REPORT

ON THE METHODOLOGY EMPLOYED

FOR THE MEASUREMENT OF

WOODY DEBRIS FROM THE JUNE 2024 STORM

ON WAIKANAE BEACH GISBORNE

AND ITS ASSESSMENT RESULTS

Sample Measurements of 24/25TH June 2024

Gisborne Waikanae Beach Woody Debris Deposits

Disclaimer: The purpose of this report is to present the methodology employed to measure a sample of the woody debris on the Gisborne Beach and to calculate the responding volume per hectare by debris class in % and m/3.

While all practical steps have been undertaken within the design and implementation of the inventory to ensure statistically valid outcomes, Forest Measurement NZ Ltd nor its staff does not accept any liability to any person nor organisation in respect of the inventory results.

This report has been commissioned by the Eastland Wood Council.

This report has been compiled by:

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Acknowledgement: I hereby acknowledge the skill of Jack Cumming in the identification of the various species and the efficient establishment of the 30 sample plots.

Signed:

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1. Summary

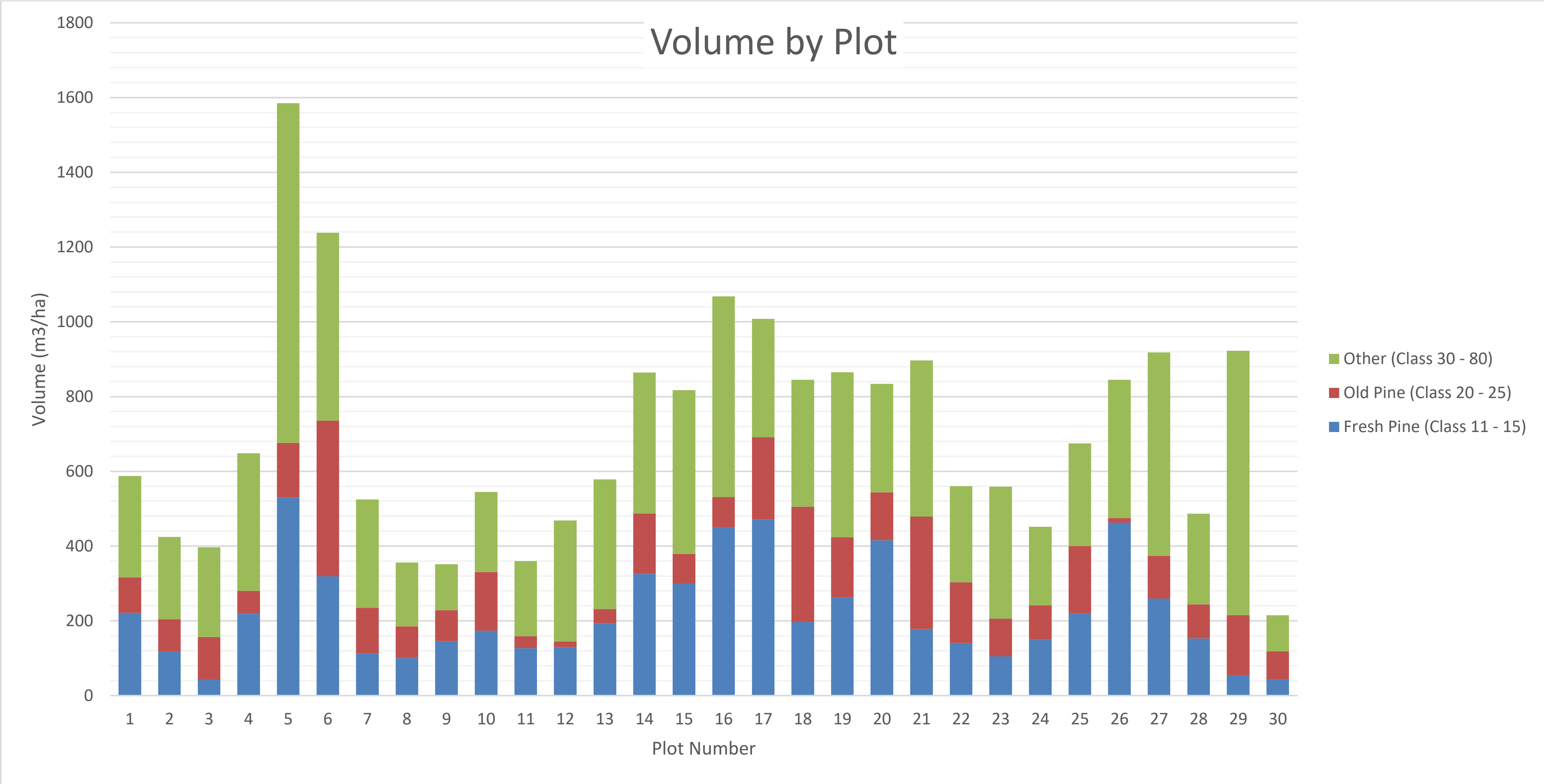
A high intensity rainfall and an exceptionally windy storm on the 24th and 25th of June 2024 caused large scale woody debris flows onto the Gisborne Beach on the East Coast of New Zealand.
This report describes the assessment of the type and quantity of the woody debris by species and age class. See Table 1.
The assessment area limits itself to an approximate 870 mtr long and approximate 10 mtr wide strip on the Gisborne beach of Waikanae. The assessment was conducted on the 8th, 9th and 10th of July 2024.
The Line Intersect Technique, commonly called a Wagner Waste Assessment, was used to measure the diameters of woody pieces equal to or larger than 7 cm. There was no minimum length.
The wave action that deposited the woody debris on Waikanae beach caused a non-random orientation of the logs and pieces. The pieces were generally positioned parallel to the ocean. In order to circumvent that bias in orientation a line intersect model was used containing an equilateral triangle with each segment of the triangle 10 mtr long.
In order to further address the non-random orientation of the pieces each plot was given an additional 10 degree offset in the orientation of the first triangle segment, segment A.
Diameters were measured using a calliper. Only single measurements were made rather than 2 measurements perpendicular to each other.
The data was imported into a spreadsheet containing the volume calculation developed by David Crawley of PF Olsen. A count was made of pieces measured as well as calculating the volume based on the intersected diameter.

Table 1: Classification of Woody Debris on the Gisborne Beach during June/July 2024 Assessment

Reference	Species	Assumed Age	Description	Assumed source for reporting	Assumed source description
11	Radiata Pine <40 years old	Since 2018	Rootball without scarf cut	Forestry - Unknown source	Possible sources include: Mature windthrow left in cutover Windthrow of any age not associated with harvesting Trees victim of riverbank erosion Trees victim of landslides
12	Radiata Pine <40 years old	Since 2018	Rootball with scarf cut >=40cm dia	Forestry - Harvest Related	Possible sources include: Stumps that were in the ground then moved by a slip Stumps that had been unearthed during construction
13	Radiata Pine <40 years old	Since 2018	Rootball with scarf cut <40cm dia, and Stem with scarf cut <40cm dia	Forestry - Not Harvest Related	Thinnings
14	Radiata Pine <40 years old	Since 2018	Stem with flush cut, scarf >=40cm dia, or processor marks	Forestry – Harvest Related	Skid waste or cutover waste
15	Radiata Pine <40 years old	Since 2018	All other	Forestry - Unknown source	Bits of stem with two broken ends. Possibly skid waste, possibly cutover waste, possibly bits of thinnings, windthrow, or other non-harvest related that broke up on the way out.
21	Radiata Pine <40 years old	Pre 2018	Rootball without scarf cut	Forestry - Unknown source	As per above but likely to have been sitting in the catchment since pre 2018
22	Radiata Pine <40 years old	Pre 2018	Rootball with scarf cut >=40cm dia	Forestry - Unknown source	As per above but likely to have been sitting in the catchment since pre 2018
23	Radiata Pine <40 years old	Pre 2018	Rootball with scarf cut <40cm dia, and	Forestry - Not Harvest Related	Thinnings

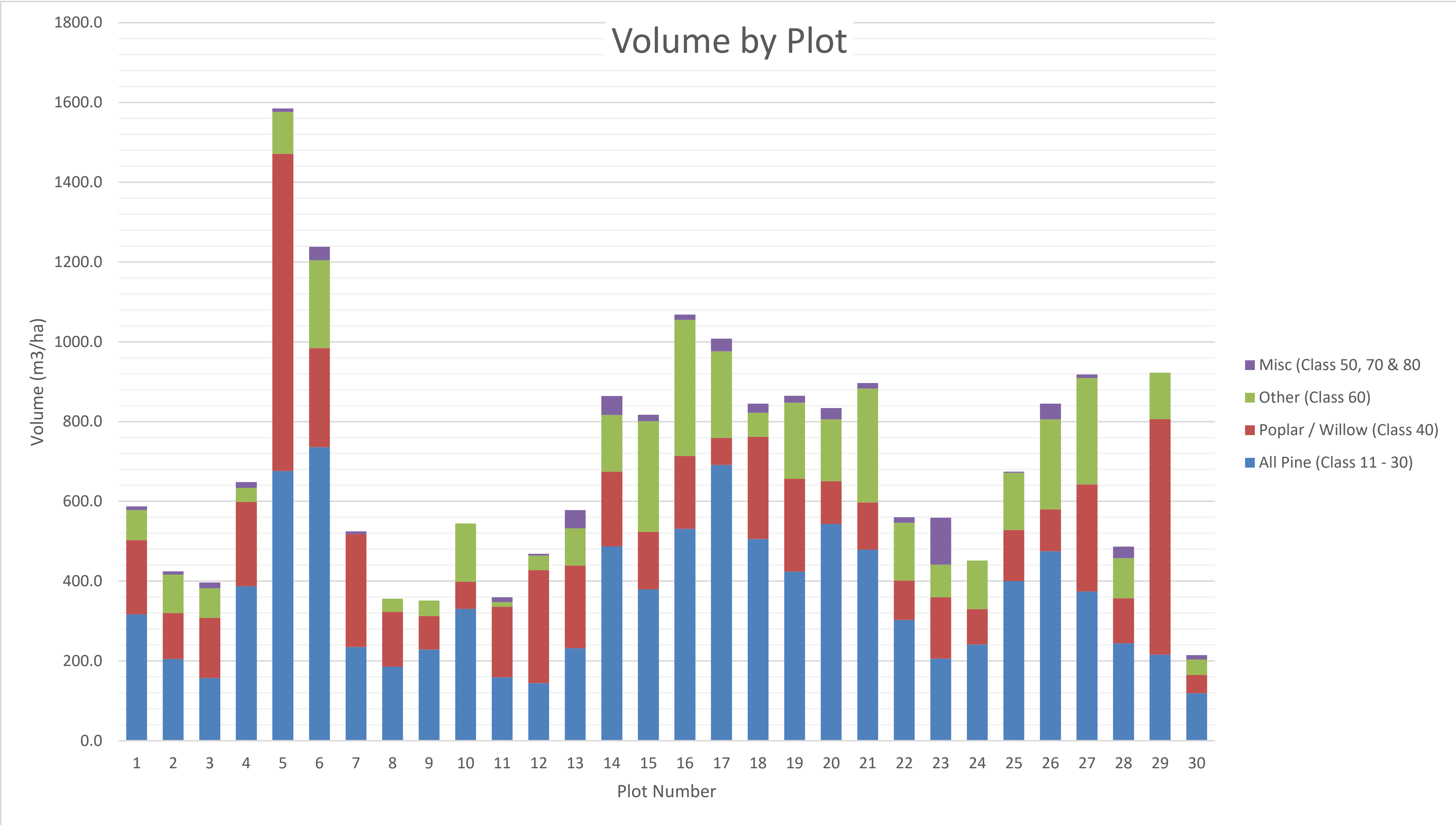
			Stem with scarf cut <40cm dia		
24	Radiata Pine <40 years old	Pre 2018	Stem with flush cut, scarf >=40cm dia, or processor marks	Forestry - Harvest Related	As per above but likely to have been sitting in the catchment since pre 2018
25	Radiata Pine <40 years old	Pre 2018	All other	Forestry - Unknown source	As per above but likely to have been sitting in the catchment since pre 2018
30	Pine >=40 years old	All	All	Unknown	Old growth pines could be from a farm or from forestry
40	Poplar / Willow	All	All	Not Forestry	
50	Native	All	All	Not Forestry	
60	Other Biodegradable	All	Estimate Volume	Not Forestry	
70	Other Non-Biodegradable	All	Estimate Volume	Not Forestry	
80	Unknown, Unsure	All	Unknown	Unknown	

