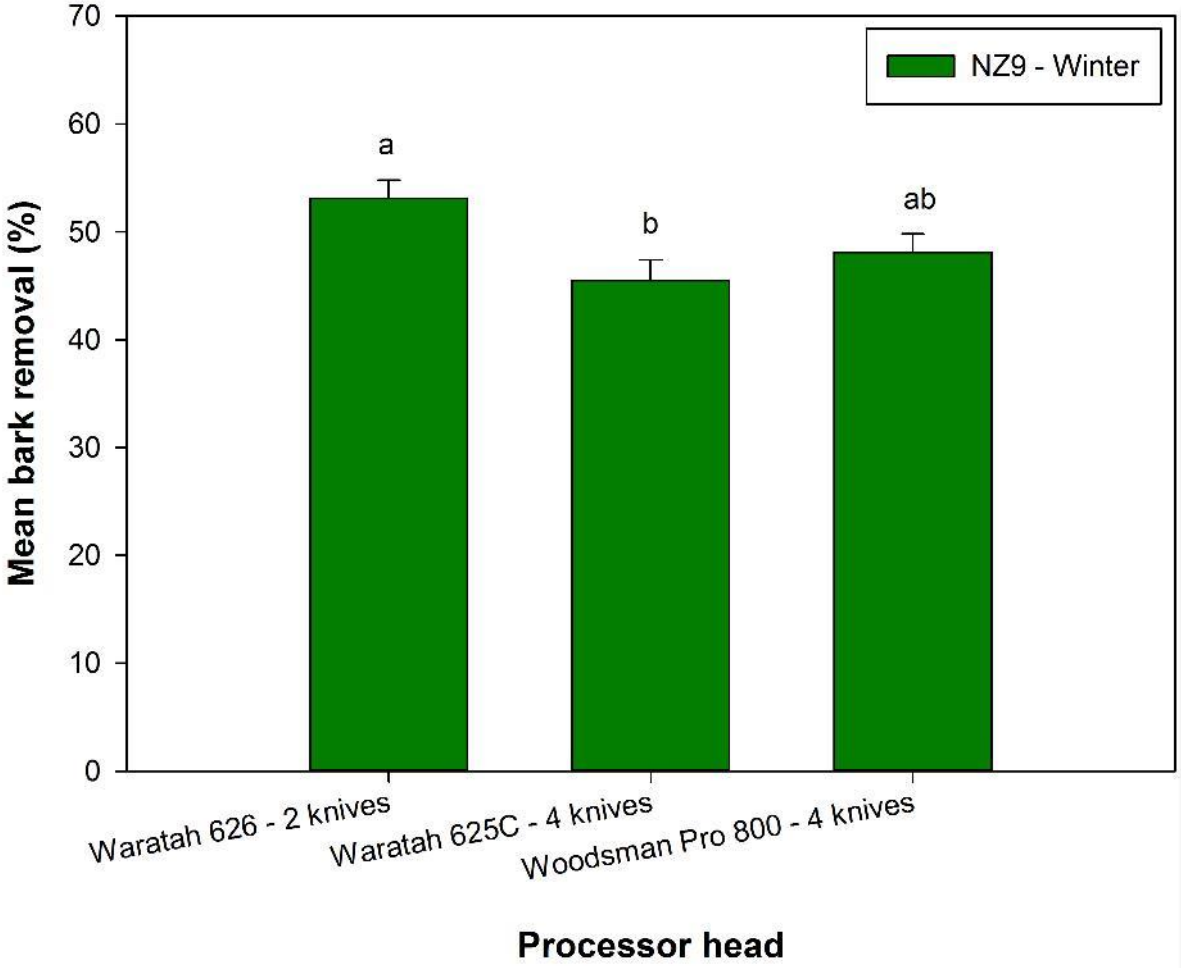
- Bark removal for the CTL harvesting systems in Australia and New Zealand was 30–35% less in absolute terms than bark removal for the tree-length/mechanized processing systems in New Zealand.
- The difference remained similar for both spring and autumn harvesting seasons.
- No data available to make summer and winter comparisons.

