

Production of quality feedstock from forest residues: sorting, comminution, and screening



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Forest Residues



Logging Slash



Forest Thinnings

103 million tons/year @ \$60/bone dry ton (Billion-ton Report, 2016)

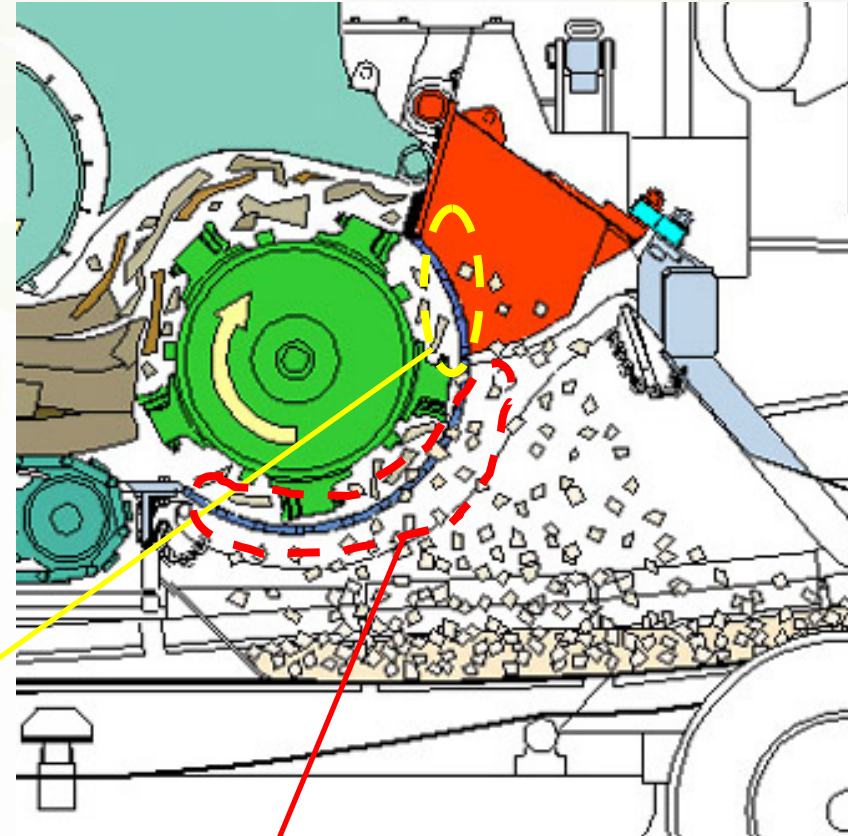
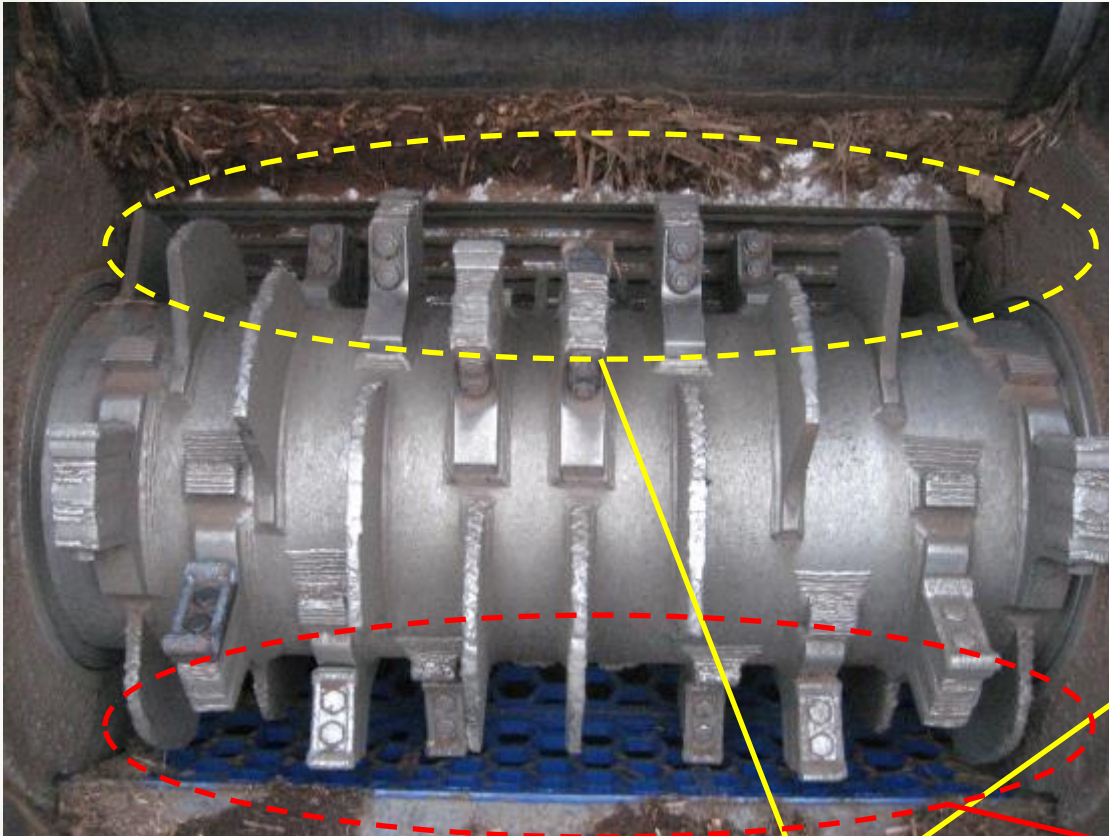
Logging Slash





Grinding

Grinding Process



(Source: Peterson Pacific Co.)