Graph 1



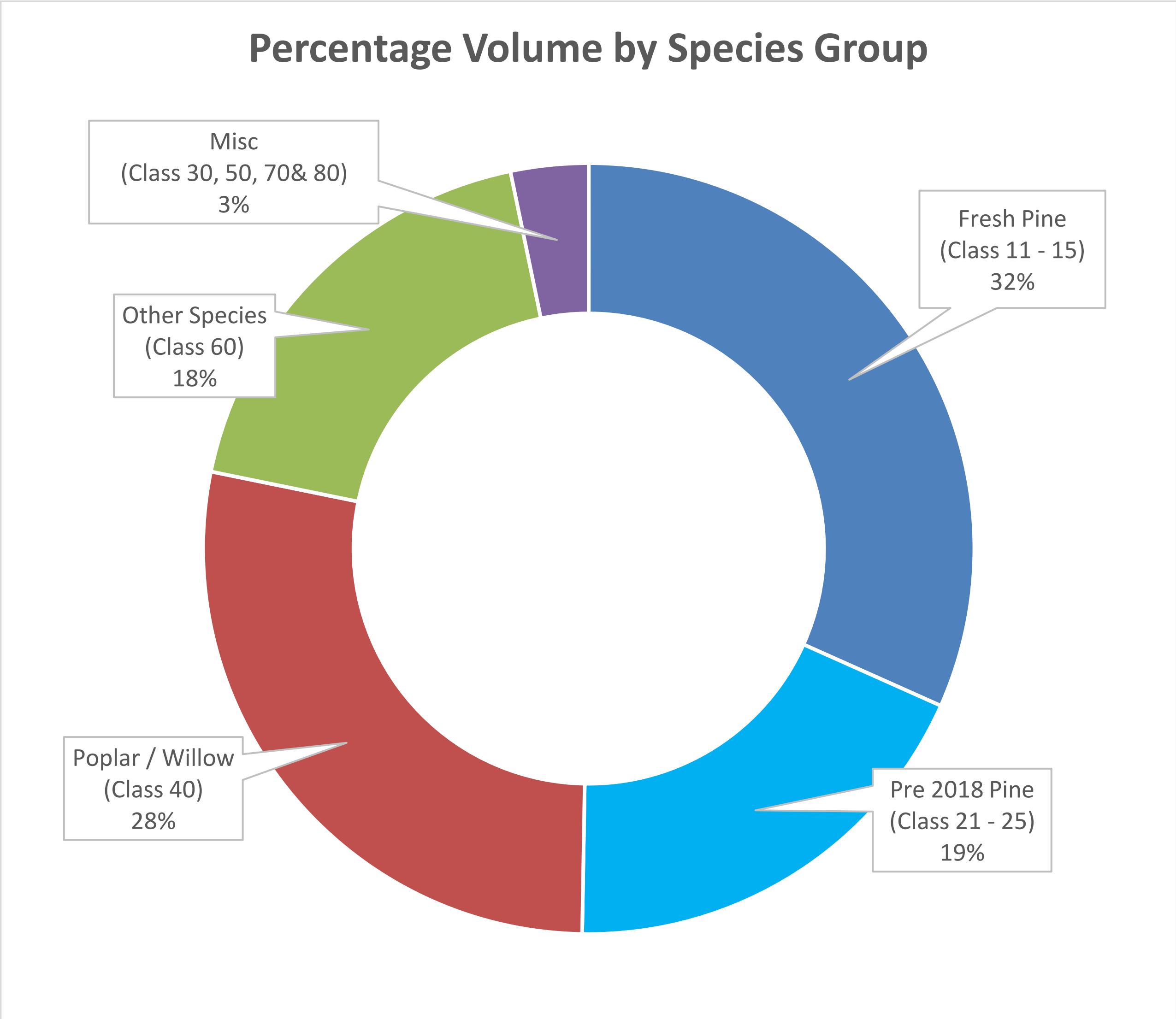
Volume by Plot
Volume (m3/ha)
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
Plot Number
Other (Class 30 - 80)
Old Pine (Class 20 - 25)
Fresh Pine (Class 11 - 15)

Graph 2



Volume by Plot
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Volume (m3/ha)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Plot Number
Misc (Class 50, 70 & 80
Other (Class 60)
Poplar / Willow (Class 40)
All Pine (Class 11 - 30)

Graph 3


Percentage Volume by Species Group
Misc
(Class 30, 50, 70& 80)
3%
Fresh Pine
(Class 11 - 15)
32%
Other Species
(Class 60)
18%
Poplar / Willow
(Class 40)
28%
Pre 2018 Pine
(Class 21 - 25)
19%

2. Introduction

The storm of 24th/25th of June 2024 deposited woody debris along the beach of Gisborne to a point well past the area known as the Pipe.
Forest Measurement NZ Ltd has been requested by the Eastland Wood Council to undertake an assessment of the type and volume of the woody debris deposited on the Gisborne Beach. The assessment area is depicted in Figure 1, an area from the Cut at Waikanae to approximately 200 mtr before the Midway Surf Club Midway. This area sampled is approximately 870 mtr long and approximately 10 mtr wide. Plots were spaced at 30 metres.

3. Sampling Methodology employed.

Line Intersect Sampling is widely employed in NZ to measure the volume of non-extracted logs on a cut over after harvesting has been completed. See attached documents by David Herries, 2013, 2014 and 2023. These articles contain the history of the Line Intersect technique as well as most of the applicable literature references.

The Line Intersect Sampling (LIS) method is commonly known in NZ as the Wagner Waste Assessment.

Appendix 1, Herries, D., 2013, Wagner Cut Over Assessment History, describes the development of the Line Intersect Sampling technique and how it became known as the Wagner Waste Assessment.

Appendix 2, Herries, D., 2014, Practitioners Guide to the Methodology. Wagner Cut Over Assessment Manual. This describes application of the LIS technique in detail.

Appendix 3, Interpine Innovation, 2023, Woody Debris and Slash Sampling Methodology Post Storm Events describes the Line Intersect Sampling technique as it applies to woody debris and slash. Please note how Aratu Forests and this author are acknowledged in the development of this technique.

Because of the non-random nature of the orientation of the debris along the beach a sampling method called Line Intersect Sampling using an Equilateral Triangle has been employed.

The waves that deposited the woody debris on the Gisborne beach have caused these logs to have an orientation parallel to the beach and ocean. In order to address this bias in orientation of the woody debris each equilateral triangle sample has a 10 degree (magnetic) bearing difference applied. The A segment of Sample Plot 1 therefor is aligned to 10 degrees, magnetic. Sample 2 on 20 degrees. Sample 3 on 30 degrees, and so on.

Plot sample 1 was taken close to the Cut at Waikanae beach on Monday morning 8th of July 2024. The tide was outgoing but still too high for the seaward side of the debris width to be included. A strict policy of not sampling between moving logs was adhered to. The start of segment A in plot sample 1 was therefore located between the town side and ocean line of debris, see Photo 1.
The start of segment A in plot sample 1 was chosen as the nearest possible spot to the Cut at Waikanae that could be safely assessed using a 10 mtr equilateral triangle. All other plots were systematically located at a 30 mtr distance from the start of the A segment. All of the remaining 29 plots therefore were located without observer bias. In other words, all the samples, except for the start of segment A in Plot sample 1, were located in a totally random but systematic method. And the use of the triangular sample as well as the 10 degree offset starting in the A segment ensures adherence to the basis of statistics where the observer has no influence in selecting the position of the measurable sample. This is an important consideration.


Photo 1: a 10 mtr equilateral triangle at Plot Sample 1 near the Waimata River mouth on Waikanae Beach.

Figure 1: Location of the 30 Debris Sample Plots on Waikanae Beach during the 8th, 9th and 10th of July 2024

30 Plot samples were measured and assessed, spaced 30 mtrs apart. The total beach length sampled therefore relates to approximately 870 metres as sample 1 and 30 are the start and finish of the measurement plots.
The total area assessed therefore is 870mtr * 9.3mtr (approx.) = approx. 8091 mtr squared =approx. 0.81 hectare. In other words: in an area of just over 0.8 ha, 900 mtr of measurement segments were assessed for diameter and specie class.

The plot distance of 30 mtr was selected as the expectation was that the beach clean-up crew would be working towards Waikanae from Monday the 8th of July onwards. It was reasoned that more plots of a shorter length were statistically more sound than fewer sample plots of a longer length. But the clean-up crew did not move further towards Waikanae and were reasonably stationary and did not further modify the assessment area until later on the 16th of July.
Measurements were completed by Plot 30. Partly because of the debris petering out, see Photo 30_2 on Page 140, partly because we got close to the machinery clean up area but also because more and more logs had already been cut to length by the beach clean-up crew. These cut logs also had often shifted somewhat from their original position.

The measurements were not restricted to pieces equal or over 1 mtr in length. Pieces shorter than 1 mtr were therefor measured. Diameters needed to be equal or over 7 cm thickness. Pieces smaller than 7cm measurements were not recorded nor assessed.

4. **Working methodology.**

1. Determine start of area of interest. This was near the Waimata River mouth, the Cut, on Waikanae Beach.
2. Determine base line segment A magnetic bearing of 10 degrees. Mark that point as start of segment A. Mark on Garmin64 GPS as Plot 1. Establish a standard and tie off measurement tape.
3. Measure the end of the 10 mtr A segment of the equilateral triangle along the 10 degree bearing. That is the start of segment B.
4. An assistant then walks to Point C to close the triangle. Point C is measured as 10 mtr from Point B by tape and 10 mtr from point A by vertex & transponder. When 10 mtr is found by vertex, Point C is marked with a standard and the measurement tape taken back to Point A.
   (A vertex is an electronic measurement tool that measures distances based on ultrasonic sound measurements to within 0.01mtr.)
5. Take photos of the sample area.
6. Once the triangular transect is established measurements can be undertaken as per attached paper by D. Herries, 2014. Each ABC segment has been marked in the data file.
7. Where the line intersects the woody debris the diameter of the slash is measured, provided the slash has a diameter of at least 7 cm.
8. The measured slash was assessed by category as prescribed by the Eastland Wood Council. See Table 1 on page 5.

This assessment was the 6th study since the woody debris measurement as a result of ex-Cyclone Hale in January 2023. The Forest Measurement NZ woody debris measurement team has accordingly gained significant experience in assessing the nature of the woody debris. Measurable pieces, when in doubt of its nature, were discussed, poked, cut (with an electric chainsaw to make the end grain visible), smelled and bark, texture, or branch implant studied in order to correctly classify the debris by specie type.

5. Some observations regarding accuracy and applicability.

This assessment does not attempt to measure to the highest degree of accuracy. It rather attempts to gain an understanding of the quantity and type of the woody deposits during and after the 24th-25th of June 2024 on the Waikanae Beach of Gisborne.

a) The sampled area is a strip of approx. 9.3 mtr wide and approx. 870 mtr long. Distance between sample plots was measured with a Garmin 64s GPS. The start point of the A segment is 30 mtr from the previous and next sample point. See Figure 1, Location of the 30 sample plots. No attempt was made to achieve sub metre length accuracy.
b) Upon reaching 30 mtr, a new sample plot will be established. However, this start point needed to be chosen also at a point between the waves and the town side of the debris strip. The direction of the A segment would be determined by the magnetic bearing governed by the Plot number. The start of the A segment in each plot, however, would be determined by the amount of debris and geared towards heavy deposits without endangering the measurement crew to waves and surging logs. The measurement crew has made a conscious attempt to minimise measurement areas containing sand only and no woody debris.
c) The measurements exclude pieces smaller than 7cm diameter. Dross volume is therefore not captured.
d) For practical reasons, only one diameter measurement per piece was undertaken rather than 2 measurements perpendicular to each other. Therefor there will be an inherent inaccuracy in the measurements as not all measured pieces would have been wholly cylindrical.
e) Deposited trees and slash of previous storms were not captured as it was high up the beach and well outside of the sample area.
f) The approximate 10 mtr width of the sample strip was in all of the 30 plots insufficient to measure the total debris width. Plots were established in the heavier deposits where they could be safely assessed. Occasionally, especially in the first 5 plots, this safety consideration meant that the heaviest deposits could not be assessed as they were still moving in the surf. The width of the debris strip was recorded in the data file as well as an estimate of the plot area that was covered by a debris depth deeper than 0.4 mtr.
g) Confidence can be gained from the adaption of our previously methodology developed immediately after ex-cyclone Hale to assess woody debris deposits by Interpine. See Appendix 3.
h) The debris measurements and its derived volume calculations only apply to the Gisborne Beach from the Waikanae Cut to an area just before Midway Surf Club. None of the volume assessments or pine versus non-pine classification applies to any other beach in Gisborne or along the East Coast. No reference can be made to any other beach, other than Waikanae in the July 2024 reporting period.

