Forest Research

New forest inventories in Britain using remote sensing and proximal data collection methods

Juan Suárez

Forest Research, Northern Research Station, UK

juan.suarez@forestresearch.gov.uk

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How many trees are in the world?

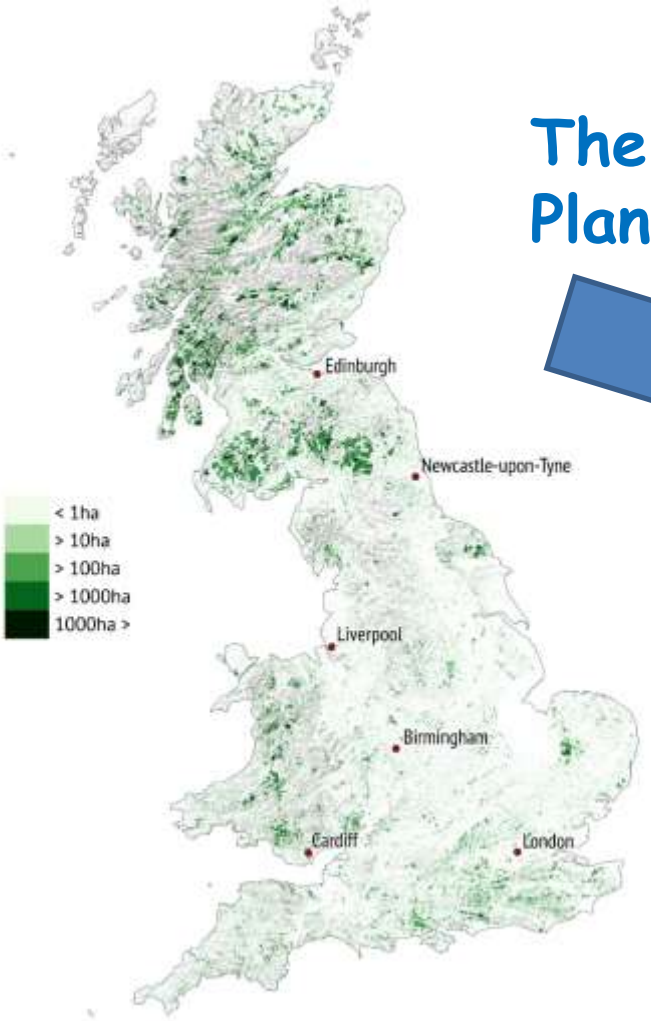
3.04 trillion trees
or 422 per person

How many trees are in the UK?

3 billion trees or
45 per person

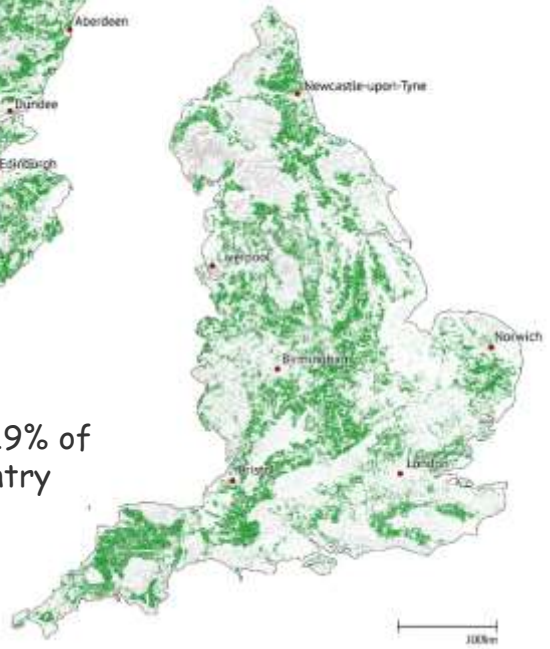
The BIG Challenge

The Big Plans



Scotland, 2.7m hectares or 1/3 of the country

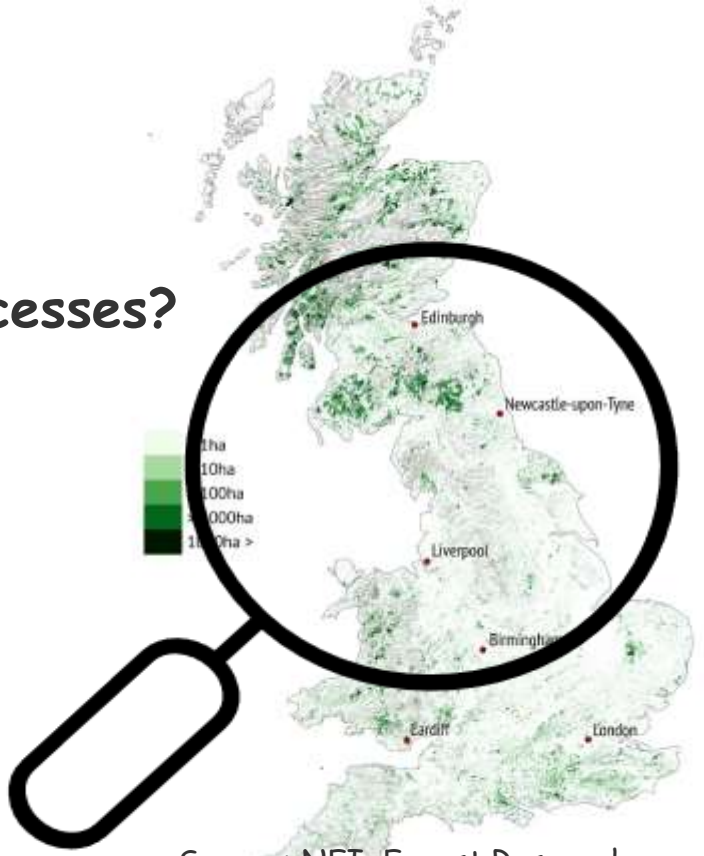
Wales, 19% of the country



England, 3.2m hectares of "low-sensitive" areas for planting trees, target 1.5 m ha OR 17% of the country

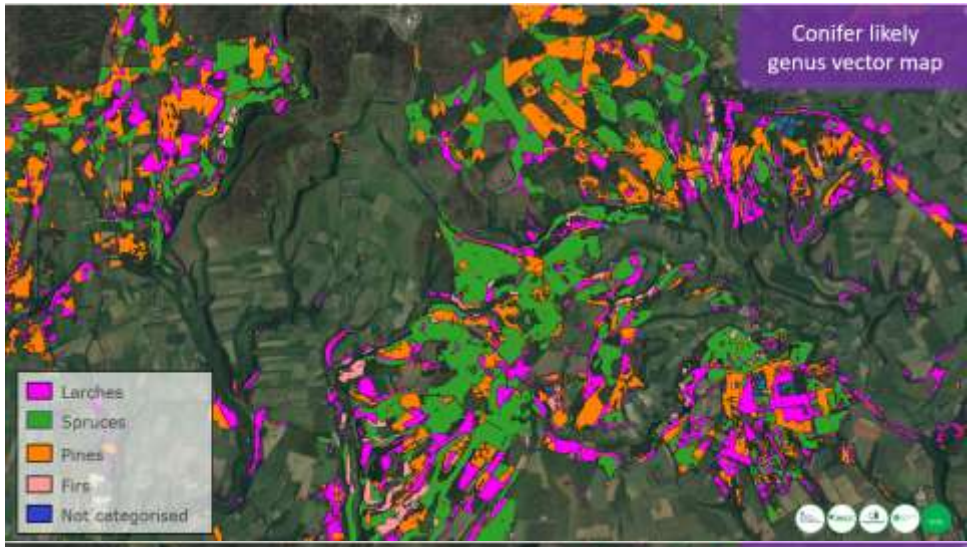
There are other questions… the 5 Ws

-Which species do we have?
-Where are trees located?
-What happened to them?
-What are they doing?
Can we monitor Forests dynamic processes?
-Where are we going?

