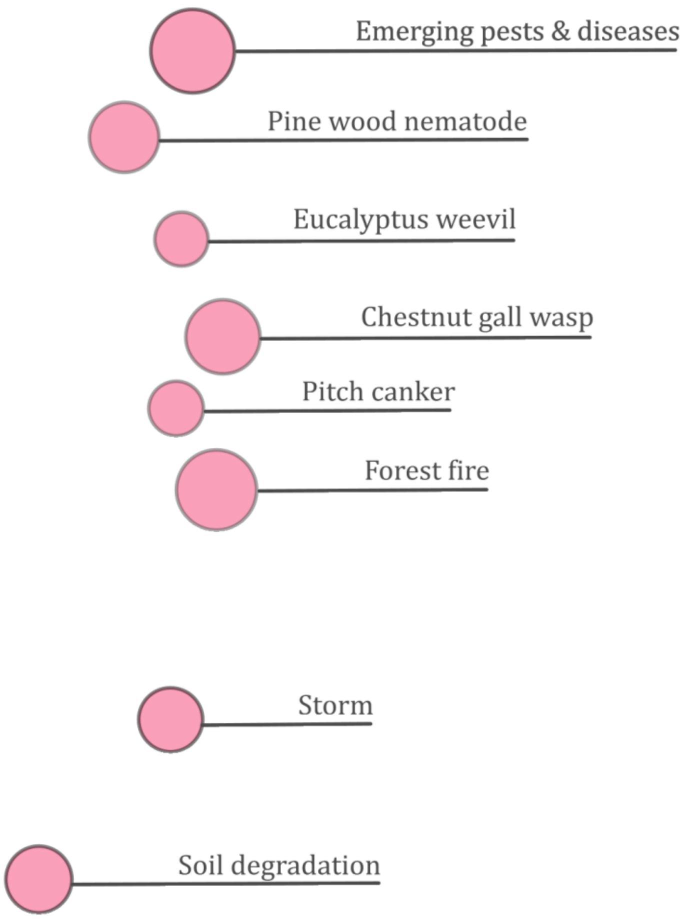
Minutes of the eucalyptus weevil (*Gonipterus platensis*) workshop

Tools for monitoring defoliation



RAIZ, Instituto de Investigação da Floresta e Papel
Eixo, Aveiro, Portugal
4 October 2017

Author of the minutes: Eduard Mauri (EFIATLANTIC)

Reviewers of the minutes: Manuela Branco (ISA), Julio Javier Diez (UVa), Francisco José Lario (TRAGSA), Juan Majada (CETEMAS), Alejandro Oliveros (ENCE), Covadonga Prendes (CETEMAS), Paula Soares (ISA), Carlos Valente (RAIZ/The Navigator Company)

Workshop organisers: Carlos Valente (RAIZ/The Navigator Company), Manuela Branco (ISA)

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PLURIFOR PROJECT
EUCALYPTUS WEEVIL RISK WORKSHOP:
TOOLS FOR MONITORING DEFOLIATION

WEDNESDAY 4 OCTOBER 2017	**Organisers:** Carlos Valente, RAIZ , +351 234 920 158, carlos.valente@thenavigatorcompany.com Manuela Branco, ISA, +351 213 653 382, mrbranco@isa.ulisboa.pt **Language:** Spanish/Portuguese/English **Venue:** RAIZ, Eixo, Aveiro, Portugal

9:45	**Welcome**	**RAIZ**
10:00	**Presentation of PLURIFOR WP2 objectives**	**Manuela Branco (ISA)**
10:15	Update of tools used in each region to deal with *Gonipterus platensis*: monitoring, control, rehabilitation. Presentations by different project partners: 5-10 min each.	
	• Asturias • Cantabria • Galicia • Portugal	
11:00	**Participative debate**: constraints and needs regarding new tools	
11:30	**Coffee break**	
11:50	**New tool to assess defoliation**	
	Presentation of a new tool based on aerial images to assess defoliation (Juan Majada, CETEMAS) Activities carried in the different regions (5 min presentation each): • Asturias /Basque Country • Cantabria • Galicia • Portugal Overall preliminary results (Marta González, Covadonga Prendes, Juan Majada, CETEMAS)	
13:00	Questions and discussion	
13:30	**Lunch** offered by RAIZ	
14:50	**Roundtable***	
	Discussion about the potentialities of the new tool. Definition of the next steps and products resulting from WP2.	
17:00	**End**	

PLURIFOR PROJECT

EUCALYPTUS WEEVIL RISK WORKSHOP:

TOOLS FOR MONITORING DEFOLIATION

* The afternoon session will be limited to partners and associated partners. The morning session will be open to all participants, partners and stakeholders.

