PLURIFOR PROJECT. EUCALYPTUS WEEVIL RISK WORKSHOP:TOOLS FOR MONITORING DEFOLIATION

New tool based on aerial images to assess defoliation. Overall preliminary results.

Regions: Asturias, Cantabria and Portugal

PLURIFOR

Covadonga Prendes Pérez

CETEMAS. Forest and Wood Technology Research Centre

(http://www.cetemas.es)

CETEMAS

Interreg Sudoe

INTRODUCTION

BEFORE START SPEAKING, SOMETHINGS TO TAKE INTO ACCOUNT…

The PLURIFOR Project is at the moment at an early stage

The results to be presented today are preliminary and may vary considerably along the project

The purpose of this talk is twofold:

1. On the one hand it aims to show the first results obtained by the partners of Asturias, Portugal and Cantabria.
2. On the other hand the presentation of these preliminary results aims to be a starting point for the debate, where all partners can contribute ideas and decide what will be the steps to be follow in the future

INTRODUCTION

WORKFLOW TO WORK ASSES DEFOLIATION WITH VEGETATION INDEXES

1 Data adquisition

UAV: eBee RTK
Sensors:
S110 RGB
WX Sony RGB
S110 NIR
S110 RED EDGE
SEQUOIA

2 Data processing to create reflectance maps of the different bands (NIR, RED, GREEN, RED EDGE)

3 Vegetation index maps (NDVI, SAVI, GCI…)

4 Asign a value of each index to the vegetation inside the plots

- Individual tree level
- Plot level

5 To assess which is the most suitable index to predict the degree of defoliation within a eucaliptus stand

6 Inclusion of the selected index (or indexes) in predictive models that can be used the developmente of risk management plans

METHODOLOGY

VEGETATION INDEX MAPS

There are many vegetation indexes in the literature….

As a first try, CETEMAS choose the ones below:

NIR
RED
GREEN

NAME	FORMULA	CHARACTERISTICS
Normalized Difference Vegetation Index (NDVI)	$\frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + \rho_{red}}$	Values between -1 y 1
No linear index(NLI)	$\frac{\rho_{NIR}{}^2 - \rho_{red}}{\rho_{NIR}{}^2 + \rho_{red}}$	Explores a non linear relation between bands
Infrared Percentage Vegetation Index (IPVI)	$\frac{\rho_{NIR}}{\rho_{NIR} + \rho_{red}}$	Values between 0 y 1.
Green Normalized Difference Vegetation Index (GNDVI)	$\frac{\rho_{NIR} - \rho_{green}}{\rho_{NIR} + \rho_{green}}$	Similar to NDVI, but using the GREEN band.
Normalized Red Green Difference Vegetation Index (NGRDI)	$\frac{\rho_{green} - \rho_{red}}{\rho_{green} + \rho_{red}}$	
Green Chlorophyll Index (GCI)	$\frac{\rho_{NIR}}{\rho_{green} - 1}$	It used to assess the amount of light absorbed by the leaves
SAVI (Soil Adjusted Vegetation Index)	$\frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + \rho_{red} + L}(1 + L)$	Minimice the effect of the ground. L=0.5

VEGETATION INDEX MAPS

METHODOLOGY

RED EDGE
RED
BLUE

NAME	FORMULA	CHARACTERISTICS
Normalized Difference Red Edge (RENDVI)	$\frac{\rho_{NIR} - \rho_{red\ edge}}{\rho_{NIR} + \rho_{red\ edge}}$	Values between -1 y 1. Above 0 it is considered as vegetation
Red edge Chlorophyll Index (REGCI)	$\frac{\rho_{NIR}}{\rho_{red\ edge} - 1}$	It used to assess the amount of light absorbed by the leaves
MTCI (MERIS terrestrial Chlorophyll Index)	$\frac{\rho_{NIR} - \rho_{red\ edge}}{\rho_{red\ edge} - \rho_{red}}$	Under revision

Spatial of the vegetation index maps: Resolution 10 cm

WORKFLOW TO WORK ASSES DEFOLIATION WITH VEGETATION INDEXES

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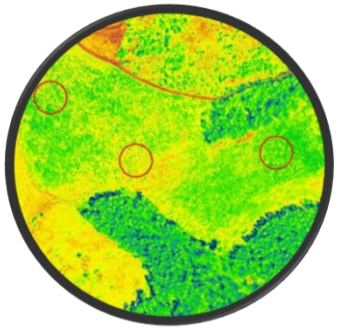
METHODOLOGY

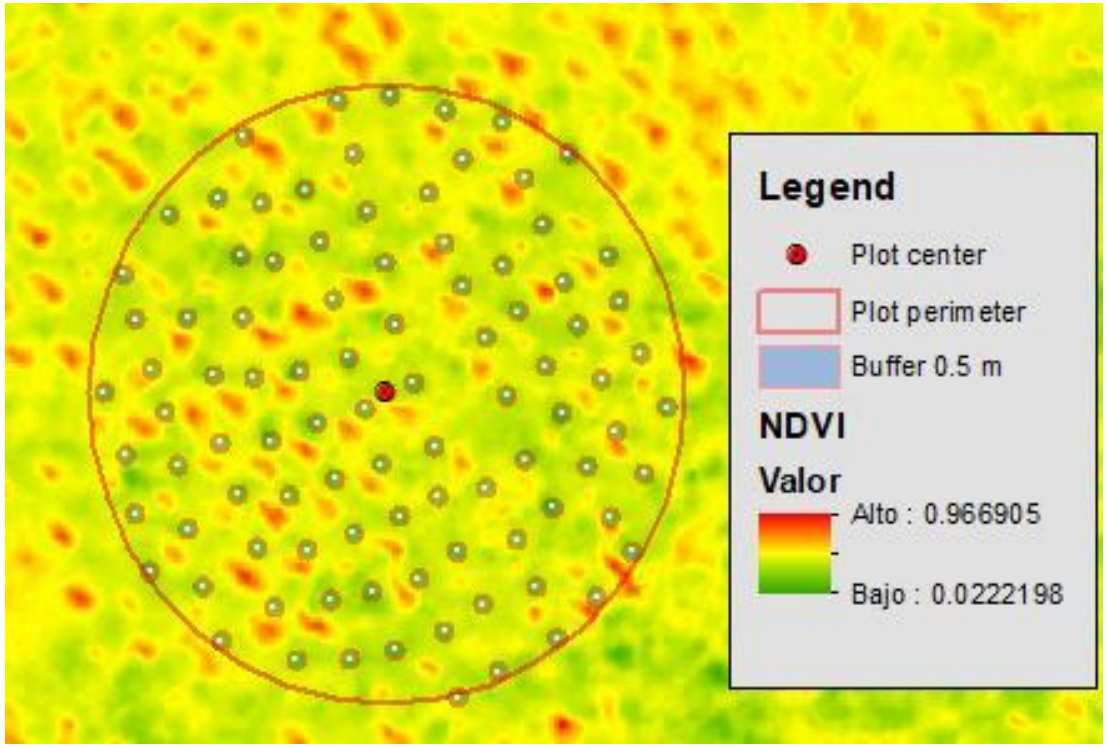
4 Asign a value of each index to the vegetation inside the plots