6. Measurement Results

Data was electronically entered in the field by segment. This data was subsequently transferred to a volume calculation worksheet that is readily available in NZ and the formula originally constructed by David Crawley of PF Olsen.

Table 2: Measurement of number of pieces of debris, its average diameter and the % of that particular class on Waikanae Beach.

Class	11	12	13	14	15	30	40	50	60	70	80	21	22	23	24	25	
Category Count	38	4	30	27	470	1	605	43	395	33	2	5	0	3	2	147	1805 observations
% of Category Count	2	0	2	1	26	0	34	2	22	2	0	0	0	0	0	8	100%
Average diameter cm	24	15	19	25	13	51	13	12	13	12	18	27	0	23	42	22	

Table 3: Volume in m3/ha and percentage by Plot Number & Classification as measured

Plot #	11	12	13	14	15	30	40	50	60	70	80	21	22	23	24	25	Class
1	15	6	7	87	107	0	186	0	75	0	9	0	0	0	0	95	588
2	0	0	0	0	117	0	115	0	97	8	0	0	0	0	0	88	424
3	2	0	0	0	40	0	151	7	74	7	0	0	0	0	0	115	397
4	30	0	15	22	152	107	211	12	35	3	0	0	0	0	0	61	649
5	28	0	81	59	361	0	795	5	105	3	0	28	0	0	0	119	1585
6	40	0	60	32	187	0	248	34	220	0	0	0	0	0	0	417	1238
7	0	0	41	0	72	0	283	7	0	0	0	0	0	0	0	122	525
8	0	0	40	0	61	0	138	0	33	0	0	0	0	0	0	85	356
9	20	0	22	0	104	0	84	0	39	0	0	0	0	0	0	83	351
10	93	0	0	30	51	0	68	0	146	0	0	0	0	0	0	157	545
11	0	0	16	3	108	0	177	3	11	10	0	0	0	0	0	32	360
12	0	0	20	0	110	0	283	0	36	5	0	9	0	0	0	5	469
13	37	0	12	31	114	0	207	27	93	20	0	0	0	0	0	38	578
14	11	0	15	212	89	0	187	10	142	20	18	0	0	37	0	124	864
15	105	6	52	32	104	0	144	0	277	16	0	0	0	0	0	80	817
16	76	0	8	59	307	0	183	13	341	0	0	20	0	0	0	61	1068
17	95	11	68	73	225	0	68	11	217	21	0	24	0	0	0	197	1008
18	0	0	7	35	156	0	257	0	60	22	0	0	0	16	0	292	845
19	110	18	0	15	120	0	232	6	191	12	0	0	0	0	0	161	865

Volume by Plot in m3/Hectare

	11	12	13	14	15	30	40	50	60	70	80	21	22	23	24	25	
20	44	0	0	73	298	0	107	19	155	10	0	0	0	0	0	128	834
21	0	0	0	48	131	0	118	8	285	6	0	0	0	0	0	301	897
22	27	0	8	0	106	0	98	2	145	12	0	0	0	0	0	163	560
23	0	0	0	0	105	0	153	118	82	0	0	0	0	0	95	6	559
24	0	0	0	0	150	0	88	0	122	0	0	0	0	0	0	91	452
25	0	0	0	0	220	0	129	3	143	0	0	103	0	0	0	78	675
26	235	0	25	0	202	0	105	37	226	2	0	0	0	0	0	12	845
27	3	0	0	0	257	0	269	3	267	6	0	0	0	0	0	114	918
28	74	0	0	6	73	0	113	11	100	18	0	0	0	15	53	23	487
29	23	0	0	0	32	0	591	0	116	0	0	0	0	0	0	161	922
30	0	0	0	0	44	0	46	11	39	0	0	0	0	0	0	75	215
Total	1065	41	497	817	4202	107	5836	345	3874	202	27	183	0	68	148	3484	
																Average m3/ha	**697**
%	**5.1**	**0.2**	**2.4**	**3.9**	**20.1**	**0.5**	**27.9**	**1.6**	**18.5**	**1.0**	**0.1**	**0.9**	**0.0**	**0.3**	**0.7**	**16.7**	100.0

Volume by Class in m3/hectare

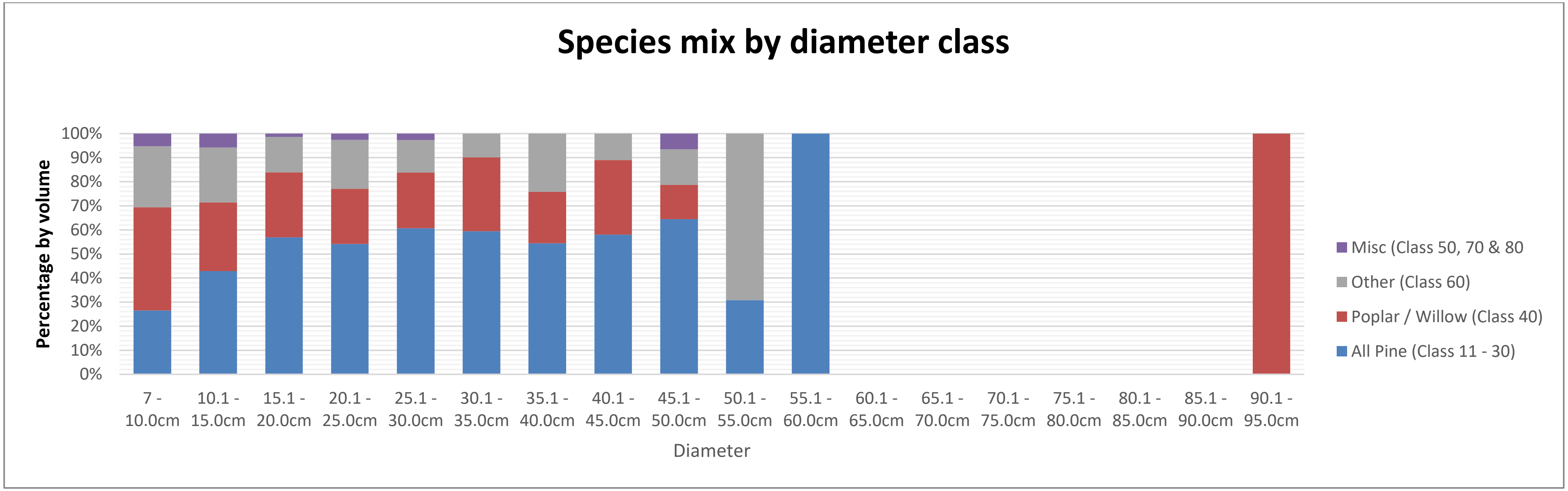
Table 4: Volume by Class and Plot Number excluding diameters under 10 cm.

Plot Number	11	12	13	14	15	30	40	50	60	70	80	21	22	23	24	25	Total
1	15	6	7	87	107	0	170	0	69	0	9	0	0	0	0	95	**565**
2	0	0	0	0	112	0	90	0	77	8	0	0	0	0	0	88	**377**
3	0	0	0	0	23	0	115	7	63	4	0	0	0	0	0	112	**327**
4	30	0	15	22	146	107	191	5	17	0	0	0	0	0	0	59	**596**
5	28	0	81	59	354	0	769	5	94	0	0	28	0	0	0	119	**1542**
6	40	0	60	32	166	0	237	32	218	0	0	0	0	0	0	417	**1208**
7	0	0	41	0	61	0	270	0	0	0	0	0	0	0	0	120	**499**
8	0	0	40	0	55	0	120	0	33	0	0	0	0	0	0	83	**338**
9	20	0	22	0	92	0	65	0	35	0	0	0	0	0	0	83	**326**
10	93	0	0	30	38	0	64	0	146	0	0	0	0	0	0	157	**537**
11	0	0	16	0	106	0	148	0	6	10	0	0	0	0	0	29	**326**
12	0	0	20	0	86	0	246	0	31	5	0	9	0	0	0	0	**409**
13	37	0	12	31	84	0	173	14	70	16	0	0	0	0	0	32	**482**
14	11	0	15	212	79	0	174	7	132	20	18	0	0	37	0	124	**843**
15	102	6	52	32	89	0	112	0	259	16	0	0	0	0	0	80	**763**

Volume by Plot in M3/Hectare

16	76	0	8	59	294	0	166	11	314	0	0	20	0	0	0	58	**1021**
17	95	11	68	73	203	0	53	8	192	21	0	24	0	0	0	197	**960**
18	0	0	7	35	138	0	228	0	50	22	0	0	0	16	0	292	**806**
19	110	18	0	15	115	0	208	6	173	8	0	0	0	0	0	159	**832**
20	44	0	0	71	278	0	81	16	143	10	0	0	0	0	0	126	**790**
21	0	0	0	48	110	0	101	6	261	4	0	0	0	0	0	301	**851**
22	27	0	8	0	96	0	79	0	123	12	0	0	0	0	0	163	**530**
23	0	0	0	0	93	0	135	118	68	0	0	0	0	0	95	6	**537**
24	0	0	0	0	150	0	76	0	108	0	0	0	0	0	0	88	**446**
25	0	0	0	0	204	0	111	0	124	0	0	103	0	0	0	78	**644**
26	235	0	25	0	189	0	93	34	204	0	0	0	0	0	0	12	**818**
27	0	0	0	0	243	0	249	0	257	6	0	0	0	0	0	114	**896**
28	74	0	0	6	60	0	93	11	85	18	0	0	0	15	53	20	**463**
29	23	0	0	0	25	0	573	0	104	0	0	0	0	0	0	157	**912**
30	0	0	0	0	42	0	38	9	25	0	0	0	0	0	0	75	**219**
Total	**1057**	**41**	**497**	**811**	**3839**	**107**	**5228**	**288**	**3482**	**181**	**27**	**183**	**0**	**68**	**148**	**3442**	**19400**
																Average	**647**

Graph 4: Species mix by Diameter and Percentage of Volume



(The 90.1 -95cm class is formed by a single poplar rootball with a cut stem)

Graph 5. Species mix by diameter and Volume (m3/ha)

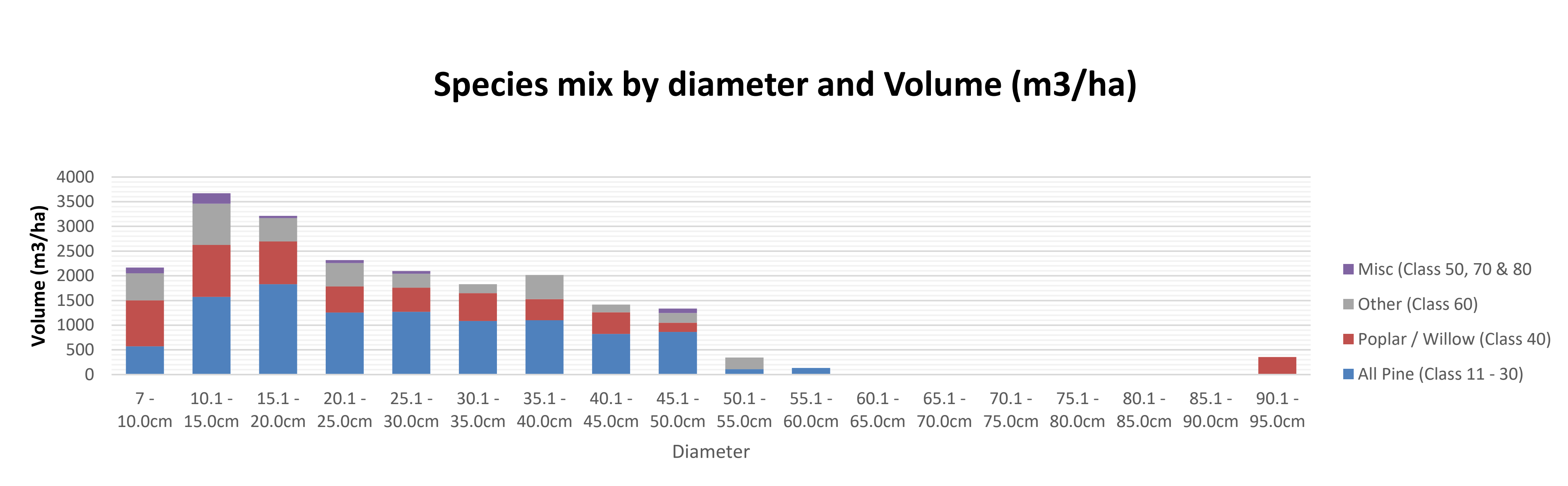


Table 5: Comparison with the previous Gisborne Beach Studies **Gisborne Beach; Hale Gabrielle and July 2024 Comparisons**						
	Hale		**Gabrielle**		**July 2024**	
# of plots	31		30		30	
Length of plots	30	mtr	50	mtr	30	mtr
Total Sample length	930	mtr	1500	mtr	900	mtr
Total # of pieces measured	314		714		1805	
# of Pieces Pine	216	69%	478	67%	728	40%
# of Pieces Non Pine	98	31%	236	33%	1077	60%
Minimum diameter assessed	10	cm	10	cm	7	cm
Minimum length assessed	1	mtr	1	mtr	Not applied	
Volume Pine in %	56	%	56	%	51	%
Volume Non Pine in %	44	%	44	%	49	%
Volume Pine in m3/ha	157	m3/ha	192	m3/ha	355	m3/ha
Volume Non Pine in m3/ha	122	m3/ha	148	m3/ha	341	m3/ha
Total Volume in m3/ha	279	m3/ha	340	m3/ha	696	m3/ha

When diameters of 7, 8 and 9 cm are omitted from the July 2024 data the average volume/ha drops to 647 m3/ha.

