WASTE TO WISDOM

Production of Quality Feedstock From Forest Residues for Biomass Conversion Technologies

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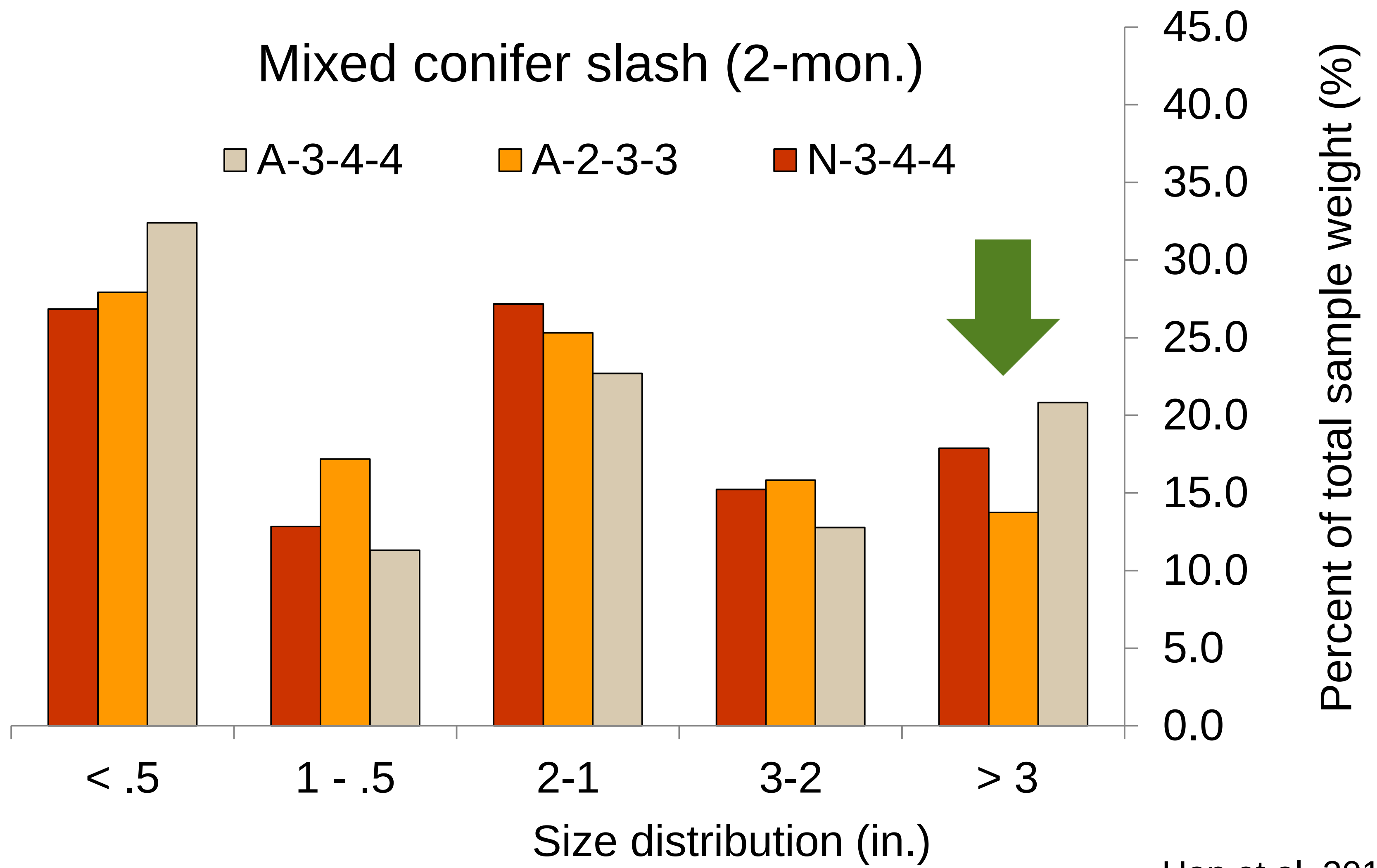
Subtask goals

- Develop methods to improve feedstock quality generated from forest residues
- Provide recommendations for feedstock procurement managers

Biomass Conversion Technology	Current desired feedstock specifications			
	Particle size (mm)	Limitations	Moisture Content (% wet basis)	Ash content (%)
Biochar	< 102	Limited fines	< 25	< 20
Torrefaction (pilot)	< 19	Fines OK	< 30	no limit
Torrefaction (commercial)	< 38	< 5% particles < 3 mm	< 30	no limit
Densification	< 51	Fines OK	4 - 15	no limit
Gasification	< 38	< 10% particles < 13 mm	10 - 30	< 15