Workshop registration by 29 September 2017. Places are limited to 50 people.

With the participation of

Eucalyptus weevil WP2 objectives

Eucalyptus weevil risk partners and associated partners

Region	Organisation	Contact person	Associated partners for this risk
Asturias	CETEMAS	Juan Majada	ENCE Energía y Celulosa, S.A. 112 Asturias Asociación de propietarios forestales de Asturias (PROFOAS) Asociación asturiana de empresarios forestales de la madera y el mueble (ASMADERA) Servicio regional de investigación y desarrollo agroalimentario (SERIDA) Consejería de agroganadería y recursos autóctonos (Gobierno del Principado de Asturias)
Cantabria	UVa	Julio Diez	Gobierno de Cantabria
Portugal	ISA	Manuela Branco	Altri Florestal Instituto da Conservação da Naturesa e das Florestas RAIZ - Instituto de Investigação da Floresta e Papel
Galicia[a]	TRAGSA[a]	Francisco José Lario Leza[a]	ENCE Energía y Celulosa, S.A.

[a] financed by project DATABIO Data-driven Bioeconomy 732064 (H2020-ICT-2016-1)

Tools and risk management plans to be developed within PLURIFOR project

As decided by the PLURIFOR Technical committee n°2 meeting (25-26 January 2017 at NEIKER, Parque Tecnológico de Bizkaia, Parcela 812, calle Berreaga 1, Derio, Spain), the following tools and risk management plans will be developed by the eucalyptus weevil risk team in WP2:

- Develop new monitoring tools using aerial images and compare data accuracy with defoliation data from field surveys;
- Update the Portuguese national plan and adapt to other regions (e.g.: Asturias).

Attendees

Attendees

Participants

First name	Last name	Organisation
Adrián	Navarro Pacheco	TRAGSATEC
Alda	Antunes	ICNF
Ana	Fernandes	ICNF
Ana	Reis	Altri Florestal
António	Macedo	CELPA
Catarina	Gonçalves	RAIZ
Celio	Duarte	RAIZ
Clara	Ararif	Altri Florestal
Dina	Ribeiro	ICND
Eduard	Mauri	EFIATLANTIC
Edurne	Lacalle Galdeano	USSE
Federico	Ruiz	ENCE Energía y Celulosa, S.A.
Felix Manuel	Lopez Cuervo	Agrícolas Ingenieros Pravia C.B. (USSE)
Fernando	Basurco	ENCE Energía y Celulosa, S.A.
Helena	Marques	ICNF
Iván	Castaño Fernández	Agrícolas Ingenieros Pravia C.B. (USSE)
João	Rua	ISA
Juan	Majada Guijo	CETEMAS
Leire	Salaberria Isasi	USSE
Luis	Almeida	Associação Florestal do Baixo Vouga
Luis	Caparica	ICNF
Luis	Fontes	RAIZ
Marta	González-García	CETEMAS
Nuno	Borralho	RAIZ
Pablo	Martínez Álvarez	University of Valladolid (UVa)
Paula	Afonso Pinto	ICNF
Ricardo	Marinho	Forestis - Associação Florestal de Portugal

Speakers

First name	Last name	Organisation
Alejandro	Oliveros García	ENCE Energía y Celulosa, S.A.
Carlos	Valente	RAIZ
Covadonga	Prendes Pérez	CETEMAS
Francisco José	Lario Leza	TRAGSA
Julio Javier	Diez Casero	University of Valladolid
Paula	Soares	ISA

Organisers

First name	Last name	Organisation
Carlos	Valente	RAIZ
Manuela	Branco	ISA

Absent

First name	Last name	Organisation
Edmundo	Sousa	INIAV, IP
José Manuel	Rodrigues	ICNF
Luis	Bonifácio	INIAV
Luis	Leal	Altri Florestal
Luis	Sarabando	Associação Florestal Baixo Vouga
Sónia	Lopes	ICNF/DCNF Centro
Teresa Maria	Vasconcelos	Escola Superior Agrária Coimbra

Presentation of tools to monitor defoliation

Update of tools used in each region

Goal

Update of tools used in each region to deal with eucalyptus weevil (*Gonipterus platensis*) on monitoring, control and rehabilitation. Presentations by different project partners: 5-10 min each.

