Characterization of Live and Dead Fine Biomass of Two Stands in Northern Hardwood Forest, New Hampshire

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Introduction

Roots play a key role in tree access to soil resources (water and nutrient uptake) and mechanical stability, they are still a poorly understood component of forest ecosystems (Jagodzinski, 2016). Roots comprise with fraction of the total wet or dry weight of the vegetation in forest ecosystems. Generally, tree roots account for 15–30% of the total tree biomass (Persson 2002). Roots provide anchorage, they supply soil-borne resources, modify soil properties and drive rhizosphere phenomena (Gregory 2006).

The vertical distribution pattern of roots along soil depth is useful information to facilitate understanding of the nutrient flow in forest ecosystem. In practical terms, determining the vertical pattern of fine roots is also important to obtain unbiased estimates of their biomass and dynamics via an optimal sampling scheme. However, the vertical distribution of roots is difficult to measure and its best measured by excavation in rocky soils (Yanai et. al 2006; Lyford and Wilson 1964; Lyford 1980).The most common approaches for field sampling of root biomass are soil excavation and soil coring (Bledsoe et al. 1999). In this study, soil excavation is useful since using quantitative soil pits reduces uncertainty caused by small- scale spatial variation by sampling a larger soil volume than coring techniques (Fahey et al, 2017). This was used to obtain data on the root distribution with depth of living (biomass) and dead (necromass) fine roots in terms of dry weight.

Knowledge about the amount of roots, particularly the active and live roots, and their distribution in the soil profile of different forest stands provide us with information essential for comparison between different forests. Increased fine root biomass and increased live/dead ratios in the forest soil are to a great extent caused by site factors favoring growth such as high soil temperature and rich availability of water and mineral nutrient (Persson 1980, 2000). Characterizing the distribution and biomass of tree roots is challenging because of high variability and difficult access. The inability to detect differences or changes in root biomass is a common limitation in comparative and experimental research (Park et al. 2008). Moreover, variation in root biomass across forest landscapes results from such influences as stand age and species composition; soil properties including soil depth, parent material composition, texture, and fertility; and topography, drainage, and microclimate (Vitousek and Sanford 1986, Cairns et al. 1997, Tateno et al. 2004). In older forests, where recycling of nutrients by decomposition is proportionally more important, we might expect relatively more roots to be found near the surface, where most mineralization occurs (Yanai et. al 2006).

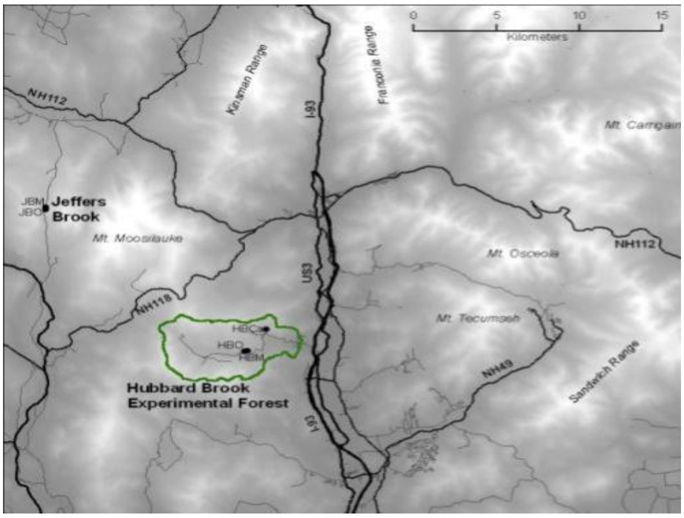
The purpose of the present study was to present data focused on the characterization of both living and dead fine roots of two stands. Thus, the main objective of the study was to characterize fine root distribution in Northern Hardwood stands, White Mountain National Forest, New Hamsphire. It was hypothesized that: (1) There is a significant difference in accumulation of both living and dead fine roots in soil from HBO (old stands, >100 years) and HBM stands (mid-aged, 30 years). And (2) A reduction of the amount of both live and dead fine roots occurs with increasing soil depth.

MATERIALS AND METHOD

Site Description

The study site is located in the Hubbard Brook Experimental Forest in the White Mountain National Forest, New Hampshire, USA (Figure 1; Table 1). The climate is humid continental, with a mean annual temperature of 4.4 ^{0} C. Annual precipitation is 140 cm, evenly distributed throughout the year (Smith & Martin, 2001).

