Remote sensing approaches to forest resource inventories for resin yield modelling

R. Alonso Ponce

rafa.alonso@fora.es

föra
forest technologies

incredible

"Resin resource modelling tools in a context of climate change"

Madrid, January 21/22, 2019

Remote sensing approaches to forest resource inventories for resin yield modelling

Intro / Objective

What can remote sensors do to predict resin production?

↓

Estimate stand attributes and individual-tree variables at lower costs ensuring accuracy

Sources of remote data

Remote data

- Active sensors: LiDAR (airborne, terrestrial)

- Passive sensors: multispectral images

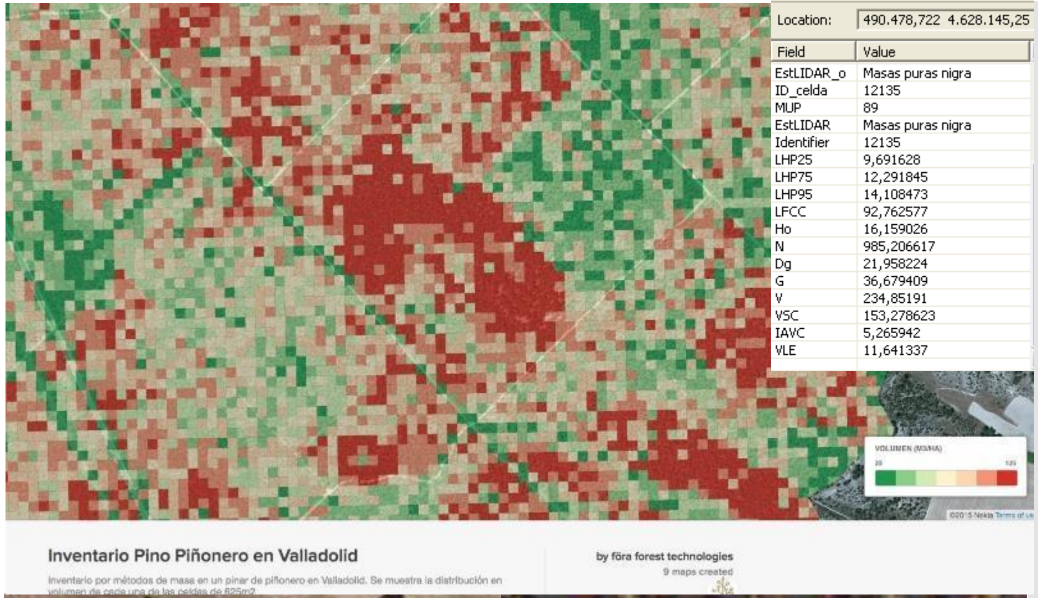
NOT ONLY!!

Stand and individual-tree variables

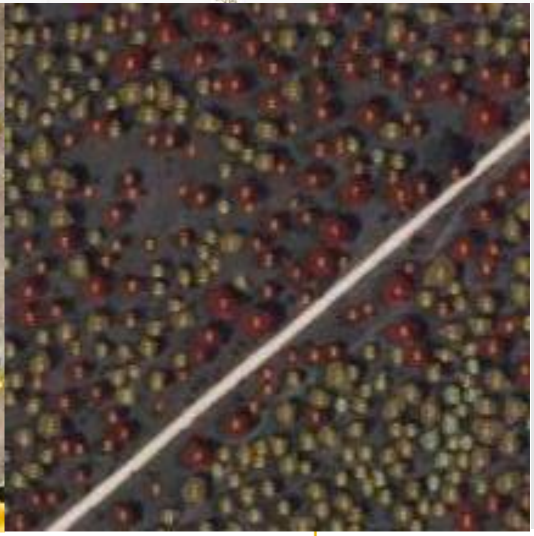
Classifications (species identification)