OPTION 1

ASSIGN AND INDEX VALUE TO EACH TREE



From the central coordinates of each tree, a buffer of 0.25 / 0.5 is created to delimitate the crown



Tree	Defoliation	NDVI	RENDVI	SAVI
1	2	0.58	0.09	0.23
2	2	0.52	0.08	0.36
3	1	0.59	0.16	0.47

Vegetation Index average value per tree

AVERAGE VALUE OF THE INDEX WITHIN THE PLOT IS CALCULATED AS THE SUM OF ALL THE AVERAGE VALUES PER TREE

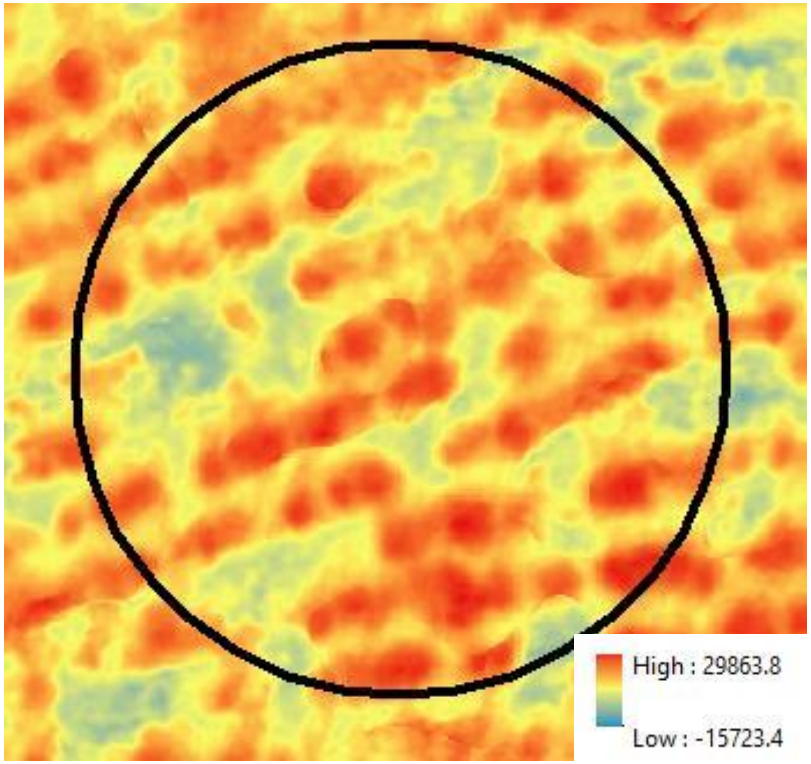
METHODOLOGY

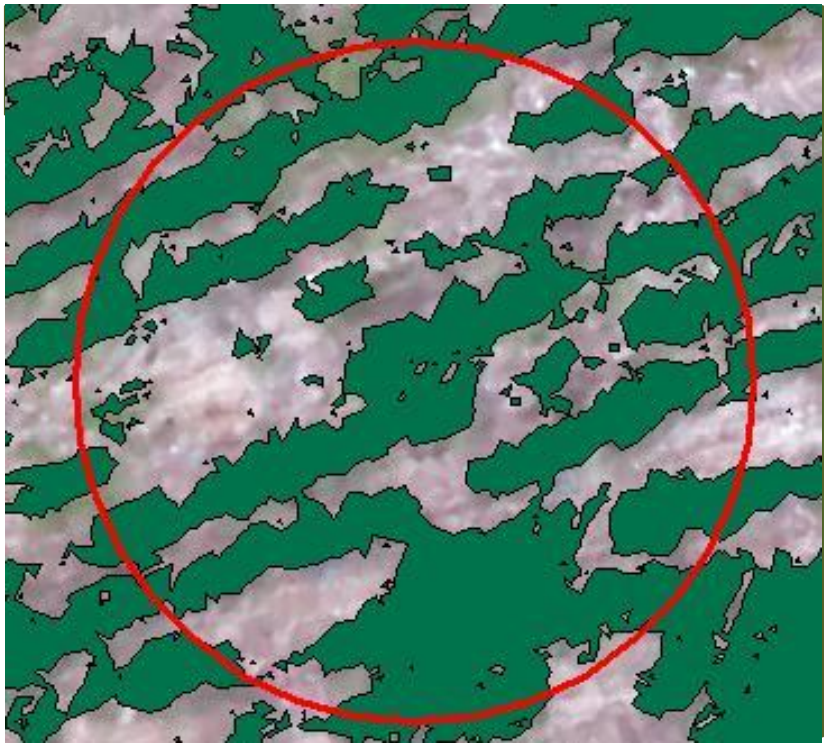
4 Asign a value of each index to the vegetation inside the plots

OPTION 2

ASSIGN AND INDEX VALUE TO EACH PLOT

How to eliminate the effect of the ground?





Soil Index
DVI = NIR - RED → Maximum likelihood classification: Ground/Vegetation pixels → Vegetation pixeles converted to polygon