Figure 1. Location of stands and site that samples were collected in the White Mountains of New Hampshire (Vadeboncoeur et al., 2012). The gray scale is representative of elevation with the lightest areas being the highest elevations (Darkest <200 m and lightest >600 m).



Excavation of roots from soil pits

In this study, soil excavation is useful since using quantitative soil pits reduces uncertainty caused by small- scale spatial variation by sampling a larger soil volume than coring techniques (Fahey et al, 2017). This was used to obtain data on the root distribution with depth of living (biomass) and dead (necromass) fine roots in terms of dry weight.

About three 0.7 m^2 square quantitative soil pits were excavated in each of the stands. The soil pits were excavated using a secured frame as a reference plane for calculating the volume of excavated soil (Yanai et.al, 2006; Hamburg 1984). The forest floor was collected in two layers, the Oie (L + F) and Oa (H). The mineral soil was collected in four depth intervals (0–10, 10–30, 30–50, and >50 cm). Most of the soil samples were sieved in the field, with the exception of the Oie, which is difficult to sieve when moist. The Oa horizon soils were sieved to 6 mm and all the other strata were sieved to 12 mm.The roots that did not pass through the sieve was collected and weighed. The soil passing through the sieve was repeatedly subsampled with a trowel for later root picking. Vertical roots were cut to correspond to the multiple depth increments from which they were excavated.

Root Processing

All roots and soil samples for root picking were stored in a cooler in the field and then refrigerated until they could be processed, which was generally within 1 month from sample collection. Live roots were divided into size classes into following root diameter fractions: <1, 1–2, 2–5, 5–10, 10–20 and 20-100 mm. Dead roots were separated from live roots but were not sorted by size. Dead roots were recognized based on distinct morphological characteristics Table 1. It is essential to use well defined morphological criteria while sorting the root fragments into species and live and dead root categories. Live fine roots were defined as roots with white or to a varying degree brownish/suberized root tips, often well branched. Dead roots were brownish and easily broken. The dry weight were estimated for all root fractions after drying in an oven at 60°C to constant weight (at least for 48 h).

Table 1. Morphological criteria Live/Dead Fine Roots

Morphological criteria	Live	Dead	Source
Stele color	white or slightly brown	brownish/ dark	Persson & Stadenberg, 2009; Schuurman,1971)
Elasticity	elastic	broke easily	Vogt and Persson 1991; Schuurman,1971
Root branching	well branched	broken off/ separated	Vogt and Persson 1991

Statistical analysis

The main output of this project is the raw data for the 2018 root samples collected from two different stands. However, just to give quick estimation the data was presented in graphs to show the average live and dead roots, ratio of live/dead roots and average dry weight of roots per pit.

