



CLASSIFICAZIONE DELLE SPECIE FORESTALI CON DATI MULTISPETTRALI E LASER SCANNING MULTIPIATTAFORMA

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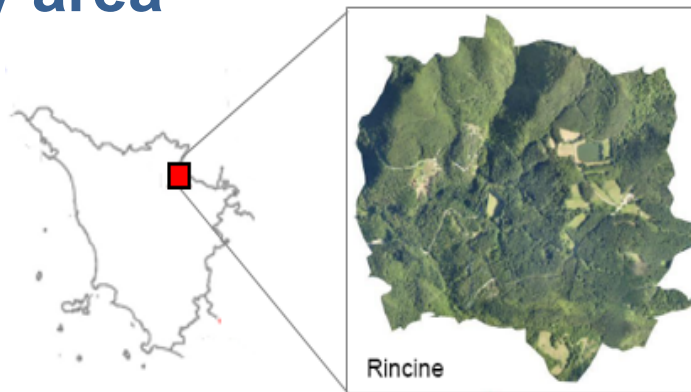
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Aim

Evaluate the potential use of data derived from multispectral and laser scanning sensors mounted on small-unmanned aerial vehicle (UAV) and conventional for the classification of forest species.

Study area

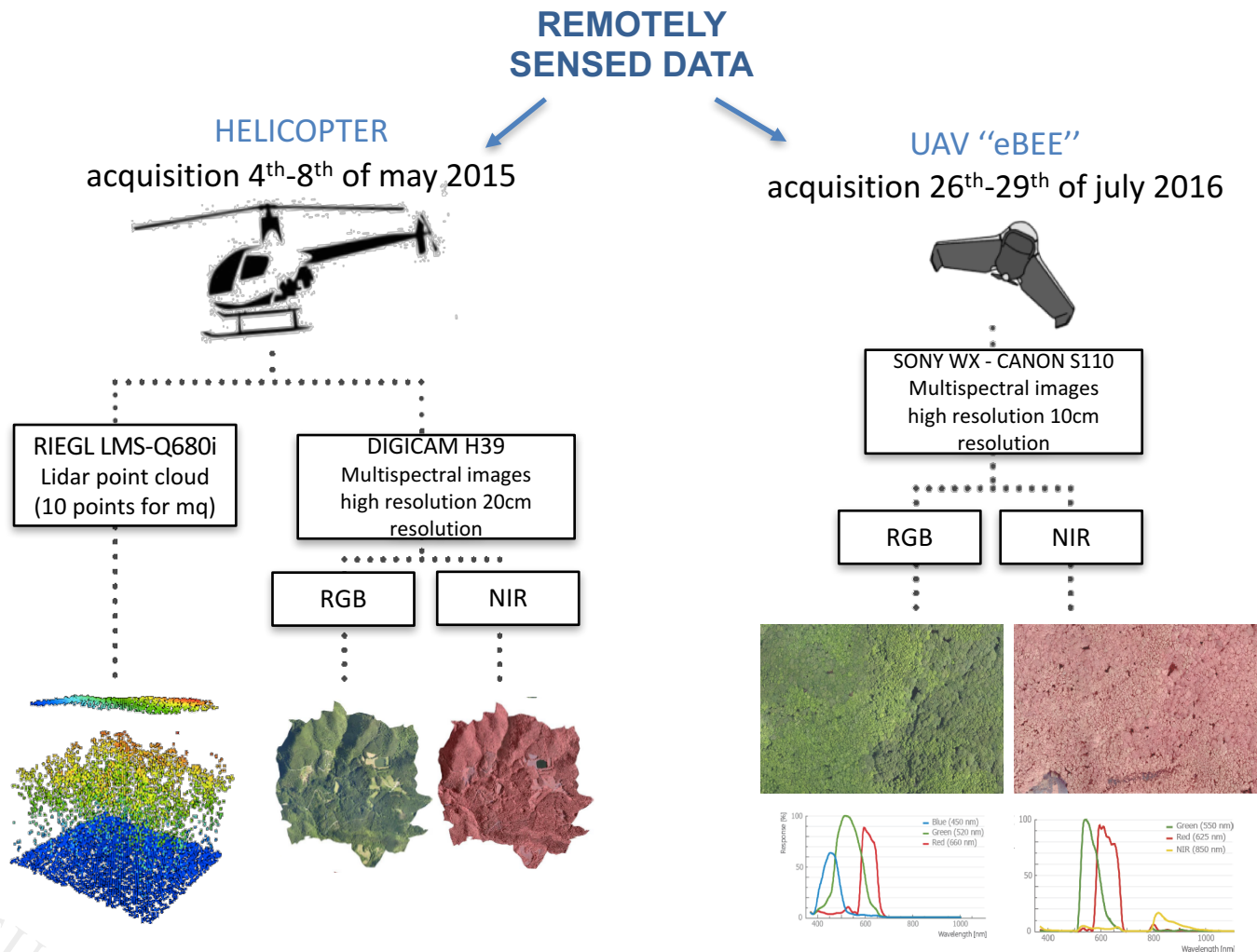


Species	ha
Preudotsuga menziesii	73.730
Mixed broadleaf	54.853
Quercus cerris	44.321
Pinus nigra	40.774