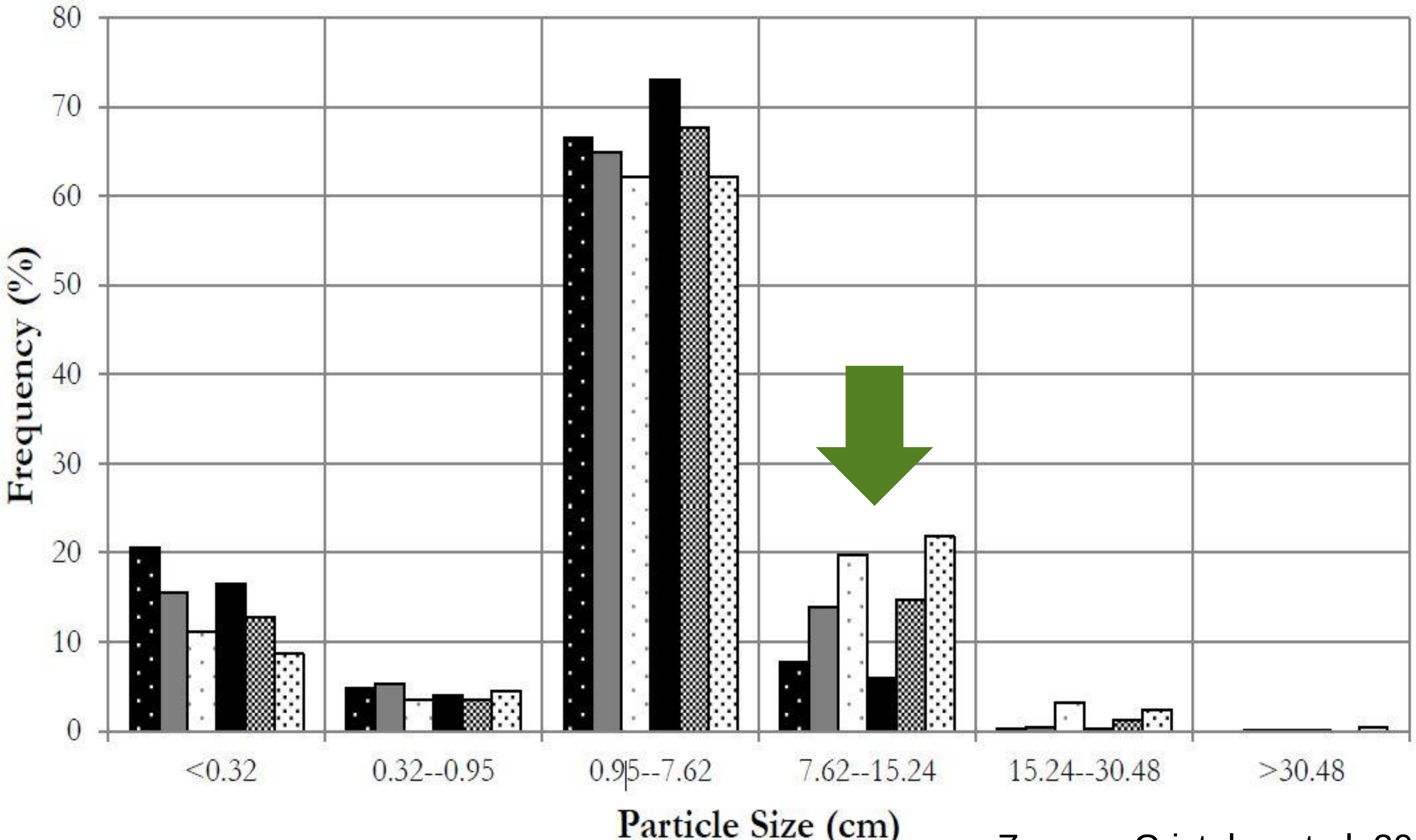
Typical comminution operation

Particle size distribution of grindings



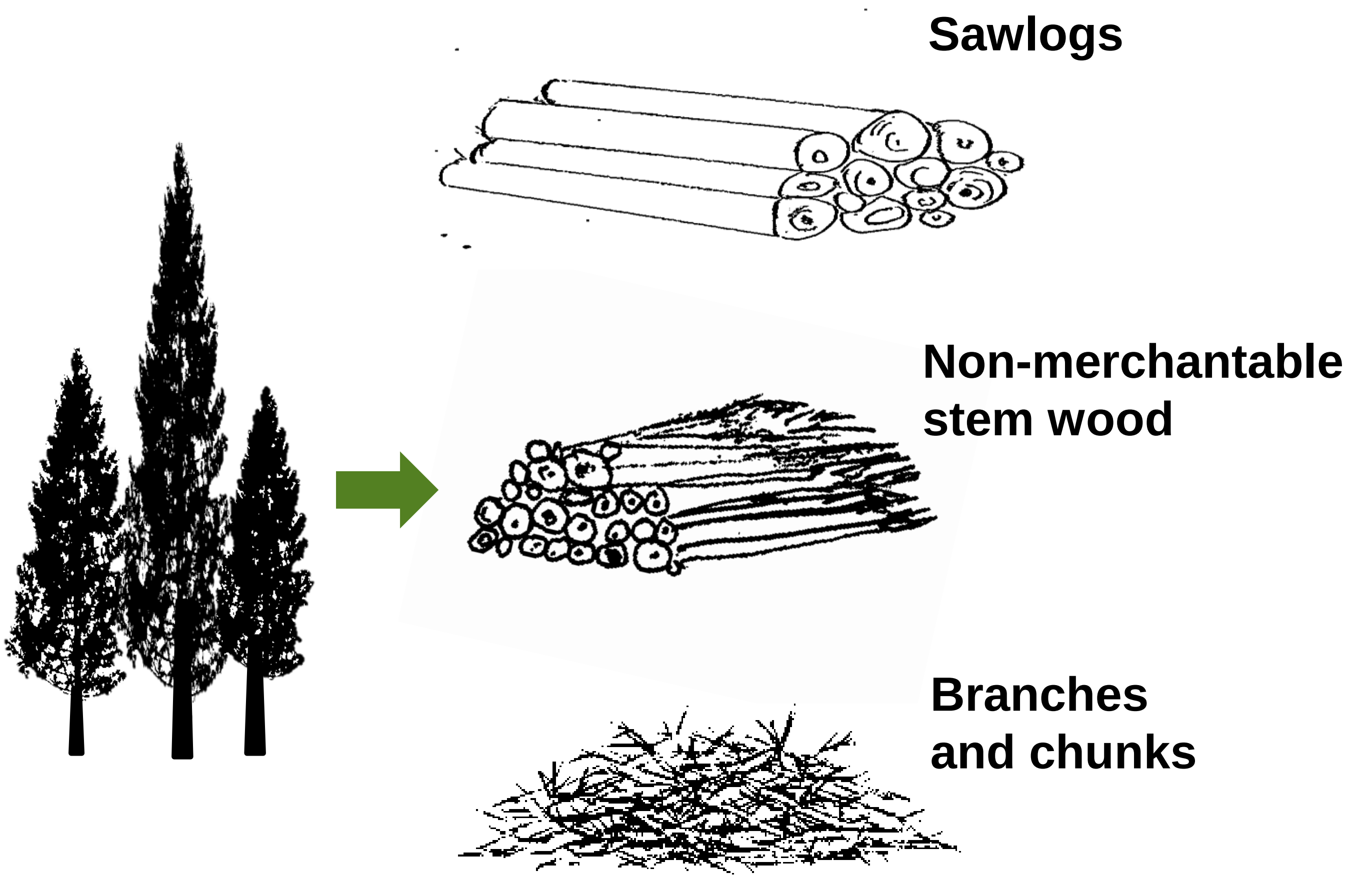
Han et al. 2015

Particle size distribution of grindings