Anvil

Screens (Grates)

Particle Size Distribution



Ground materials



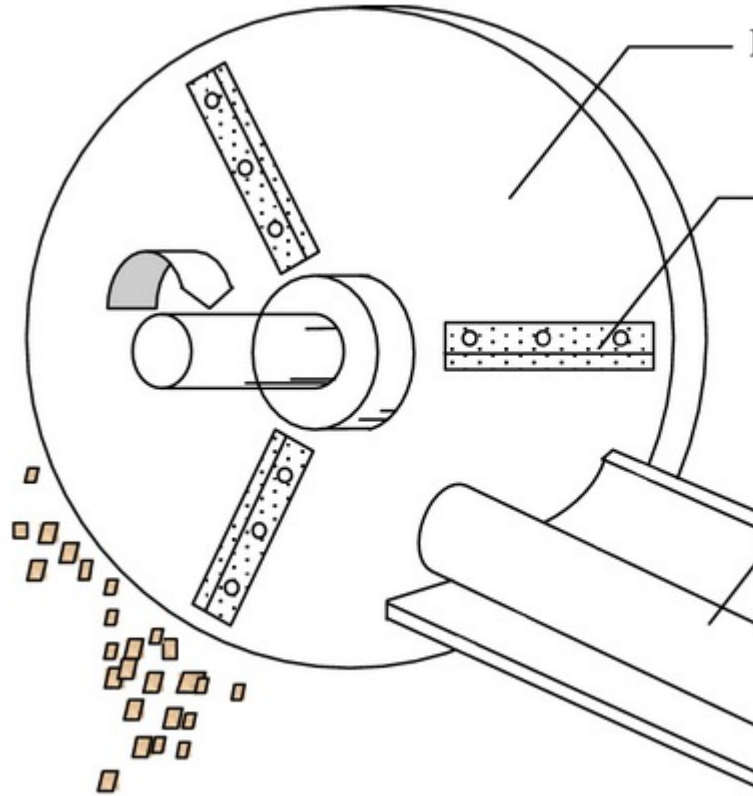
Small-Diameter Trees



Whole tree chipping



Disc Chipper



Drum Chipper

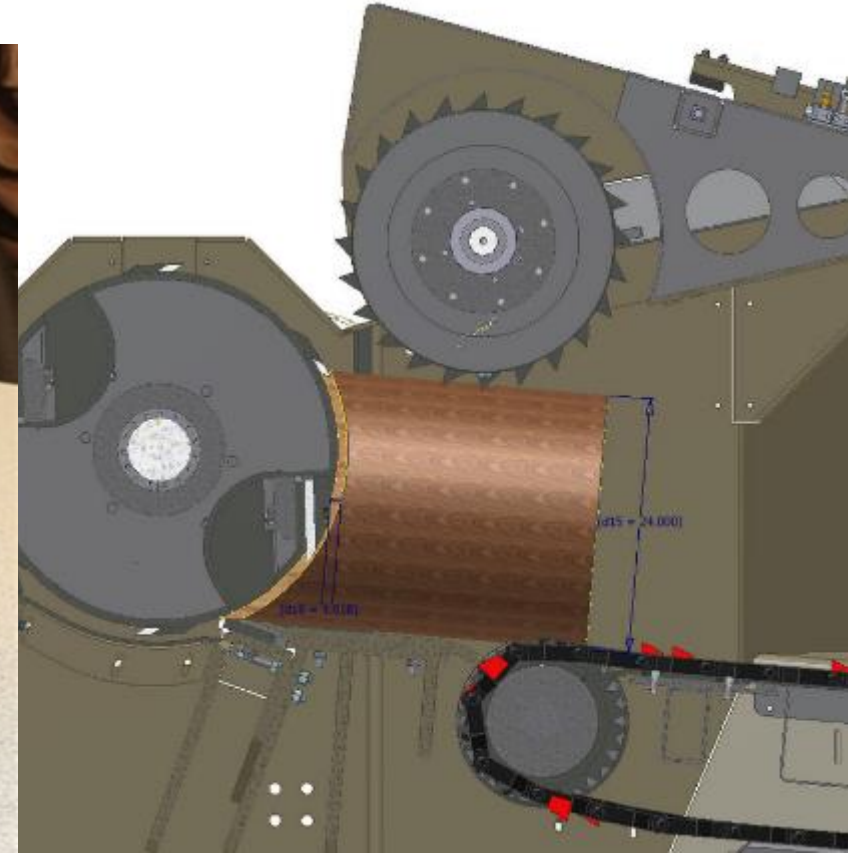


Illustration: <https://www.researchgate.net/publication/312111111>

Peterson Pacific Corp.