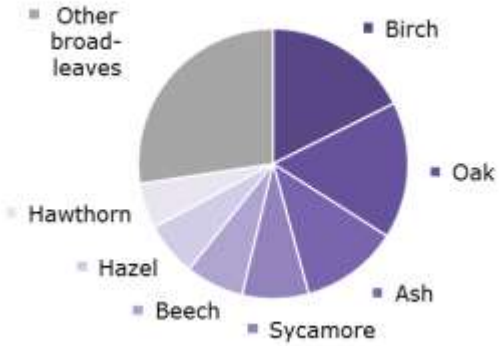


Source: NFI, Forest Research

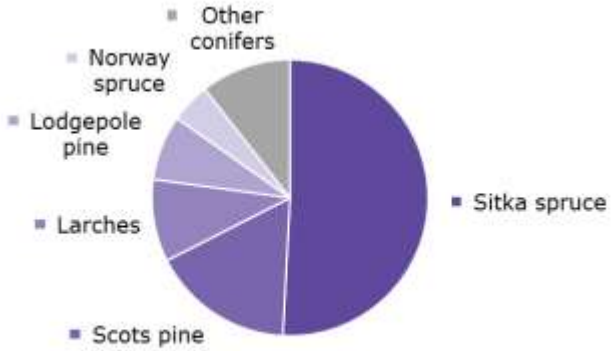
Which species do we have?



Broadleaves



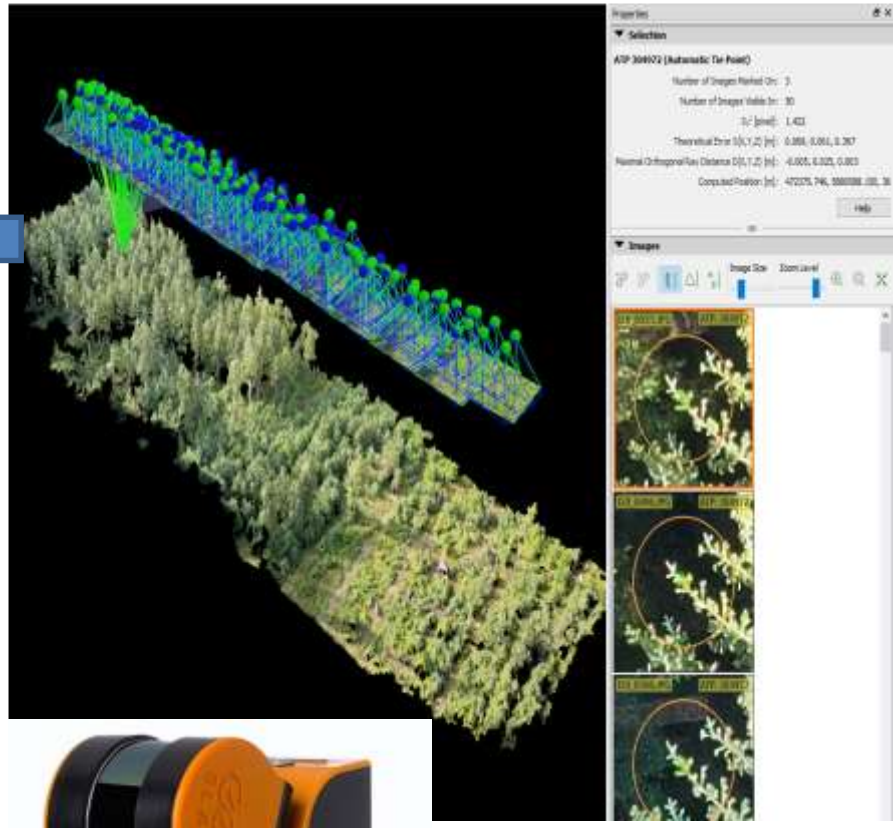
Conifers



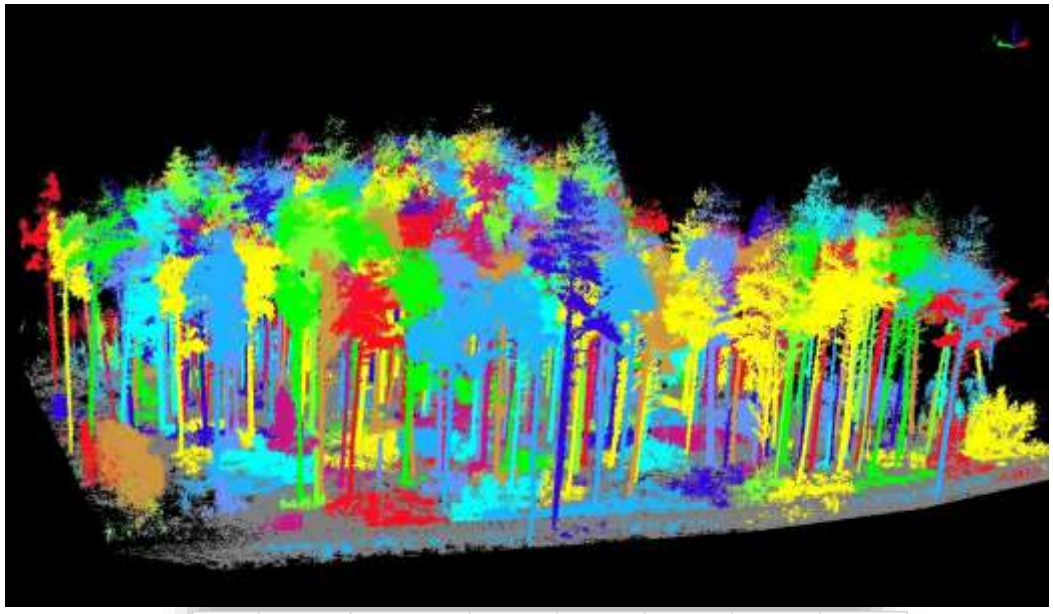
Source: Scott Dearden and Conor Strong

Where are trees located?