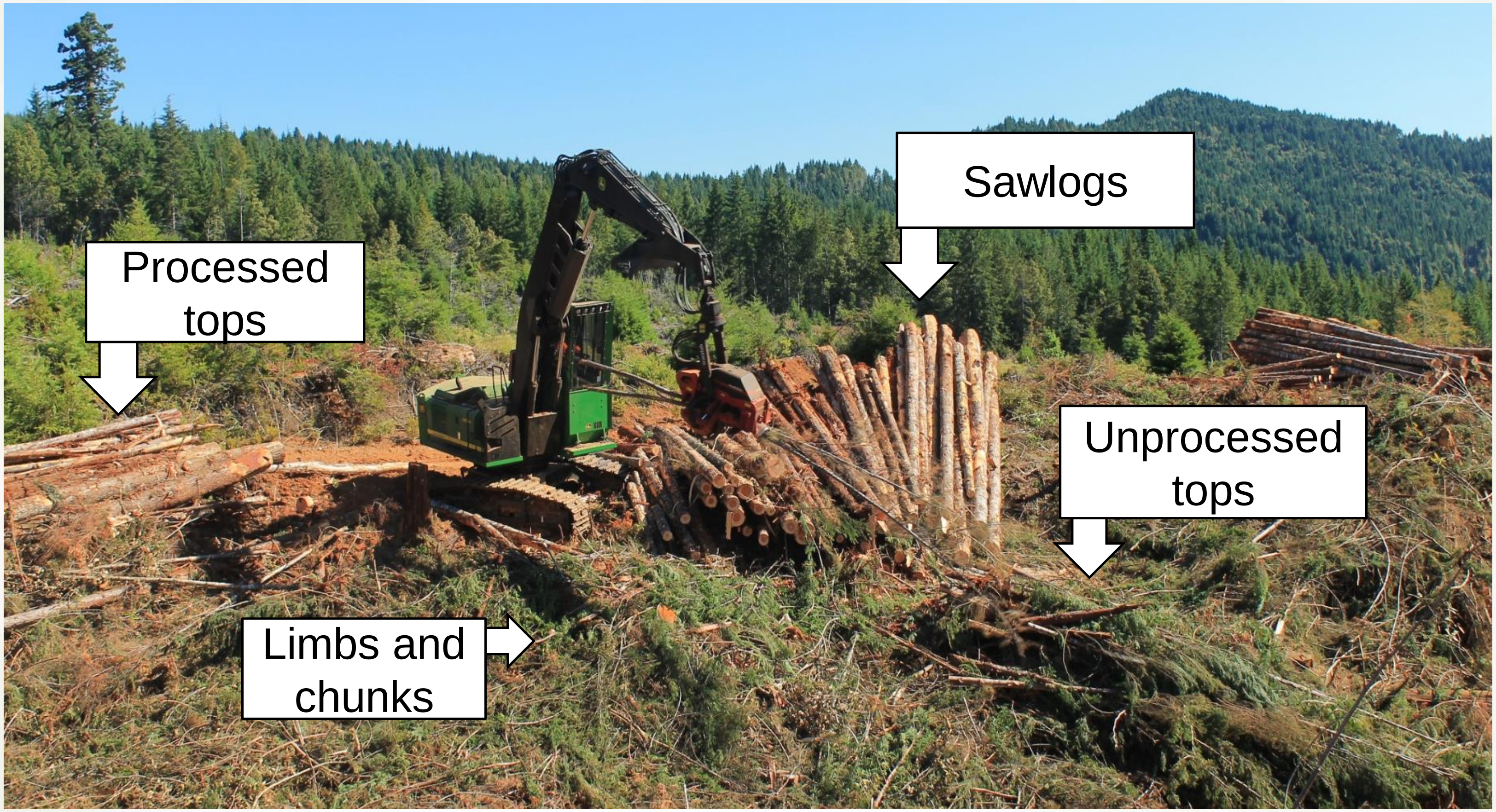
Zamora-Cristales et al. 2015

Sorting Forest Residues

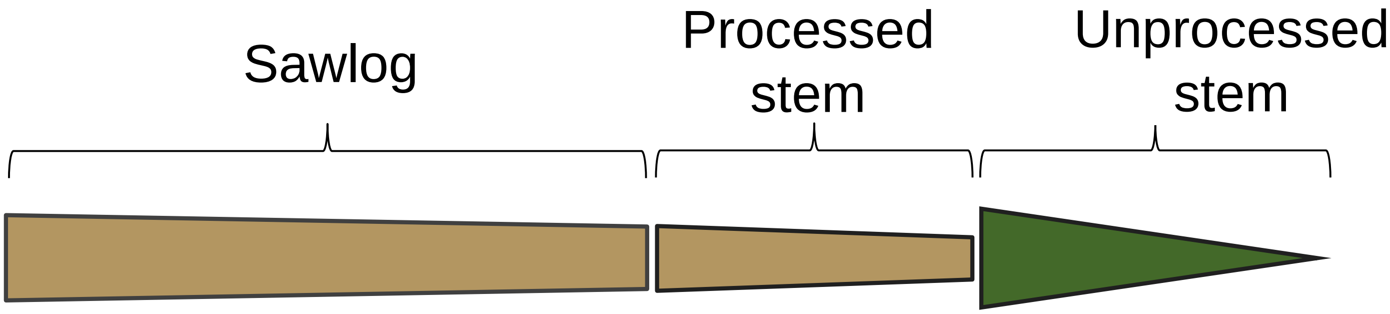


Kizha and Han, 2015

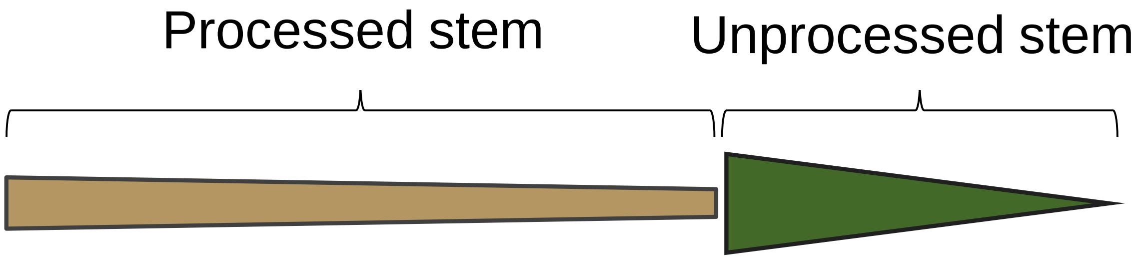
Sorting forest residues



- Merchantable sawlog tree