Result

Figure 2. Average Live Fine roots dry

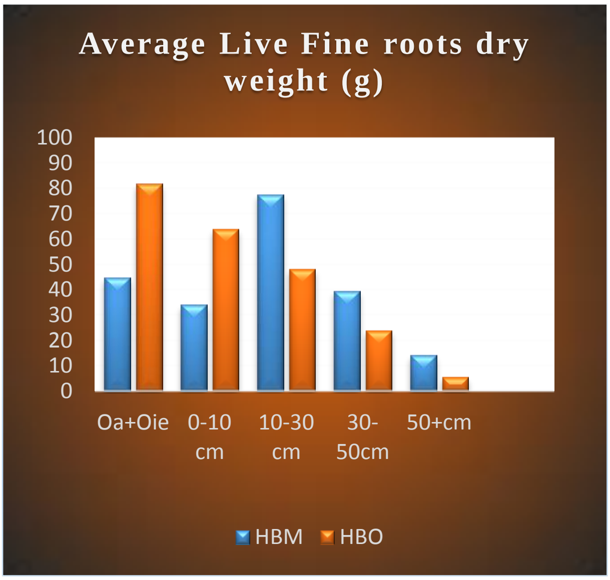
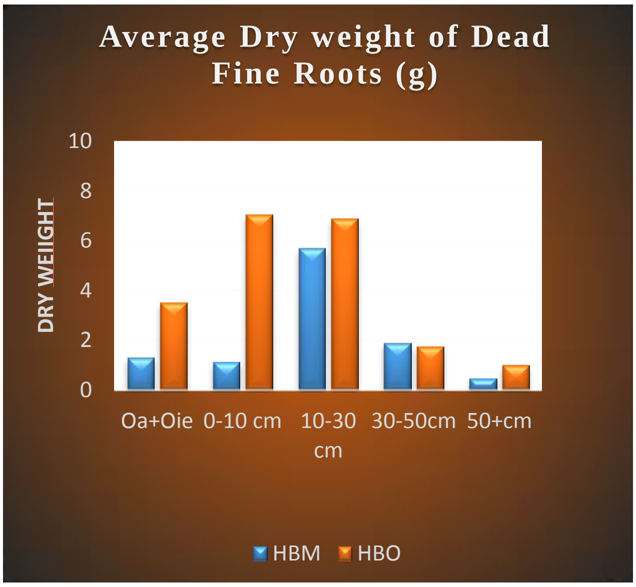
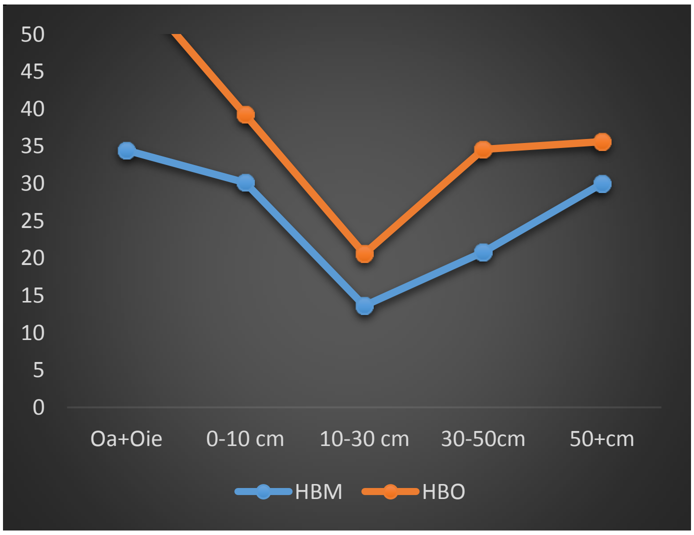


Figure 2.1 Average Dead Fine roots dry



Figures 2.0 and 2.1 shows the average dry weight of live fine and roots between the middle-aged (HBM) stands and old stands (HBO). HBO stands (>100 years) has the highest live fine and dead root dry weight distribution compared to HBM stands (30 years) at 10-30cm soil depth.

Figure 3. Average Live/dead root Ratio



As shown in Figure 3.0 , HBM stands has the highest live/dead ratio compared to HBO stands. The live/dead ratio decreased at 10-30 cm depth for both stands.

This supports the previous study that the live/dead ratio decreased with depth for both tree— and field-layer species and seems to be a most powerful vitality criterion of the fine roots (Persson, H., & Stadenberg, I. , 2009).

Figure 4.0 Average root dry weight in Mid-aged Stands

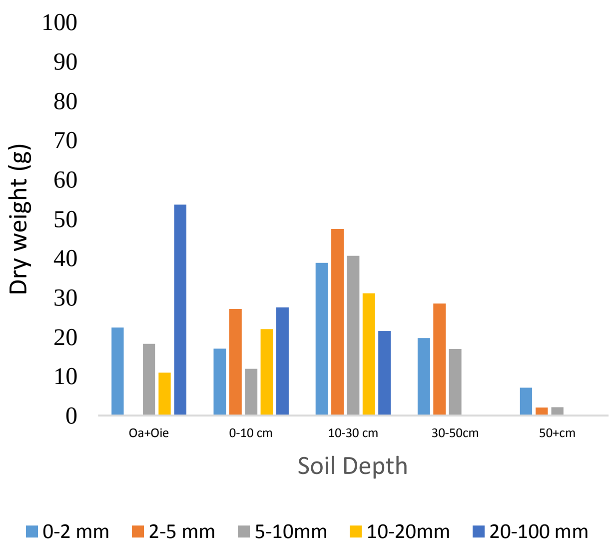
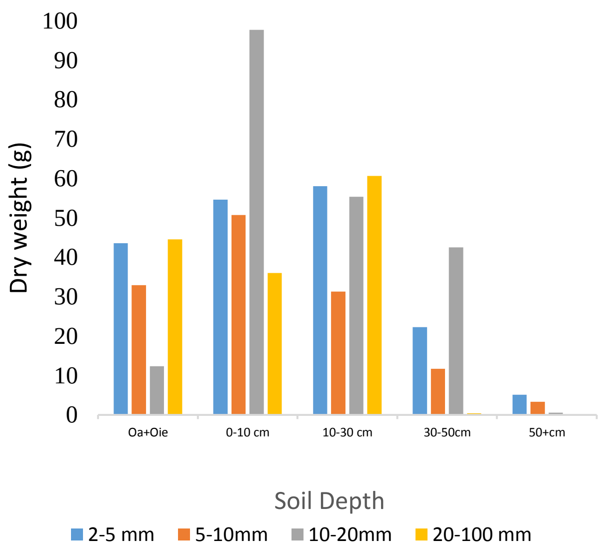