LiDAR inventory methodologies

- Stand level

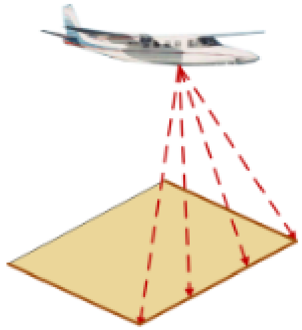


- Individual tree

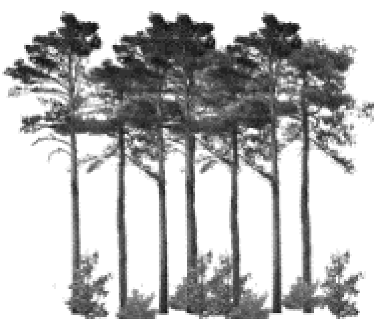


Stand level method

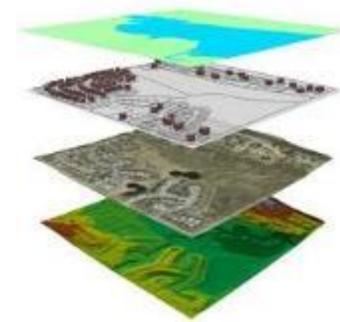
Phases



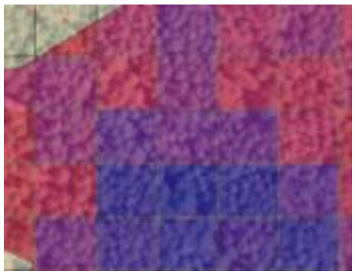
Data surveys



- Plot calculation
- LiDAR data processing
- LiDAR metrics in plots
- Model fitting
- Validation
- Calibration

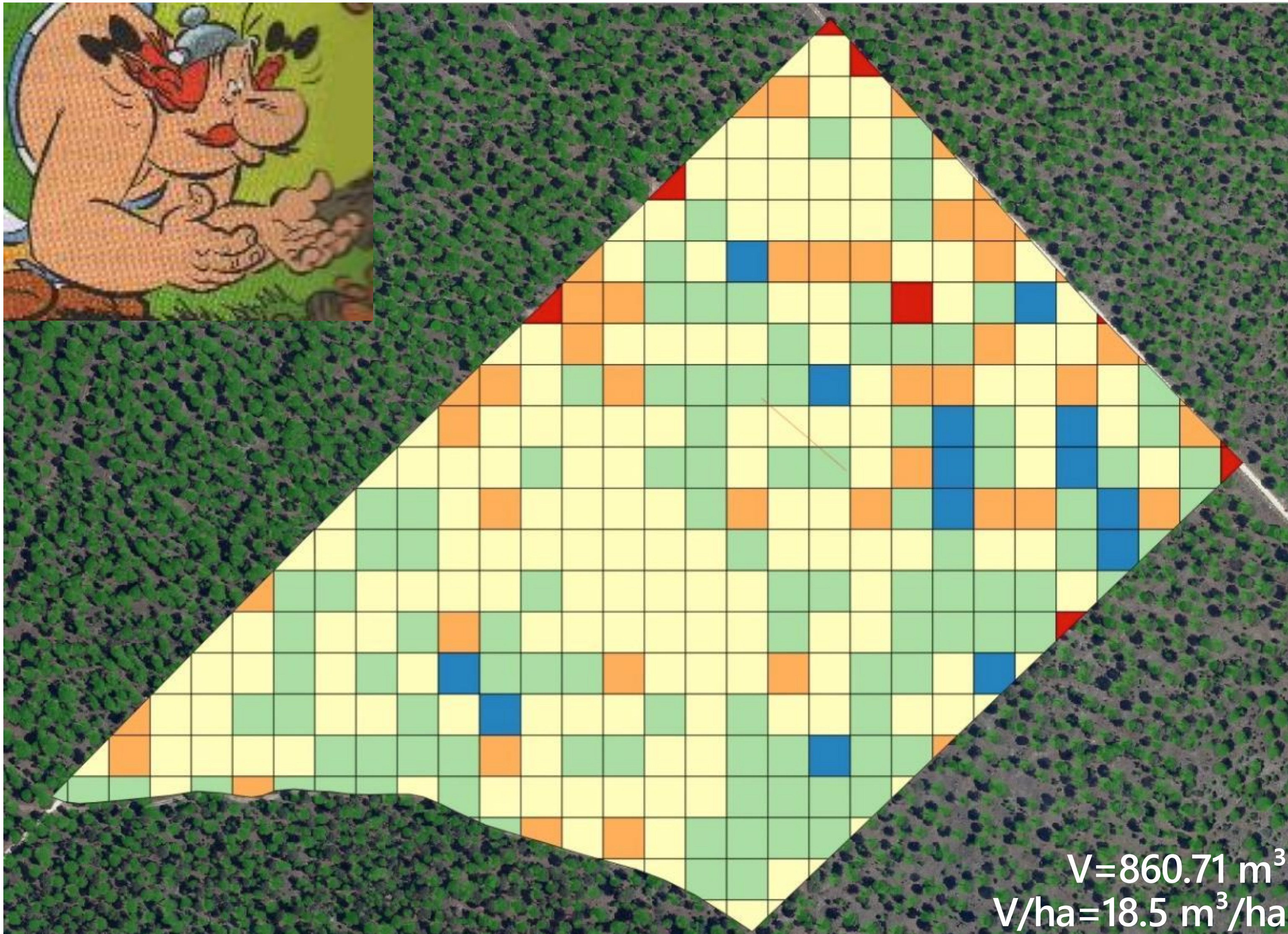


Thematic cartography
(SV, Ho, G, Dg, N, VI)