Knives

Particle Size Distribution



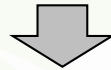
Stem wood chips



Whole tree chips

Waste to Wisdom - Project Overview

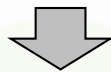
Forest Residues



Production of Quality Feedstock



In-woods Biomass Conversion



Biochar



Briquettes

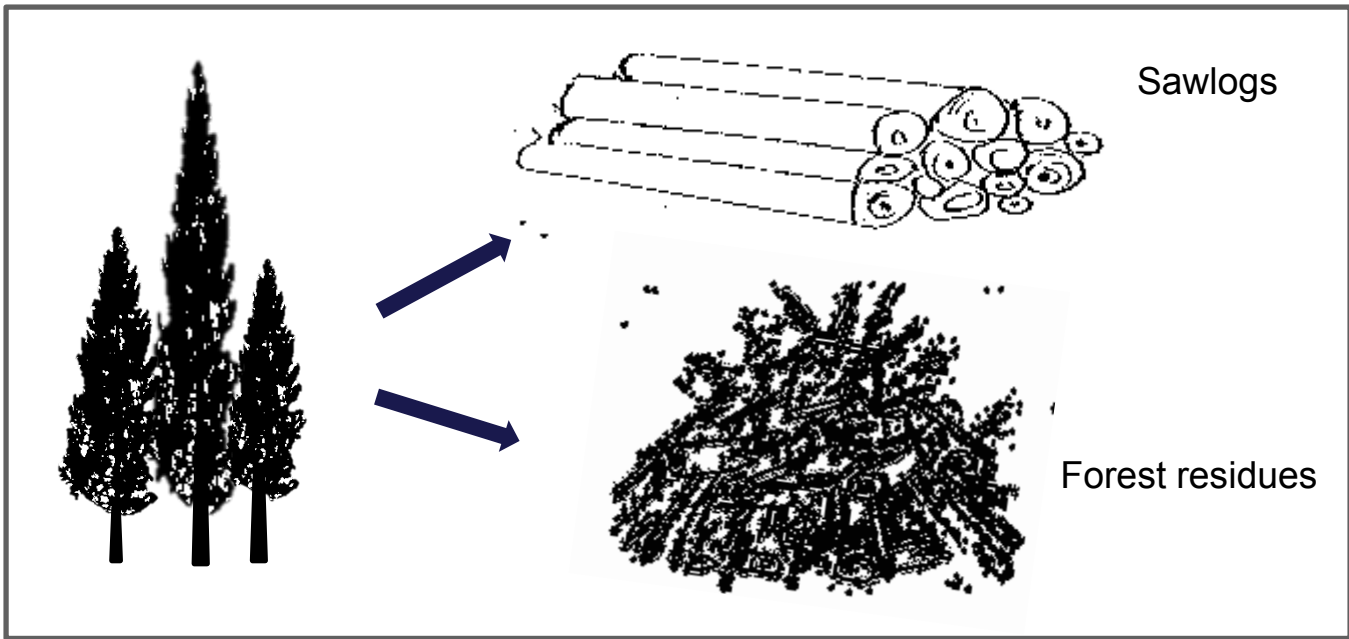


Torrefied chips

Desired feedstock specifications

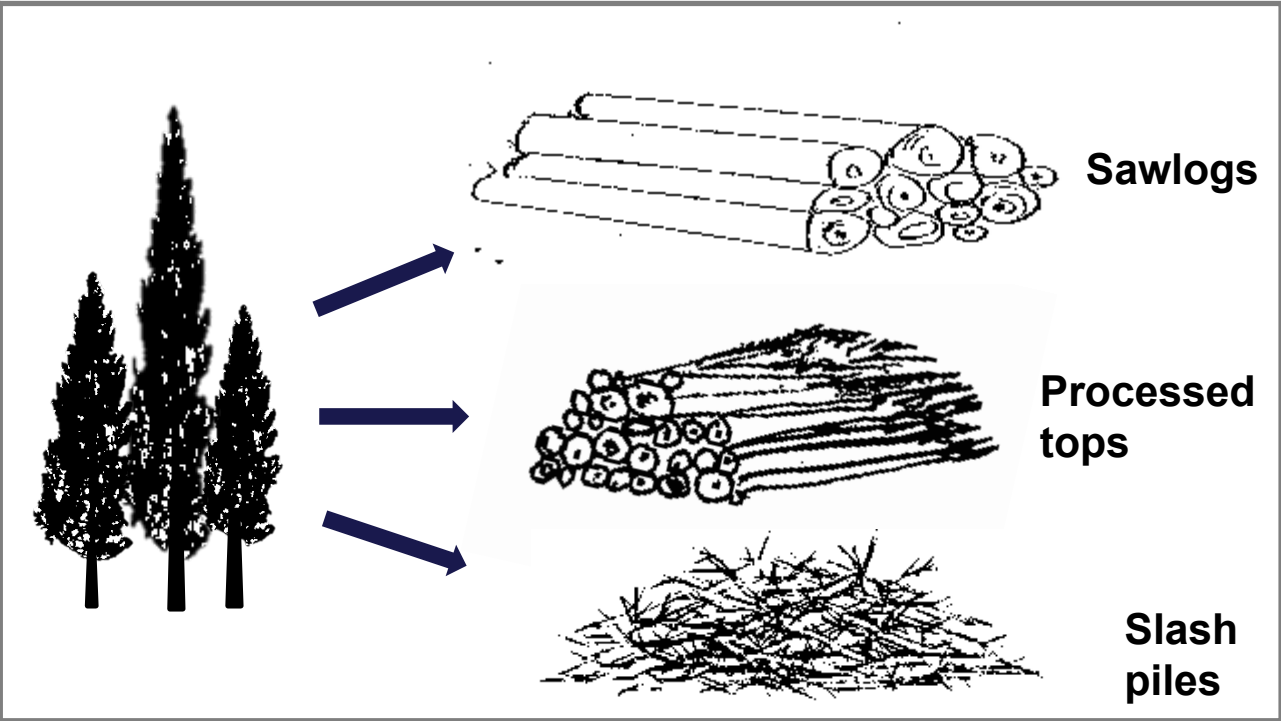
Biomass Conversion Technology	Product	Particle size (inch)	Moisture Content (% wet basis)	Ash content (%)
Gasification	Biochar	0.1 - 4	< 25%	< 15%
Torrefaction	Torrefied chips	0.1 – 1	< 30%	no limit
Densification	Briquettes	< 2	4% - 15%	no limit

(Schatz Energy Research Center, 2017)