Figure 4.1 Average root dry weight in Old-aged Stands



Average root dry weight is highly distributed in 10-30 cm soil depth in HBM stands. While in HBO stands average roots started to distributed between 0-10 cm to 10-30 cm soil depth. Fine dry weight is declining with soil depth in both stands and course root dry weight (10-20mm) biggest at 0-10cm.

Figure 5.0 Average Dry weight in Mid-aged Stands/Pit

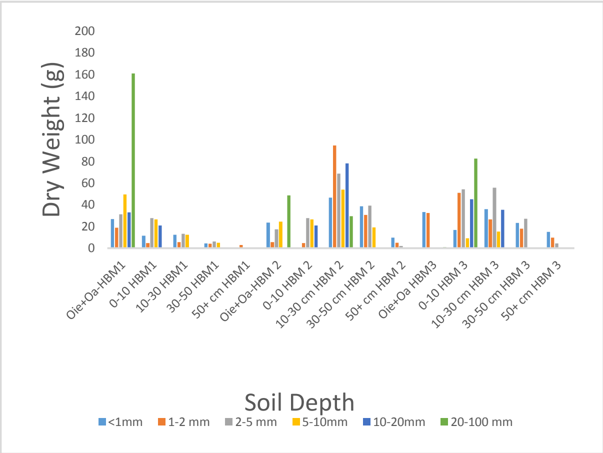
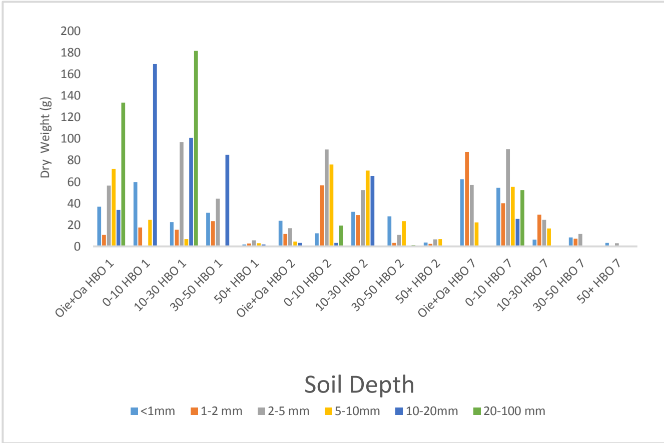


Figure 5.1 Average Dry weight in Old-aged Stands/Pit



As revealed in figure 5, HBM 2 and 3 had likely similar root dry weight distribution compared in HBM 1. While in figure 5.1 , HBO 1 had highest root dry weight compared to HBO 2 and 7 soil pit.

Conclusion

Soil depth tended to have the greatest root mass, though in the older stands, there was more biomass in the 10–30 cm depth (Park et al. 2007). Older forests, where recycling of nutrients by decomposition is proportionally more important, relatively more roots to be found near the surface, where most mineralization occurs (Yanai et. al 2006).

In other side, dead ratios in the forest soil are to a great extent substantial flow of carbon and nutrients from root caused by site factors favouring growth such as high litter into the forest soil at the same time occurs soil temperature and rich availability water and during the growth period. Root litter is decomposed mineral nutrient (Persson 1980). Thus there were more fine roots at the site with the poorest soil quality. Keyes & Grier (1981) also found larger amounts of fine root biomass in poorly productive sites. When the physical and chemical conditions of the soil are good, trees can take up enough water and nutrients with lower root densities. In combination with root density, the soil hydraulic conductivity plays an important role in the ability of root systems to take up water (de Willigen & van Noordwijk, 1987).