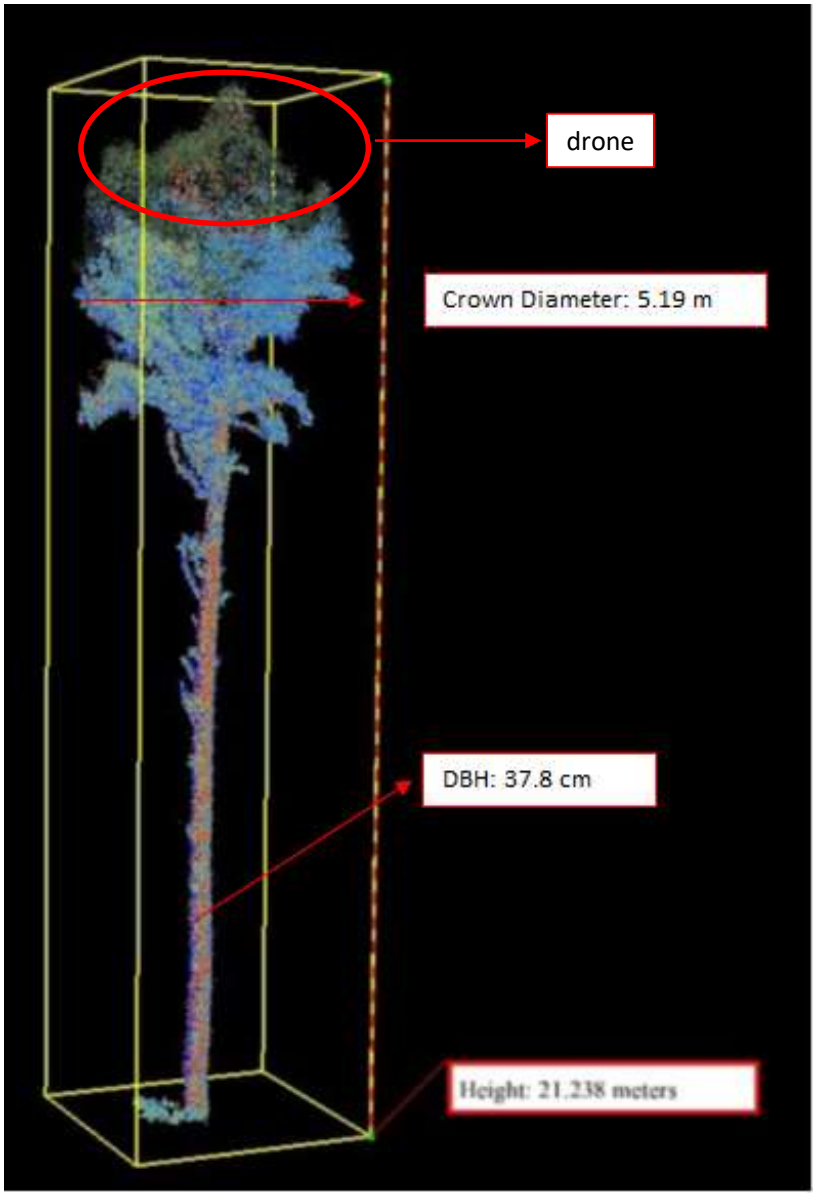
Structure from Motion (SfM)



Where are trees located?

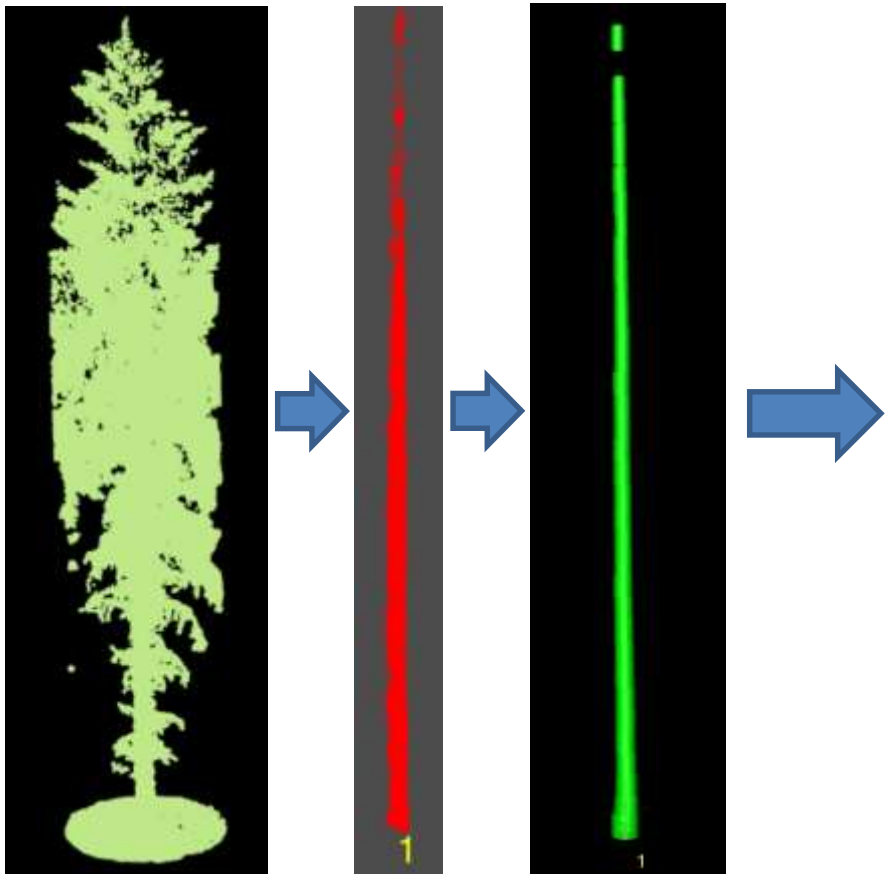


TreeID	Tree LocationX	Tree LocationY	Tree Height	DBH	Crown Diameter	Crown Area	Crown Volume
1	241136.5	708116.752	22.683	0.108	6.158	29.787	171.204
2	241156.6	708130.169	16.734	0.141	2.807	6.189	23.876
3	241156.6	708114.448	20.412	0.315	4.182	13.738	63.35
4	241144.5	708118.63	20.983	0.283	4.684	17.23	103.962
5	241145	708129.461	17.014	0.233	4.981	19.486	66.312
6	241153.9	708130.09	17.943	0.275	3.867	11.742	61.339
7	241139.7	708117.187	2.516	0	0.837	0.55	0.779
8	241151.3	708126.85	17.599	0.269	4.815	18.21	87.958
9	241154.7	708113.868	5.206	0.085	2.328	4.258	5.464
10	241142.6	708109.197	2.785	0.908	0.483	0.184	0.142
11	241156.4	708127.288	4.584	0.127	0.454	0.162	0.492
12	241147.3	708121.923	17.541	0.309	5.152	20.847	114.277
13	241129	708120.23	2.18	0.42	0.859	0.58	0.708
14	241139.3	708130.346	17.071	0.203	4.423	15.367	57.879
15	241143.8	708117.128	2.196	0.325	2.191	3.769	3.87
16	241140	708128.533	17.83	0.273	3.776	11.2	64.24
17	241130.8	708120.931	17.424	0.578	6.754	35.823	161.829
18	241126.6	708124.623	3.986	0.373	0.655	0.337	0.487
19	241150.2	708120.727	17.765	0.263	4.931	19.095	98.912



Where are trees located?