Castanea Sativa	29.357
No forest	22.135
Quercus pubescens	5.195
Fagus sylvatica	2.713
Alnus glutinosa	2.187
Totale	275.265

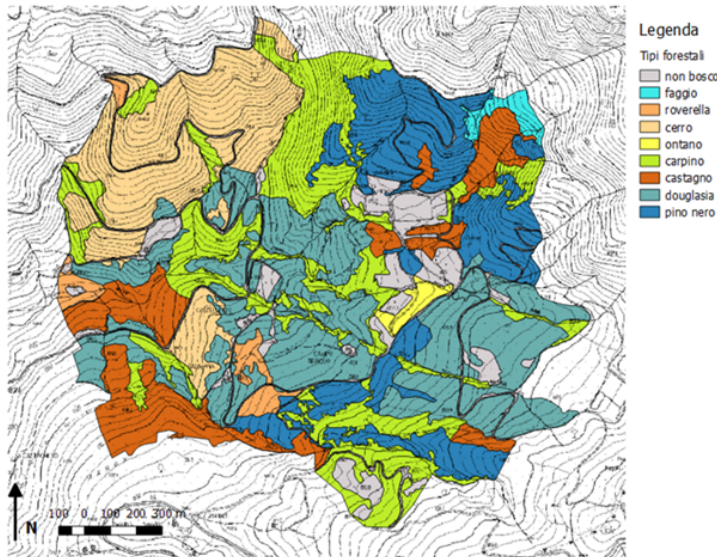
Rincine (Florence) forestry complex is 270 ha area

The Apennine mountains is characterize by the presence of extensive forests of Castanea Sativa, Fagus sylvatica, deciduous Quercus ssp. (eg, downy and turky oak) and species introduced for reforestation: Pinus nigra and Preudotsuga menziesii.

Data



Forest types map (scale 1: 10000)



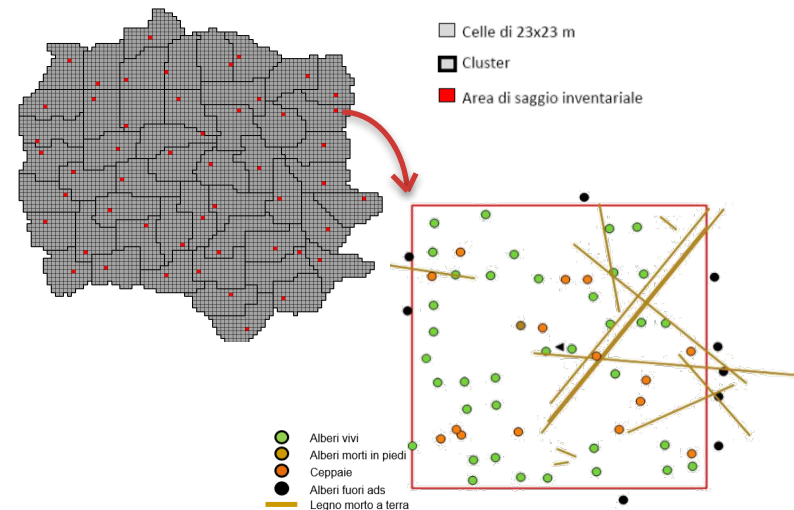
Legenda Tipologie Forestali (EFTs) fotointerpretati a Rincine