VEGETATION MASK

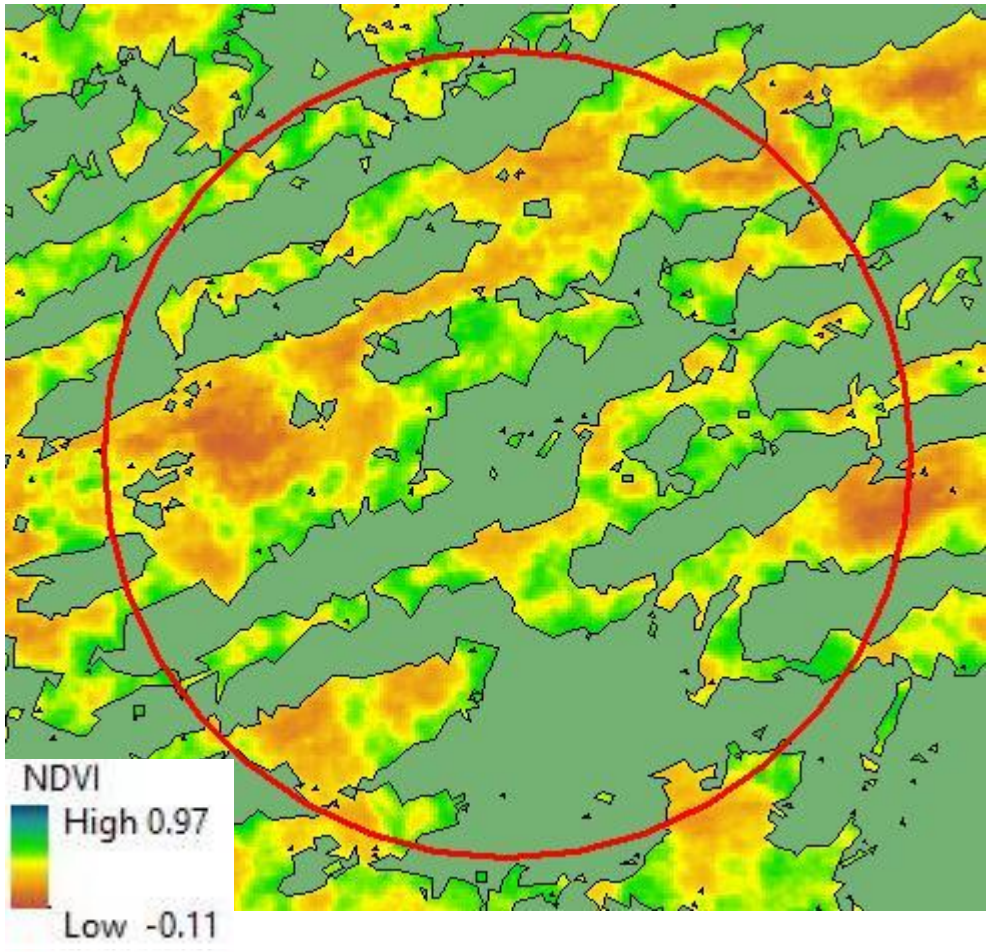
METHODOLOGY

4 Asign a value of each index to the vegetation inside the plots

OPTION 2

EXTRACTION OF INDEX VALUES FOR EACH PLOT

Vegetation mask applied to the 6 plots



ArcGIS ESRI

PLOT	NDVI	GNDVI	RENDVI	SAVI
1	0.61	0.66	0.21	0.35
2	0.61	0.65	0.21	0.34
3	0.58	0.63	0.20	0.35
4	0.69	0.71	0.24	0.38
5	0.71	0.71	0.24	0.39
6	0.66	0.68	0.23	0.36

VEGETATION INDEX
AVERAGE VALUES PER PLOT

METHODOLOGY

5 To assess the most suitable index to predict the degree of defoliation

STATISTICAL ANALYSIS

It is under development at the moment.

The preliminar analyzes are trying to find differences in the average values of the indexes according to defoliation classes

6 Inclusion of the selected index (or indexes) in predictive models

It is under development at the moment.