Stand level Forest Inventory flux

Stand level method
Results



Individual tree method

föra
forest technologies

incredible
"Resin resource modelling tools in a context of climate change"
Madrid, January 21/22, 2019

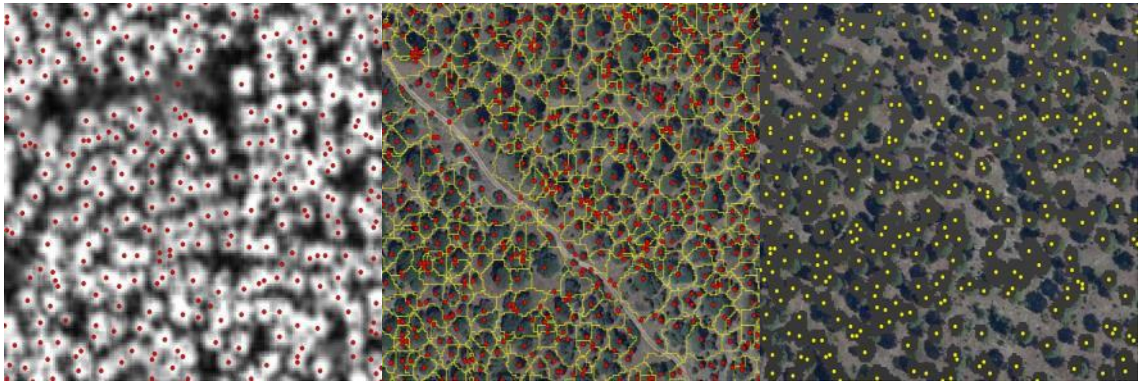
Individual tree method

Individual tree method

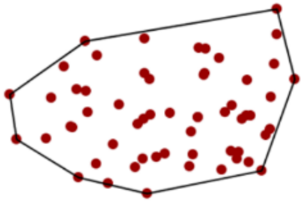
Approaches

Crown raster models

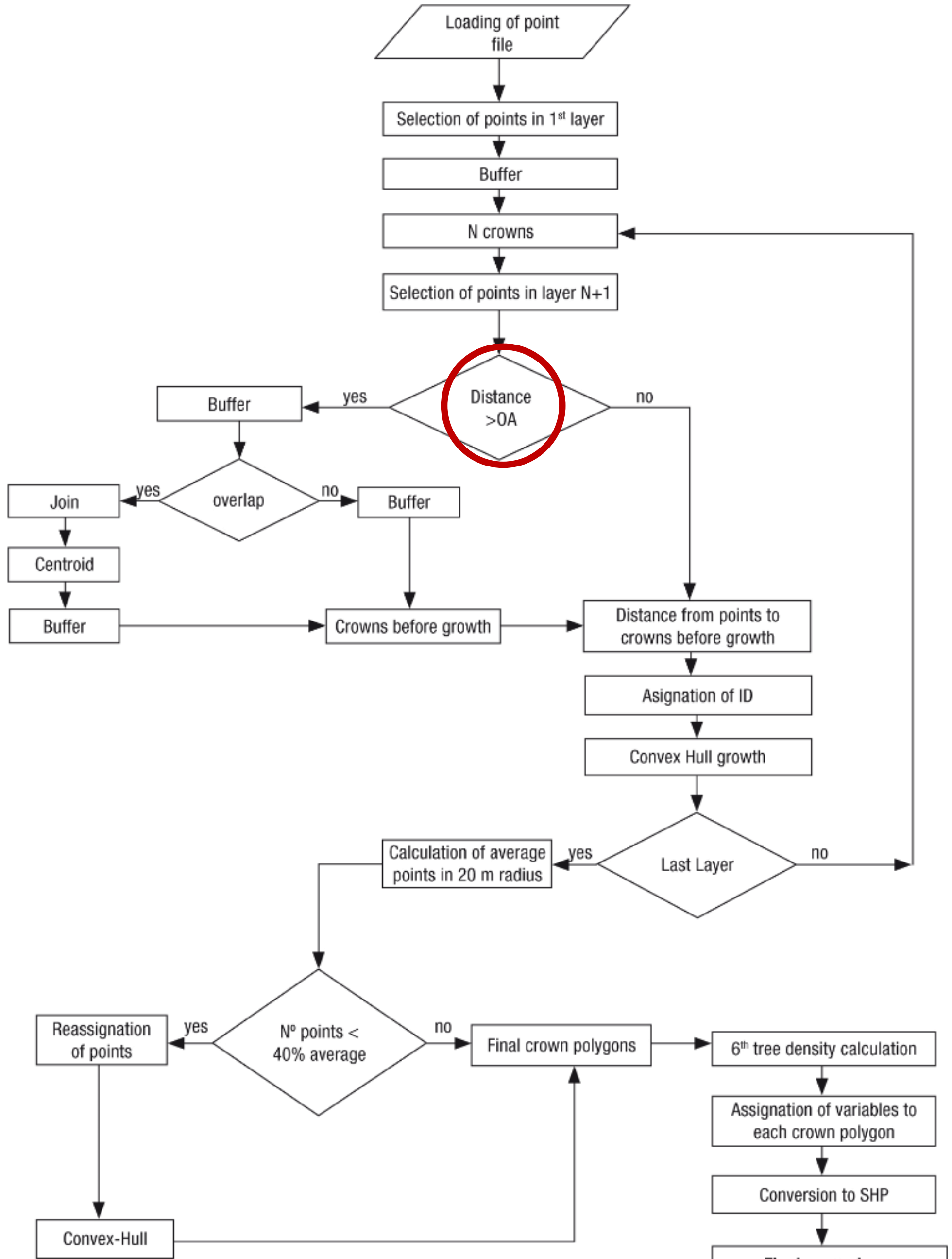
- Variable-window filtering
- Watershed segmentation
- Region growing