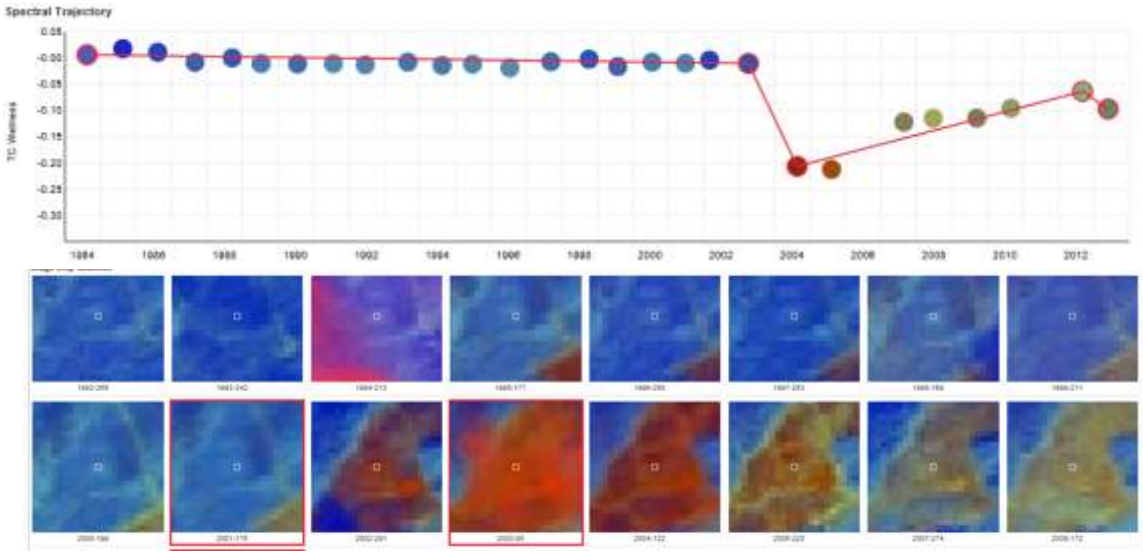
Reconstruction of stem profiles



	TreeID	Segment	X	Y	Radius	Error	AvgHeight	N
1	1	1	-17.53903	7.037840	0.29234796	0.0014862970	0.3656768	1084
2	1	2	-17.56081	7.025208	0.25654544	0.0007262826	0.7480973	2598
3	1	3	-17.57246	7.033874	0.23164961	0.0007324386	1.2470507	2187
4	1	4	-17.59054	7.043299	0.21158950	0.0006658642	1.7538767	2279
5	1	5	-17.59245	7.062224	0.20760750	0.0006143630	2.2538120	2349
6	1	6	-17.59744	7.061986	0.20681464	0.0007376114	2.7449919	1980
7	1	7	-17.60485	7.075518	0.20374520	0.0008178060	3.2450518	1911
8	1	8	-17.60522	7.087647	0.20018794	0.0006331408	3.7421126	1806
9	1	9	-17.60551	7.097774	0.19801973	0.0006362345	4.2541146	1592
10	1	10	-17.60834	7.101378	0.19314777	0.0007074113	4.7416008	1620
11	1	11	-17.60534	7.111123	0.19282668	0.0007393210	5.2472676	1739
12	1	12	-17.59714	7.115566	0.19008622	0.0009818980	5.7443693	1301
13	1	13	-17.59986	7.115121	0.17958328	0.0008372263	6.2580303	1273
14	1	14	-17.59743	7.119706	0.18212190	0.0009800801	6.7533206	1263
15	1	15	-17.60035	7.123136	0.18225153	0.0011998649	7.2562225	1098
16	1	16	-17.60144	7.124760	0.17653747	0.0011435685	7.7432031	1112
17	1	17	-17.60380	7.137519	0.18135210	0.0012792960	8.2274332	962
18	1	18	-17.60251	7.152461	0.18171898	0.0013329007	8.7584915	968
19	1	19	-17.60418	7.132808	0.16686686	0.0015148452	9.2613016	817
20	1	20	-17.60565	7.136744	0.16927358	0.0022116890	9.7254893	606
21	1	21	-17.60639	7.161991	0.17636872	0.0013957290	10.2471290	731
22	1	22	-17.60936	7.137662	0.15913918	0.0017389435	10.7609714	573
23	1	23	-17.62312	7.140086	0.15708909	0.0024288684	11.2370986	436
24	1	24	-17.61830	7.152087	0.15605877	0.0023002041	11.7480889	378
25	1	25	-17.61791	7.151719	0.14960401	0.0024284949	12.2424251	371
26	1	26	-17.61489	7.160408	0.15124548	0.0030171064	12.7291011	275
27	1	27	-17.61248	7.165521	0.14717513	0.0031003842	13.2232044	270
28	1	28	-17.61167	7.153258	0.13773561	0.0041274031	13.7534276	174
29	1	29	-17.60246	7.165888	0.14434142	0.0045682638	14.2172584	113
30	1	30	-17.59347	7.178635	0.14867545	0.0052401965	14.7412882	102