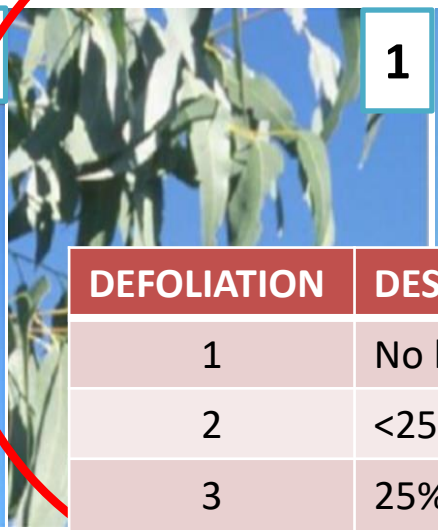
DAMAGE INVENTORY

REGION:CANTABRIA

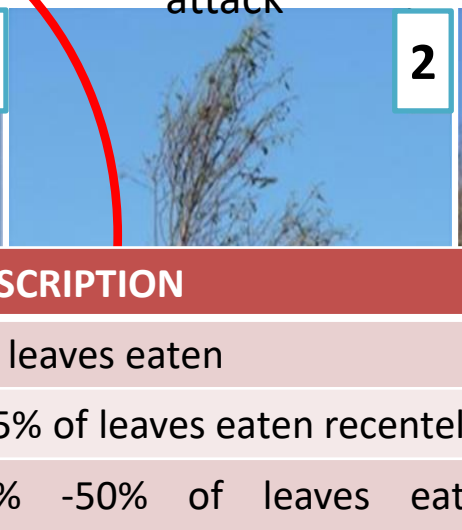
PRELIMINARY RESULTS

No attack

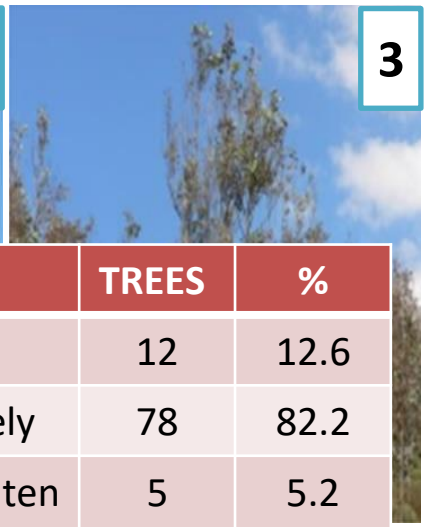
Weak attack



Moderate to strong attack



Very strong attack



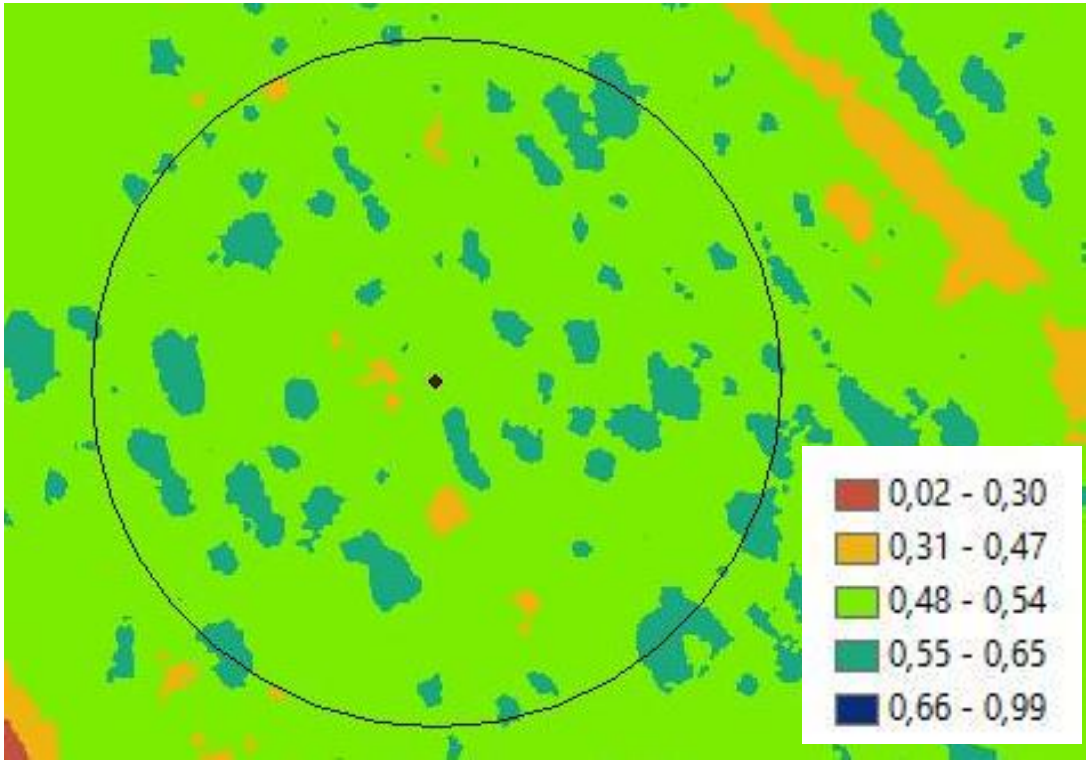
1 PLOT MEASURED IN AUGUST

According to the Defoliation measurements carried out inside the plot, only the three first intervals are present (82.2 % of the trees belong to defoliation level 2)

DEFOLIATION	DESCRIPTION	TREES	%
1	No leaves eaten	12	12.6
2	<25% of leaves eaten recentely	78	82.2
3	25% -50% of leaves eaten recently	5	5.2
4	50% -75% of leaves eaten recently	0	0
5	> 75% leaves and 1/4 of those leaves + 50% of their sup. Intact.	0	0
6	> 75% leaves eaten <1/4 of those leaves + 50% of their sup. Intact.	0	0
7	Total consumption of recent sprouting. Vestiges of petioles.	0	0
	Total	95	100

GRAPHIC ANALYSIS

In the Plot of Cantabria the Gonipterus attack is weak, so the value of NDVI don´t show relevant variations between trees.



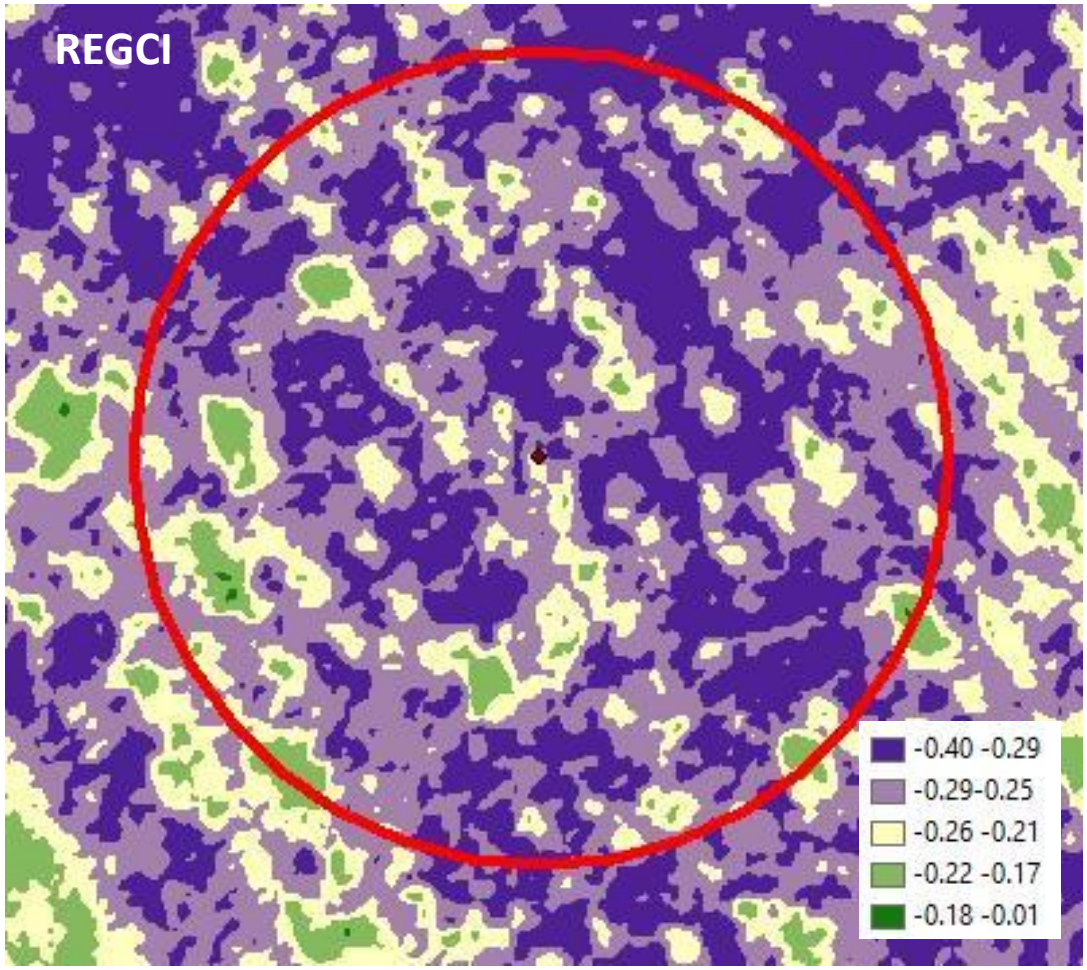
Orange and brown pixels belong to the ground, so they should be removed of the analysis

There are no differenced groups of trees within the vegetation

The highest values (dark green) represent healthier vegetation

GRAPHIC ANALYSIS

In the case of REGCI vegetation index



Dark purple pixels belong to the ground, so they should be removed of the analysis

It seems to detect more variability inside the vegetation than the NDVI
Statiscal analysis would be needed to confirm how well the index is performing.