Crown delineation



Crown delineation approach

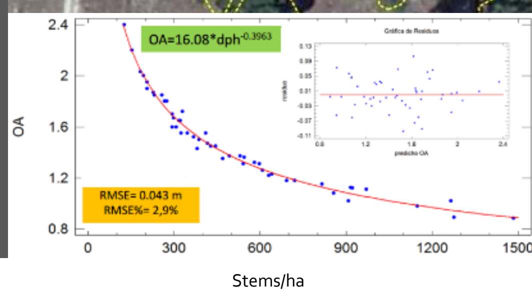


Valbuena et al., 2016

föra forest technologies

incredible
"Resin resource modelling tools in a context of climate change"
Madrid, January 21/22, 2019

Crown delineation approach

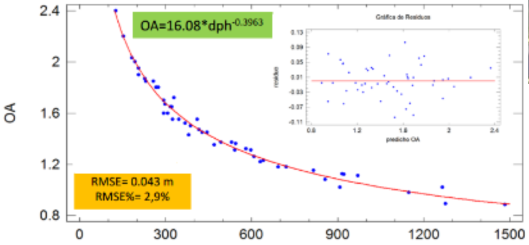


Ecuación	R^2	RMSE
H = 0.78375 + 0.98429*HLidar	0.952	0.85m
H_0 = 0.9663 + 0.9835*$HLidar_0$	0.964	0.76m
Dn= 53.7181 + 1.1949*HLidar - 6.6853*LN(densidad_lidar_6º)	0.882	2.66cm
Npies/ha= 0,9885*$Pies6^{1.0055}$	0.986	34.7 pies/ha
VCC = VCC=1,0166075*$e^{(-1,119+0,4354*LN(denslid)+0,9007*Raiz(Hlidar)+0,6761*(PC / PP)}$	0.879	38 m^3/ha
AB = -11.3469+3.3122*(Hlidar/OA)+19.7399*(PC/PP)	0.762	5.5m^2/ha

föra forest technologies

incredible
"Resin resource modelling tools in a context of climate change"
Madrid, January 21/22, 2019

Crown delineation approach



Ecuación	R^2	RMSE
H = 0.78375 + 0.98429*HLidar	0.952	0.85m
H_0 = 0.9663 + 0.9835*$HLidar_0$	0.964	0.76m
Dn= 53.7181 + 1.1949*HLidar - 6.6853*LN(densidad_lidar_6º)	0.882	2.66cm
Npies/ha= 0,9885*$Pies6^{1.0055}$	0.986	34.7 pies/ha
VCC = VCC=1,0166075*$e^{(-1,119+0,4354*LN(denslid)+0,9007*Raiz(Hlidar)+0,6761*(PC / PP)}$	0.879	38 m^3/ha
AB = -11.3469+3.3122*(Hlidar/OA)+19.7399*(PC/PP)	0.762	5.5m^2/ha