Project Evaluation

The study, characterization, and quantification of plant root growth and root systems has been and remains an important area of research in all disciplines of plant science and nutrient cycling.

The main objective of the study was to characterize root distribution in Northern Hardwood stands, White Mountain National Forest, New Hamsphire. However, the current number of samples (6 pits) were not enough to give conclusion the result of the study.

Root processing requires large number of samples, labor-intensive, time-consuming processing in lab and requires skills in judgement between live and dead roots. Due to time constraints, the output of this project is the simple graphical representation of the initial result and raw data for the 2018 root samples.

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Appendices

Appendix 1

Root Processing

Lab set-up

Sorting based on diameter

Group of fine roots

Bagging of samples

Oven drying

Life is like a roots, its hard and complicated but the best weapon to sort it is to wear your best smile and work hard to reach something…a step ahead..

Amy2018capstoneproject

Inventory and re-bagging

Appendix 2

Products

1. 2018 Root Processing Protocol
2. Data Sheet

The route to root processing

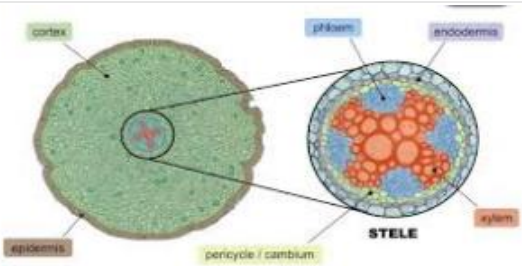
Posted on September 26, 2018 by labblogposts

Roots collected from the top of the screen from soil pits in 2018

1. Get a sample out of the freezer. Weigh it and record the weight on the data sheet.
2. Place the sample on a big sheet of paper and sort the roots into diameter classes (< 1, 1-2 mm, 2-5 mm, 5-20 mm, and 20-100 mm). Use calipers to confirm diameters. Cut small roots where they attach to larger roots if they belong in a different pile. Roots identified as dead at this point can go into a different pile.

3. Wash the roots. Separate live from dead roots, and distinguish live roots from dead. Dead roots may feel squishy, be decayed, or be distinguishable by morphological criteria.

Morphological criteria	**Live**	**Dead**	**Source**
Stele color	white or slightly brown	brownish/dark	Persson & Stadenberg, 2009; Schuurman,1971)
Elasticity	elastic	broke easily	Vogt and Persson 1991; Schuurman,1971
Root branching	well branched	broken off/ separated	Vogt and Persson 1991
Texture	smooth	wrinkled	(Gwenzi et al., 2011).



Subsampling can be used to speed up processing when there is too much material <1 mm in diameter. This may happen for the samples collected above the screen in the Oie, Oa and 0-10 cm depth increments. Combine all <1 mm roots into one pile and subdivide them into six or more groups. Weigh each of the piles, to be used for scaling the results to the whole sample. Randomly select two groups to process.

Subsampling of <1 mm size

4. Bag the rest of the root diameter classes (1-2 mm, 2-5 mm, 5-20 mm, and 20-100 mm) and label bags indicating the site, plot, depth class, diameter class, and date of collection. Use coin envelopes if the samples are small.

5. Put samples in the oven at 60 degrees C for at least two days. When samples have dried to a constant weight (they don't lose more weight on further drying), weigh the samples and record the masses on the datasheet.