Table 6: Minimum diameter set at 10cm during July 2024

Gisborne Beach; Hale Gabrielle and July 2024 Comparisons

	Hale		**Gabrielle**		**July 2024**	
# of plots	31		30		30	
Length of plots	30	mtr	50	mtr	30	mtr
Total Sample length	930	mtr	1500	mtr	900	mtr
Total # of pieces measured	315		714		**1240**	
# of Pieces Pine	216	69%	478	67%	**569**	45%
# of Pieces Non Pine	98	31%	236	33%	**671**	55%
Minimum diameter assessed	10	cm	10	cm	**10**	cm
Minimum length assessed	1	mtr	1	mtr	**Not applied**	
Volume Pine in %	56	%	56	%	**52**	
Volume Non Pine in %	44	%	44	%	**48**	
Volume Pine in m3/ha	157	m3/ha	192	m3/ha	**336**	
Volume Non Pine in m3/ha	122	m3/ha	148	m3/ha	**310**	
Total Volume in m3/ha	279	m3/ha	340	m3/ha	**646**	m3/ha

7. Conclusion

30 trianglar line plots were established on Waikanae Beach in Gisborne early July 2024. In the 30 line plots of 30mtr each, 1805 pieces of woody debris were measured. Of these, 40% in count were pine pieces and 60% non pine. In volume however, measured as m3/hectare, 51% was pine and 49% non pine.
The woody debris on Waikanae Beach in July 2024, both in count and volume, significantly exceeded the debris measured after Hale and Gabrielle.

8. References

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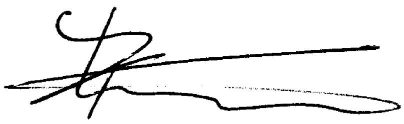
Kees Weytmans
20/07/2024

Signed:



Appendix 1.

Harvest Cutover Residue Assessment History

by David Herries | Sep 29, 2013 | Forest Inventory, Harvesting, Value Recovery |

Above is shown Figure 1 Typical Harvest Cutover in P. radiata

Over the years many of our clients from forest owners, harvesting crews and forest supervisors have asked about harvest cutover assessment methodology. Many have struggled with the concept of the **line intersect sampling** procedure, so I thought it might pay to document a little practical history about this method, and why it is used.

To some, cutover waste assessment is called 'Wagner Logging Waste Assessment" and actually many of the Forest Industry training documents still refer to this assessment in this manner. This term was commonly adopted by the NZ Forest Service in their manual of procedures written by Swale in 1974. The name "Wagner" refers to a person, Van Wagner whom in 1968 used and applied the technique during his involvement in Fire Research for the Canadian Forest Service. He used it for estimating the quantity of slash or larger sized fuel on the ground.

However it is little known that he adapted this from a technique developed in 1957 by a young forester Peter Olsen (whom later created his own company PF Olsen here in New Zealand), whom was faced with the problem of determining an economic means of estimating volume of logging residue.

To quote Olsen at the time;

"There was a need to focus on recovery of all merchantable material (being min 1.2m length and 10cm SED). The logging company at the time believed it was not worth the hassle to extract to this limit so normal practice was to leave

somewhat larger pieces. Hence need to measure as a penalty payment was introduced"

He experimented with circular plots but quickly found them time-consuming and difficult to quantify as many pieces trans versed the boundary, and inter-plot variation was so great that a huge number of plots were required to obtain precision levels required to justify any royalty payment. Transect plots were long and narrow and reduced the inter-plot variation, but were still very time consuming and many more pieces trans-versed the boundary (unlike standing trees) making it more difficult to quantify. He decided these traditional techniques were simply uneconomic to implement in relation to the value of the merchantable material remaining. And moved to develop the idea of the Line Intercept Technique (LIS) with Dr William Warren, which is used for cutover waste assessment today.
This builds on a **"relationship between the number of pieces intersected by a line run at random through an area and the volume contained in that area".**
At the time and still true today, the Line Intercept technique took 20% of the time and yet was able to give a more precise answer, in which confidence in royalties could be allocated.
It was implemented in 1958 in Kaingaroa Forest and designed specifically for the purposes of penalty royalty payments by the forestry company for remaining merchantable material. Dr William Warren a researcher with the Forest Service at the time worked with Peter Olsen on the sampling design and methodology and later published this work in 1964. It was this paper that Van Wagner picked up and used.
This is no different to today's reasons for carrying out a cutover waste assessment.

- **Stumpage Sales Administration:** where standing volume is sold, it is often the buyer's responsibility to harvest and remove all merchantable logs. Waste assessment is used to determine volume of wood left behind, and is charged to the buyer even though it has not been removed.
- **Yield Reconciliation:** most forest areas have a pre-harvest inventory carried out prior to being harvested. Waste assessment is required to correctly reconcile any differences between the pre-harvest inventory and log volumes produced.
- **Logging Compliance:** quality assurance standards for harvest contractor in terms of a key performance indicator for value recovery.
- **Planning for Re-establishment:** volume of waste in the cutover indicates hindrance, or additional site preparation tasks for establishment operations.

Figure 2 Typical line intercept sample across a clear-fell harvest cutover in P.radiata.

The line intercept sampling can be tailored to identify any type of mechantable material volume remaining onsite. If you would like more information about cutover assessment or would like to get some done for any of the reasons above feel free to contact us.

Original Published Science Papers of Interest

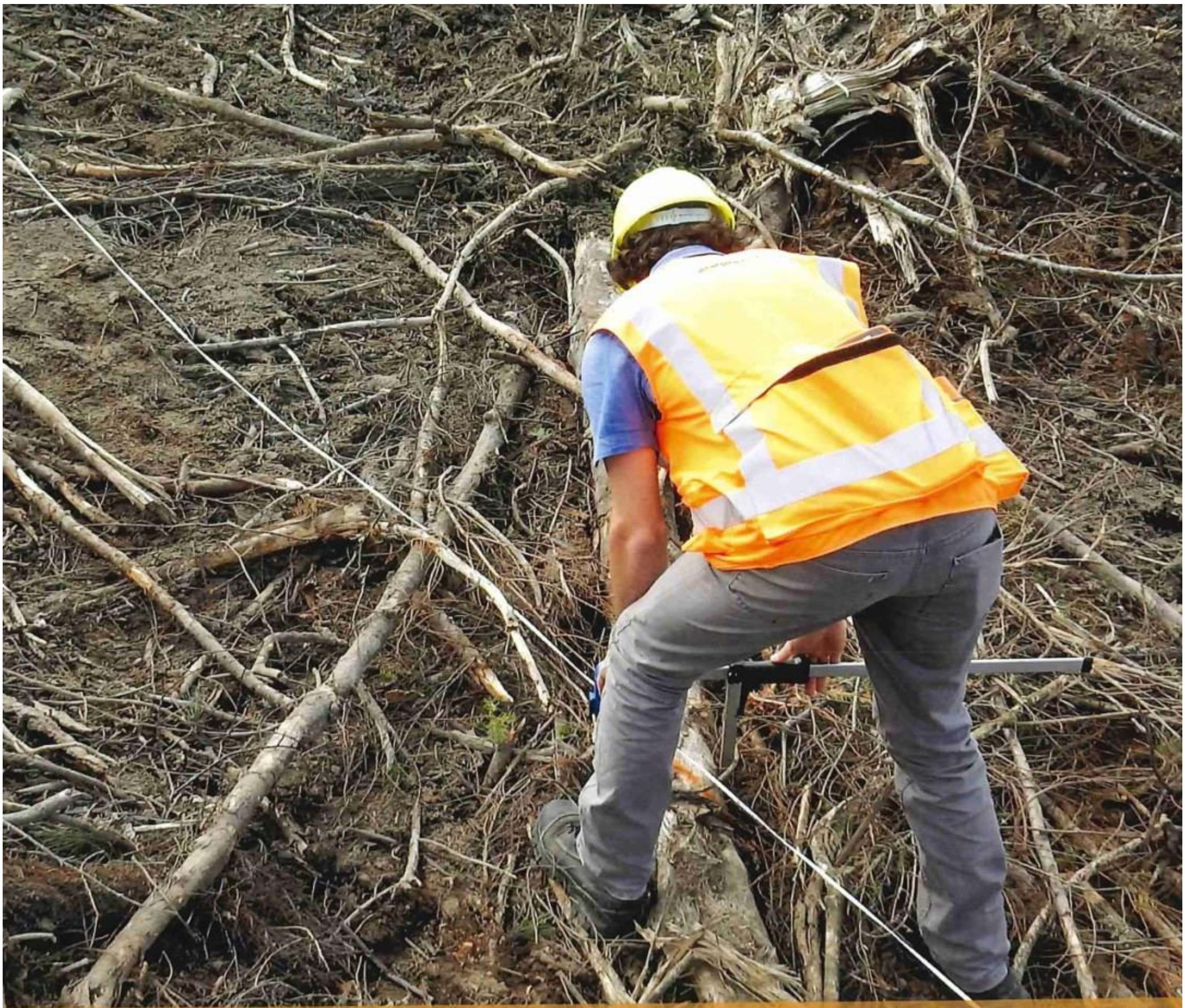
Van Wagner, C.E., 1968. The line intersect method in forest fuel sampling. For. Sci., 14: 20-26.

De Vries, P.G., 1986. Sampling Theory

Warren.W.G. and Olsen,P.F.,1964: A line intersect technique for assessing logging waste. Forest Science, vol.10 pp.267-276

Warren, W.G., 1989. Line intersect sampling: a historical perspective. In: State-of-the-art Methodology of Forest Inventory: A Symposium Proceedings. USDA Forest Service, Pacific Northwest Research Station, Portland, OR, pp. 33–38.

Further detail on this can be found in a review of the line intersect approach.
Competenz Unit Standard 6956 – Level 4 – Carry out waste assessment in cutover forest



Carry out waste assessment in cutover forest

Learning and Assessment Guide

Name

Forestry

Unit 6956

Level 4 | Credits 5 | Version 5

Competenz
SKILLS FOR INDUSTRY

Appendix 2: Line Intersect Technique by David Herries

Wagner Cut Over Assessment   MANUAL

by David Herries   on 29/07/2014 9:54 a.m.
Category: Harvesting; Forest Inventory; Value Recovery

Practitioners Guide to the Methodology

Introduction

Concerned with improving the recovery of merchantable volume across a harvest cutover, a harvest supervisor or forest owner will often need to quantify how much is left post harvest. The time and effort spent doing so must be put in context of the value of the potential residue volume remaining, and hence the development of the technique of line intersect sampling (LIS).