- Castagneto → 8.7 Chestnut forest
- Cerreta → 8.2 Turkey oak, Hungarian oak and Sessile oak forest
- Douglasieta → 14 Introduced tree species forest
- Faggeta → 7.3 Apennine-Corsican mountainous beech forest
- Ostrieto → 8.8 Other thermophilous deciduous forests
- Pineta di pino nero → 10.2 Mediterranean and Anatolian Black pine forest
- Querceto di roverella → 8.1 Downy oak forest

50 squared plots

23 meters sides (plot size = 529 m²) DBH > 2.5 cm (FRESH LIFE)

- the coordinates of the center, with GPS Trimble JUNO (with a measurement error of 2-5m);
- the position of each tree using a hypsometer HAGLÖF VERTEX to measure the topographic distance between the reference center and the stem of the plant, and a compass Meridian Wyssen MI-4006 to measure the angle in degrees to the north, sighting in the direction of the tree from the center;
- for each tree were noted the species and the dendrometric attributes: DHB, heights, crown base heights and crown widths; using a caliper, a tape measure and hypsometer;
- time of surveys.



Method

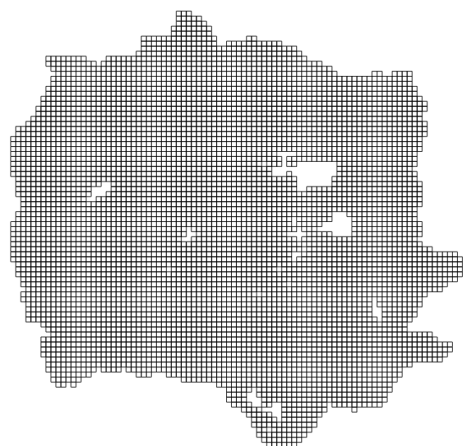
Two supervised classifiers were tested:

Random Forest

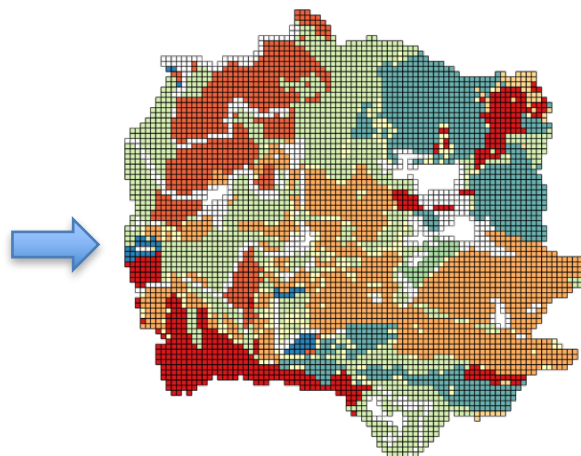
a learning method, that combines K binary CART trees to make a prediction.

kNN

A method that identifies the most similar k cells in the multidimensional space with n variables, and assigns the cell to be classified the most frequent class among the most similar k



The study area was divided with a grid of 5312 square cells of 23 m "no forest" cells were excluded from the analysis: **4800 cells** remained

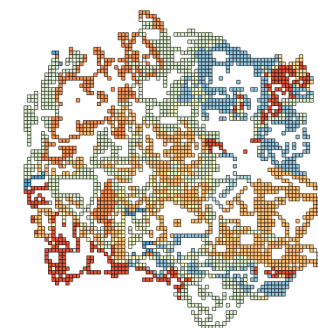


Each cells was classify by photointerpretation based on the prevailing tree species (canopy cover > 75%) and the accuracy evaluated with the 50 inventory plot

1° level OA = 0.92 2° level OA = 0.95
3° level OA = 0.96 4° level OA = 1



1685 cells
were choose
as training



3115 cells
were
choose as
test

Cod	Species	Level 1 9 class	Level 2 7 class	Level 3 3 class	Level 4 2 class
1	Castanea Sativa Mill	X	X		
2	Quercus cerris L.	X	X		
3	Pseudotsuga menziesii Mirb.	X	X		
4	Fagus sylvatica L.	X	X		
5	Alnus glutinosa L.	X	X		
6	Pinus nigra J.F.Arnold	X	X		
7	Quercus pubescens Willd	X	X		
8	Mixed broadleaf	X			
9	Mixed broadleaf and coniferous	X		X	
10	Coniferous			X	X
11	Broadleaf			X	X