- Non-merchantable tree



Material generated from sorting and processing residues

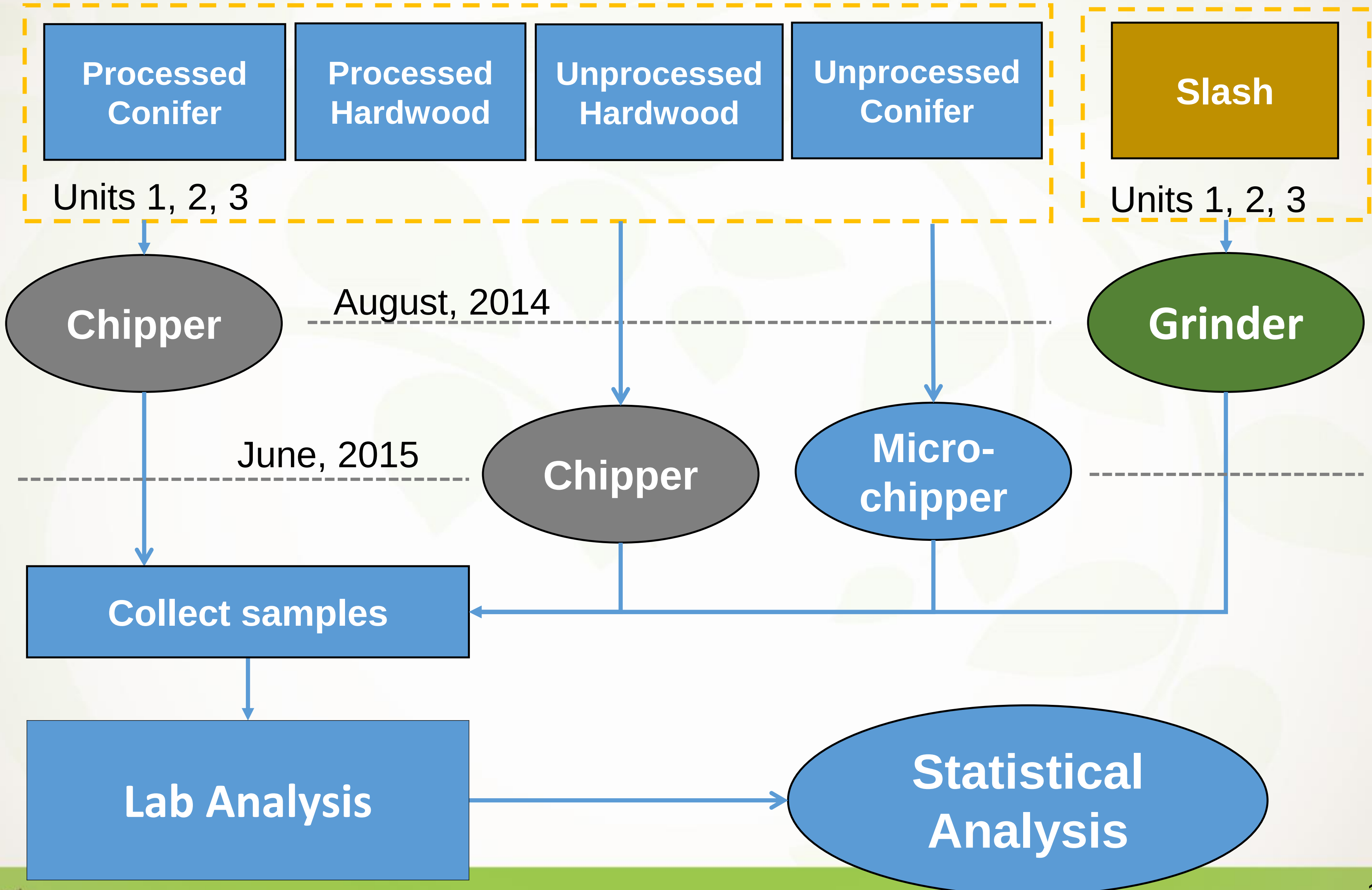
PC = processed conifer, PH = Processed hardwood, UC = unprocessed conifer, UH = unprocessed hardwood