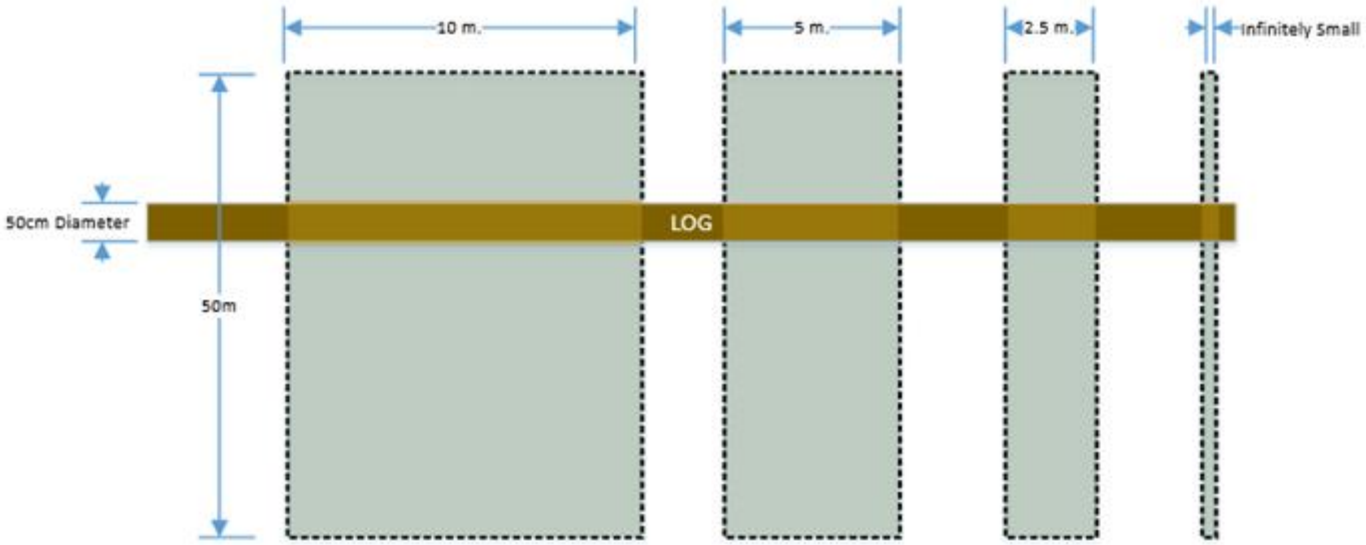
The use of LIS for cutover residue assessment is in essence simple and well proven, however many questions arise in its practical use. The aim of this report is to provide a quick reference to a number of practical aspects of the line intersect method for cutover residue assessment for harvest supervisors wishing to understand and implement this technique in different conditions. This is not planned as a conventional review of literature, nor does it introduce any new theory. Instead, it is intended to fill the gap between theory and procedure handbook and to promote the best possible understanding of the method, combined with a brief simulation and worked example.

Line Intersect Sampling

Since its original description for merchantable cutover residue assessment in Kaingaroa Forest by Warren and Olsen in 1964, the line intersect method (LIS) has been extensively used for measuring the quantity of wood lying on or near the ground. A number of people over the years continued to develop the technique (Bailey 1970, Wagner and Wilson 1976, Hall 1986, Bell et al 1996), proof its mathematical basis in depth and extend its application (De Vries 1973), review the practical aspects of LIS to overcome bias and improve precision (Wagner, 1982), and carry out a series of simulation studies (Pickford and Hazard 1978, Bell et al. 1996).

Understanding the Nature of the Line Intersect Method

The line intercept is best pictured as a strip sample of infinitesimal width (Figure 1). The data collected are diameters of wood pieces at their points of intersection with a sample line. The sample line is really a vertical plane, and the tally in effect collects a series of circular cross-sectional areas from the intersected wood pieces (Wagner, 1982).



	Transect A	Transect B	Transect C	Transect D (LIS)
Transect Width (m)	10	5	2.5	Infinitely Small
Transect Length (m)	50	50	50	50
Area (m2)	500	250	125	Infinitely Small

Piece Diameter (cm)	50	50	50	50
Plot Volume (m3)	2.0	1.0	0.5	Infinitely Small
Volume Per Area (m3/ha)	39	39	39	39[*1]

Note: *1 probability theory factor removed for this example as piece is a cylinder and crosses at right angles

Figure 1 - Picturing a strip sample of infinitesimal width

Of course the log shown in Figure 1 cross at right angles for each transect, which is often not the case. Therefore the actual cross sectional areas are really ellipses of various shapes, but a factor derived from probability theory (π/2) allows the cross sectional area to be summed as circles.

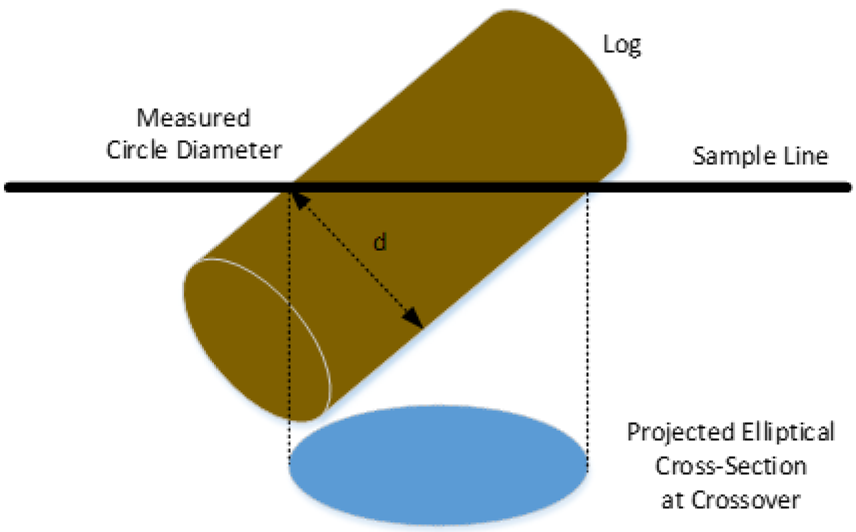


Figure 2 – The elliptical cross-section at the intersection of a sample line. Addition of the probability theory factor means only 'd' needs to be measured above.

Figure 1, also represents a log with no taper which is often not the case. Because LIS simply collects an unbiased sample of cross sections from the wood pieces lying on the ground, Pickford and Hazard 1978 found by way of a range of simulation studies that LIS was unaffected by any kind of variation in diameter throughout the length of the pieces.

The basic equation is then derived (Wagner 1968):

$$V = \left(\frac{\pi^2}{8L}\right)\sum d^2$$

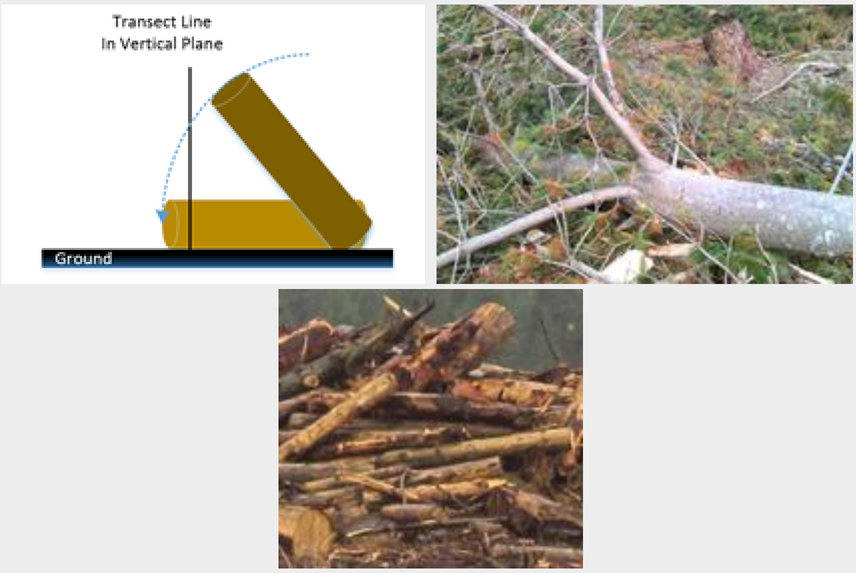
Equation 1:

Where: V= volume per unit area (m3/ha), d= piece diameter at intersection (cm), L= length of the sample line (m), $\pi^2/8$= product of π/2 (probability theory factor mentioned above) and π/4 (factor to convert d^2 to circular area).

Assumptions for use of LIS

LIS as described in Equation 1 embodies several assumptions which are important to consider when implementing or considering any changes to procedure manuals.

Assumption	Practical Consideration
Ground Slope	Quoting the resulting volume for residue assessment is by way of horizontal map area. Therefore it is important to correct all transects either by way of a slope correction factor after data collection or by increasing the transect line length during data collection. This is usually done for each transect segment. The latter is the recommended norm during cutover residue assessment. It is worthy of comment that fire fuel loading is often quoted as actual ground area rather than horizontal map area, therefore slope correction is not done (Wagner, 1982). *Equation 2: Slope Distance = (distance)/cos(slope*π/180)* Where: slope= degrees
Pieces Occur	The basic equation assumes all pieces are horizontal (or on the ground plane when considered with slope adjustment). If a piece is tilted, its probability of being intersected by the sample line is obviously lessened. If many pieces are tilted there will be fewer intersections for a given wood volume. A correction factor can be calculated 1/COS*h where h is the angle of tilt from horizontal

Horizontall y.	(Wagner, 1982). This error is very low at low angles, being 0.4% at 5 degrees (h) and <10% at 25 degrees (h). Whether it is worth correcting for this error is a matter of judgement for an individual survey design. If only the larger merchantable material (commonly 3-3.7m in length and 10cm SED) is being assessed this will often be dealt with in a practical manner in the field by estimating the lay of the piece in the ground plane (Figure 3a). The most error arises measuring slash (branch and top material) especially where the smaller pieces are attached to larger ones (Figure 3b). (c) (b) (a)  *Figure 3 (a) simple consideration of pieces occurring off horizontal (b) example of difficulty in assessing branch material for tilt when attached to larger pieces, but across the cutover most merchantable size volume on cutover is already be lying on the ground plane. (c) difficulty of using LIS across a slash pile due to this assumption with "most" pieces unable to be easily assessed for tilt from ground plane.*
Piece Orientatio n is Random	The basic equation assumes all pieces are randomly orientated, with all angles equally represented. However orientation bias, in which pieces are lined up in more than one direction than another, can result from windthrow residue or different styles of logging (cable, cut to length at stump, skidder). Practical difficulty is that it may be obvious or it may not be. It has been shown this can contribute to the largest potential bias and precision in the use of LIS. However since orientation bias can easily be neutralised through transect sample layout, it makes sense to always design a sample layout to insure against it. The most common method currently used in New Zealand for cutover residue assessment is a right angle transect where a single 50m transect is divided into two 25m transects at right angles (Figure 4a). However it was shown by Wagner (1968) and again reproofed by Bell et al (1996) that the best unbiased method was an equilateral triangle (Figure 4b). However as shown again in 2002 by Linnell Nemec and Davis, the difference in time associated with layout favours the use of right angled transect being some 50% faster to install compared with the equilateral triangle, and allowing the extra transect line distance to be spread out more across the cutover area (same total transect sample length split across more transect plots). Therefore the right angled transect has remained popular and widely implemented, and is equally recommended here. The length of each line transect plot is discussed in section 1.2.3 regarding sample size, but of interest 50m was derived by Warren and Olsen in the 1964 procedure of using transects of ¼ chain in length which is ~50m. Many have experimented with this length but it remains in common use today.

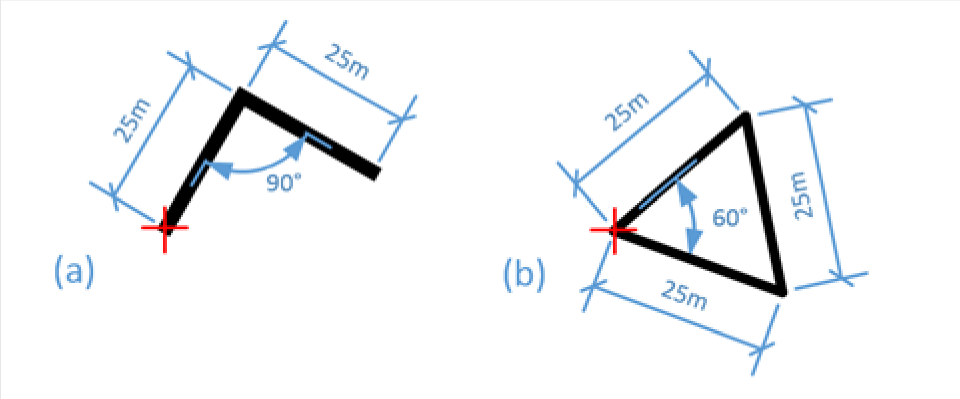


Figure 4 (a) 25m Right Angled Transect (b) 25m Equilateral Triangle

With the shape of individual transects selected it is important to consider the wider layout of these transects to reduce orientation bias. In 1996 a method of creating baselines and a continuous transect of linked right angled transects was also proposed by Hall. This seems to have not been adopted into practice due to the need to adjust baselines in field based on extracted haul directions and difficulty in ensuring the total transect length is optimised across the cutover area (Figure 5c). Therefore a systematic grid-point system is favoured for locating LIS start points and these being easily spaced throughout the cutover to meet the total transect line length sample requirements. Some procedures implement a unidirectional layout of transect (Figure 5a), primarily because of the distinct time advantage over a fully random orientated layout (minimising walk distance between ends of transect and next start point). Howard and Ward (1972) concluded this was suitable comprise for residue assessment on flat to rolling terrain where tractor logging is practiced because the piece layout is generally random. However a random orientation pattern is recommended by most research to date where any bias in piece orientation is suspected (Figure 5b). This is important as when we assume the probability theory factor ($\pi/2$), piece orientation must be random either by the nature of the pieces or the random orientation of the transects.