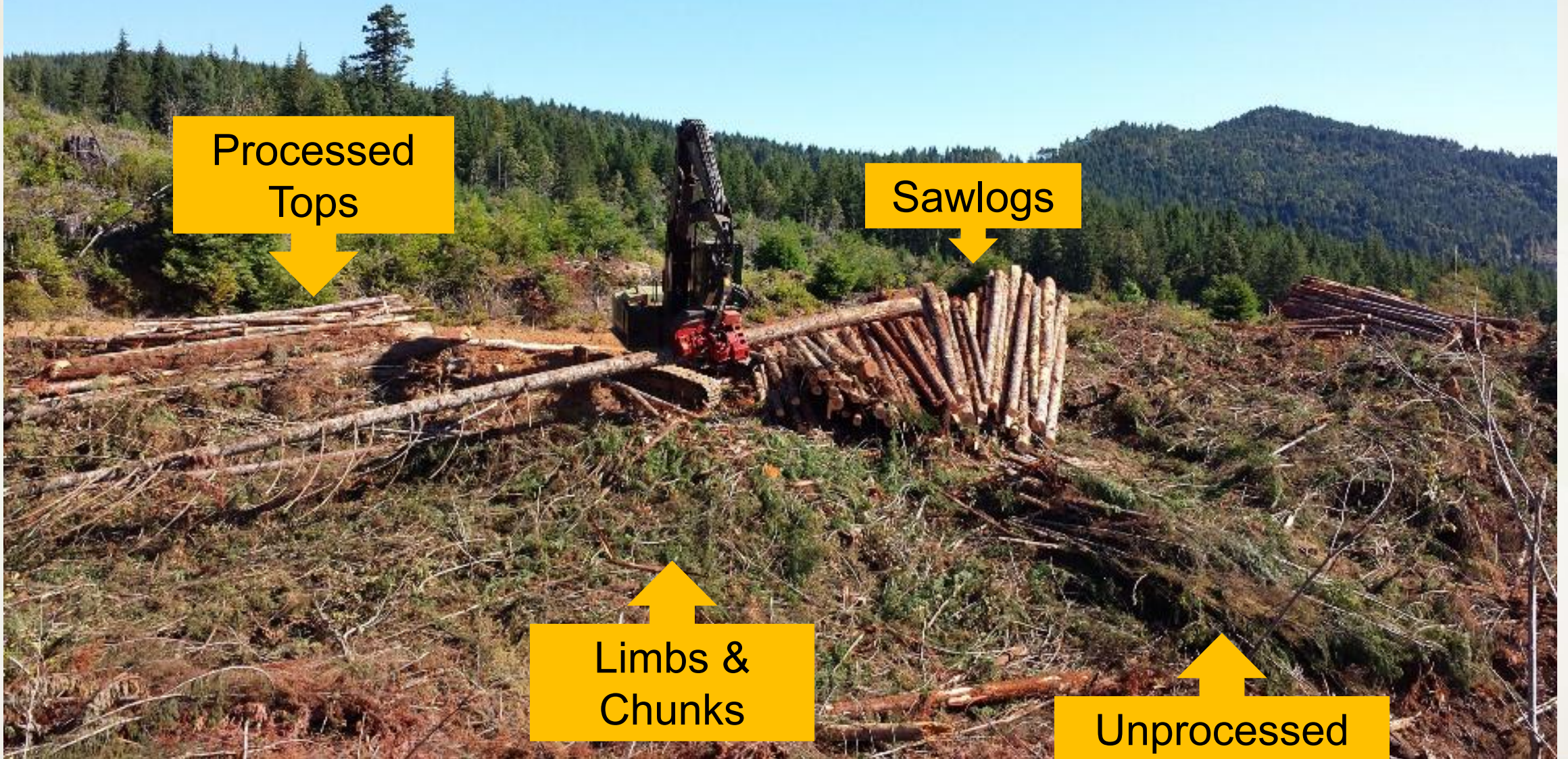


Current practice

Sorting tree tops



Sorting & processing tree tops during timber harvesting



Forest Residues Sorted and Processed



Processed conifer



Unprocessed conifer



Processed hardwood



Unprocessed hardwood

Production of quality feedstock from forest residues

- Size distribution:
 - Chipped materials: >95% chips less than 2 inches
 - Ground materials: >55% ground materials larger than 2 inches

Material type		Ave. particle size (inch)	Ash content (%)	Moisture content (%)	Bulk density (lb/ft ³)
Processed conifer	Chipped	0.68	0.27	26	14.24
Unprocessed conifer		0.72	0.64	27	14.92
Processed hardwood		0.71	1.03	29	20.11
Unprocessed hardwood		0.81	1.07	27	19.34
Slash	Ground	1.87	1.50	19	8.57

Chipped Materials



Ground Materials



Machine Performance

Machine type	Horsepower	Productivity (tons/PMH)	Fuel consumption (gal/ton)	Cost (\$/ton)
Morbark 30 disc chipper	875	41.59	0.43	10.75
Peterson Pacific 4300B drum micro-chipper	765	46.66	0.54	9.44
Nelson sawdust chipper	400	19.61	0.36	4.77