A hierarchical classification system was adopted

Level		1° and 3°			2° and 4°		
Cod	Totale	Test	Training	% Training	Test	Training	% Training
1	464	291	173	37%	291	173	37%
2	575	323	252	44%	323	252	44%
3	1239	829	410	33%	829	410	33%
4	48	29	19	40%	29	19	40%
5	43	23	20	47%	23	20	47%
6	789	481	308	39%	481	308	39%
7	46	28	18	39%	28	18	39%
8	306	217	89	29%	-	-	-
9	1290	804	336	31%	-	-	-
Totale	4800	3115	1685	35%	2004	1200	60%

Cells were divided training and test



PLATAFORM	DATA SOURCE	N BANDS	VARIABLES	TOT
Helicopter	RGB	3	sum, mean, median, sd, min, max, range, minority, majority, variety	30
	NIR	3	sum, mean, median, sd, min, max, range, minority, majority, variety	30
	NDVI	3	sum, mean, median, sd, min, max, range, minority, majority, variety	30
	Point Cloud	1	textural metrics (14), density (10-90), z_standard, intensity_standard, all, sum, mean, min, max, sd, ske, kur, p01, p05, p10, p20, p25, p30, p40, p50, p60, p70, p75, p80, p90, p95, p99, b10, b20, b30, b30, b40, b50, b60, b70, b80, b90	57
	All Helicopter's			147
Ebee	RGB	3	sum, mean, median, sd, min, max, range, minority, majority, variety	30
	NIR	3	sum, mean, median, sd, min, max, range, minority, majority, variety	30
	NDVI	3	sum, mean, median, sd, min, max, range, minority, majority, variety	30
	Point Cloud	1	textural metrics (14), density (10-90), z_standard, intensity_standard, all, sum, mean, min, max, sd, ske, kur, p01, p05, p10, p20, p25, p30, p40, p50, p60, p70, p75, p80, p90, p95, p99, b10, b20, b30, b30, b40, b50, b60, b70, b80, b90	57
	All Ebee's			147

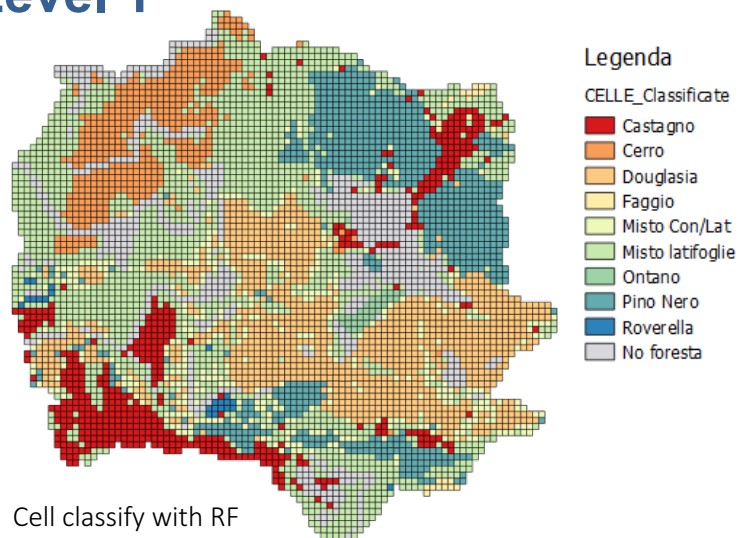
The classifiers were trained on the 1685 training cells
and validate on the 3115 test cells

Results

		4800 cells				3204 cells			
		Level 1		Level 3		Level 2		Level 4	
		RF	KNN	RF	KNN	RF	KNN	RF	KNN
Helicopter	RGB	0.647	0.604	0.822	0.803	0.761	0.717	0.926	0.902
	NIR	0.566	0.538	0.771	0.752	0.728	0.688	0.871	0.843
	NDVI	0.580	0.566	0.763	0.761	0.712	0.704	0.855	0.860
	NP	0.625	0.585	0.785	0.775	0.746	0.706	0.880	0.851
	ALL	0.708	0.679	0.836	0.825	0.842	0.810	0.921	0.932
UAV	RGB	0.460	0.399	0.691	0.645	0.543	0.486	0.768	0.714
	NIR	0.442	0.405	0.691	0.677	0.536	0.494	0.778	0.741
	NDVI	0.420	0.377	0.655	0.639	0.502	0.473	0.738	0.715
	NP	0.474	0.458	0.661	0.669	0.616	0.560	0.768	0.770
	ALL	0.544	0.518	0.730	0.717	0.544	0.518	0.730	0.717