Sorted material characterization

Material type		Bark cover (%)	Average volume (m^3/piece)
Processed conifer	PC	68	0.19
Processed hardwood	PH	71	0.17
Unprocessed conifer	UC	92	0.19
Unprocessed hardwood	UH	95	0.15

- 24% reduction in bark cover as a result of processing

Research design



Chipping 2- and 12-month old sorted material

- Half of the material prepared for the study was chipped in Aug, 2014 (2-month old)
- The other half was chipped in June, 2015 (12-month old)

Grinding 2-month old slash material

Micro-chipping 12-month old sorted material

Laboratory analysis

- Particle size distribution
- Moisture content
- Bulk density
- Ash content

Results and Discussion

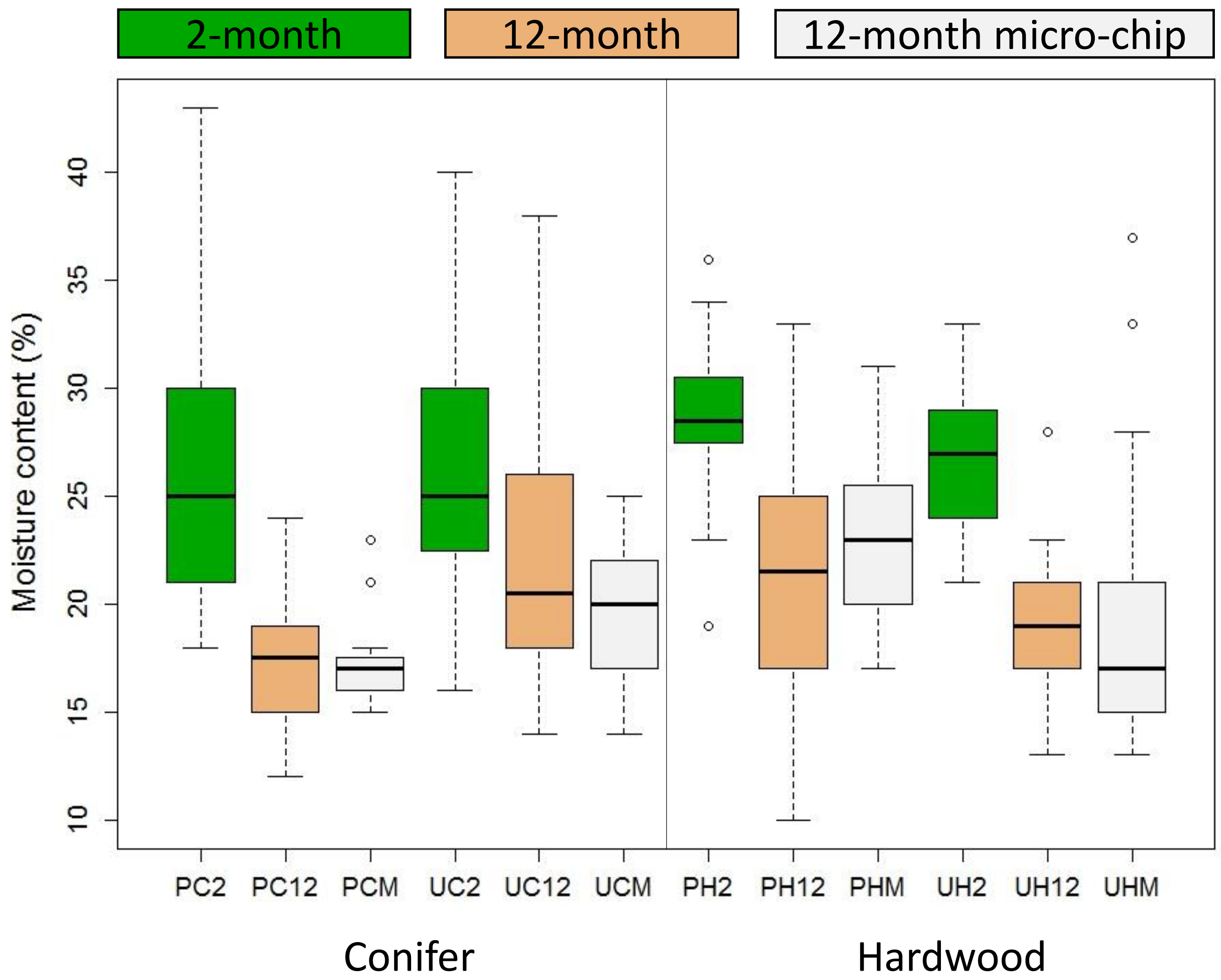
Material type	Machine*	Age (months)	Average moisture content (%)	Geometric mean particle length (mm)	Average bulk density (kg/m³)	Average ash content (%)
PC	C	2	26	17	228	0.27
	C	12	18	12	203	0.26
	M	12	18	6	236	0.25
PH	C	2	29	15	322	1.03
	C	12	21	17	252	0.69
	M	12	23	5	300	0.88
UC	C	2	27	18	239	0.64
	C	12	22	15	217	0.43
	M	12	20	4	227	0.35
UH	C	2	27	20	310	1.07
	C	12	19	15	252	0.99
	M	12	20	7	293	1.18
Slash	G	2	19	48	138	1.50

* C = Chipper, M = Micro-chipper, G = Grinder

Moisture content

Air-dying stems for an additional 10 months resulted in 7.25% reduction in moisture content across all material types.