Various types of feedstock produced from forest residues

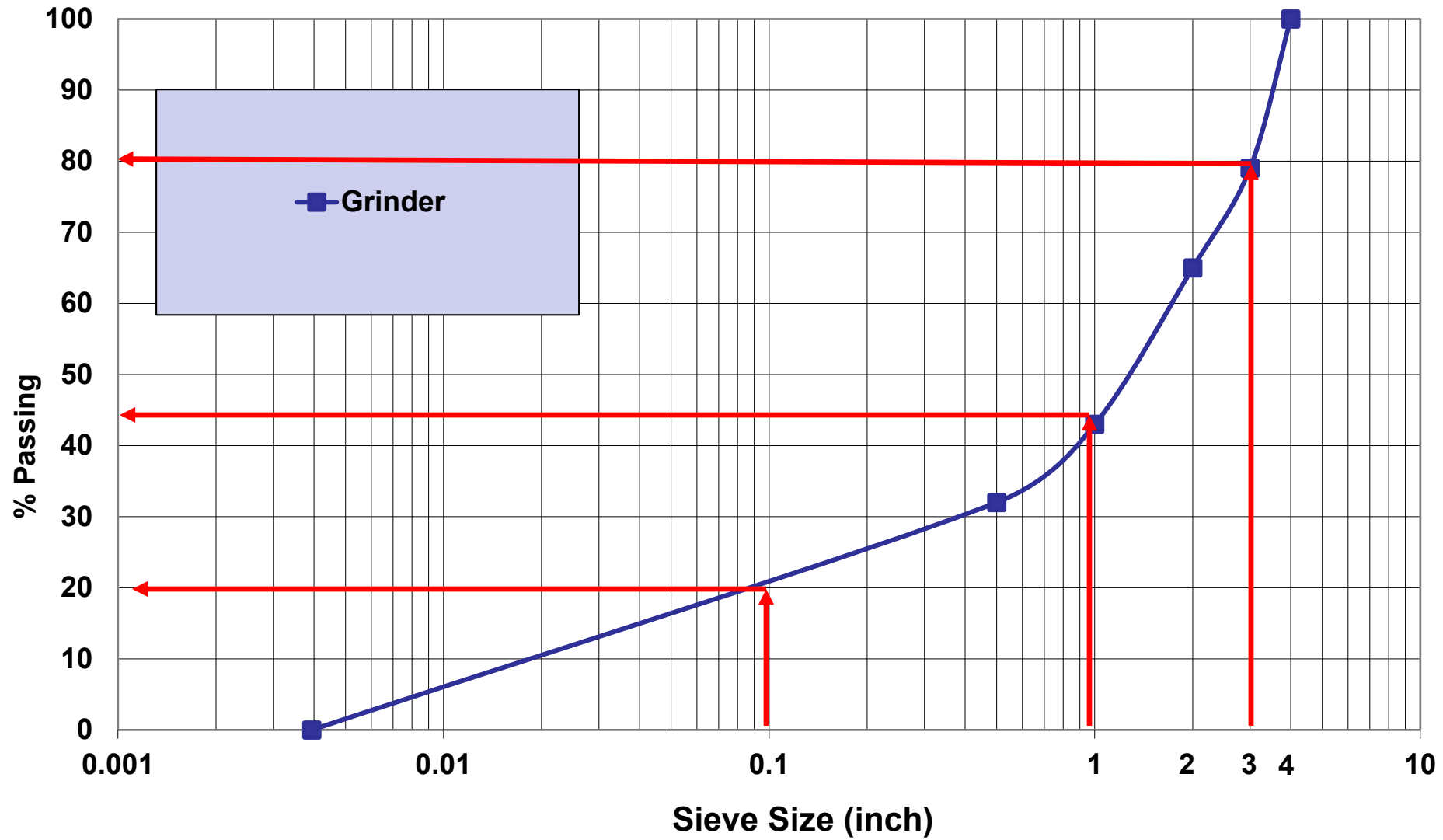


wood chips
(<0.75 inch)

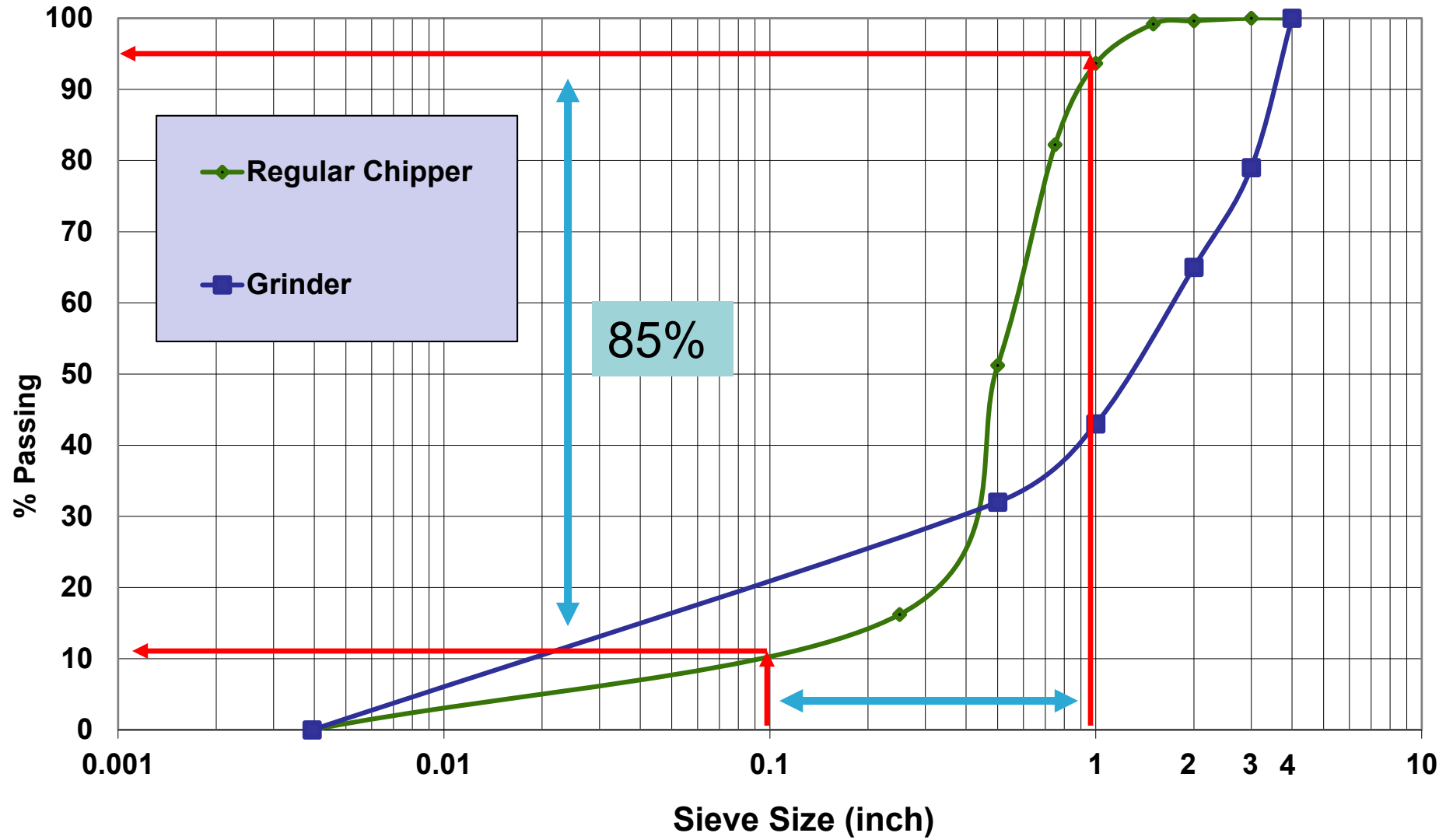
micro-chips
(<0.25 inch)

sawdust
(<0.16 inch)