DAMAGE INVENTORY

REGION:ASTURIAS

RESULTS

No attack | Weak attack | Moderate to strong attack | Very strong attack

DEFOLIATION	DESCRIPTION	FREQUENCY	%
1	No leaves eaten	146	9.1
2	<25% of leaves eaten recentely	1019	63.4
3	25% -50% of leaves eaten recently	331	20.6
4	50% -75% of leaves eaten recently	56	3.5
5	> 75% leaves and 1/4 of those leaves + 50% of their sup. Intact.	24	1.5
6	> 75% leaves eaten <1/4 of those leaves + 50% of their sup. Intact.	14	0.9
7	Total consumption of recent sprouting. Vestiges of petioles.	5	0.3
	Total	1608	100

6 PLOT MEASURED

According to the Defoliation measurements carried out inside the 6 plots, levels 1, 2 and 3 are the most frecuent (93% of the cases)

STATISTICAL ANALYSIS

REGION:ASTURIAS

DESCRIPTIVE STATISTICS OF THE 2 STUDY AREAS (COBERTORIA + SESTELO)

All the statistics for the 27 flights and the 9 vegetation indexes has been calculated . They are shown in table below

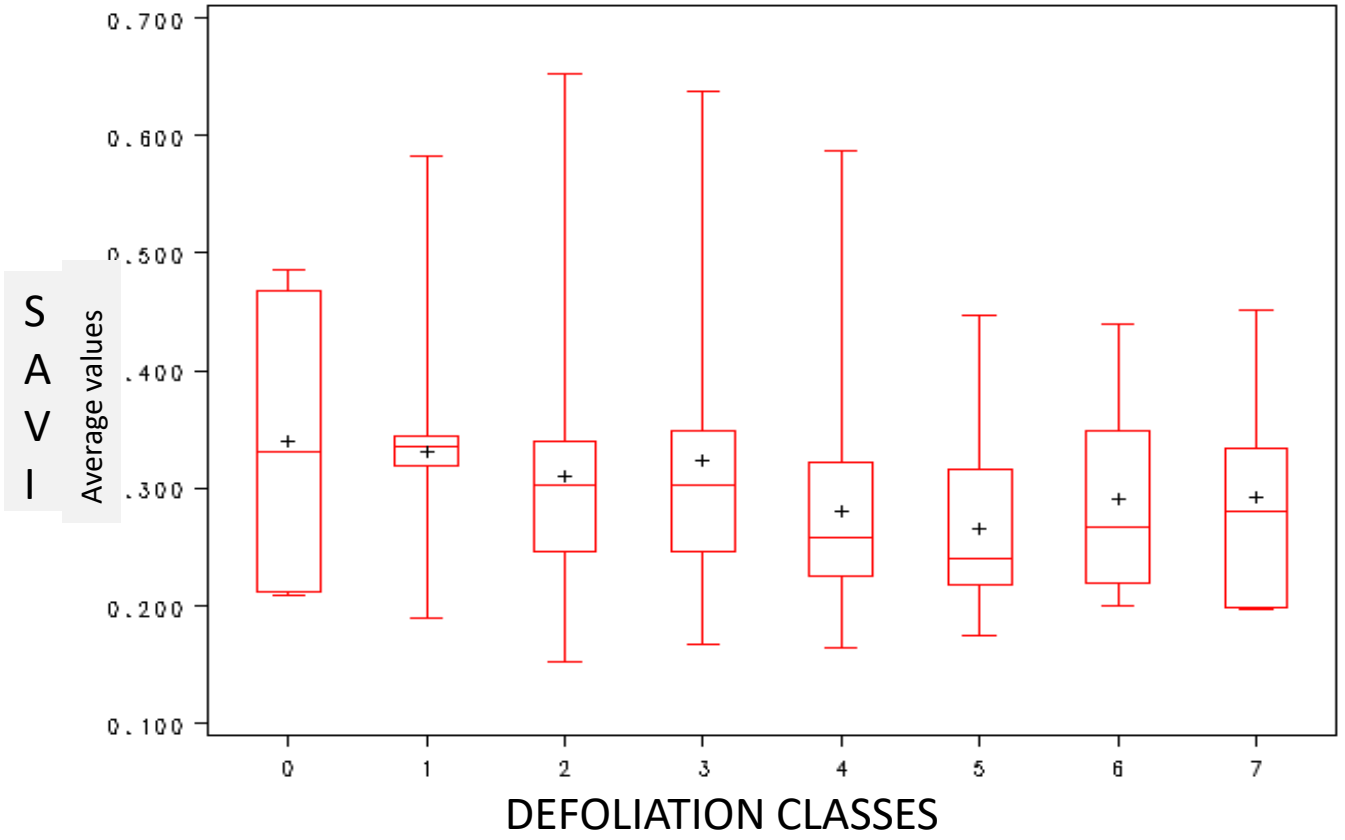
VARIABLE	N	Average	Dev tip	Minimum	Maximum
d	1587	6.58	3.27	1.50	17.75
htotal	1572	6.90	2.73	1.20	16.20
hcrown	1569	3.82	2.53	0.90	18.60
NDVI	1608	0.59	0.13	0.33	0.89
GNDVI	1608	0.67	0.11	0.48	0.91
IPVI	1608	0.80	0.07	0.67	0.95
GCI	1608	-0.31	0.11	-0.70	-0.12
NLI	1608	0.05	0.32	-0.55	0.76
NGRDI	1608	-0.13	0.04	-0.25	-0.01
RENDVI	1360	0.24	0.19	-0.12	0.70
REGCI	1360	-0.32	0.09	-0.61	-0.13
SAVI	1608	0.31	0.09	0.15	0.65

STATISTICAL ANALYSIS

REGION:ASTURIAS

Which indexes seem to perform better in order to estimate defoliation?