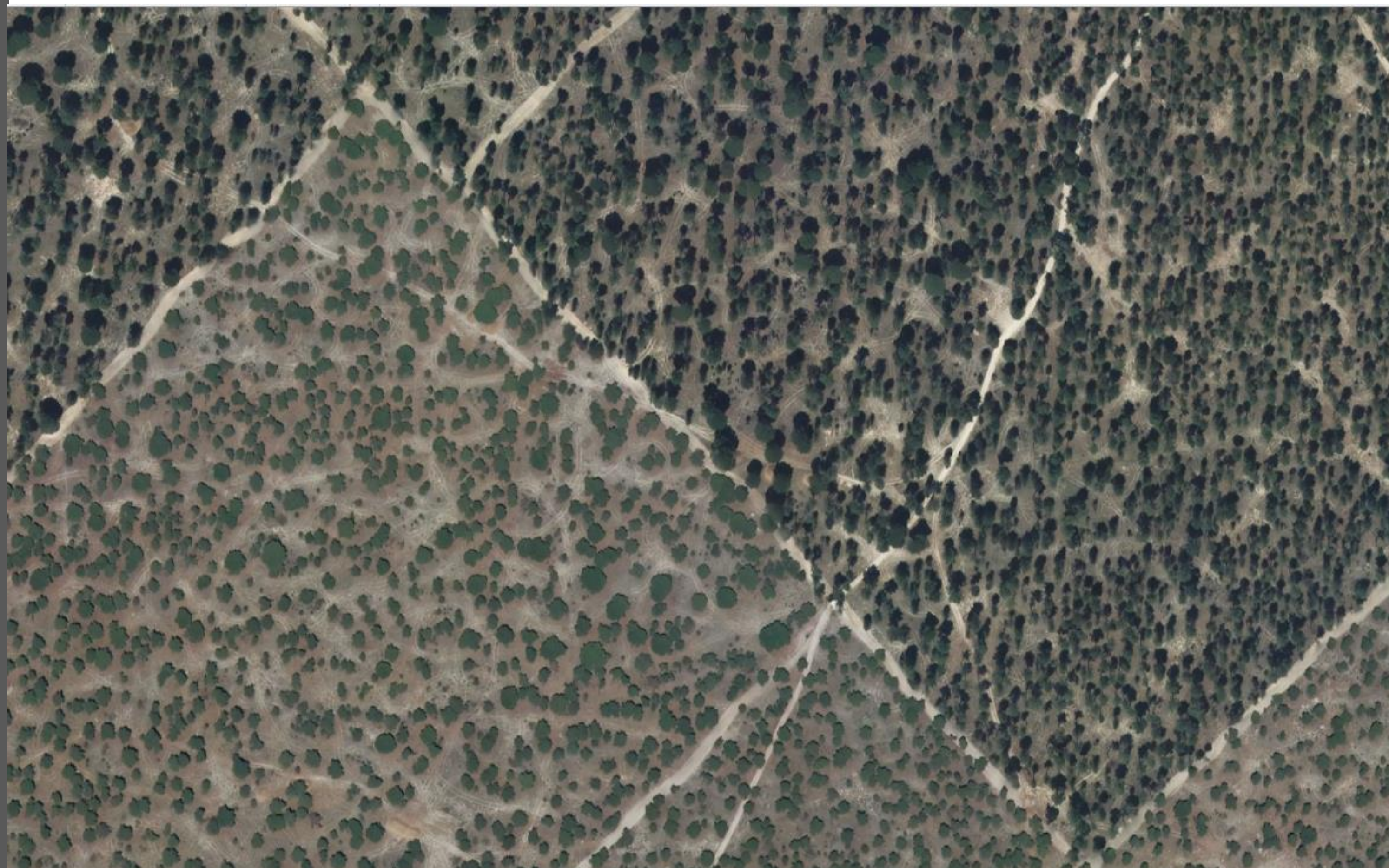
föra forest technologies

incredible

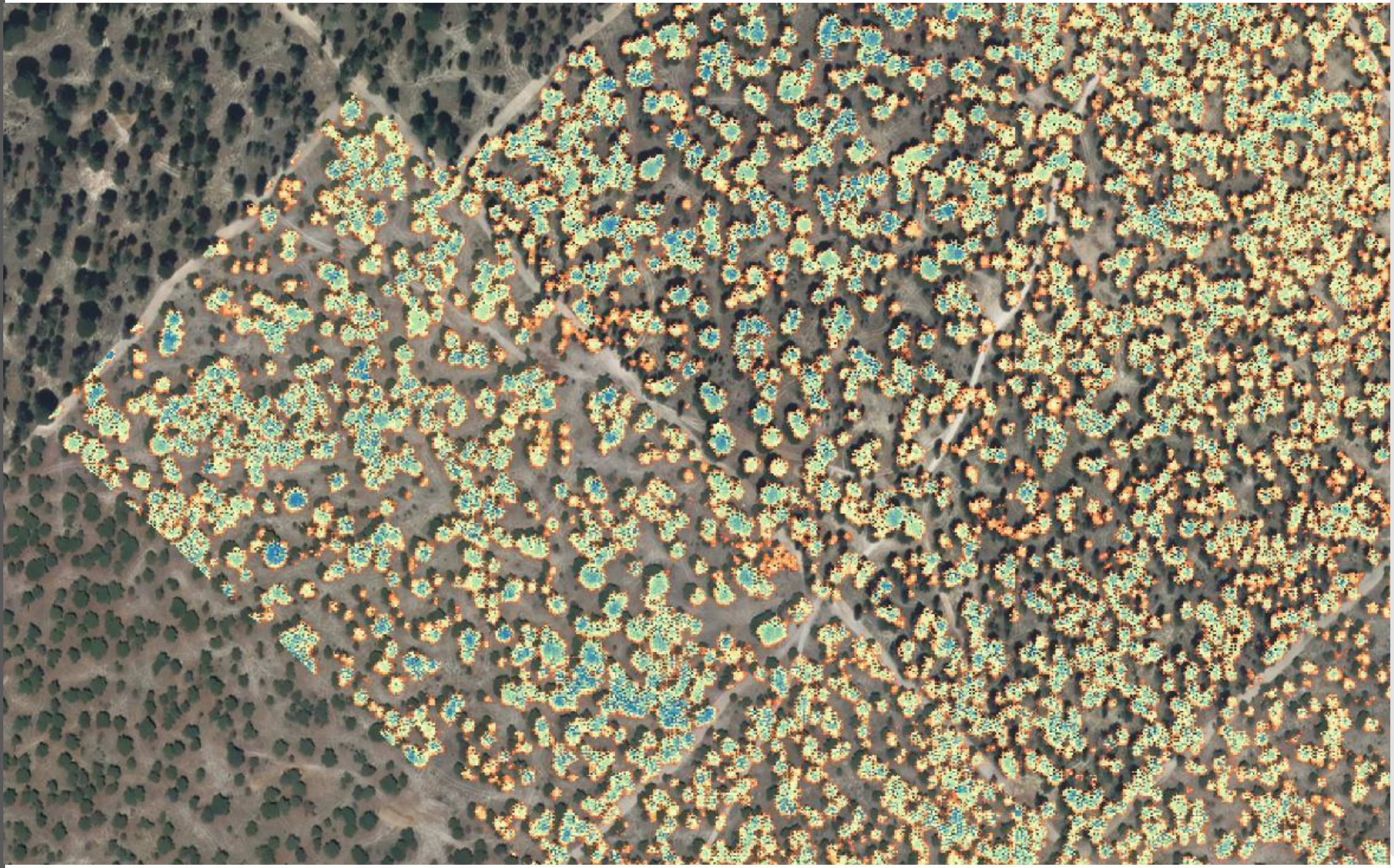
"Resin resource modelling tools in a context of climate change"

Madrid, January 21/22, 2019

Indivual tree method
Results



Indivual tree method
Results



m³
ha

föra
forest technologies

incredible
"Resin resource modelling tools in a context of climate change"
Madrid, January 21/22, 2019