Asturias

Covadonga Prendes, CETEMAS

Up until now, for the PLURIFOR project CETEMAS has:

- Installed 6 study plots in 2 eucalyptus stands attacked by eucalyptus weevil;
- Captured data (mainly concerning defoliation and phenology) in the study plots using a UAV with different cameras.

Study area consist in two stands (of at least 5 ha) of young (4-6 years old) *Eucalyptus globulus* plantations in two separate regions that exhibit two different classes of defoliation: one stand with low defoliation and the other with high defoliation. Within each stand, three 16-m radius circular plots were installed to cover high, middle and low slope conditions. Trees were geolocated (in order to locate each tree in the aerial images), they were measured (height and dbh) and their level of defoliation was visually evaluated (as the percentage of leaves lost).

From April to July, aerial photos were taken with the fixed-wing UAV: eBee RTK. Three cameras were used: RGB, near infrared (NIR) and red edge (RE), to obtain images with a resolution of 10 cm/pixel. Each stand was flown in three different months and with the three different cameras (27 flights in total) to get information of 5 spectral bands (red, green, blue, NIR and RE). Radiometric correction was performed with a calibration target in order to obtain images which are comparable among different periods of time. These images were used in the setting up of several vegetation indexes maps like: SAVI, GNDVI, NDVI, RENDVI, etc.

Cantabria

Julio Diez, Universidad de Valladolid (UVa)

In Cantabria, 40% of the land area is forested and 20% of the forested area is covered by eucalyptus plantations (8% of the whole region area, concentrated on the northern half near the Atlantic Ocean). As this region is colder than Portugal and Galicia, defoliation is less important.

The Cantabria Government has two publications for the integrated pest management (IPM) of the eucalyptus weevil:

- A guide for the integrated pest management of *Gonipterus sp.* (2015), and
- An integrated management plan against pathogens of the eucalyptus in Cantabria (2015).

They are both related to the current national and European legislation and are based in two general principles of the integrated pest management:

- Biological, biotechnological, cultural and physical methods of control must have priority over chemical ones,
- Risk assessment of the pests must be determined through the evaluation of population levels, their stage of development and the presence of useful fauna, the phenology of the trees affected, the climatic conditions and other parameters of interest.

The guide and the plan emphasize on the surveillance stage: it should warn forest managers when the pest has reached a level from which it could easily achieve the maximum tolerated threshold, which could cause future problems to the stand that compromise timber production. The objective is therefore to prevent reaching the maximum tolerated threshold before it is too late. These future losses of timber production should be economically higher than the cost of the treatment in order that the latter would be justified. In the case of the eucalyptus weevil, its threshold is set by the amount of eggs (oothecae), larvae and adults together with the percentage of defoliation within a stand.

For biological control, the maximum tolerated threshold is fixed to ten oothecae per twig. Biological control measures include the release of the eucalyptus weevil's parasitoid *Anaphes nitens*, silvicultural improvements to enhance the vigour of the trees (site preparation and clearing, adequate quality of the plants, proper plantation methods and treatments). Within the genetic improvement, there are several research lines on selection of resistant provenances or species. Nevertheless, there are no *Eucalyptus globulus* varieties nowadays tolerant or resistant to the weevil. Biological control methods are the most spread; whereas chemical ones are only used on punctual occasions when biological control is not possible.

For using chemical control, the maximum tolerated threshold is fixed to 20% of defoliation. Chemical products are applied during the first larval stages, especially in stands with unfavourable conditions for the growth of *E. globulus*, such as poor or flooded soils or located above 350 m above the sea level. It is important to point out that the products chosen for weevil control should be harmless to its parasitoid *A. nitens* in any stage of its cycle.

The integrated management plan requires that the efficacy and efficiency of all treatments must be evaluated continuously; monitoring them before, during and after their application.

The use of remote sensing images taken by UAV represents a new tool that allows the improvement of the current integrated management plan.

Galicia

Alejandro Oliveros, ENCE Energía y Celulosa, S.A.

For ENCE, the loss of timber production caused by the eucalyptus weevil is a very relevant problem, as well as for north-western Spanish forest owners. Up to 16% of the volume increase, or 1 million cubic metres, is lost every year, the equivalent of 30 million of euros. Replacing *Eucalyptus globulus* by *E. nitens* is not the most appropriate solution because yield of pulp production is lower with the latter species.