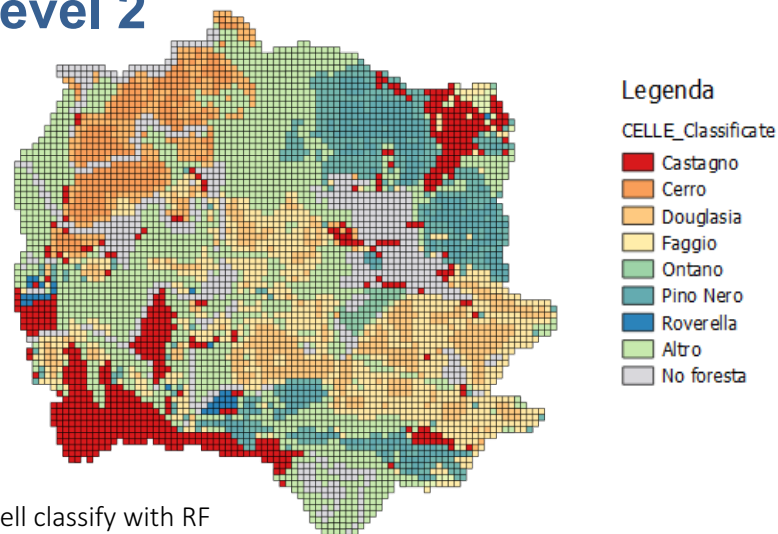
- 5 models for data source
- OA are mostly > 0,7
- Helicopter data works better than UAV data
- RF is better than kNN