Source: Jaz Stoddart

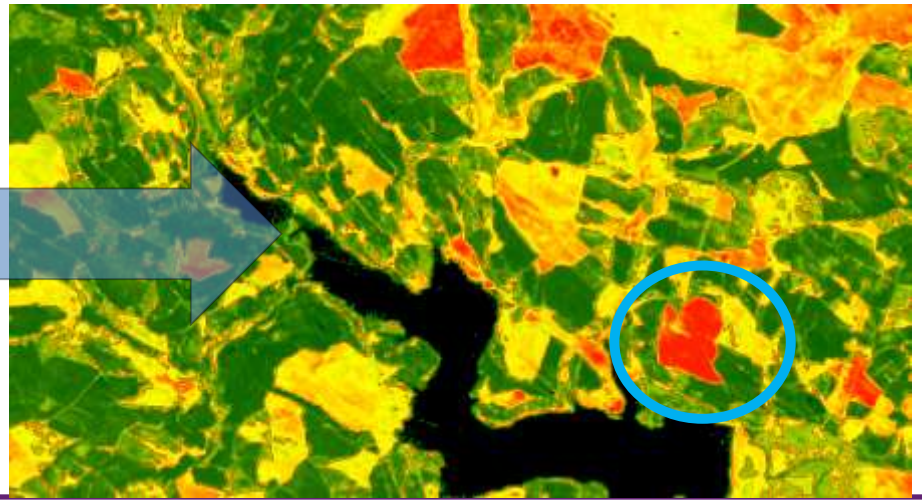
Monitoring disturbances-GE Engine



Identifies trends in noisy data e.g. central Summer period

Date, magnitude, duration of periods of change

Source: TimeSync, DEFRA EODIP9 project



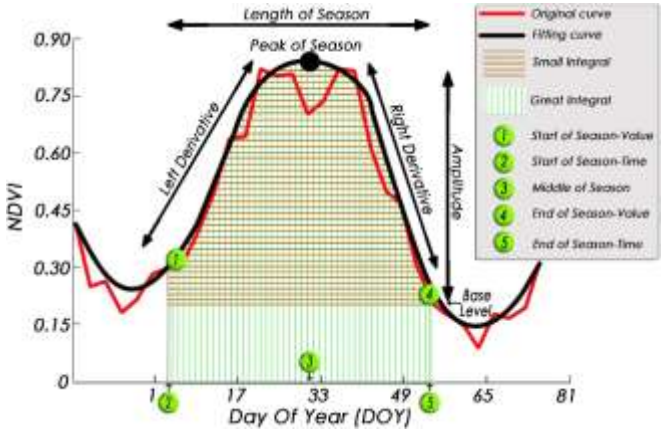
Sentinel-1 detection of windthrow

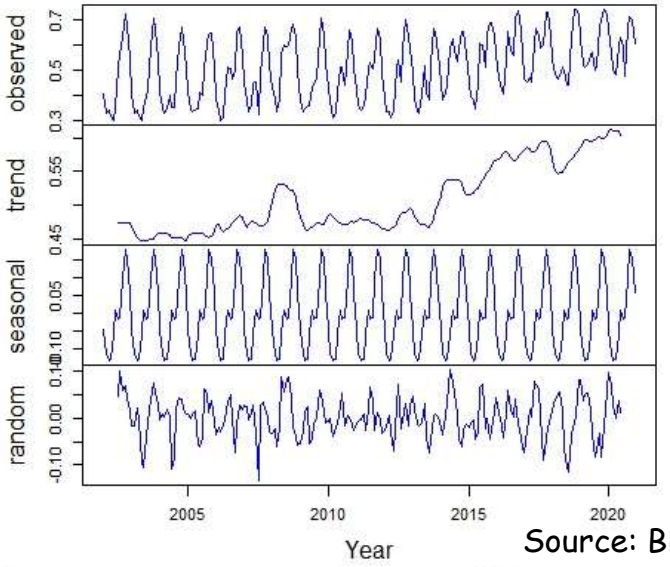
Species	Volume (m^3)
Birch	457
Corsican pine	6,291
Douglas fir	10,577
European larch	39
Grand fir	376
Hybrid larch	955
Japanese larch	10,479
Lodgepole pine	44,267
Mixed broadleaves	546
Mixed conifers	2,094
Mixed Conifer Plantations	345
Noble fir	161
Norway spruce	65,052
Red cedar	1,596
Scots pine	51,252
Sycamore	54
Total	**194,543**

	Total volume Standing Before storm (m^3)	Total Volume lost after the storm (m^3)	% Volume Lost after storm (%)	Future Volume Lost in 2025 (m^3)	% Volume Lost in 2025 (%)
Sitka spruce	9,436,930	760,182	8.1%	827,239	7%
Other species	2,336,057	194,543	8.3%	N/A	N/A
IFT in NFI	12,689,341	727,213	5.7%		
Grand Total					

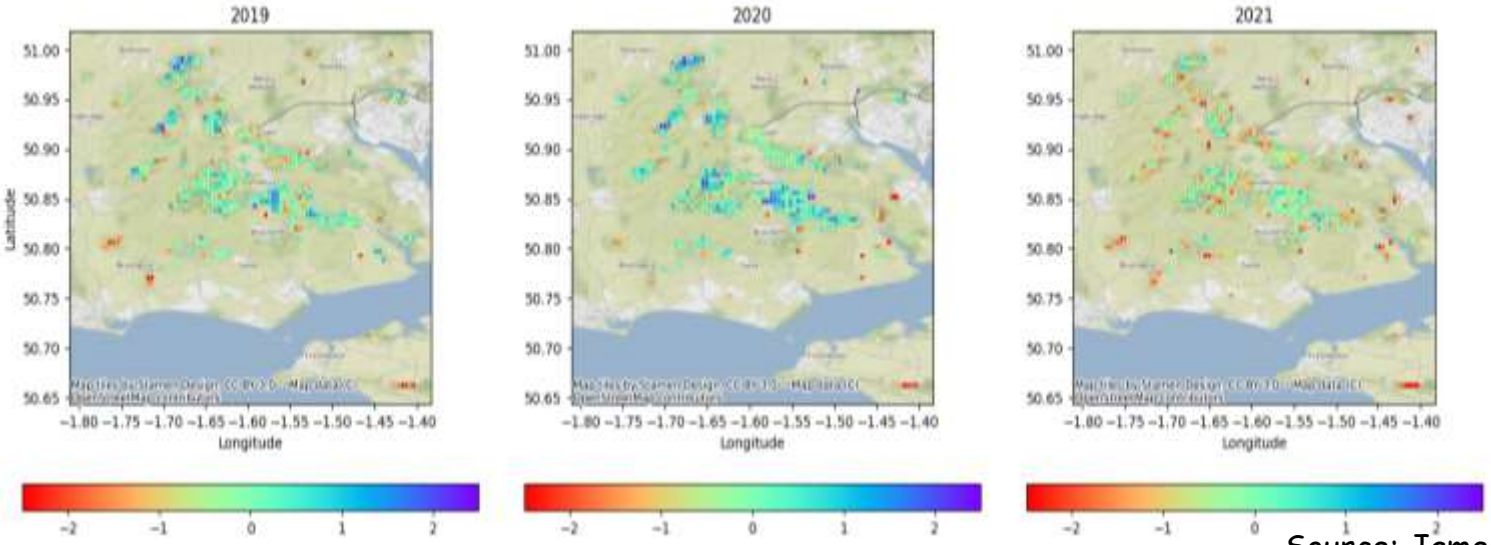
What are they doing?