For the 2016-2017 biological control campaign in Galicia, ENCE and the Government of Galicia have collaborated to locate defoliation and distribution of the eucalyptus weevil. ENCE has also collaborated with 30 professionals and 16 organisations of the forest-timber sector to create two new *Anaphes nitens* rearing facilities to increase the treatment capacity (in Spain there is another one in Asturias, by SERIDA, and another in Ourense that belongs to TRAGSA), and has improved monitoring and cost-benefit analyses. ENCE has also conducted trials to establish the propagation and the density of *A. nitens* in eucalyptus plantations under biological control by this parasitoid. Some results of these trials show that:

- The first treatment has a release cost of 47 euros/ha. The second year, the cost is reduced to 13 euros/ha, and the third year the cost is only 7 euros/ha (chemical control measures cost between 25-30 euros/ha/year). Afterwards, the cost should remain constant or be marginally lower;
- The moment of release of *A. nitens* is key, the best results are found when there are few oothecae and before the emergence of the larvae;
- Biological control with *A. nitens* provides little improvement in measured mature stands with a defoliation level higher than 50%;
- The thresholds used for the visual evaluation of the defoliation are too wide to notice the year-to-year reduction of defoliation during the first years of biological control measures.

Future developments are to:

- Compare this constant cost of 7 euros/ha/year with the benefits obtained from this treatment;
- Achieve a method of biological control that would not need the annual release of *A. nitens*.

Biological control with *A. nitens* has still some drawbacks:

- In some areas of the Iberian Peninsula, the parasitoid does not stabilize the population of eucalyptus weevil, for now, so one or two releases per year are constantly needed. For this reason some forest managers prefer the chemical control when the 2nd level of defoliation is reached: it is a faster and cheaper method;
- Small non-treated eucalyptus lots pose problem, as all adjacent plantations must be treated to be effective. However, ownership fragmentation makes this difficult. Forest owners should associate to apply uniform and extended treatments.

Portugal

Carlos Valente, RAIZ/The Navigator Company

Thirteen phytophagous arthropod species of Australian origin have been found in association with *Eucalyptus* spp. in Portugal, most of them within the last 15 years. The eucalyptus weevil arrived to Portugal in 1995 and is currently the most important eucalyptus pest in the region. Up to 50% of the area planted with eucalyptus in Portugal is affected by the weevil. Economic losses are estimated at

650 million euros during the last 20 years, and 1 million cubic metres of timber production is lost every year.

Anaphes nitens releases started in Portugal in 1997 and about 300,000 parasitoids have been released since 2000. This natural enemy adapted quickly and managed to keep the pest under control throughout most of the country. However, *A. nitens* failed to prevent severe attacks in mountain areas in the central and northern parts of Portugal. For this reason, since 2008 other natural enemies have been searched in Tasmania, the place of origin of the eucalyptus weevil.

Among several egg and larval parasitoids found in Tasmania, the research team (RAIZ/The Navigator Company, Altri Florestal, and ISA) selected *Anaphes inexpectatus* for further studies. Laboratory studies suggest that this parasitoid may be an effective biological control agent without affecting non-target species. However, field data does not show good results yet. Field releases started in 2012 and parasitism is still very low (< 5%). Further releases and monitoring will be performed to assess the efficacy of *A. inexpectatus*.

Meanwhile, other Tasmanian natural enemies have been studied. For example, the larval parasitoid *Entedon magnificus* is a promising candidate for a biological control programme.

Another path of research is the study of resistant eucalyptus. RAIZ/The Navigator Company has identified alternative eucalyptus species and hybrids that are more resistant than *E. globulus* to defoliation. Yet, these eucalypts are not as good as *E. globulus* in terms of their forest potential or wood properties.

Chemical control has also been used effectively against this pest. Two insecticides are allowed in Portugal: Epik (acetamiprimid) and Calypso (thiacloprid). However, insecticides have some disadvantages/ risks, such as:

- Non-target organisms may be affected;
- Risk of soil and water contamination;
- Repeated applications are necessary;
- Legal and forest certification restrictions;
- Public concern over pesticide use.

The integrated pest management procedures that have been performed by The Navigator Company resulted in a steep decrease of the eucalyptus area affected by *G. platensis*, from 10,000 ha in 2010 to 2,000 ha in 2016 (of about 85,000 ha owned by the company).