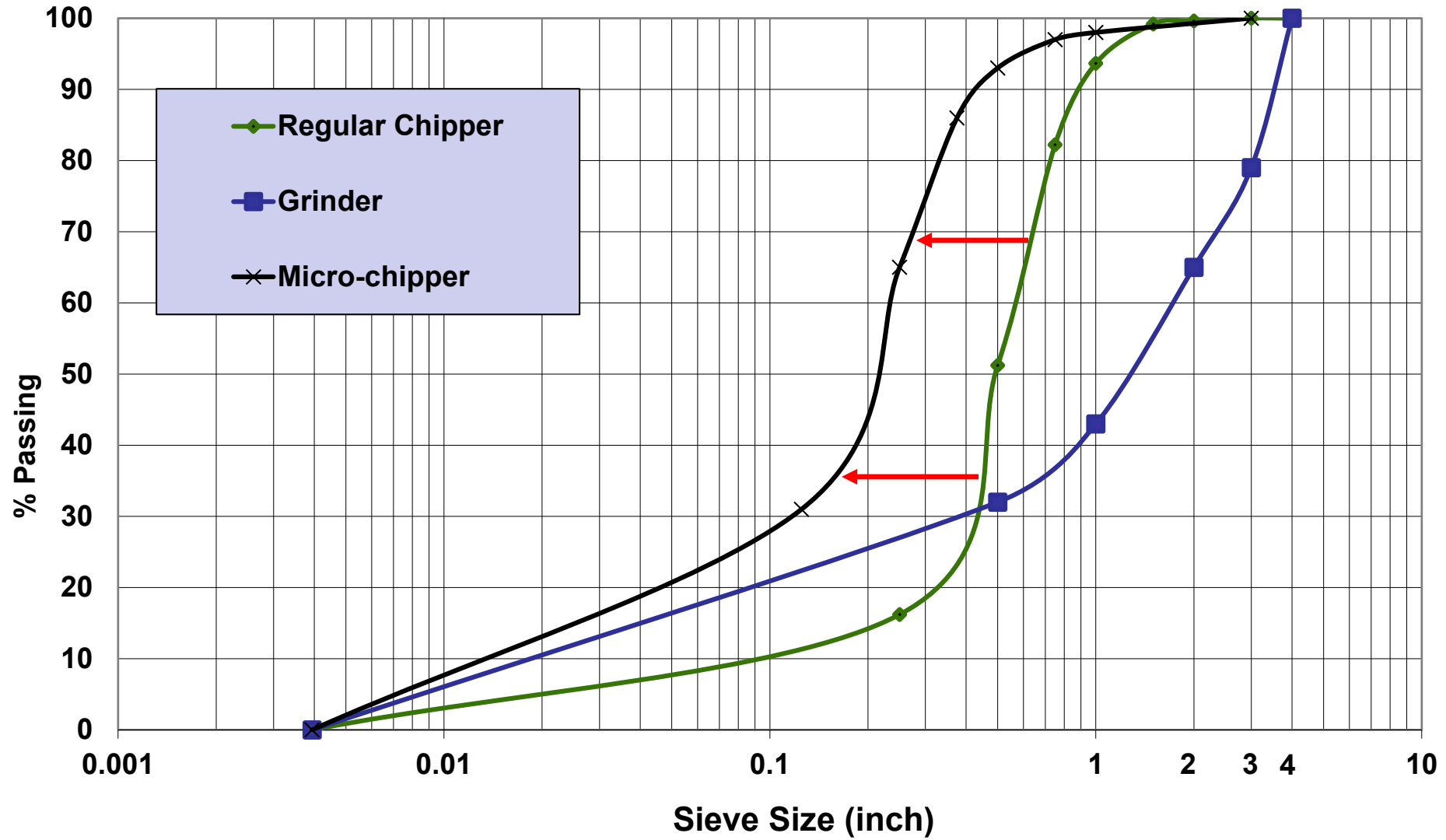
Cumulative Size Distribution by % Mass



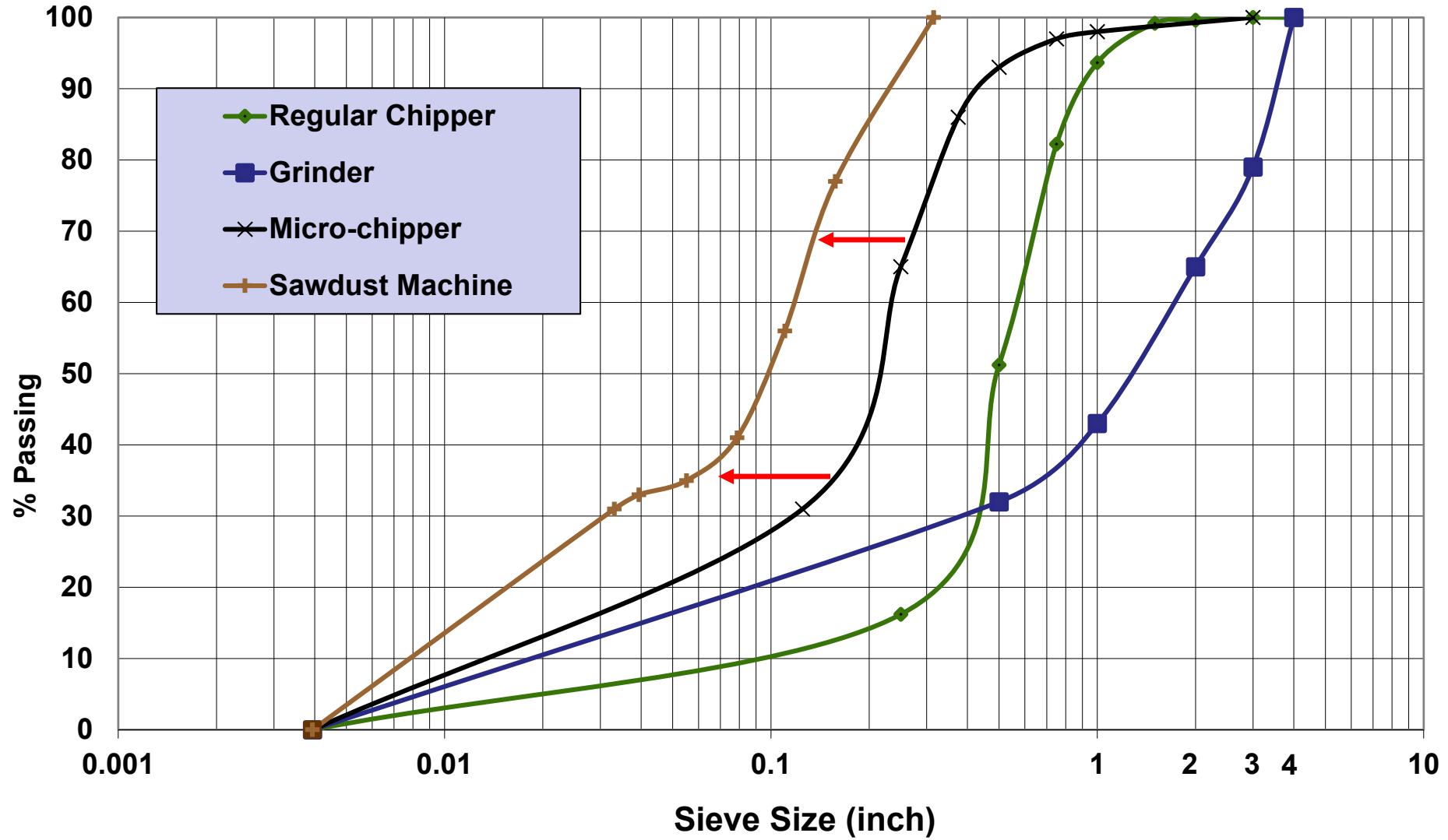
Cumulative Size Distribution by % Mass



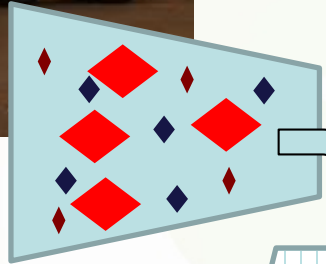
Cumulative Size Distribution by % Mass



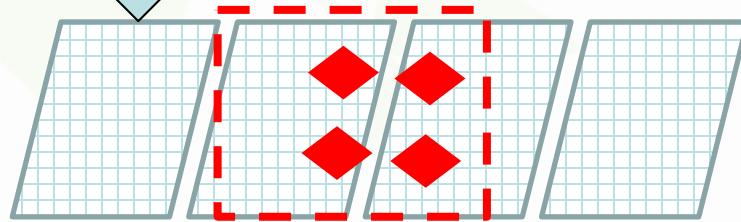
Cumulative Size Distribution by % Mass