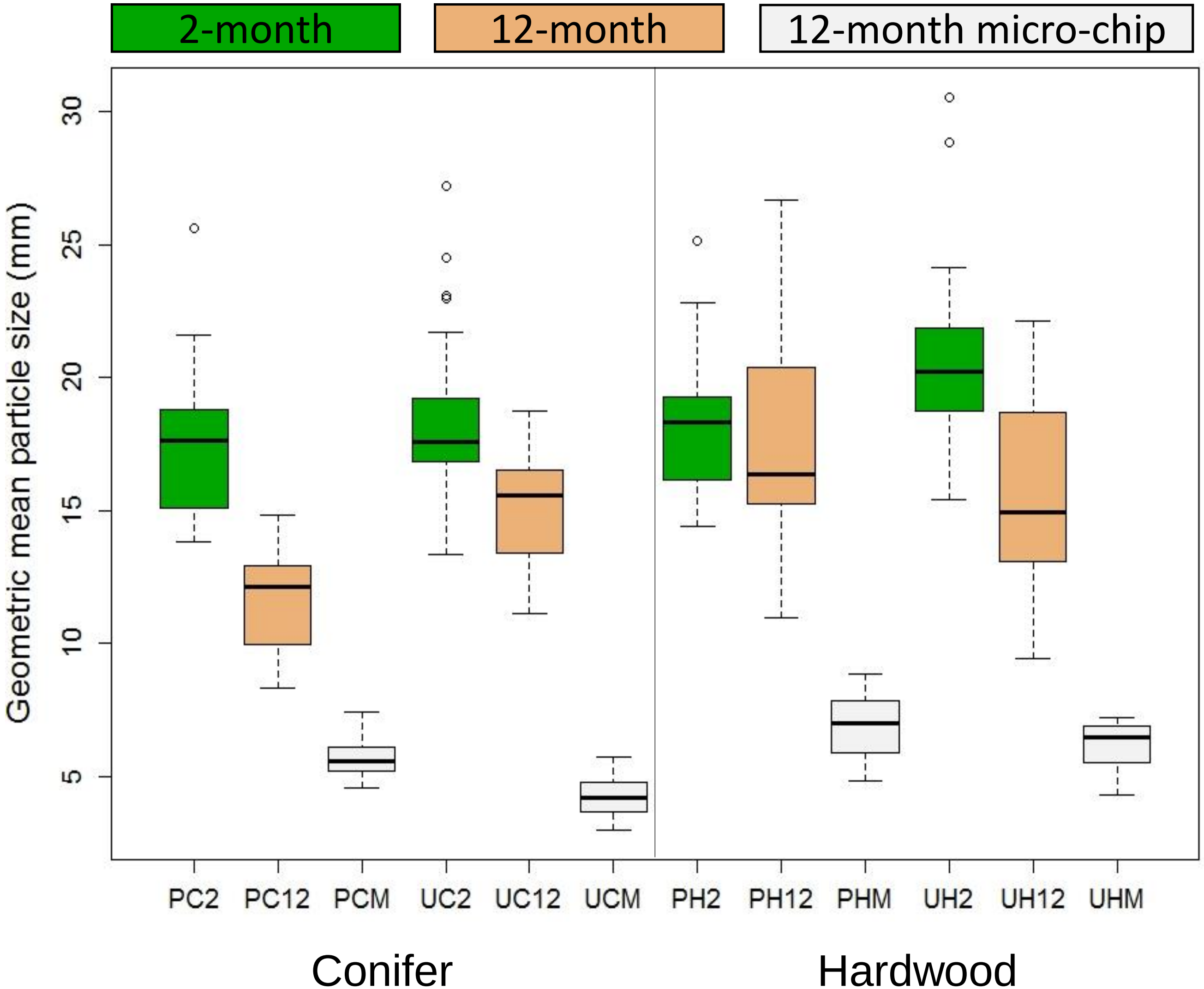
There was no significant difference in moisture content between processed and unprocessed material.