To conclude:

- Eucalyptus weevil is an economically important pest, despite partial control by *A. nitens*.
- Insecticides remain an important management tool, but a better IPM approach is our goal.
- Our main research efforts are to develop:
    - Biological control with other Australian parasitoids;
    - Resistant eucalypts with good forest potential and good wood properties for pulp and paper production.

- All the work is being conducted in close collaboration with Portuguese and Spanish pulp and paper companies (Altri Florestal and ENCE), universities (e.g. ISA-UL), national forest authorities (ICNF), and forest owners associations (CELPA).

New tool to assess defoliation

Goal

Introduce the new tools that are being developed under the PLURIFOR project. This material will be the starting point of the afternoon roundtable debate, where all partners can contribute with ideas and decide what will be the steps to be followed in the future.

A new tool based on aerial images to assess defoliation

Francisco José LarioLeza, TRAGSA

Content

1. Methodology of data acquisition (field measurements and remote sensing)
2. Methodology of the processing of remote sensing data
3. Building of the preliminary decision-making model
4. Graphical outputs
5. Conclusions

Methodology of data acquisition (field measurements and remote sensing)

The study area was a 14-ha *Eucalyptus globulus* plantation in A Coruña (Galicia, Spain) partially defoliated by *Gonipterus platensis*. Trees were 6-7 years old and 7-10 metres high. Eight plots of 12 trees (96 trees in total) were sampled. Individual tree measurements included: percentage of defoliation of the upper third of the crown (ENCE methodology), stem and crown morphology, phenology, foliage density.

Remote sensing data was captured with two cameras: RGB (3.11 cm/pixel) and multispectral (11.6 cm/pixel); and with two types of drones: fix-wing (eBee) and multirotor (Aibot X6).

Methodology of the processing of remote sensing data

Orthophotos were merged and twelve vegetation indices were calculated. Through photointerpretation of aerial photos, tree crowns were located in the vegetation indices maps and their crowns were delineated. The twelve vegetation indices were extracted from each crown and descriptive statics (mean and standard deviation) were calculated for each crown.

Building of the preliminary decision-making model

Half of the trees (48), randomly selected, were used to build the model. Remote sensing descriptive statistics significantly correlated with the six defoliation classes were initially retained to build the model. The dependent variable was the percentage of defoliation transformed to a binary response representing if the tree should be treated against eucalyptus weevil or not given its percentage of defoliation (if defoliation is between 11% and 60%, it should be treated). A logistic regression was built with this binary dependent variable and the retained remote sensing descriptive statistics. Six variables were eliminated and ten were retained. The model explained 64.7% of the deviation. The model was truncated before no defoliation higher than 60% was observed.

The model was then tested with the other half of the trees. Using the cut-off threshold (0.35) that maximized the sensitivity and the specificity, the model reached a sensitivity of 95%, a specificity of 96% and a percentage of successful prediction of 95%.

Graphical outputs

On the map, for each crown, the model could predict the likelihood (in percentage) of the tree to need treatment and, using the cut-off threshold that maximized the success of prediction, indicate if the tree should or should not be treated against the eucalyptus weevil.

Conclusions

Assessing the defoliation and the need of treatment is possible using remote sensing using drones. The fix-wing drone can cover 70 to 100 ha in one day, but is limited by the wind speed. The multirotor drone is slower, but because it is less affected by winds, it can produce more accurate imagery.

Some points need to be solved to scale-up this methodology:

- A cheaper way has to be found to delimitate the crowns from the rest of the image;
- This is a preliminary model, more simple models could be found, and they must be adapted to different topographical and phenology situations;
- An operative methodology should be found to reduce the costs.

If a more robust model cannot be built for a whole region, different models could be adapted for particular regions and/or conditions.

Portugal

Paula Soares, ISA

The objectives of the study were:

- Use remote sensing images obtained from drones to detect defoliated areas in eucalyptus plantations.
- Using these images within defoliated areas, distinguish different classes of defoliation.
- Monitor the evolution of defoliation.
- Develop vegetation indices related to photosynthetic activity to monitor defoliation.