Deck Screen Machine

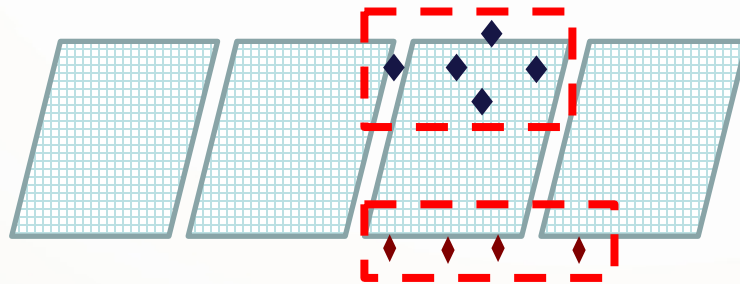
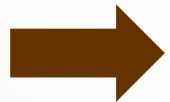


Top screen
(2 in.)



Over size (>2 in.)

Bottom screen
(3/8 in.)

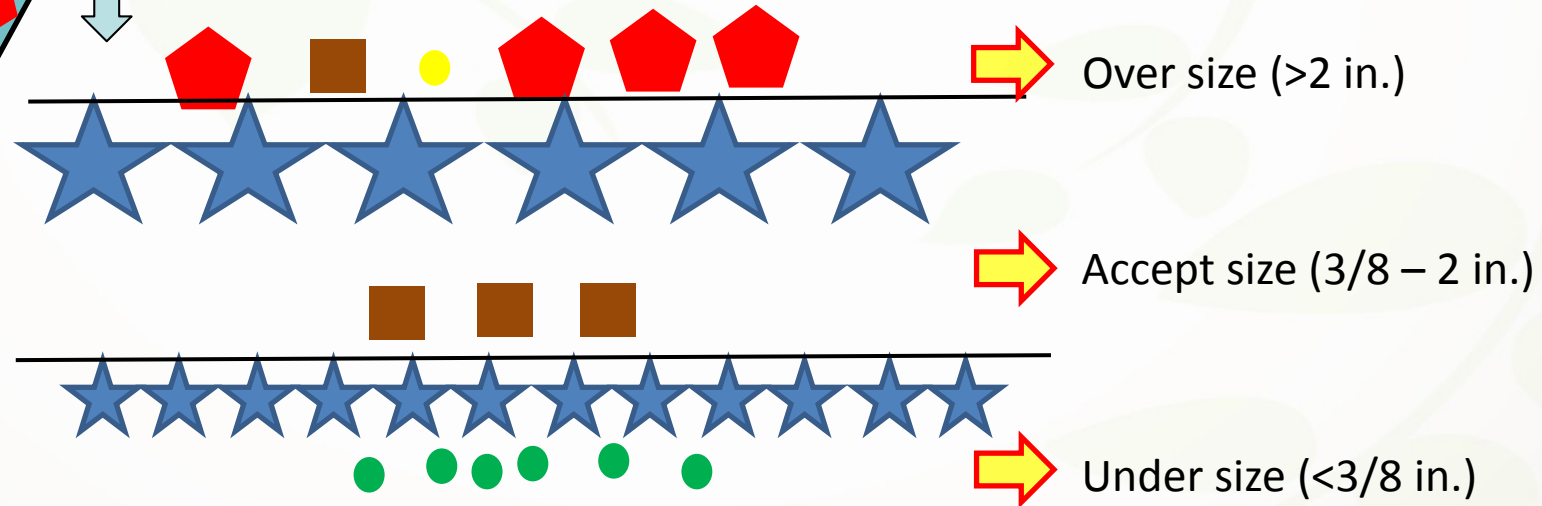
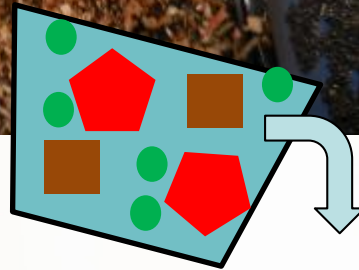


Accept size (3/8 – 2 in.)



Under size (<3/8 in.)