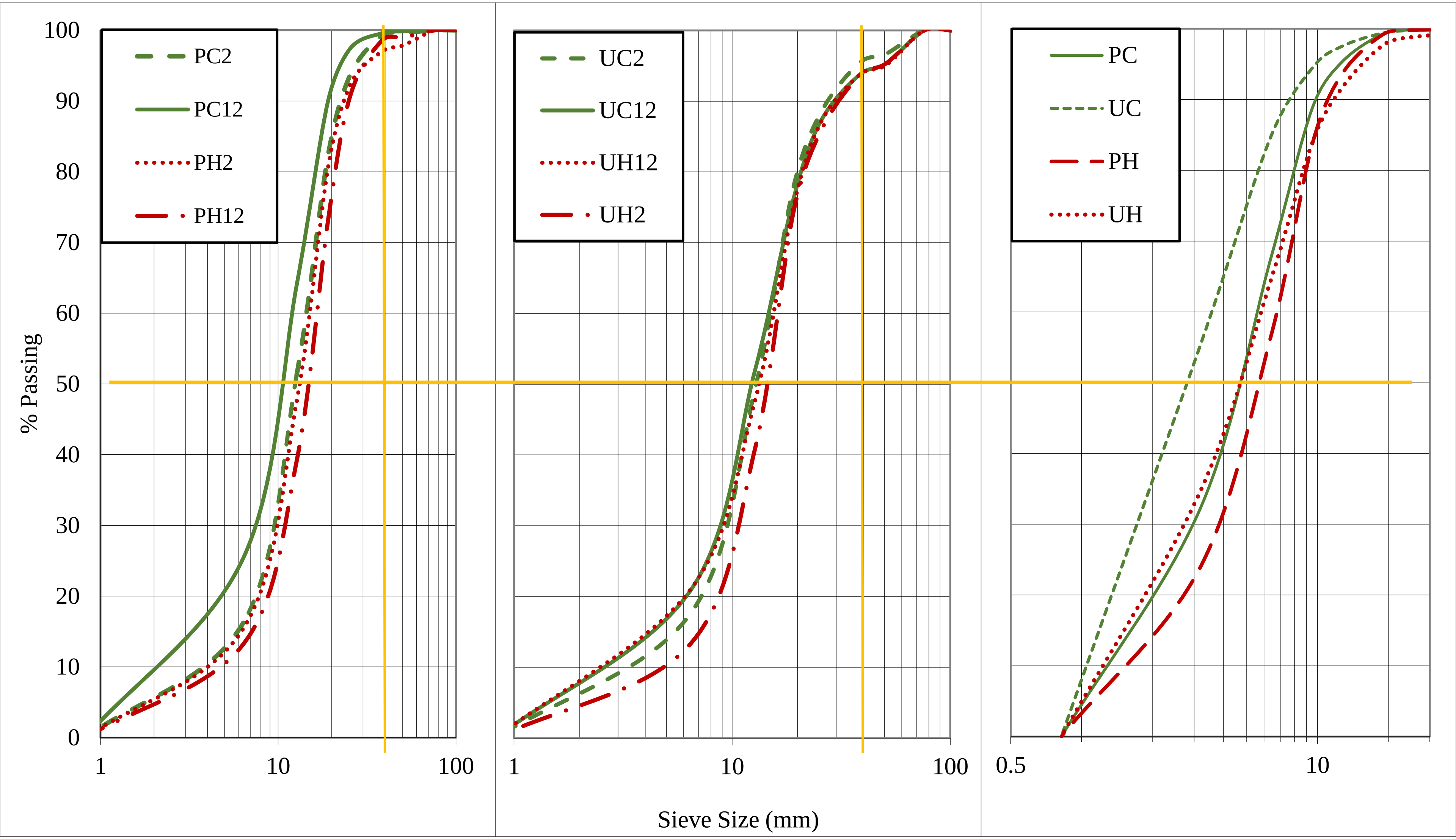
Particle size

Significant difference in GMPS for PC, UC, and UH due to aging.

Fine fractions increased 10 and 7% for PC and UH, respectively.



Cumulative distribution graphs



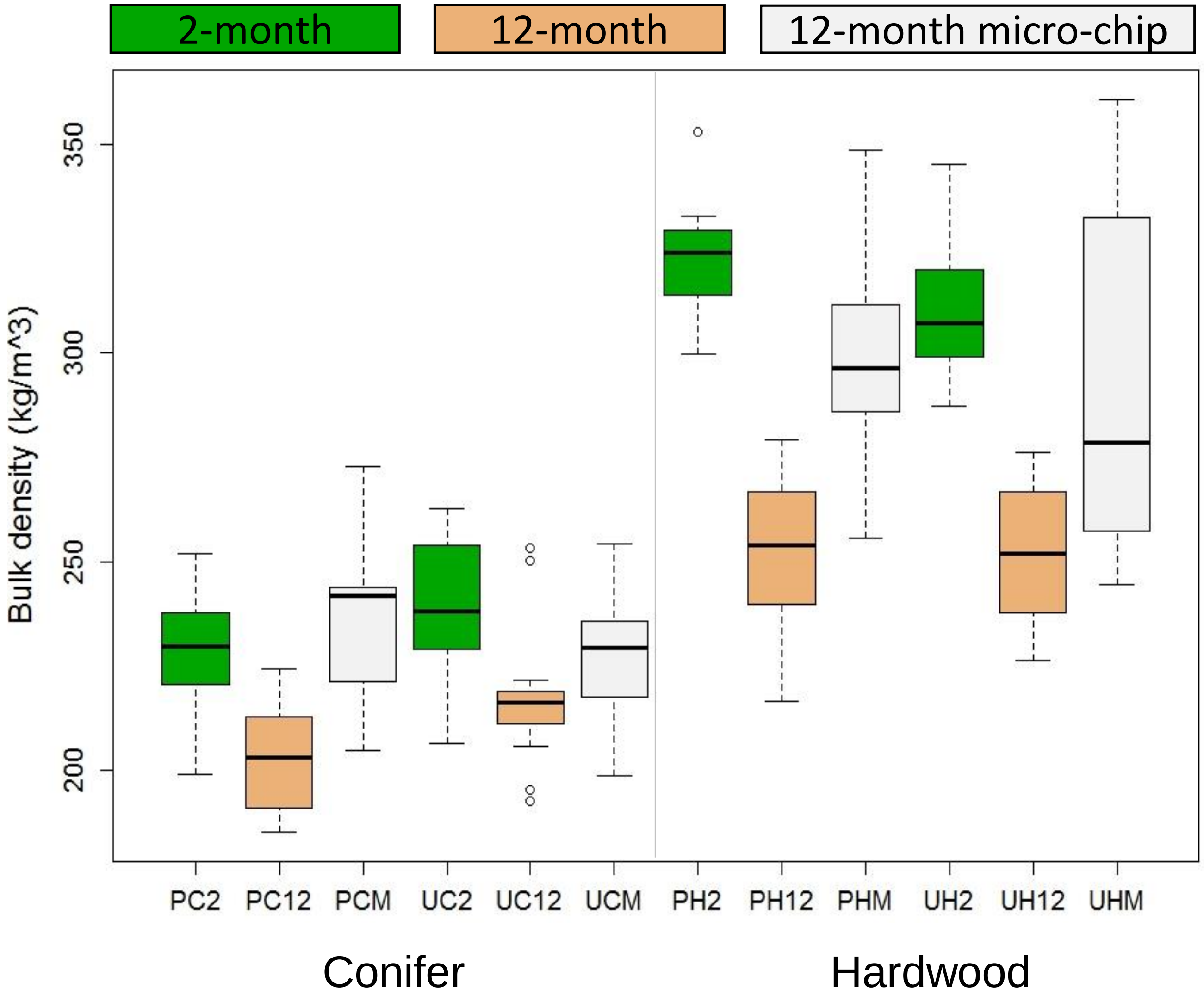
Processed material Unprocessed material Micro-chip material

Bulk density

Species and age significantly influenced bulk density.