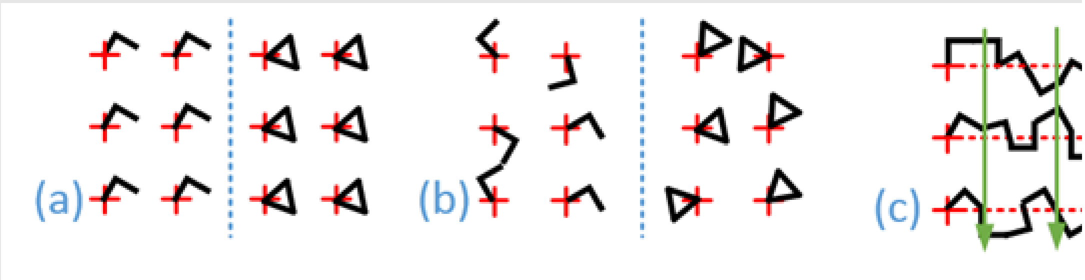


Figure 5 (a) systemic unidirectional transect layout (b) random orientation transect layout (c) continuous transects on baselines perpendicular to haul extraction direction (green arrows)

Pieces are Round

A non-circular piece cross section could introduce error if only measured in one dimension with a calliper. This is because πr^2 is used to calculate cross sectional area (functional form shown in Equation 1 is $d^2\pi/4$). The simplest way to handle this is take two measurements and average providing a representative diameter as shown in Figure 6. This is recommended for all pieces >25cm in diameter, or obviously out of round (Wagner, 1982). Of interest formulae are available for when pieces are of different shapes (Wagner, 1982). DeVries (1973) also enhanced the versatility of Equation 1 by allowing the collection of direct attributes such as piece volume (through collection of LED, SED, and Length and traditional log volume equations), yet still aggregating these to a per unit area. This however does reduce the efficiency of LIS with more data needed for each intersection point and could add potential shape bias (crutch zones, mid piece diameter reductions, chamfer zones do not often adhere to standard paraboloid or cylinder volume formulas). If volume only is required Equation 1 is still the preferred method for cutover residue assessment.

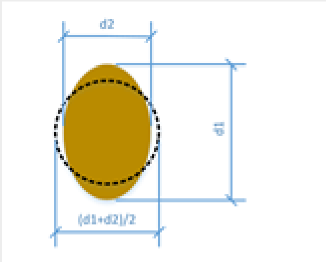


Figure 6 representative cross sectional area from two calliper diameter measurements averaged.

Intercepts are Independent

All intercepts with the transect line are independent. If a piece intercepts the line more than once this is counted as many times as it intercepts as shown in Figure 7. In practice an example of this is if at one intercept a piece is considered merchantable volume yet when the same piece is intercepted again it is considered non merchantable, and only merchantable intercept is measured. If both were merchantable at cross-over both are measured.

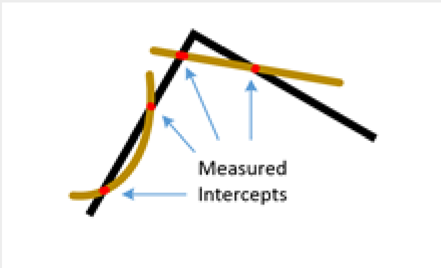


Figure 7 All intercepts are considered independently of pieces, in this case there are 4 intercepts considered for measurement.

Definition of Volume

The LIS methodology provides a method for calculation of harvest cutover assessment volume of round pieces (Equation 1). This volume in itself is not defined, nor is the LIS methodology linked to any assumptions of this definition. Therefore it is important for implementation to define the target volume which is desired to be assessed across a harvest cutover (e.g. at least merchantable pulp >3m in log length and 10cm SED with no rot, shatter, or excessive sweep >SED/1). Once this volume classification is defined, a LIS transect will only focus on intercepts that meet this criteria, ignoring any volume encountered. A common set of volume types surveyed in New Zealand at time of writing is shown in the Table below.

Table 1 Common Merchantable Volume Definitions in New Zealand

Type	SED	LED	Length	Sweep	Comment
Pulp	>=10cm	n.a	>=3.7	<=SED/1	No rot, insect damage or internal shatter
Pulp	>=10cm	n.a	>=3.0	<=SED/1	No rot, insect damage or internal shatter
Binwood	>=10cm	n.a	>=0.8 <=var.	<=SED/1	No rot, insect damage or internal shatter
Extractable Size	>=10cm	var.	var.	<=SED/1	Must be >=0.1m3 with no rot, insect damage or internal shatter

Sample Intensity

The precision of the result and hence resulting sample size, as in all sampling procedures depends on the size of the sample and the variability of the residue material assessed.

Before making some practical guidelines the following key principals identified by Wagner (1982) are worthy of taking time to consider:

1. The level of precision depends primarily on the total size of the sample (total transect line length, not the number of smaller transect sections). Therefore it is not the number of transect sections/hectare that is important but the sum of those sections to the total length of sample e.g. 34 transects*50m=1700m.
2. Theoretically the size of the cutover area sampled is irrelevant, it is the variability of the material being sampled that counts.
3. It follows that for a given total line length the number of sections is within limits immaterial. For example; 20 sections of 50m should provide the same standard error as 10 sections of 100m each.
4. Transect sections may be either physically separated or parts of a longer continuous line.
5. Precision is also related to concentration, that is to the number of intersections per unit length of transect line.
6. Unnecessary precision is costly, to double the precision (half the standard error), would require for times the total transect length.

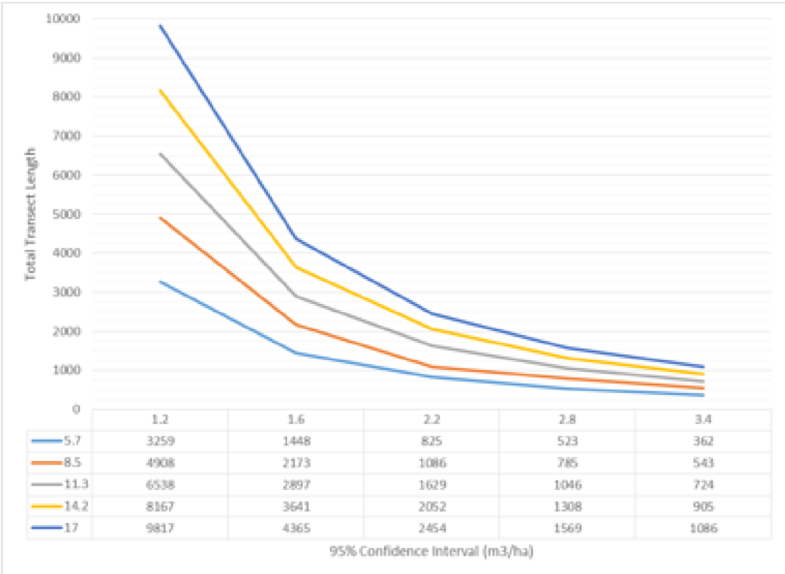
These principles require some practical comments: It seems unrealistic to spread a scatter of transect lines across a too larger area (point 2). It also makes sense to cover the entire cutover area with several shorter transects than few larger transects (point 3). This helps by taking advantage that transects can be separated (point 4) and provides better statistical understanding of the concentration of pieces across the cutover (point 5). It is recommended that this is done in at least 10, but preferably 20 transect sections to gain stability in the precision (point 3 and 5). It is important that these transect sections be independent from each other for the principals of random sampling to apply, therefore they must not be too close nor too short to provide this (hence joining of 2 or 3 sections for the right angled transect or the equilateral triangle transect and distributing these on a systematic grid). Precision of 20-30% probable limit of error (PLE (95%CI/mean)) will suit most cutover residue assessment applications, but for some it might be that 40% PLE would be acceptable (point 6). For example 40% PLE on a cutover with 20m3/ha merchantable volume is ±8m3/ha. If the tolerance is 5m3/ha you can still with great confidence conclude the cutover exceeds tolerance. If a royalty payment is due a higher precision might be required, but if this was just a key performance indicator (KPI) for the harvesting operator's contract then this would be likely be fine.

Table 2 which has been adopted by Warren and Olsen in 1964 after a range of pilot studies still provides practical guide on total transect length by variability of residue material to be assessed. For example this indicates that for a 20-30% PLE that at least 20 to 32 line transect segments of 50m right angles (1000-1600m) will be suitable depending on the expectation of residue material onsite (or 13 to 21 equilateral triangles). Therefore many practitioners have implemented a sampling design of at least 1 day's assessment across cutover area of any size. Then depending on the confidence required and the results further sampling can be completed.

Table 3 outlines a workflow example for initial setting of a sample size.

Table 2 Total transect length for varying residue volumes (adapted from Warren and Olsen 1964)

Expected Volume (m3/ha)	Target 95% CI (m3/ha)				
	1.2	1.6	2.1	2.8	3.4
5.7	**3259**	1448	825	523	362
	20%	30%	40%	50%	60%
8.5	4908	**2173**	1086	785	543
	13%	20%	27%	33%	40%
11.3	6538	2897	**1629**	1046	724
	10%	15%	20%	25%	30%
14.2	8167	3641	2052	**1308**	905
	8%	12%	16%	20%	24%
17.0	9817	4365	2454	1569	**1086**
	7%	10%	13%	17%	20%



*Expected PLE shown in Red, PLE of 20% shown in yellow, PLE range to 30% in orange and 40% in pink

Table 3 Practical Guideline Steps for Sample Size Definition

Steps	Example Workings to Provide an Indicative Sample Size
Define expectation of residue volume	10-12m^3/ha

Define expectation of precision	Expectation of residue merchantable <=5m^3/ha onsite, 30% PLE would likely be the outer limits to provide confidence that the contractor has exceeded 5m^3/ha
Calculate total length of transect	Total transect length 724m (from table 2)
Decide on transect plot subsample type (right angled transect or equilateral triangles)	Right angled transects in 50m segments.
Divide the total transect length into a minimum of 10 to 20 transect sections.	15 plots
Plot Layout	Typically systematic random sampling grid is used, but consider using Quazi-random plot layout to allow for increased sampling if required.

Additional Outputs from LIS

Information about piece lengths, end diameters, defects can be determined by measuring additional attributes on all pieces or subsampling a portion of the transect line. This is covered in detail by Wagner (1982). One that will likely be of interest to harvest supervisors wanting to more understanding on the type of volume, is piece length distribution per unit area. This will require additional information to be collected and therefore may reduce the cost effectiveness of the main sample. If there is a demand for this procedures could be expanded to include additional measurements or classification.

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INTERPINE INNOVATION

Woody Debris and Slash Sampling Methodology Post Storm Events

by admin | Mar 6, 2023 | Uncategorised | 0 comments

Objective

Quantify woody debris / slash content along the coastal, and inland catchment areas, characterizing it by woody debris source or type, volume per hectare, and the total volume accumulated.

Sampling Methodology Review

Line Intercept Sampling Plots

Due to the nature of the debris, the Line Intercept Sampling (LIS) technique will be adapted from that used for cutover waste assessment as per NZQA Unit Standard 6956 – Carry Out Waste Assessment in Cutover Forest. Since its original description for merchantable cutover residue assessment in Kaingaroa Forest by Warren and Olsen in 1964, the line intercept method (LIS) has been extensively used for measuring the quantity of wood lying on or near the ground. This continued to develop and be tested as a simple and practical methodology (Bailey 1970, Wagner and Wilson 1976, Hall 1986, Bell et al 1996). Proof its mathematical basis (De Vries 1973) and a review of the practical aspects of LIS to overcome bias and improve precision (Wagner, 1982, Pickford and Hazard 1978, Bell et al. 1996), meaning it has been adapted worldwide for woody debris and woody fuel loading sampling. Therefore the use of LIS for woody residue assessment is simple and well-proven.

An equilateral triangle sample plot should be used to remove the bias of piece orientation as it is accumulated on the beach from the waves or alongside a river. Each side of the triangle will be 10m, with each plot being a total length of 30m (horizontal length), with a total sample length of 30m per sample point with 10m on each side as per Figure 1. Where the slope of the transect is greater than 5 degrees, a slope-adjusted distance should be applied to each side of the triangle by simply adding a small distance on each side.