Forests are dynamic processes…





Source: Bireda Alemayehu



Source: James Hitchcock

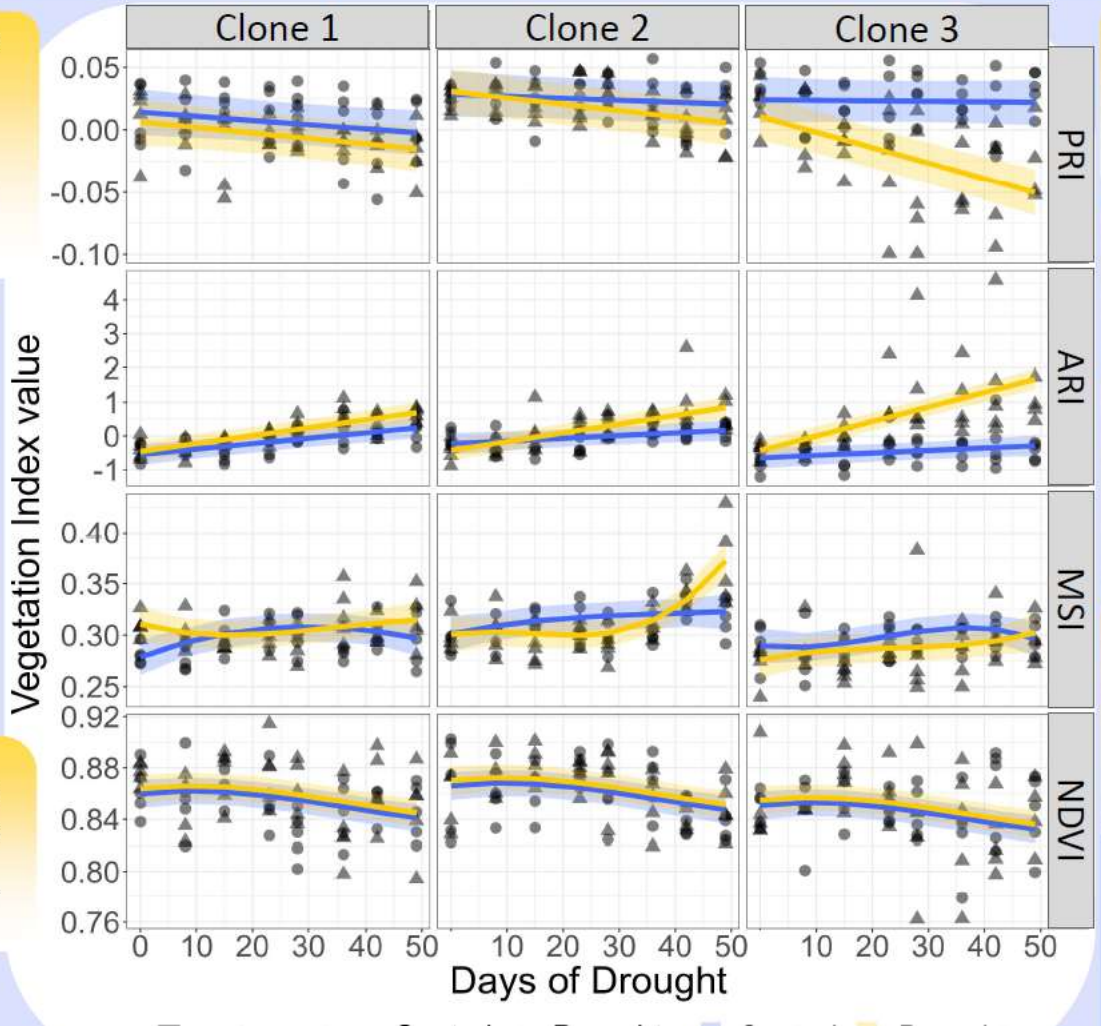
Key Results

PRI - Sensitive to the xanthophyl cycle and photosynthetic efficiency **Decreases** under stress

ARI - Sensitive to anthocyanins **Increases** under stress

MSI Sensitive to foliar water content **Increases** under stress

NDVI Plant 'greenness'. Indicator of plant health **Decreases** under stress



PRI and ARI are sensitive to drought

Photo protectant pigments in the needles dissipate excess energy when water availability is low and photosynthesis is compromised

Clones differ in stress response

Clone 3 has the strongest pigment response under stress. Suggesting a lower drought tolerance

Water content does not initially drop

MSI is similar between treatments through early drought as plants close stomata and hold onto existing water.

Rapid drop off in water content in clone 2 near end of drought

NDVI not sensitive to drought

NDVI is often used to indicate plant stress. However, it is not as sensitive as other indices to drought stress. Seasonal cycles cause a gradual drop of over the study period

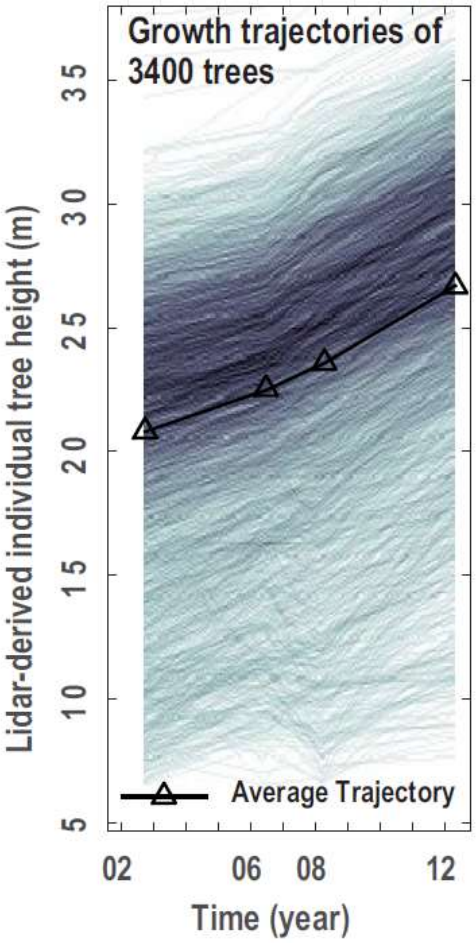
Future

Apply drought sensitive indices to forest stands using airborne or satellite mounted sensors

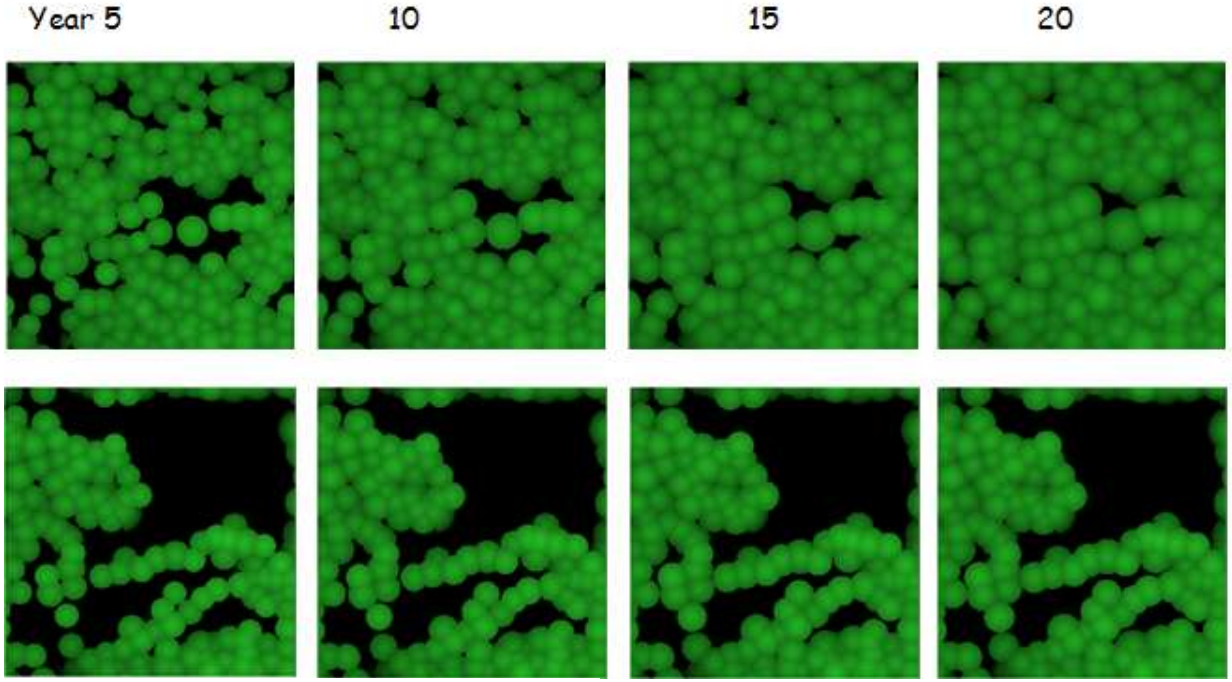
Incorporate drought tolerance metrics into Sitka spruce