In February 2017, PLURIFOR partners involved in eucalyptus weevil risk (ISA, CETEMAS, TRAGSA and UVa) shared a protocol for *Large Scale Monitoring of* Gonipterus platensis *Using Unmanned Aerial Vehicles – Field Guide for the Evaluation of Defoliation Caused by* Gonipterus platensis *and the Measurement of Inventory Plots in Eucalyptus Plantations*. Remote sensing monitoring was performed according to this protocol, in similar stands in Spain and in Portugal, and using the

Portuguese field inventory methodology, that captures more information about this pest and its damage.

Flights were done with a fix-wing drone equipped with a Canon Powershot S100 camera and four sensors:

- RGB;
- RGB modified with a near infrared (NIR) filter;
- RGB modified with a red edge (RE) filter;
- Sequoia multispectral (RGB, green, red, NIR and RE).

The flight was defined for a 90% frontal overlap and 80% lateral overlap. Flight altitude was adapted to final resolution and to the sensors. The orthophotos' final resolution was 10 cm/pixel.

An area of 100 ha in Sever do Vouga region was defined to be flown. Two *Eucalyptus globulus* stands, with six and seven years old in second rotation (coppiced stands), were selected, one with high to severe defoliation and another with moderate to high defoliation. The first flight, in April, was done in the beginning of larval activity and before insecticide application. The second flight, in July, was done when defoliation was advanced. Field inventory was performed in six plots (three in each stand) two weeks before the second flight to validate remote sensing images used to evaluate the defoliation.

Preliminary results show that the defoliation level is directly related to the radiation captured by the sensor coming from the understory. If one of the objectives is to monitor the evolution of the defoliation of trees, all silvicultural interventions carried out in the field that result in a change in the "green surface" (e.g. weed cleanings) will influence the analysis of the images and the definition of the indexes of vegetation. For this reason, evaluation of defoliation by remote sensing must be accompanied by a field inventory. The up-scaling of this method will not be available in a short term.

Overall preliminary results on assessing defoliation with vegetation indexes

Covadonga Prendes, CETEMAS

Objectives

- Show the first preliminary results by the partners from Cantabria, Asturias and Portugal.
- Debate the orientation and methodology proposed by CETEMAS to change or improve them; all partners can contribute ideas and decide what will be the steps to be followed in the future.

The presented results are preliminary and may vary considerably along the project.

Concluded tasks

1. Remote sensing data and field inventory data acquisition: UAV: eBee RTK; sensors: S110 RGB, WX Sony RGB, S110 NIR, S110 RE, Sequoia multispectral.
2. Data processing to create reflectance maps of the different bands (red, green, blue, NIR, RE).

3. Vegetation indexes maps creation using the NIR camera (red and green bands: NDVI, NLI, IPVI, GNDVI, NGRDI, GCI, SAVI) and the RE camera, red and green bands: RENDVI, REGCI, MTCI.

Ongoing tasks

4. Assign a value of each index to the vegetation inside the plots: at individual tree level or at plot level.
5. Assess which is the most suitable index to predict the degree of defoliation within a eucalyptus stand.
6. Include the selected index (or indexes) in predictive models that can be used in the development of improved risk management plans.

Assign a value of each index to the vegetation inside the plots

There are two options:

- Assign an index value to each tree: from the central coordinates of each tree (obtained by centimetric accuracy GPS and total station), tree crowns have been delimitated trying two different radius: 0.25 m and 0.5 m. Vegetation index average value per tree is the average of all pixels belonging to a tree crown (pixel within the radius). The average value of the index for the plot is calculated as the sum of all the average values per tree.
- Assign an index value to each plot: the main issue is to eliminate the effect of the ground. A vegetation mask must be created using a soil index that classifies each pixel as soil or as vegetation. Index values are extracted from this vegetation mask and its average value is the average of all pixel values under the mask.

In both cases, damage inventory has to be performed on the field, with visual evaluation of eucalyptus weevil defoliation.

Assess which is the most suitable index to predict the degree of defoliation

Statistical analyses are under development. The preliminary analyses are trying to find differences in the average values of the indexes according to defoliation classes. The resulting indexes are also influenced by the used sensor.

Include the selected indexes in predictive models

Statistical analyses are under development.

Cantabria results

In Cantabrian plots, the eucalyptus weevil attack is weak so defoliation classes' values are unbalanced: all the trees with defoliation belong to the two first defoliation classes (out of seven) and some trees feature no defoliation (13%). For this reason value of NDVI does not show relevant variations between trees. The REGCI vegetation index seems to detect more variability inside the vegetation than the NDVI. Statistical analysis would be needed to confirm how well the index is performing.