BOX PLOT OF VEGETATION INDEX SAVI– DEFOLIATION CLASSES

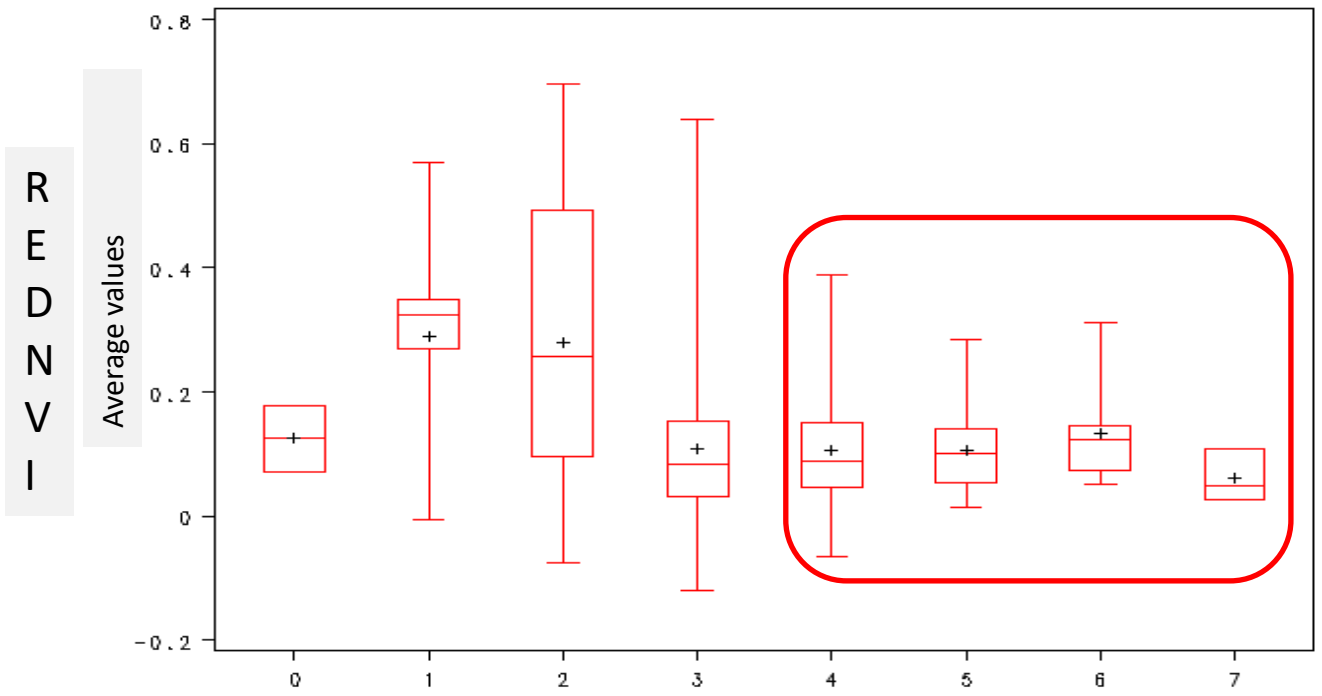


SAVI index is not able to distinguish between defoliation classes

Which indexes seem to perform better in order to estimate defoliation?

Indexes using red edge band are able to distinguish between defoliation classes when the damage is strong (4, 5, 6,7)

BOX PLOT OF VEGETATION INDEX REDNVI – DEFOLIATION CLASSES

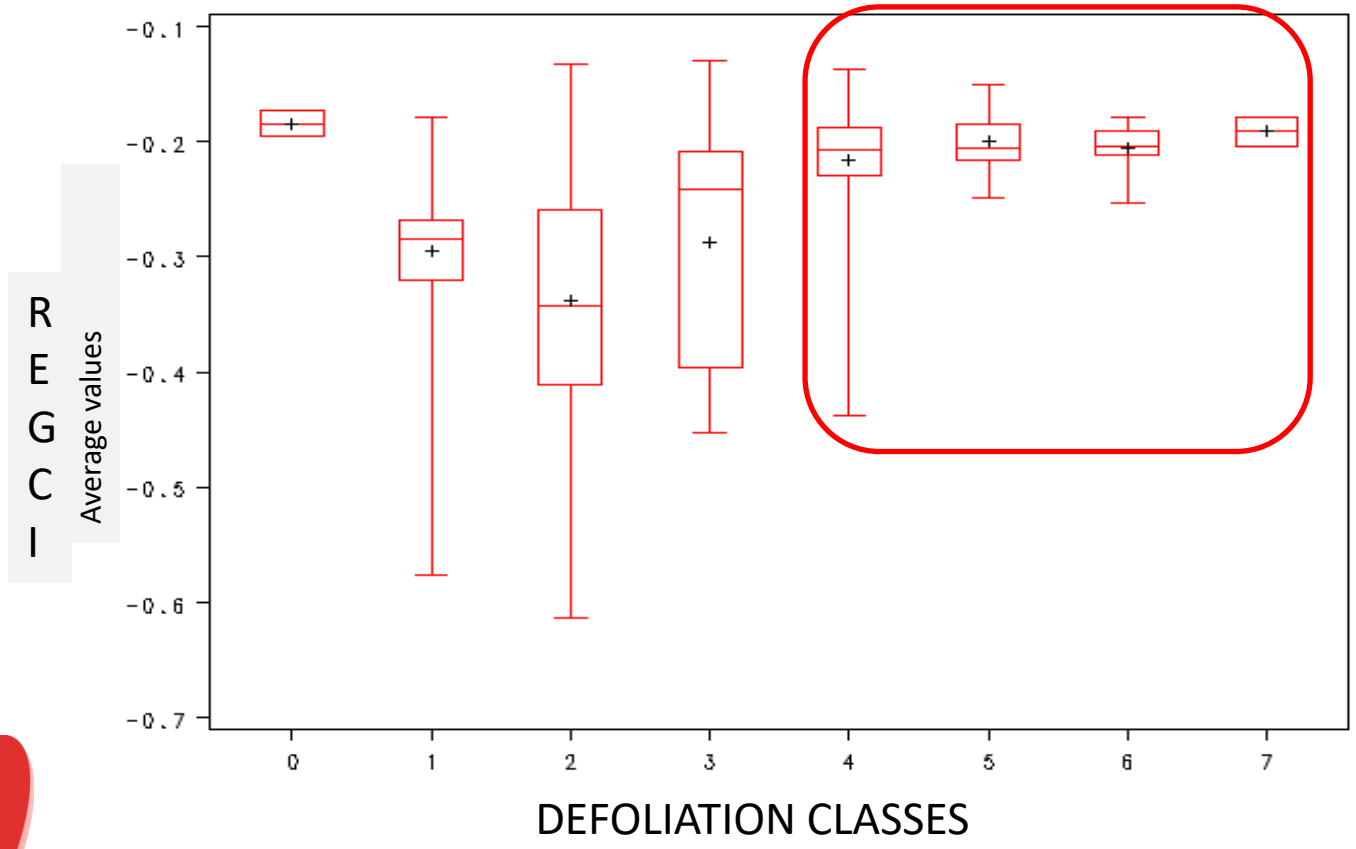


RESULTS

STATISTICAL ANALYSIS

REGION:ASTURIAS

BOX PLOT OF VEGETATION INDEX REGCI – DEFOLIATION CLASSES



When interpreting box plots, two things must be taken into account

- We didn´t do outliers detection yet (it will reduce dispersion)
- Defoliation classes values are unbalanced, the presence of extreme values of defoliation is very low

DAMAGE INVENTORY

REGION:PORTUGAL

PRELIMINAR RESULTS

No attack

Weak attack

Moderate to strong attack

Very strong attack

8 plots measured in June

According to the Defoliation measurements carried out inside the 8 plots, levels 5, 6 and 7 are the most frecuent (>75% leaves eaten or total consumption)