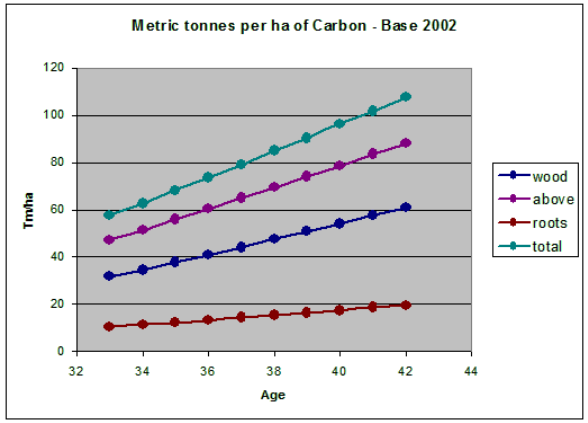
Source: Gerrard English

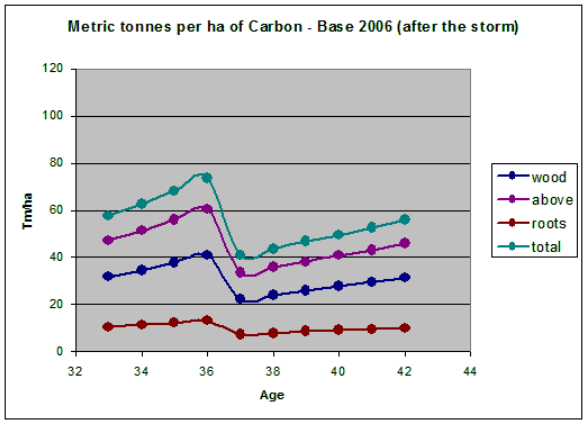
Monitoring forest stand dynamics



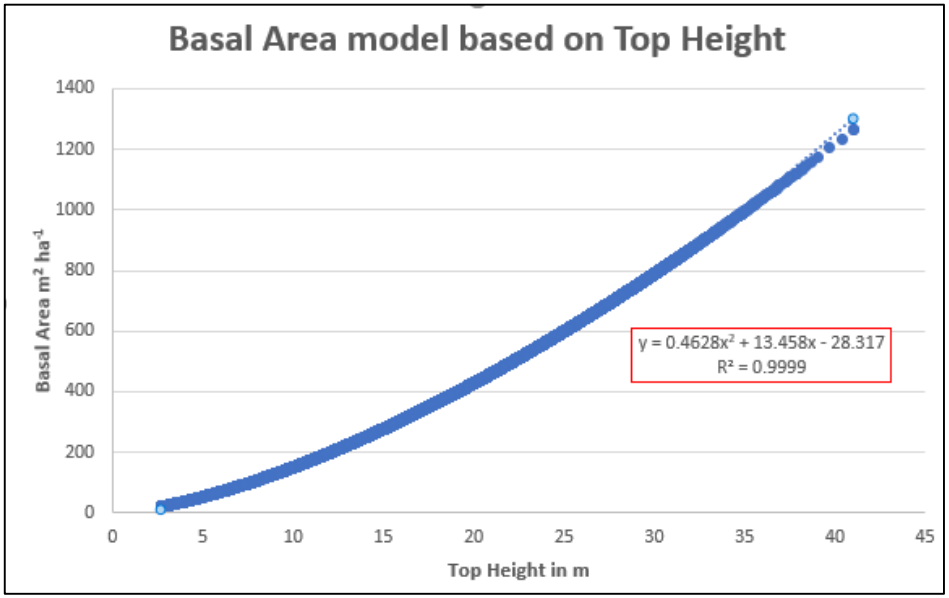
Zhao et al., 2018

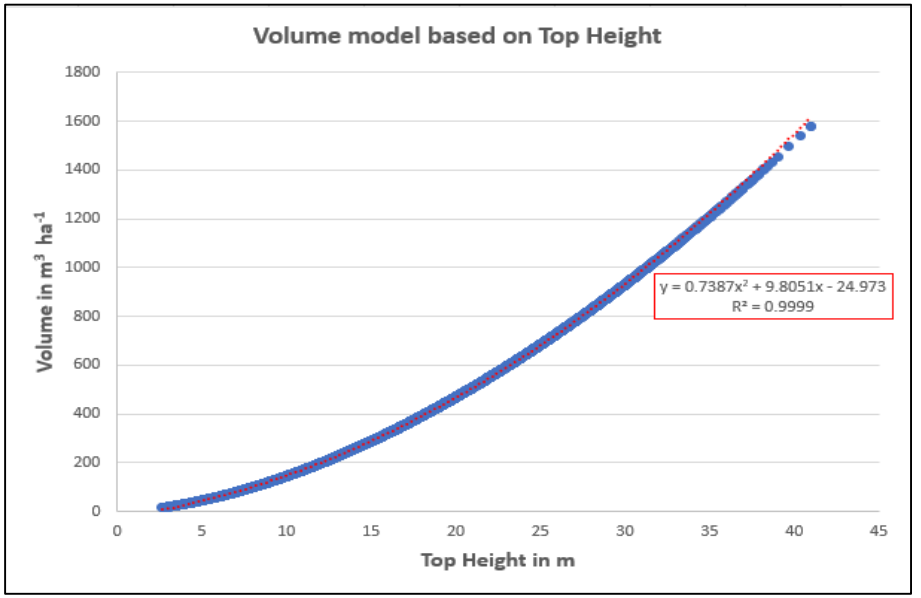




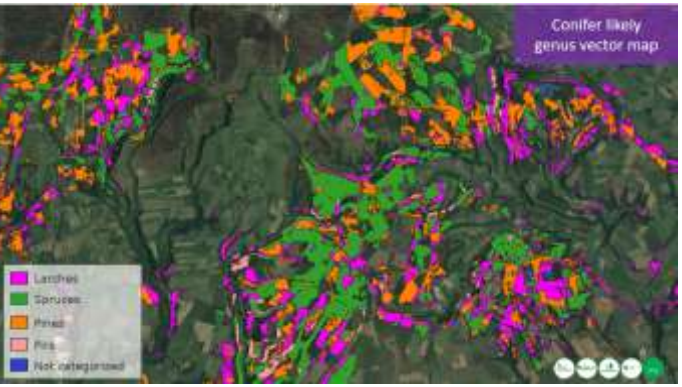


What are they doing?