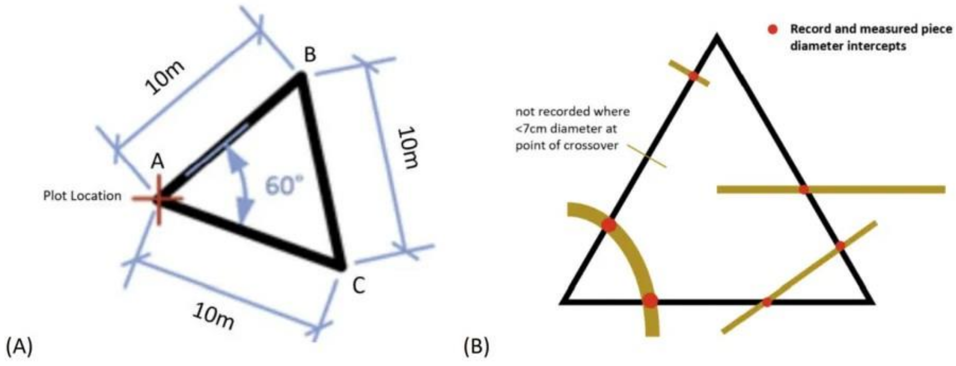

Figure 1 - (A) Line Intercept Sampling Equilateral Triangle (B) Measure and Record Piece Diameters at Crossover

Each woody debris piece would be measured for the diameter at which point it intercepts the line, even if it intercepts more than once. To avoid measuring smaller twig / small branch material a cut-o diameter of less than 7cm will be used, whereby all material greater than or equal to 7cm will be recorded and measured. Comments should be made, combined with photos collected of each to characterise the small debris. There is no minimum length restriction recorded piece.

To further address the bias in debris accumulation orientation it is proposed that each equilateral triangle sample has a random orientation to the predominate river ow or beach front based on random bearing between 0 and 90 (Figure 2).

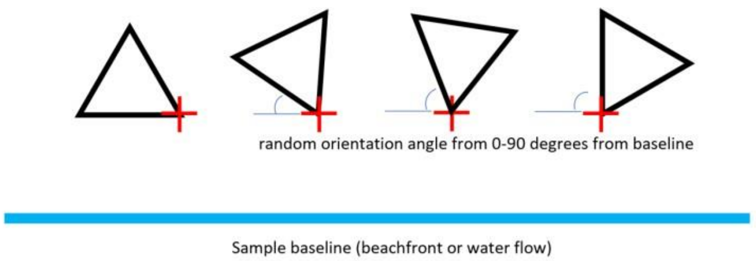

Figure 2 - Sample orientation to a baseline to ensure sample remains unbiased to direction of accumulation of woody debris.

Measurement of Pieces

Diameter is to be measured to the nearest cm in line with the woody debris orientation as shown in Figure 3.

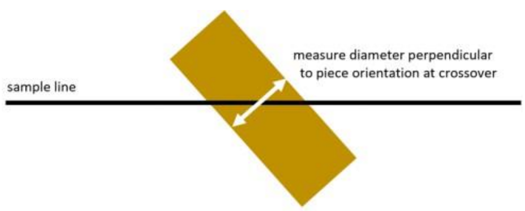

Figure 3 - Measurement of diameter of each intersecting pieces

Classification of Debris

Each intercept diameter measured will be classified into the following.

CODE	CLASS
N	Native Species
CH	Conifer (Pine/Douglas) Plantation Harvest Residue *evidence of ush cuts / slovens / processor damage / branches cut o*
CT	Confer (Pine/Douglas) Plantation Tree Residue *evidence of full tree slippage of preharvest standing trees / full tree lengths / root plates visible / branches attached.*
CN	Conifer (Pine/Douglas) Non-Plantation *old man's pine, riverbank large old open grown pine.*
CO	Conifer (Pine/Douglas) Other, *unsure of classes above.*
PT	Posts / Timber
PW	Poplar or Willow

Calculating Woody Debris Volume and Summary

Volume will be calculated using the following LIS formula.

Volume of debris: $Volume\ m^3 / ha = (\pi^2/8*L)*sum(d^2)$

Where:

V= volume per unit area (m3/ha)
d= piece diameter at intersection
(cm) L= length of the sample
line (m)

Resulting dataset will yield volume per ha by woody debris type. This yield of woody debris can then be applied to the mapped area of woody debris.

Depth of transects will be recorded and maybe used to add bulking factors for depth of woody debris.

Locating LIS Sampling Plots and Intensity

Plots should be randomly located within pre-identified mapped areas. Due to the nature of the material in isolated piles or long narrow beach accumulation the plot placement can be adapted from one of two approaches.

1. Predefined Plot Locations

The preferred method, where random plots using geo-spatial plot sample tools (e.g GeoMaster Assessment Planner) identifies plots which will be navigated to using a GPS. Plots will be placed using a random sampling approach (best suited for narrow width of the sample areas).

1. Onsite Random Systematic Grid Plot Locations

Select a systematic interval between plots e.g., every 25m or 50m along the baseline (beachfront or river flow). Where possible sketch / draw on a map of the accumulated debris area. This will include taking photos using a mobile device, and/or drone imagery, video or mapped orthophoto to aid in later mapping of area in hectares of woody debris. This is to ensure during analysis the data can be qualified by total area of the debris pile and the sampling intensity applied.

Methodology Workflow in Practice

1. Determine the baseline (beach, river flow)
2. Locate plot using GPS or random systematic grid, mark with stick paint mark – POINT A.
3. Record the GPS Location of the plot.
4. Determine plot orientation from base line with a random number between 0 and 90 (select from Table 1).
5. Using a 30m tape or survey rope, hold the tape at 0m and 30m at Point A. Lay out the first transect of 10m from the start point to POINT B. Then completed the triangle by pulling the remaining tape out to 20m POINT C.
6. Record wood debris diameters where piece at intercept is =>7cm and classify each piece by type.
7. At each corner check slope of transect and where greater than 5 degrees add an additional length to transect as per Table 2, recording any additional wood debris.
8. Record as depth of the pile per transect 10m length which was not able to be assessed (if you measured all the pieces then depth will be 0m). Record to nearest 0.5m
9. Continue to measure wood debris each side of the triangle.
10. Take photos of each side of the transect, and any other items of interest for future reference.

Mapping Woody Debris

Using aerial imagery along the length of the coastline to be assessed, map polygon areas of debris. Locate plots as per random plot methodology across the mapped area. Provide a GPX, Shape le and PDF Map.

Satellite or Aerial Photography

A range of imagery sources may be used, whereby initially use of Planet Labs 3-4m resolution satellite imagery can be used as shown in Figure 4 and Figure 5.

Figure 4 Coastline to be assessed with a image from the 20th Feb showing the slash appearing in the 3-4m imagery at Aropaoanui Beach.

Aerial photography or higher resolution satellite imagery (example Figure 6) can also be used depending on the area and availability to help improve the mapping quality

Figure 6 - 0.5m resolution Satellite imagery of the coastline of Aropaoanui Beach and while taken at 7pm it has large shadowing the slash accumulation areas are very easy defined.

Drone Mapping

Where areas are likely not to have other imagery sources or the debris is quickly changing (being chipped, remove from site or continuing to wash away), it will be useful to capture the site with drone mapping. Automated detection of woody debris could also be applied to the scale of imagery as shown in Figure 7

Flight Specifications: typically, an 80-120m above ground level mapping grid flight, with a 70% overlapping swath should result in an effect map in most circumstances for an orthomosaic image of woody debris. This makes collecting time efficient and depending on the resolution of the camera will result in a <5cm pixel over the area

Appendix A – Random Bearings 0 to 90 and Slope Adjustment Table for 10m

Random Number Table Between 0-90				
46	74	90	46	61
88	3	53	75	1
3	3	69	27	70
58	56	59	2	66
22	8	71	57	51
89	64	69	60	38
79	30	85	29	9
90	11	32	60	40
50	82	11	4	74
70	73	66	68	88
1	69	42	83	33
10	2	22	74	70
59	50	63	22	79
66	69	56	77	65
72	47	5	8	27
26	15	88	5	28
62	64	65	61	66
52	59	69	27	81
26	66	44	69	65
2	63	61	52	84
62	2	54	60	73
65	48	45	11	19
6	25	73	72	60
79	16	19	6	85
7	4	43	51	10
38	71	43	22	58
10	14	4	35	1
50	78	4	49	34

Slope	Slope Adjusted 10m Dist. (m)	Extra Length (m)
0	10.00	0.00
5	10.04	0.04
7.5	10.09	0.09
10	10.15	0.15
12.5	10.24	0.24
15	10.35	0.35
17.5	10.49	0.49
20	10.64	0.64
22.5	10.82	0.82
25	11.03	1.03
27.5	11.27	1.27
30	11.55	1.55
32.5	11.86	1.86
35	12.21	2.21
37.5	12.60	2.60
40	13.05	3.05
42.5	13.56	3.56
45	14.14	4.14
47.5	14.80	4.80
50	15.56	5.56
52.5	16.43	6.43
55	17.43	7.43
57.5	18.61	8.61
60	20.00	10.00
62.5	21.66	11.66
65	23.66	13.66
67.5	26.13	16.13
70	29.24	19.24

Appendix B – Plot Form Paper Format

WOODY DEBRIS SURVEY FORM				
Plot Ref		Date & Time:		
Location Description:				
GPS:				
Random Orientation Bearing (0-90):				
Transect	**Slope (Deg)**	**SlopeDist (m)**	**Debris Depth (m)**	**Comment**
A (A to B)				
B (B to C)				
C (C to A)				

Transect (ABC)	Diameter (cm)	Class/Type	Comment

Notes

References

Bell, G. et al., 1996. Accuracy of the line intersect method of post-logging sampling under orientation bias. Forest Ecology and Management, 84(1-3), pp.23–28.

Competenz Unit Standard 6956 – Level 4 – Carry out waste assessment in cutover forest.

Hall, P., 1998. Logging Residue at Landings, (May), pp.1996–1998.

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Wagner, C.E. Van, 1968. The line intersect method in forest fuel sampling. For. Sci., 14: 20-26. De Vries, P.G., 1986. Sampling Theory

Wagner, C.E. Van, 1982. Practical aspects of the line intersect method.

Warren, W.G., 1989. Line intersect sampling: a historical perspective. In: State-of-the-art Methodology of Forest Inventory: A Symposium Proceedings. USDA Forest Service,
Paci c Northwest Research Station, Portland, OR, pp. 33–38.

Warren.W.G. and Olsen,P.F.,1964: A line intersect technique for assessing logging waste. Forest Science, vol.10 pp.267-276

Further detail on this can be found in a review of the line intercept approach.

- Harvest Cutover Residue Assessment > History | Interpine Innovation
- Cutover Residue Assessment Using Line Intercept Sampling | Interpine Innovation
- Drone based Harvesting Cutover Merchantable Volume Assessment | Interpine Innovation