2. Data Sheet

2018 Root Processing Data (On sieve + Oie Samples)

Site: Hubbard Brook, NH Season Collected: Summer 2018 Method: Soil pit excavation			Dry Weight (g)							
			Live	Dead						1-100+ mm Dead (g)
Stand	Plot	Depth (cm)	<1mm		1-2 mm	2-5 mm	5-10mm	10-20mm	20-100 mm	
HBM	1	Oie+Oa	26.69	3.062	18.76	31.2	49.58	32.8	161	0
	1	0-10	11.32	1.204	4.65	27.5	26.53	20.83	0	0.31
	1	10-30 cm	12.3	3.7	5.4	13.3	12.4	0	0	0
	1	30-50 cm	4.343	3.333	4.04	6.2	4.86	0	0	0
	1	50+ cm	0.359	1.191	2.94	0	0	0	0	0
HBM	2	Oie+Oa	23.55	0.40	32.26	23.8	35.6	29.3	0.83	0
	2	0-10 cm	10.8	3.83	26.5	28.76	13.7	19.8	153.6	4.9
	2	10-30'	46.62	4.24	94.56	68.49	53.84	77.97	29.32	26.29
	2	30-50 cm	38.5	1.001	30.56	39.11	18.92	0	0	9.57
	2	50+ cm	9.68	0.165	4.98	2.07	0	0	0	0
HBM	3	Oie+Oa	33.18	0.44	12.33	15.3	5.2	21.52	110.23	3.75
	3	0-10 cm	16.55	1.064	77.47	109.44	24.25	80.41	82.5	4.114
	3	10-30'	35.95	0.564	26.48	55.63	15.24	35.25		
	3	30-50 cm	23.11	1.358	17.86	27.06	0	0	0	5.563
	3	50+ cm	15.05	0.9	9.71	4.26	0	0	0	0
HBO	1	Oie+Oa	36.92	1.955	10.64	56.61	72.08	33.97	133.59	2.039
	1	0-10	59.81	4.2	17.48	23.1	24.87	169.71	0	0
	1	10-30'	22.5	4.5	15.6	97.14	6.8	100.72	181.8	0
	1	30-50 cm	31.4	0.53	23.6	44.3	0	85.1	0	0
	1	50+ cm	1.83	0.16	2.67	5.84	3.14	1.8		0.044
HBO	2	Oie+Oa	24.32	1.529	11.5	16.92	4.4	3.2	0	6.65
	2	0-10	12.21	2.51	45.38	73.3	71.82	0	19.43	0
	2	10-30 cm	32.3	18.4	29.2	52.3	70.4	65.4	0	15.69
	2	30-50 cm	28	1.58	3.18	10.88	23.42	0	1.322	0
	2	50+ cm	3.732	0.9	2.3	6.6	6.8	0	0	0
HBO	7	Oie+Oa	62.62	4.55	87.71	57.29	22.34	0	0	5.5
	7	0-10	54.48	14.14	40.061	90.581	55.36	25.654	52.52	
	7	10-30 cm	6.32	1.755	29.4	24.62	16.6	0	0	26.13
	7	30-50 cm	8.5	3.5	7.1	11.6	0	0	0	0
	7	50+ cm	3.2	2.043	0.406	2.875	0	0	0	0

2018 Root Processing Data
Sieve roots

Site: Hubbard Brook, NH
Season Collected: Summer 2018
Method: Soil pit excavation

			Live	Dead	Dry weight (g)					Dead (1 to 100mm)
Stand	Plot	Depth	<1mm		1-2 mm	2-5 mm	5-10mm	10-20mm	20-100 mm	
HBM	1	Oa	0.009	0.062						
		0-10 cm	0.029	0.043		0.091				
		10-30 cm	0.057	0.007						
		30-50cm	0.036	0.025						
		50+cm	0.013	0.050						
HBM	2	Oa	0.01	0.074						
		0-10 cm	0.271							
		10-30 cm	0.045	0.027	0.080					
		30-50cm	0.031	0.020						
		50+cm	0.032	0.009						
HBM	3	Oa	0.171	0.152	0.128					
		0-10 cm	0.05	0.047						
		10-30 cm	0.042	0.06						
		30-50cm	0.007	0.012						
		50+cm	0.016	0.016						
HBO	1	Oa	0.123	0.151						
		0-10 cm	0.135	0.087						0.032
		10-30 cm	0.031	0.034						
		30-50cm	0.038	0.045						
		50+cm	0.029	0.114						
HB0	2	Oa	0.050	0.034						
		0-10 cm	0.148	0.141	0.088					
		10-30 cm	0.045	0.089						
		30-50cm		0.067	0.156					
		50+cm	0.033	0.025						
HB0	7	Oa	0.022	0.23						
		0-10 cm	0.111	0.154						
		10-30 cm	0.008	0.067						
		30-50cm	0.006		0.027					
		50+cm		0.017						

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