62.6% OF THE TREES ARE IN THE HIGHEST CATHEGORIES OF DEFOLIATION

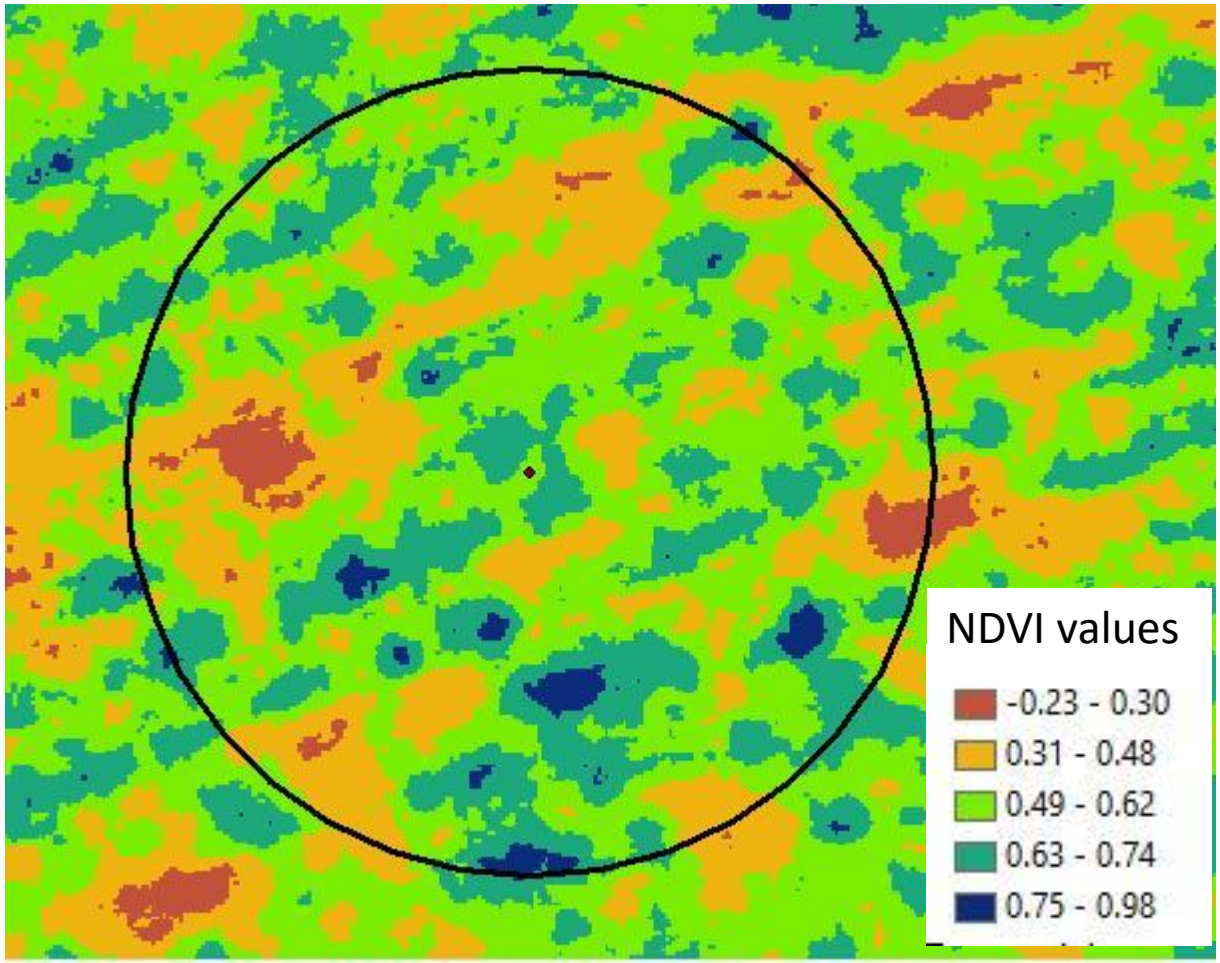
DEFOLIATION	TREES	PERCENTAGE
1	14	7.5
2	25	13.4
3	15	8.0
4	16	8.6
5	25	13.4
6	60	32.1
7	32	17.1
TOTAL	187	100

PRELIMINARY RESULTS

GRAPHIC ANALYSIS

REGION:PORTUGAL

In Plot 1 with has a very strong attack (LEVEL 3), the value of NDVI changes notably inside



Orange and brown pixels belong to the ground, so they should be removed of the analysis