Indivual tree method
Results

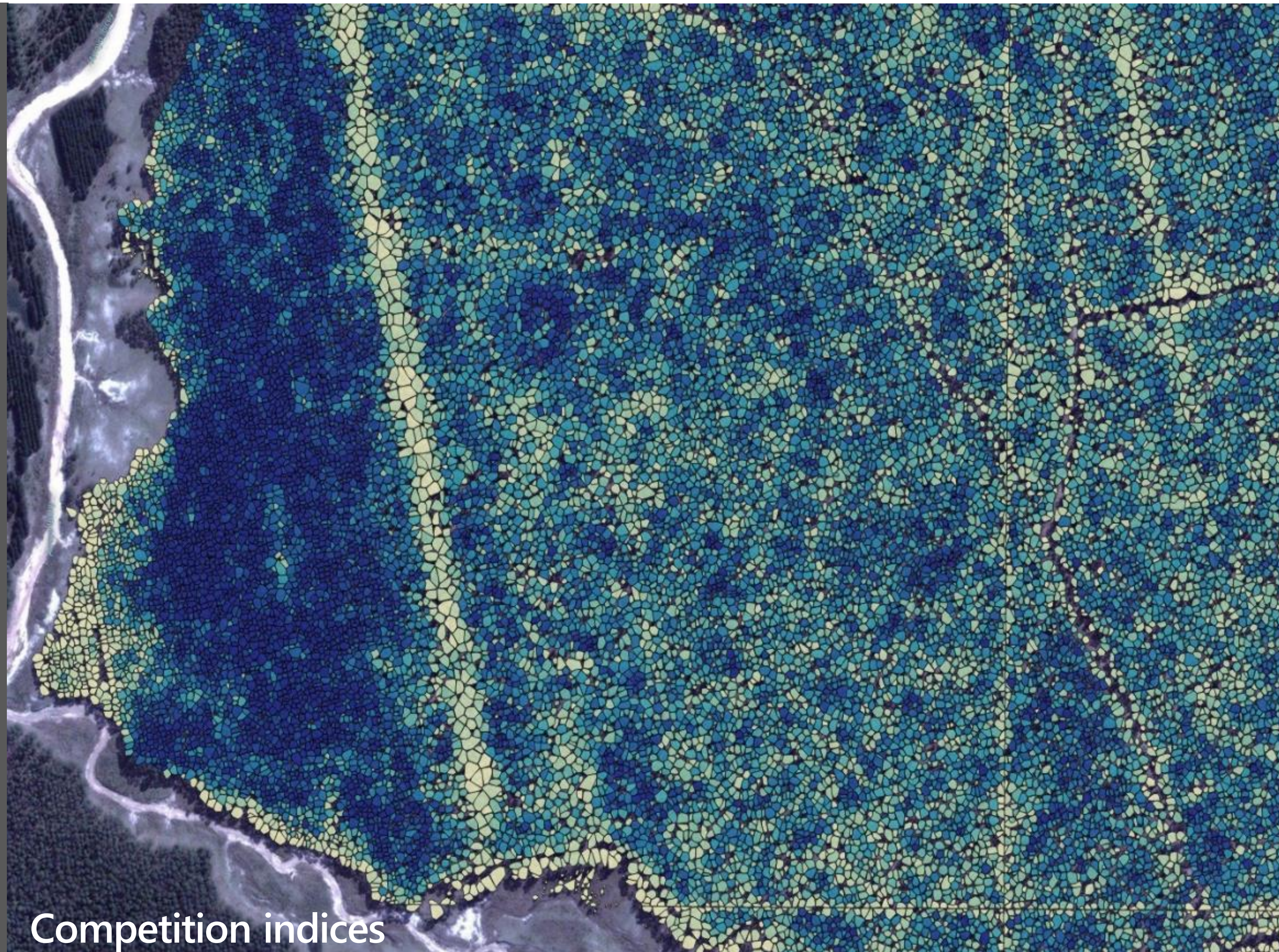
pie_a_pie :: Objetos totales: 5794, Filtrados: 5794, Seleccionados: 0

	ID	SUPERFICIE	ALTURA_MAX	ALTURA_MIN	ALTURA_COP	NUMERO_PUN	CAPA	DISTANCIA_	DENSIDAD	Layer	GRUPO	PIESRESINA	AREA	H	d	g	v
1	69104	35.5065905572	12.6100000000	8.3400000000	4.2700000000	21	12.0000000000	9.9530146187	177.0000000000	RODALES 27	GRUPO DE PRE...	1970	229937.2680000...	13.9	34.4	0.0929	0.5773
2	69100	21.5743310798	11.1200000000	3.9600000000	7.1600000000	12	11.0000000000	11.9453508216	123.0000000000	RODALES 29	GRUPO MEJORA	2201	224292.6020000...	12.4	31.1	0.0760	0.4251
3	69172	8.0611444411	11.7500000000	9.0400000000	2.7100000000	7	11.0000000000	10.6611517319	154.0000000000	RODALES 26	GRUPO MEJORA	2179	238159.1090000...	13.0	32.5	0.0830	0.4846
4	69154	14.9672167251	9.6300000000	3.0300000000	6.6000000000	11	9.0000000000	14.3321371886	85.0000000000	RODALES 26	GRUPO MEJORA	2179	238159.1090000...	10.9	27.4	0.0590	0.2936
5	69152	23.9749499996	15.6400000000	9.7100000000	5.9300000000	16	15.0000000000	9.2407047891	205.0000000000	RODALES 29	GRUPO MEJORA	2201	224292.6020000...	16.8	39.9	0.1250	0.9247
6	69150	11.4118050295	12.3300000000	5.7700000000	6.5600000000	10	12.0000000000	11.8559057014	125.0000000000	RODALES 30	GRUPO DE REG...	1570	230813.1420000...	13.6	33.8	0.0897	0.5463
7	69063	15.9599000000	14.6600000000	9.4700000000	5.1900000000	11	14.0000000000	12.8281916107	106.0000000000	RODALES 29	GRUPO MEJORA	2201	224292.6020000...	15.9	38.3	0.1152	0.8098
8	69062	21.4325500008	14.0600000000	7.2800000000	6.7800000000	14	14.0000000000	18.6182873810	51.0000000000	RODALES 29	GRUPO MEJORA	2201	224292.6020000...	15.3	37.2	0.1087	0.7373
9	69039	23.3933500008	11.7900000000	8.1800000000	3.6100000000	15	11.0000000000	12.2480865853	117.0000000000	RODALES 29	GRUPO MEJORA	2201	224292.6020000...	13.1	32.7	0.0840	0.4941
10	69028	25.5905113296	13.3400000000	7.0000000000	6.3400000000	15	13.0000000000	12.6645420367	109.0000000000	RODALES 29	GRUPO MEJORA	2201	224292.6020000...	14.6	35.9	0.1012	0.6576
11	69079	20.1399253338	12.7300000000	3.9800000000	8.7500000000	13	12.0000000000	11.6500067060	129.0000000000	RODALES 29	GRUPO MEJORA	2201	224292.6020000...	14.0	34.6	0.0940	0.5879