Asturias results

As in Cantabria, in Asturian plots nearly all the trees with defoliation belong to the two first defoliation classes (84%; out of seven) and some trees feature no defoliation (9%). Only 6% of the trees show a higher defoliation level. Indexes using red edge band are able to distinguish between defoliation classes when the damage is strong. Because defoliation classes' values are unbalanced, the presence of extreme values of defoliation is very low.

Portugal results

In Portuguese plots, defoliation classes' values are more balanced. Only 7.5% of the trees are not defoliated, while 30% of the trees belong to the defoliation levels between 2 and 4. Levels 5 to 7 (the top three defoliation classes) are the most frequent, representing 62.5% of the trees within the plots. NDVI value changes notably inside plots with severe attack.

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.
- Comparison between sensors (Sequoia/modified cameras) Integration of data from different cameras.
- Possibility of develop an "improved index" which works better when the defoliation level is low.

Conclusions

Discussion among partners and associated partners

Moderated by Manuela Branco, ISA

Goal

Discussion about the potentialities of the news tools. Definition of the next steps to finalize tool developed under WP2; with partners and associated partners.

Discussion and decisions

After presentation of the attendees it was proposed and accepted to include two topics in the agenda:

1. Next steps for the development and conclusion of the new tool based on aerial images captured by UAV for monitoring *G. platensis*.
2. Update the existing risk management plans for *G. platensis* in a transnational scale.

Topic 1: Next steps for the development and conclusion of the new tool

It was discussed that the tools to be developed should meet the needs and objectives of the stakeholders. M. Branco indicated two possible main objectives for the forest managers:

1. To monitor defoliation on large areas in order to forecast productivity of the affected areas in combination with growth models;
2. To decide each year if a particular eucalyptus lot would be treated or not against the eucalyptus weevil in function of current defoliation status.

These two approaches will imply differences on the way of using monitoring tools.

J. Majada expressed that the tools could be used for both objectives. Preliminary results were very positive regarding the possibility to detect defoliation using remote sensing images collected by UAV in comparison with visual field observations. Still, there is work to be done on image analysis and to improve the most suitable indices. He added that Spanish forest companies would like to have a spatial-explicit tool to delimitate with a GIS the areas where quick treatment against the eucalyptus weevil is needed and that this tool would also inform forest managers if the most appropriate treatment is biological control or chemical control of the pest.

A. Reis (Altri Florestal) would like monitoring and sampling efforts to continue. She agreed with the two main objectives of the tool proposed by M. Branco. She added that the damage evaluation with the new tool would be needed yearly. This continuous evaluation would also be used to measure the efficacy and efficiency of the treatments in order to track the recovery of the plantation in the short term. She would also like, if possible, that the tool could predict the abundance of the eucalyptus weevil from climate or weather variables for long term forecast of the pest.

J. Majada and F.J. Lario informed that PLURIFOR partners involved in eucalyptus weevil risk are already searching for funding to continue the improvement of the tool. J. Majada added that there would be the possibility to continue the development of the tool during PLURIFOR project WP 3 and WP 4, possibly adding more UAV flights. F.J. Lario said that TRAGSA will do another flight in Galicia, in November, over a larger eucalyptus plantation area with more field variability in order to increase the robustness of the model. This flight could take place on autumn, when the damage is caused by the adult weevils; this information could be used as indicator of larval defoliation for the following year. TRAGSA has used a thermal camera in Galicia, while CETEMAS did not in Asturias. M. Branco said that in Portugal there will not be more UAV flights and all the data has been sent to CETEMAS to be analysed.

Then, it was discussed the timing, as the first version of the new tool should be presented in March 2018. M. Branco said that the tools will not be finished by April 2018. However, the description of the tool can be completed by April 2018. It was concluded that until then, under the PLURIFOR project the partners could present the guidelines explaining the tool, its application and how to use for monitoring eucalyptus defoliation by the weevil. In particular, the guidelines will indicate flight conditions, vehicle characteristics, cameras, type of sensors and vegetation indices that should be used to acquire information regarding defoliation levels.

According to J. Majada, for February or March it would be possible to:

1. Establish the working methodology for the capture of remote sensing images with flight plans;
2. Know how different inventory protocols affect the results, with a comparative study between the Spanish and the Portuguese inventory methodologies (the Portuguese methodology is more complete but more expensive);
3. Do the comparisons of different multispectral sensors that *a priori* can generate better information but maybe not better results. This is possible only in the case of Portugal because they have Sequoia and modified cameras. CETEMAS is currently working on the comparison of the flights done with both sensors.