Results: Effect of pre-processing and processing activities



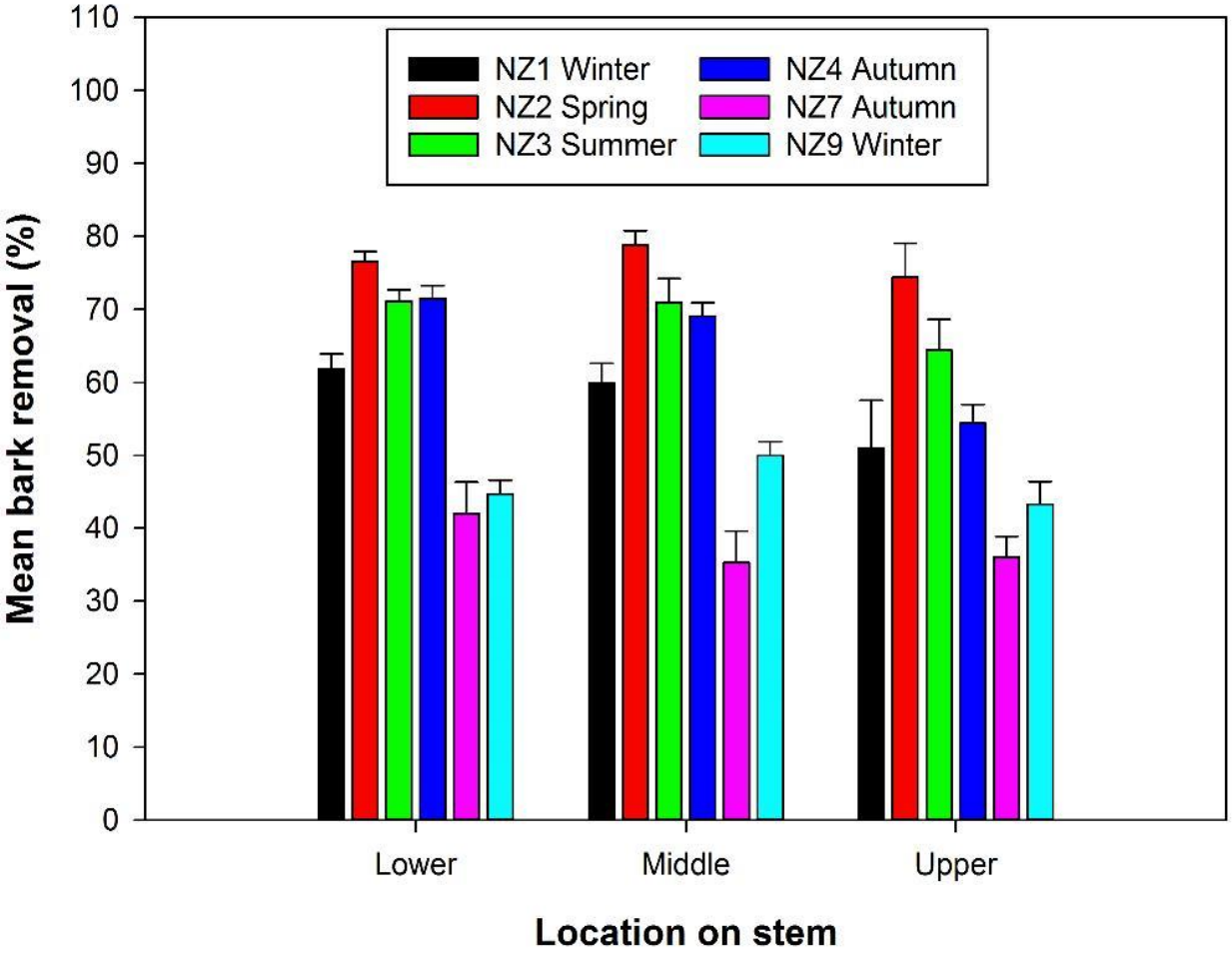
- Analysis of the NZ5 and NZ6 data sets showed that a little under 60% of the bark was removed from stems during felling and tree-length extraction to a landing.
- Another 20% was removed while mechanically processing the stems into logs.
- Significantly, less bark was removed for NZ8. It is expected that harvest season may account for some but not all of this difference

Results: Effect of number of delimbing knives



- No significant difference in bark removal was found between the two 4-knife processor heads (45.5 vs 48.1%).
- There were significant differences between the 4-knife Waratah (45.5%) and the 2-knife Waratah processor heads (53.1%).
- Differences explained by bark removal on small logs
- No significant difference between the 4-knife Woodsman (48.1%) and the 2-knife Waratah processor heads (53.1%).

Results: effect of location on stem



- Bark removal tended to be less on the upper portion of the stem than lower down the stem.
- For data set NZ4 bark removal was significantly lower on the upper portion of the stem than the middle and lower portions.
- For all other data sets, location on the stem had no significant effect.

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ABSTRACT

Depending on the point of view of the participants in the forest-to-customer supply chain, the presence of bark can be considered as either a benefit or a cost. Understanding which factors affect bark removal should help with managing bark quantities, and the design of harvesting systems and equipment. Over 4000 stems and logs in 11 studies were measured in Australia and New Zealand using digital photos and a line intercept method to determine the amount of bark removed during normal operations. Among other things, we have been able to show that bark removal is greater in spring than winter, with tree-length systems than cut-to-length systems, and with mechanized processing rather than manual processing systems. We were also able to show that the greatest portion of bark removal occurs during felling and extraction with tree-length operations, with a small proportion occurring during delimbing and bucking. There was limited and weak evidence that bark removal may differ with location on pine stems. Finally, we were able to show that the number of knives on a processor head can affect bark removal, although we would recommend that further research be carried out on this topic, since the results ran counter to expectations.

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KEYWORDS
Bark loss; mechanized processing; harvesting season; processor head design

Summary

1. Bark removal is greater in spring than winter, with TL systems than CTL systems, and with mechanized processing rather than manual processing systems
2. A greater portion of bark removal occurs during felling and extraction with TL operations, with a small proportion occurring during delimbing and bucking
3. We were not able to conclusively confirm that bark removal is greater on the upper portion on pine stems
4. The number of knives on a processor head can affect bark removal, although we would recommend that further research be carried out on this topic

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