Level 1



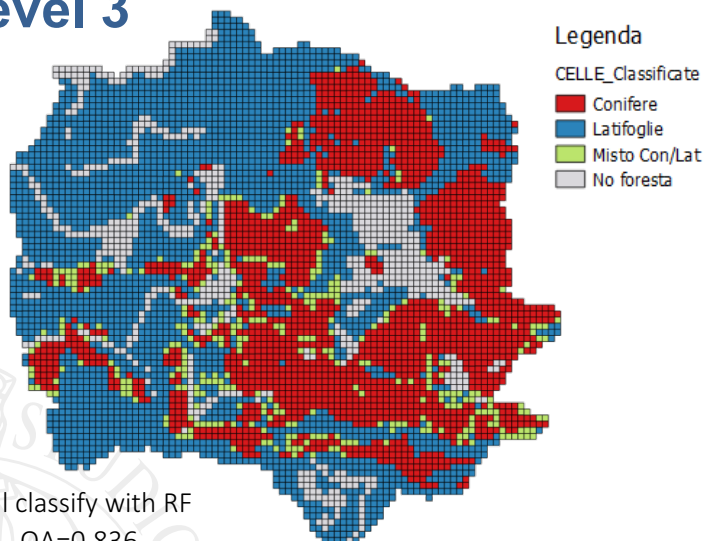
Cell classify with RF
OA=0.708

Level 2



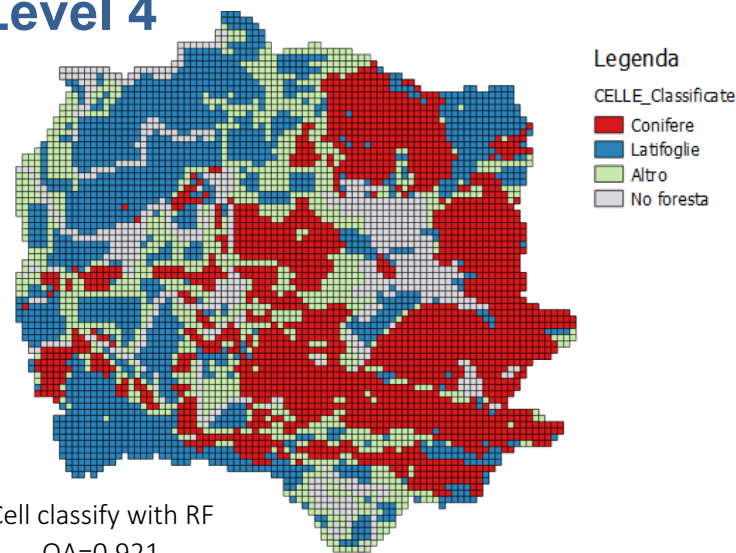
Cell classify with RF
OA=0.842

Level 3



Cell classify with RF
OA=0.836

Level 4



Cell classify with RF
OA=0.921

Random Forest

Call:

```
randomForest(formula = specie ~ ., data = train, ntree = 500,
```

Type of random forest: classification

Number of trees: 500

No. of variables tried at each split: 12

OOB estimate of error rate:

1. 9.67%
2. 4.08%
3. 4.99%
4. 1.25%

Confusion Matrix and Statistics

	cast	cerro	dougl	fagg	misto	mistolat	ont	pino	rov
Prediction cast	189	51	3	0	1	47	1	11	3
Prediction cerro	3	163	1	0	0	17	0	0	0
Prediction dougl	0	0	594	1	22	6	0	13	0
Prediction fagg	0	0	0	2	1	0	0	3	0
Prediction misto	10	1	139	0	109	42	0	15	3
Prediction mistolat	83	108	65	26	48	768	11	73	18
Prediction ont	0	0	0	0	0	1	11	0	0
Prediction pino	6	0	27	0	36	12	0	366	0
Prediction rov	0	0	0	0	0	1	0	0	4

Overall Statistics

Accuracy : 0.7082
95% CI : (0.6919, 0.7241)
No Information Rate : 0.287
P-Value [Acc > NIR] : < 2.2e-16

Kappa : 0.6308
McNemar's Test P-Value : NA

Confusion Matrix and Statistics

	cast	cerro	dougl	fagg	ont	pino	rov
Prediction cast	254	77	25	6	6	37	12
Prediction cerro	8	237	5	0	1	2	3
Prediction dougl	14	7	757	3	0	42	4
Prediction fagg	2	1	0	18	0	3	0
Prediction ont	0	0	0	1	16	0	0
Prediction pino	12	1	40	0	0	397	0
Prediction rov	1	0	2	1	0	0	9

Overall Statistics

Accuracy : 0.8423
95% CI : (0.8256, 0.858)
No Information Rate : 0.4137
P-Value [Acc > NIR] : < 2.2e-16

Kappa : 0.7823
McNemar's Test P-Value : NA

Confusion Matrix and Statistics

	con	lat	misto
Prediction con	1001	27	63
Prediction lat	168	1511	61
Prediction misto	141	50	93

Overall Statistics

Accuracy : 0.8363
95% CI : (0.8228, 0.8491)
No Information Rate : 0.5098
P-Value [Acc > NIR] : < 2.2e-16

Kappa : 0.7085
McNemar's Test P-Value : < 2.2e-16

Confusion Matrix and Statistics

	con	lat
Prediction con	1186	34
Prediction lat	124	660

Accuracy : 0.9212
95% CI : (0.9085, 0.9326)
No Information Rate : 0.6537
P-Value [Acc > NIR] : < 2.2e-16

Kappa : 0.831
McNemar's Test P-Value : 1.437e-12

There are several study
that achieved similar
results for classification...
combining hyperspectral
and multispectral data

*Abdollahnejad study
achieved 63,85% OA for 7
forest class classification*

*Puletti et al (2016)
achieved 94% OA for 2
classes classification*

Discussion & Conclusion

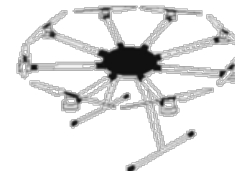
Our purpose was to test different method for forest species classification in order to provide to local manager low cost information for sustainable forest managment

- Random Forest work out better than kNN
- Helicopter data work better for all the levels
- UAV data were good for coniferous/broadleaf classification
- Other works with different data sources achieved similar OA



THANK YOU FOR THE ATTENTION

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LIFE14 ENV/IT/000414
Demonstrating Remote Sensing integration
in sustainable forest management