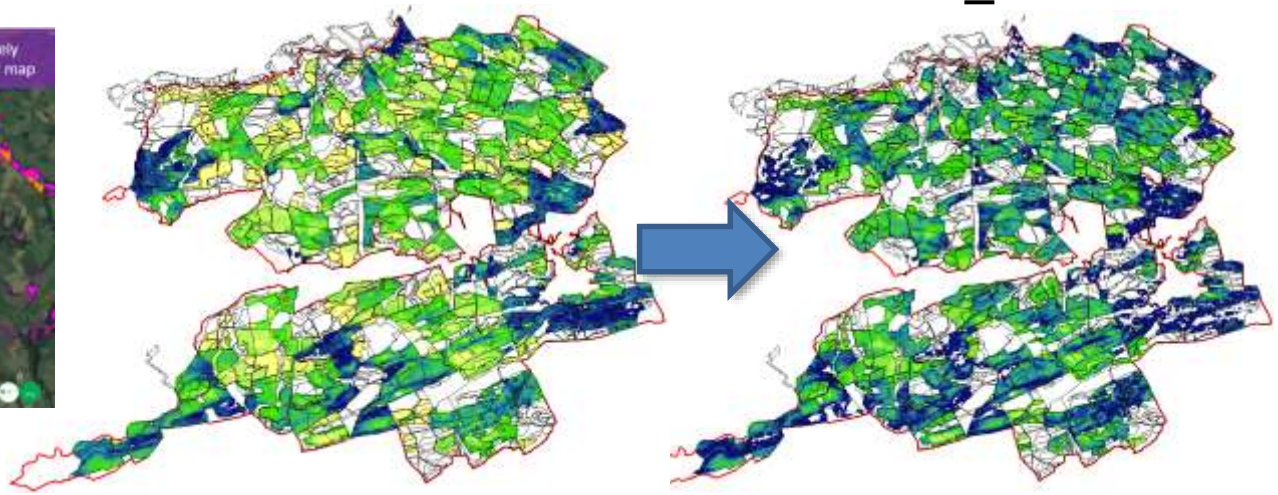


n = 62,405



Vol_2019

Vol_2029

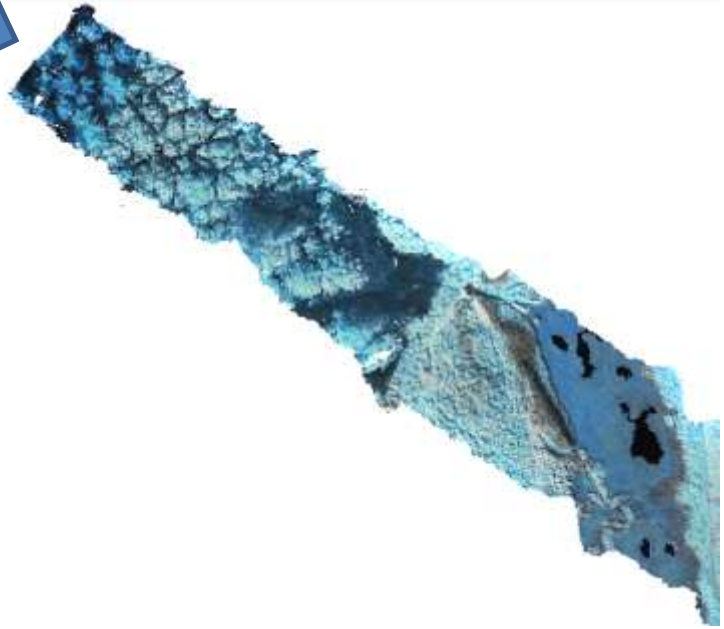


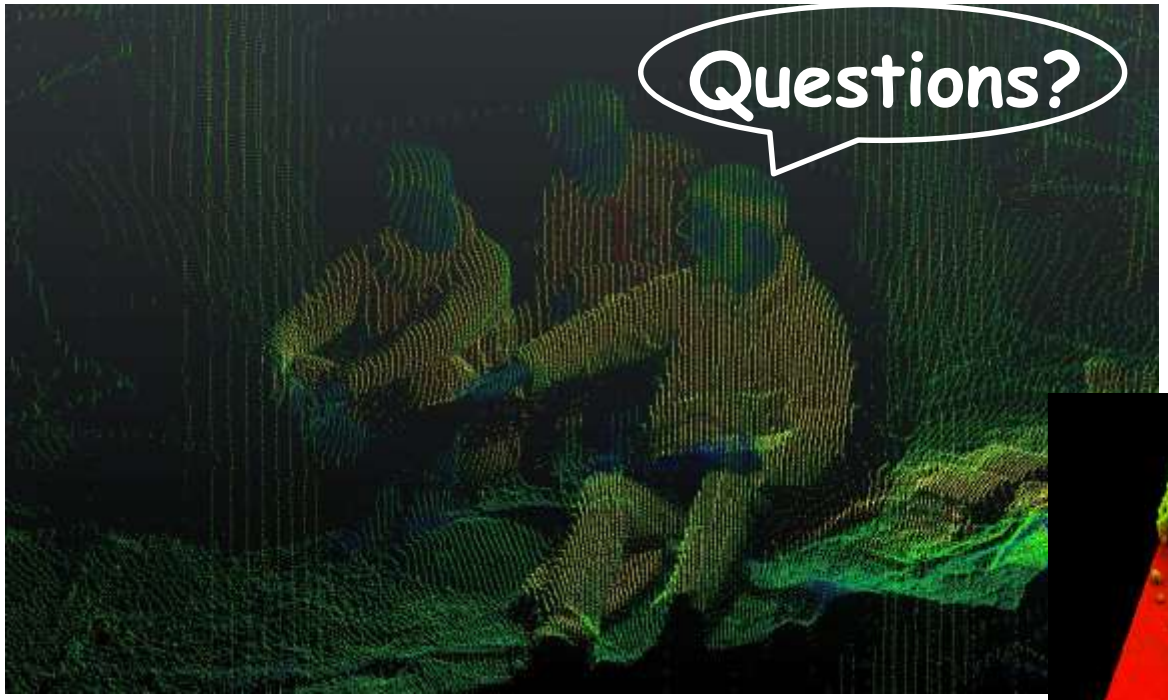
The blueprints for F-Lux UAV-LiDAR (BVLOS, VTOL)

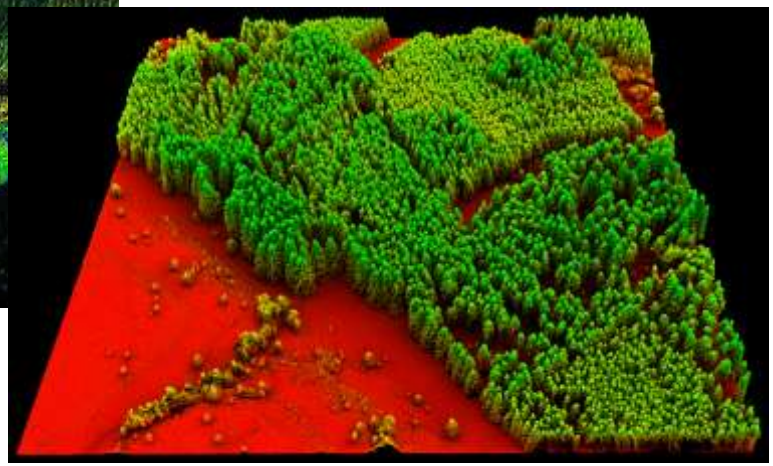
Airobot Dynamics

- Wing Span: - 4,000 mm
- Overall length: - 3,000mm
- Maximum take-off weight: -35Kg
- Cruse air speed: -25 m/s (56 mph, 90 kph)
- Cruse fuel consumption: - 0.46 Litres /ph
- Fuel capacity: - 8 litres
- Fuel configurable to: - Jet-A / TS-1 / JP-8 / JP-5, non-ethanol 93-100 octane gasoline: (R+M)/2
- Max flight time @ cruse: - 17 hours
- Min flight time: - 5 hours

Co-aligned Hyperspectral and LiDAR Headwall systems







Thank you

Juan.Suarez@forestresearch.gov.uk