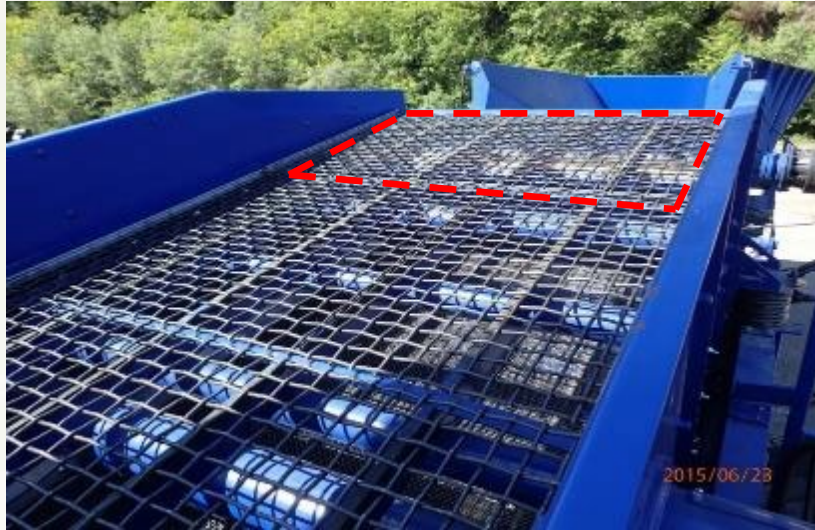
Star Screen Machine



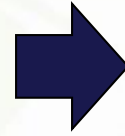
Feedstock Screening

		Wood chips		Hog fuel	
		Deck	Star	Deck	Star
Productivity (tons/hour)		29.76	64.1	15.37	55.61
Fuel consumption (gallons/ton)		0.23	0.03	0.4	0.04
Size distribution (% mass)	Under ($< 3/8$ in.)	15.07	8.04	29.75	32.03
	Accept ($3/8 - 2$ in.)	84.74	91.35	67.75	60.73
	Over (> 2 in.)	0.19	0.61	2.5	7.24

Reduce diving problems for spears



4 sets of 2 in. screens
(SS1)



one 3/8 in. and 3 sets of 2 in. screens
(SS2)

- Different screen settings did not affect screening productivity and fuel consumption
- Overall accuracy was increased from 80 % (SS1) to 84 % (SS2) by reducing >2 in. (oversize) materials in accept size.

Moisture content reduction study

Objective:

Develop on-site methods to lower moisture content

Processor piled



Teepee



Criss-cross

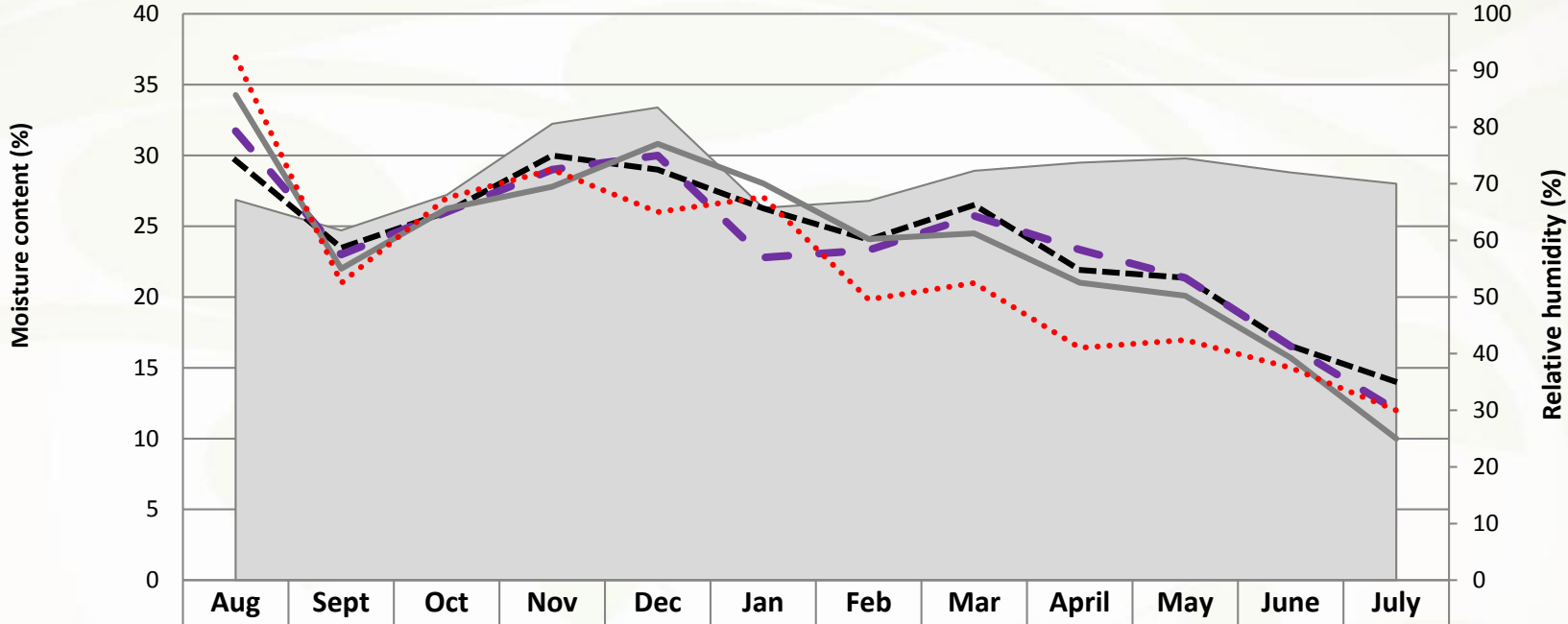


Scattered



Covered vs. Uncovered

Moisture content reduction study



	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July
Relative humidity (%)	67	62	68	81	83	66	67	72	74	74	72	70
Teepee	30	23	26	30	29	26	24	26	22	21	17	14
Criss cross	32	23	26	29	30	23	23	26	23	21	17	12
Processor pile	34	22	26	28	31	28	24	24	21	20	16	10
Scattered	37	21	27	29	26	27	20	21	16	17	15	12

Key messages...

- ✓ Sorting stem wood from other forest residues during a timber harvest operation facilitates the use of a chipper.
- ✓ Through chipping of forest residues, we can produce various types (wood chips, micro-chips, and sawdust) of feedstock uniform in size.
- ✓ We can use different screening machines to further separate undesirable sizes of feedstocks.
- ✓ Moisture content can be reduced to less than 20% on site by allowing an increased amount of air flow in the wood piles



Sort and Process



Comminute



Screen

Thank You!



<http://wastetowisdom.com/>