Downloads

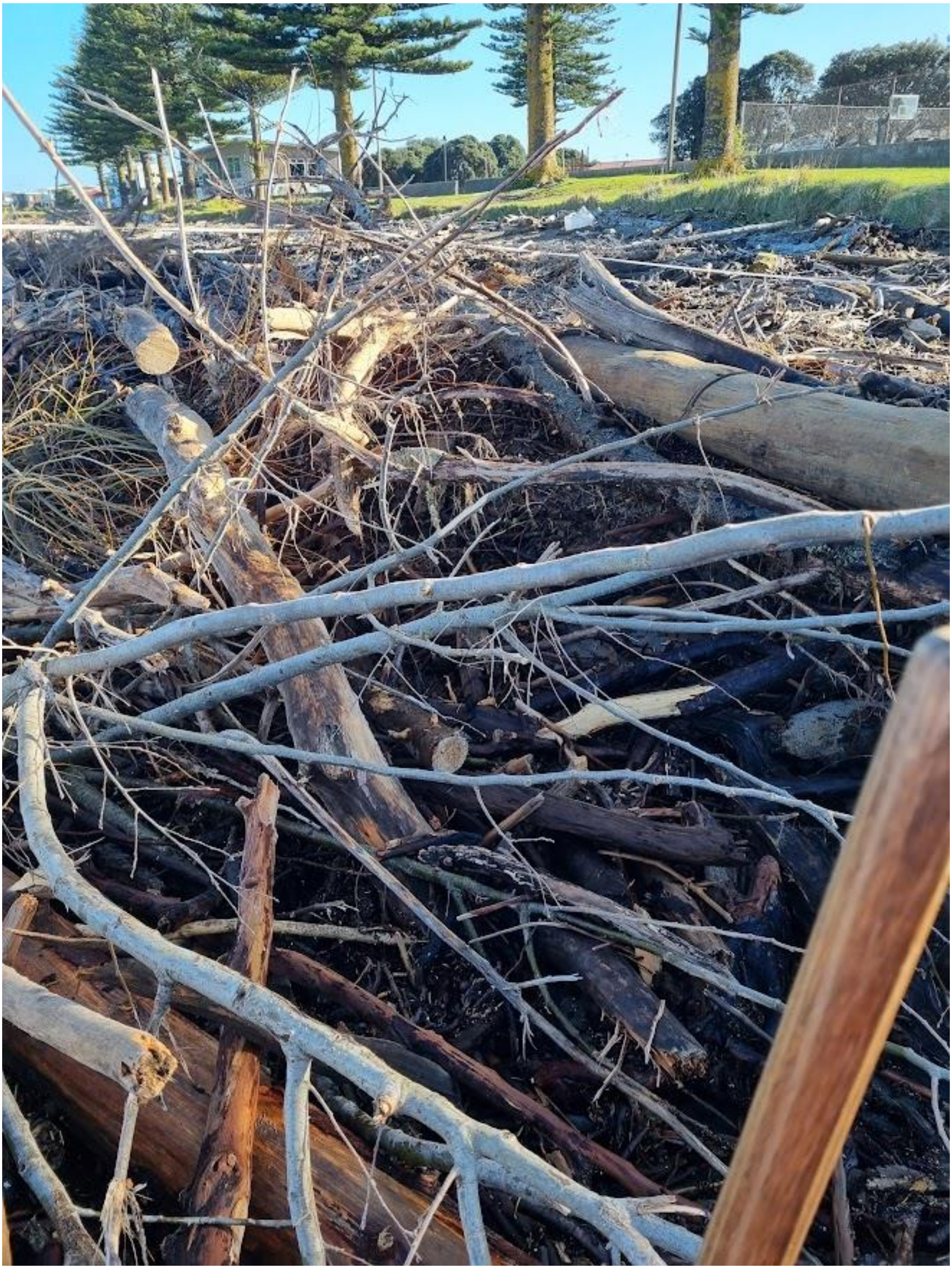
- NZQA Competenz 6956 Unit Module Study Guide:
- EXCEL Sheet – Plot Form and Appendices
- Woody Debris Sampling Methodology (as a PDF)

Acknowledgments

Pan Pac Forests, Red Axe Intelligence, Aratu Forests, HB Forestry Group, Kees Weytmans

Appendix 4. Photos pertaining to the Sampled Plots.

P1_1



P1_2

P1_3 Some unmeasurable debris due to tide and surf.

P2_1

P2_2

P2_3 Plot 2 and its close neighbourhood contained significant non-biodegradable material (Class 70) However, none of this was captured in the sample.


P2_4 Plot 2 and its close neighbourhood contained significant non-biodegradable material (Class 70) However, none of this was captured in the sample.

P3_1

P3_2

P3_3

P4_1

P4_2

P4_3 Note the crosscut on the log the measurement technician is standing on.

P5_1


P5_2


P5_3


P5_4


P5_5

P6_1


P6_2

P6_3

P6_4

P7_1

P7_2

P7_3

P7_4

P8_1

8_2

P8_3

P8_4

P9_1

P9_2

P9_3


P9_4

P10_1


P10_2


P10_3


P10_4


P11_1

P11_2

P11_3

P12_1

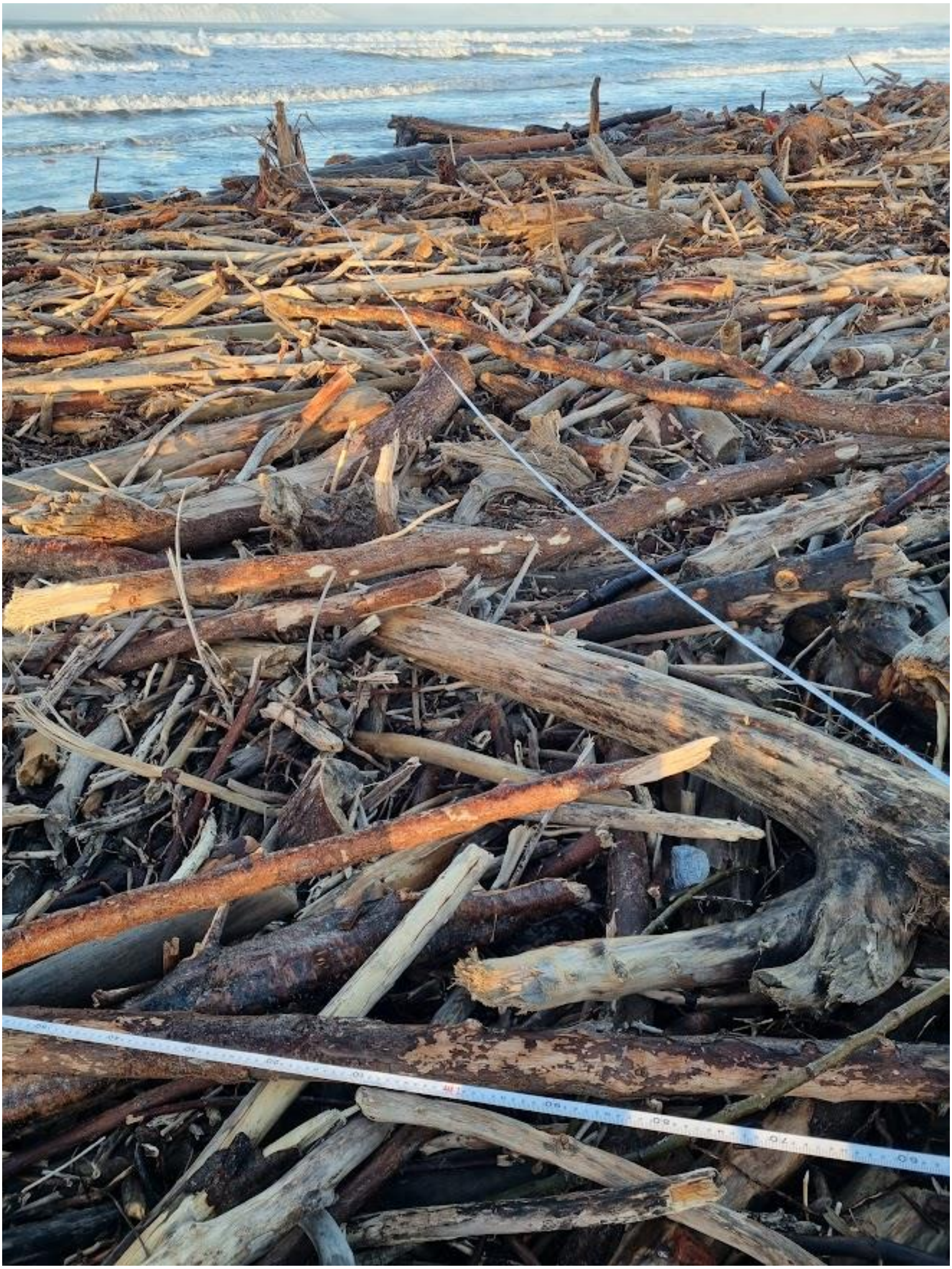
P12_2

P12_3

P13_1


P13_2

P13_3



P13_4

P14_1


P14_2

P14_3

P15_1

P15_2

P15_2

P16_1

P16_2

P16_3

P16_4

P17_1

P17_2

P17_3

P17_4

P17_5

P17_6

P17_7


Town side opposite P17


P18_1

P18_2

P18_3


Town side opposite P18

P19_1

P19_2

P19_3


Town side opposite P19

P20_1

P20_2


P20_3

Town side, opposite P20

P21_1

P21_2

P21_3

P21_4

Ocean side opposite P21

P22_1

P22_2

P22_3


P22_4


P22_4


Beach view as seen from start of A segment of P22

P23_1

P23_2

P23_3

P23_4

P23_4


P23_5

P24_1


P24_2

P24_3

P24_4

P24_5

P25_1

P25_2

P25_3


P25_4 Probable dislodged log in P25, after being cross cut on the beach.

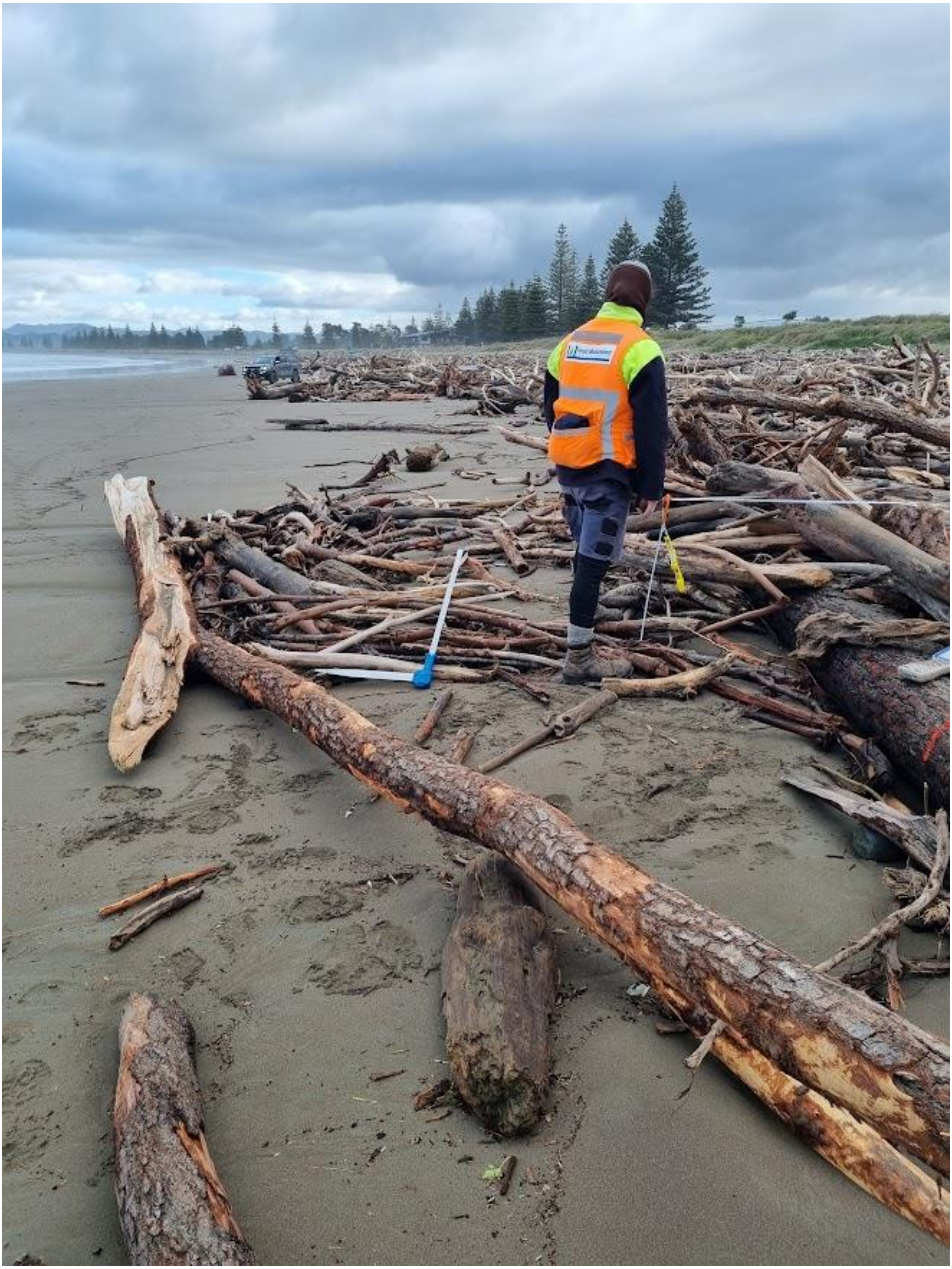

Beach view from P25


Beach view from P25 towards Waikanae

P26_1

P26_1


P26_2


Beach view towards Midway from P26

P27_1

P27_2

P27_3


P27_4

P28_1


P28_2

P28_3

P29_1


P29_2

P29_3

P30_1

P30_2


P30_3

P30_4


Beach view towards Midway from P30

30 mtr towards Midway from P30. Not assessed.

30 mtr towards Midway from P30. Not assessed.

60 mtr towards Midway from P30. Not assessed.


60 mtr towards Midway from P30. Not assessed. Note the frequent cuts of the longer wood.