There are at least 3 groups of trees within the vegetation

The highest values (blue) represent healthier vegetation

GRAPHIC ANALYSIS

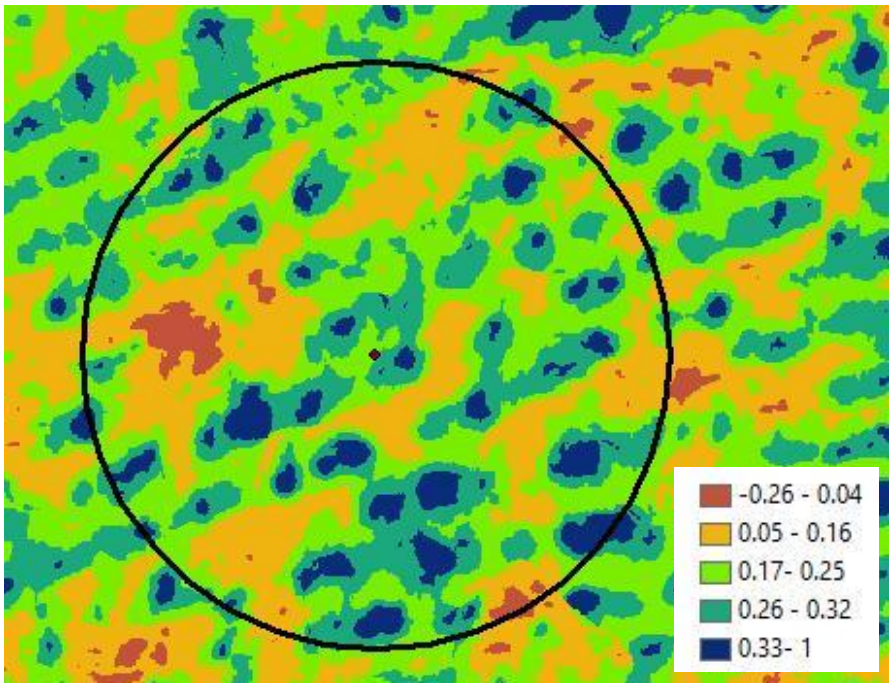
REGION:PORTUGAL

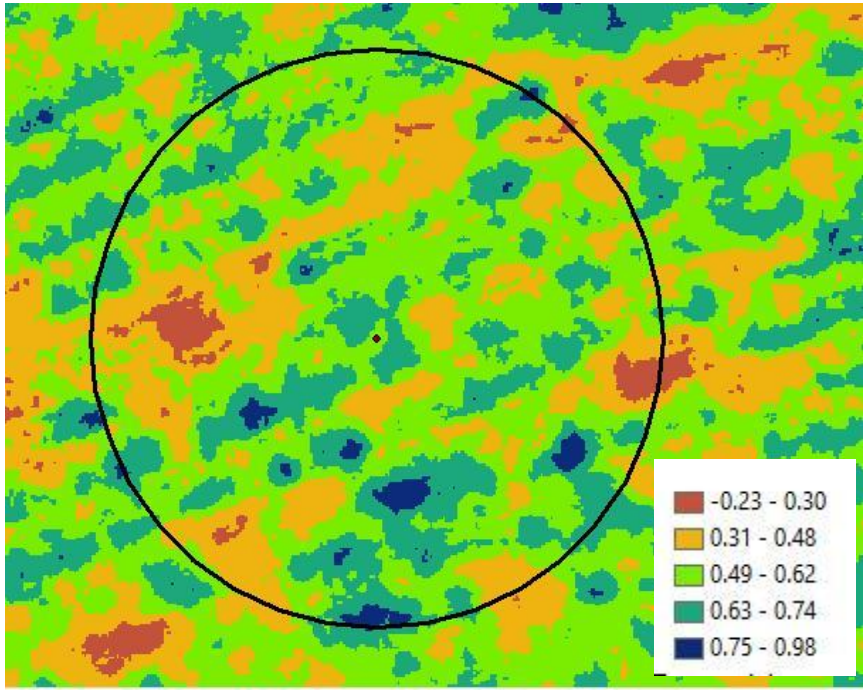
PRELIMINARY RESULTS

INFLUENCE OF THE SENSOR

S11O NIR MODIFIED CAMERA

SEQUOIA MULTIESPECTRAL SENSOR





Graphic analysis assigning a color to every definitive class, may be conditioned by the camera type

FUTURE CHALLENGES

- Criterion to assign a vegetation index value to the eucalyptus plots.
- Influence of the soil/ground in the indexes values: how to solve it?
- Extrapolation of the results to bigger areas
- Comparision between sensors (Sequoia/modified cameras)
  Integration of data from different cameras
- Posibility of develop an “Improved index”which works better when the defoliation level is low

THANK YOU FOR YOUR ATTENTION

PLURIFOR PROJECT. EUCALYPTUS WEEVIL RISK WORKSHOP:TOOLS FOR MONITORING DEFOLIATION

4 th October Eixo, Aveiro (Portugal)

Elena Canga Líbano
ecanga@cetemas.es

Covadonga Prendes Pérez
cprendes@cetemas.es

Marta González García
mgonzalez@cetemas.es

Juan Majada Guijo
jmajada@cetemas.es

CETEMAS. Centro Tecnológico Forestal y de la Madera

CETEMAS

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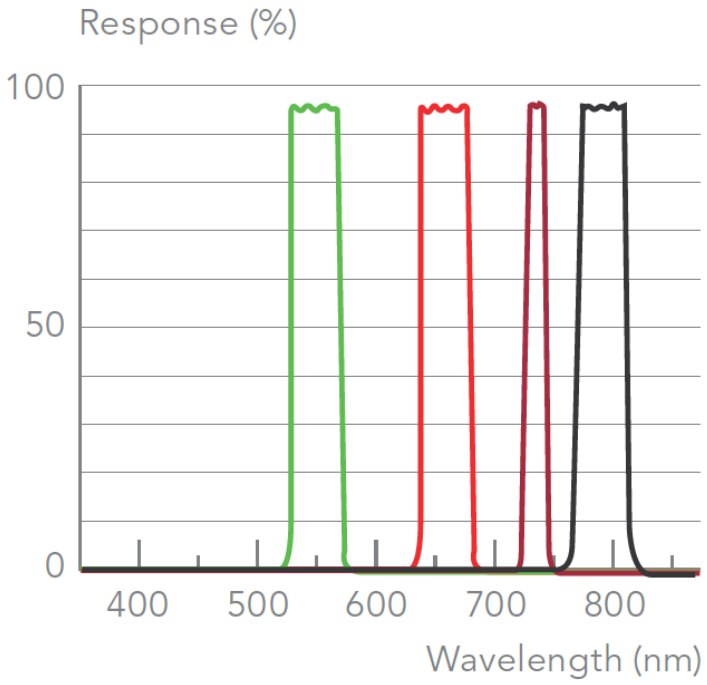
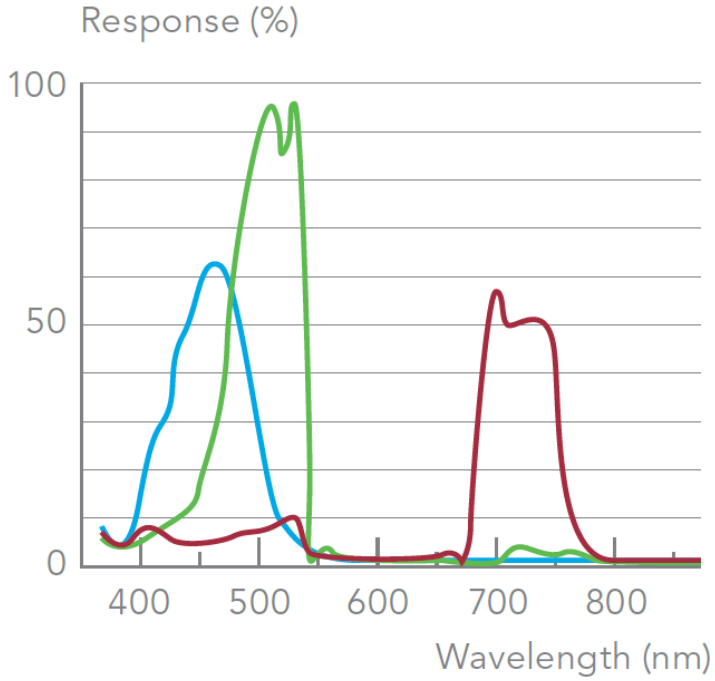
SEQUOIA



Discrete spectral bands

- Green (550BP40)
- Red (660BP40)
- Red Edge (735BP10)
- Near Infrared (790BP40)

RE MODIFIED CAMERAS



Non discrete spectral bands

- Blue (450 nm)
- Green (500 nm)
- Red Edge (715 nm)