Mostrar todos los objetos espaciales

Indivual tree method

Results



Temporal, spatial and spectral resolution

Satellite imagery sources

Platform	Resolution	#Bands	Revisit
NOAA	**1.1 km**	**5**	**12 hours**
Resurs-01	200m	4	3-5 days
LandSat 4-5	**30m**	**7**	**16 days**
LandSat 7	**15m (PAN)**	**8**	**16 days**
LandSat 8	**15m (PAN)**	**11**	**16 days**
Spot 4	10m (PAN)	4	4-6 days
Sentinel 2	**10m**	**12**	**3-7 days**
Spot 5	2.5m (PAN)	5	1-4 days
Spot 6-7	1.5m (PAN)	5	1-2 days
Ikonos	1m (PAN)	4	2 days
QuickBird	61cm (PAN)	4	3 days

Vegetation indices

Spectral indices

Vegetation Index	Equation	Reference	Remarks
Difference Vegetation Index (DVI)	$NIR - red$	Jordan (1969) [22]	Sensitive to soil background
Ratio Vegetation Index (RVI)	NIR/red	Pearson and Miller (1972) [23]	Sensitive to soil background
Normalized Difference Vegetation Index (NDVI)	$\frac{NIR - red}{NIR + red}$	Rouse *et al.* (1974) [16]	Enhances contrast between soil and vegetation
Modified Simple Ratio (MSR)	$\frac{\left(\frac{NIR}{red} - 1\right)}{\sqrt{\left(\frac{NIR}{red} + 1\right)}}$	Chen and Cihlar (1996) [1]	Improves vegetation sensitivity
Transformed Vegetation Index (TVI)	$\sqrt{\left(\frac{NIR - red}{NIR + red}\right) + 0.5}$	Deering *et al.* (1975) [32]	Modifies NDVI with only positive values; <0.71 as non-vegetation and >0.71 as vegetation
Modified Transformed Vegetation Index (MTVI)	$\sqrt{\left(\frac{c * NIR - red}{c * NIR + red}\right)}$ where c is a weighing factor	Skianis *et al.* (2007) [3]	Used with poor vegetation

Vegetation indices

Spectral indices

forest technologies

"Resin resource modelling tools in a context of climate change"

Madrid, January 21/22, 2019

Spectral indices

Vegetation indices

Vegetation indices

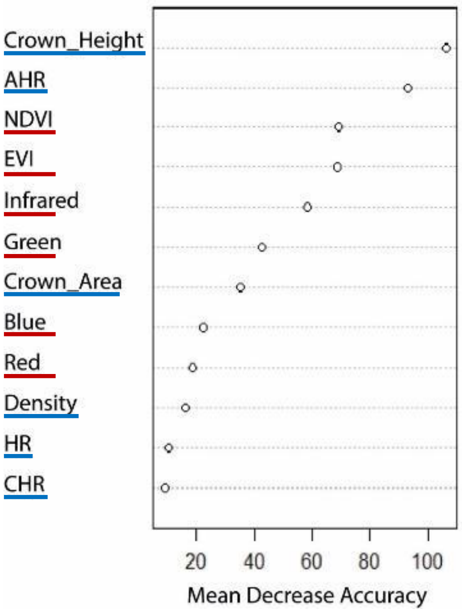
Spectral indices

Vegetation indices

Spectral indices

Combining low density LiDAR and satellite images to discriminate species in mixed Mediterranean forest

Identifying species



Training Models	Nº of variables	OOB %
LiDAR model	6	13.56
Spectral model	6	20.34
Complete model	12	6.78

Table 5. Confusion matrix obtained from the validation of the individual trees in mixed stand dataset.

		Predicted			
		Pinus pinea L.	*Pinus pinaster* Ait.	Total	User's accuracy (%)
Observed	*Pinus pinea* L.	25	21	46	54.3
	Pinus pinaster Ait.	9	26	35	74.3
	Total	34	47	81	-
Consumer's accuracy (%)		73.5	55.3	-	63.0

Distinguishing between two species of the same genus is particularly tricky!!

föra forest technologies

incredible
"Resin resource modelling tools in a context of climate change"
Madrid, January 21/22, 2019

Thanks!

rafa.alonso@fora.es
Rafael Alonso Ponce