It will not be possible to:

1. Know how the phenology influences the vegetation indexes;
2. Generate indexes that can be applied to all the regions of the project (Portugal, Galicia, Asturias, Cantabria).

Next steps will be developed by CETEMAS, finishing data analysis using vegetation index maps and data collected by the partners: assign a value of each index to the vegetation inside the plots, assess which is the most suitable index to predict the degree of defoliation within a eucalyptus stand, and include the selected indexes in predictive models for defoliation.

A document will circulate by February 2018 among the partners involved in this risk (ISA, CETEMAS, UVa and TRAGSA) in order to finalize the first draft to be sent then to associated partners.

Topic 2: Update the existing risk management plans

M. Branco informed that the initiatives started under PLURIFOR collaboration between Portuguese organizations (ICNF, CELPA) and Spanish ones were underway in order to develop a joint transnational plan for *G. platensis*. She also mentioned that the partners could develop two different plans. The first one, an operational plan that would inform forest managers about the preventive, monitoring, control and rehabilitation tools available and how to apply them. In this regard, the risk plan already developed by Cantabria is highly complete. A second type of plan would be a strategic risk plan for the Iberian Peninsula concerning the research fields and governance measures needed to be developed in order to minimize this forest risk. It was agreed that this second type of plan could be developed under PLURIFOR and it was proposed to be ready for April 2018, but this date is not definitive.

M. Branco was in charge of contacting the associated partner ICNF to get information about the Iberian plan under development.

General workshop evaluation questionnaire

Questions

Workshop content

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
1.	I was well informed about the objectives of this workshop and they were clear to me.			11	17		
2.	This workshop fulfilled my expectations.		1	9	18		
3.	The content is relevant to my job tasks concerning forest risks management.		1	11	16		
4.	The quality and depth of knowledge of this workshop were appropriate and represented state-of-the-art tools/technologies.		1	5	22		

Workshop design

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
5.	The workshop activities/case studies stimulated my learning.			10	18		
6.	The activities/case studies in this workshop gave me sufficient practice and feedback.		2	14	9	2	1
7.	It was easy for me to understand the messages of the professionals/lecturers, they were good communicators.		1	6	21		
8.	The pace of this workshop was appropriate.		1	7	20		

Workshop instructor/facilitator/lecturer

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
9.	The instructor/facilitator/lecturer was well prepared.			3	25		1
10.	The instructor/facilitator/lecturer was helpful.		1	6	22		

Workshop results

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
11.	I accomplished the objectives of this workshop.		2	5	22		
12.	I would be able to use the tools that I learned in this workshop on my tasks concerning forest risks management.	1	1	14	11	1	1
13.	The exchanges with other professionals/instructors/lecturers were fruitful and will be useful for accomplishing my tasks concerning forest risks management.			14	15		

Self-paced delivery

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
14.	The workshop was a good way for me to learn its content.			5	24		

Improvements and values

How would you improve this workshop? (Check all that apply)

_8_Provide better information before the workshop.
_2_Clarify the workshop objectives.
_1_Reduce the content covered in the workshop.
_5_Increase the content covered in the workshop.
_1_Update the content covered in the workshop.
_1_Improve the instructional methods.
_2_Make workshop activities more stimulating.
_1_Improve workshop organization.

___Make the workshop less difficult.
_1_Make the workshop more difficult.
_3_Slow down the pace of the workshop.
_1_Speed up the pace of the workshop.
_5_Allot more time for the workshop.
___Shorten the time for the workshop.
_4_Improve the tests used in the workshop.
_6_Add (more) video to the workshop.

What other improvements would you recommend in this workshop? *The order of the answers is not relevant.*

Separate attendees in work groups according to the subjects and work in groups to define the needs and propose possible solutions.

Add practical exercises.

Apply to the workshop and then disseminate practical material (graphics, video, etc.).

What is least valuable about this workshop? *The order of the answers is not relevant.*

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What is most valuable about this workshop? *The order of the answers is not relevant.*

Networking and exchanging with forest managers and scientists on the same problem. (5 opinions)
The amount of professionals and organisations with different backgrounds and perspectives meeting together to solve a common problem.
The presentation of the models and results.