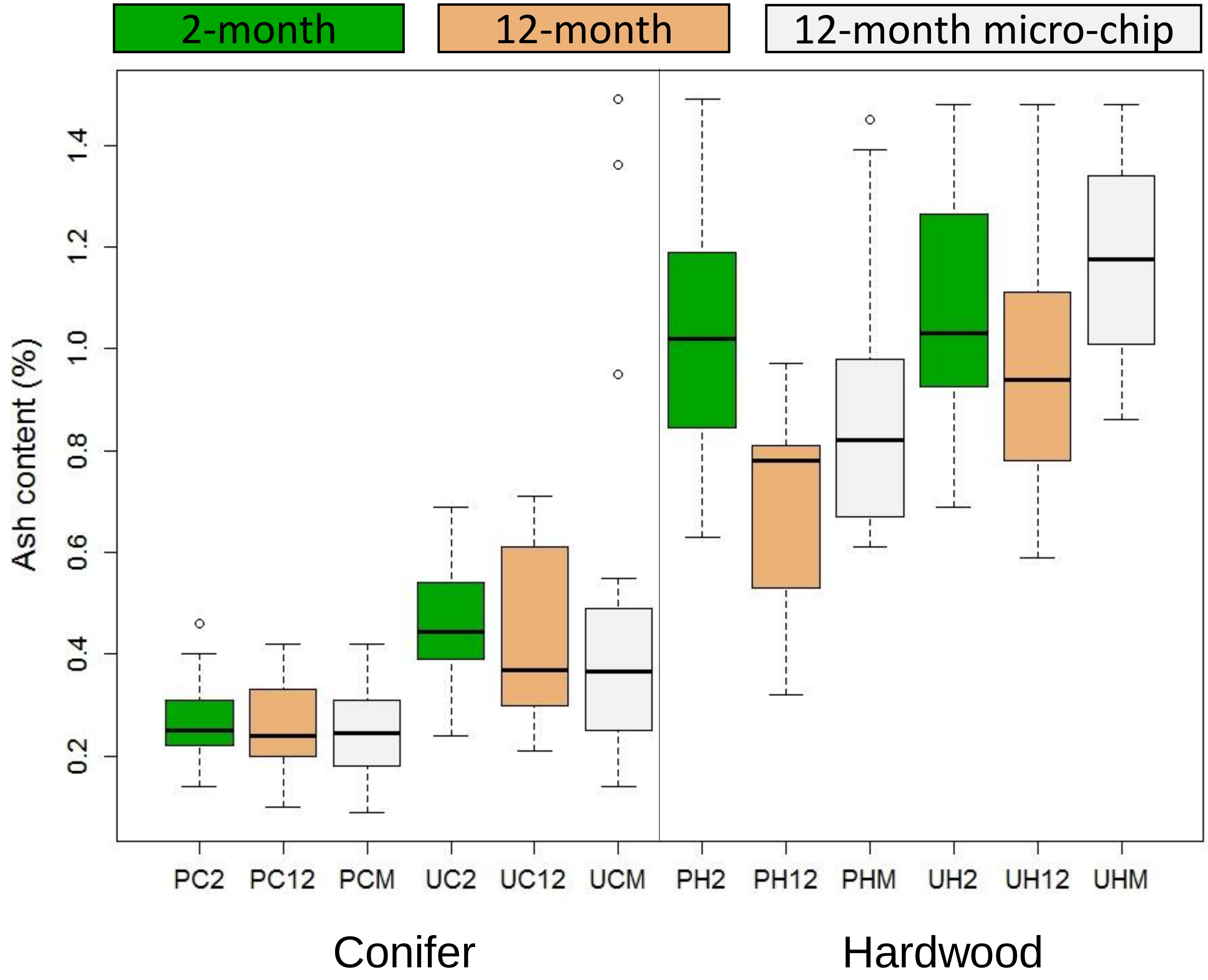
No significant difference as a result of processing.

Micro-chips increased bulk density by 13% over larger chip of same material.



Ash content

Species significantly influenced ash content.



Chipping productivity, fuel consumption and cost

Morbark disc chipper

Trailer load	Productivity BDmT[1]/PMH	Fuel consumption Liter/ BDmT[1]	Fuel consumption Liter/PMH	Cost $/BDmT[1]	Conifer / Hardwood mix
1	32.72	2.0	65.6	10.52	95 / 05
2	35.01	2.2	77.3	9.83	100 / 0
3	22.56	2.8	62.6	15.27	30 / 70
Avg.	30.10	0.44	68.47	11.87	

Peterson Pacific micro-chipper

Trailer load	Productivity BDmT[1]/PMH	Fuel consumption Liter/ BDmT[1]	Fuel consumption Liter/PMH	Cost $/BDmT[1]	Conifer / Hardwood mix
1	33.49	2.77	92.84	11.30	50 / 50
2	34.37	2.55	87.56	11.01	30 / 70
Avg.	33.93	2.66	90.20	11.16	

PMH = productive machine hour, BDmT = bone dry metric tonne.

[1] BDmT were calculated by converting green tonne values by multiplying by the average moisture content (20%).

Discussion

- The results of this work show the complexity in refining a feedstock to a desired specification.
- Managers should decide which feedstock quality is most important and base their management accordingly.
- The results are limited to the species used in this study.

Conclusions

- Through sorting and chipping we were able to considerably improve feedstock quality compared to grinding. This may justify the additional cost to sort forest residues during a timber harvest.
- Additional stem processing does not have a big impact on feedstock quality.
- Allowing material to age can have a significant impact on moisture content, particle size, and bulk density

2016 Summer research

Thank You

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