

Fighting the Invisible Enemy

Early detection of bark beetle attacks in Romania to combat illegal logging and mitigate effects of natural hazards

The story

1 of the 9 Awardees of 2023

People from all Practices and Regions have been reviewing 71 applications from which 9 were selected



DESIGNING FOR IMPACT AT SCALE



<https://sites.google.com/wwfint.org/innovation-fund/awardees-fy23?authuser=2>

Project

- The project aimed to perform an appropriate assessment (DDS Due Diligence Systems) on salvage logging using remote techniques to identify spruce forests affected by bark beetle outbreaks that show a physiological decline.
- The instrument will offer
 - a transparent investigation /forecast of salvage logging authorisation, and
 - Furthermore, preventive measures (DDS) could be developed, both in terms of illegal logging and mitigating the effects of natural hazards;
 - It may be a relevant tool fit to be used at the national/European level



Project Summary

- **Context:** Bark beetle outbreaks affect forest structure and composition, nutrient cycling, erosion processes, reduction in carbon uptake, and increase the fire risk causing economic loss.
- **Specific problem:**
 - The infested tree goes through three stages of attack: green, red, and grey attacks. While in red and grey attacks the degradation of the tree needles can be observed visually by regular field observations (visible change in color), **during the green attack stage, the foliage remains green and is difficult to detect this stage by traditional ground field survey**
 - To preclude a mass outbreak, early detection of bark beetle infestation in the “green attack” stage is, therefore, a decisive step in forest management.

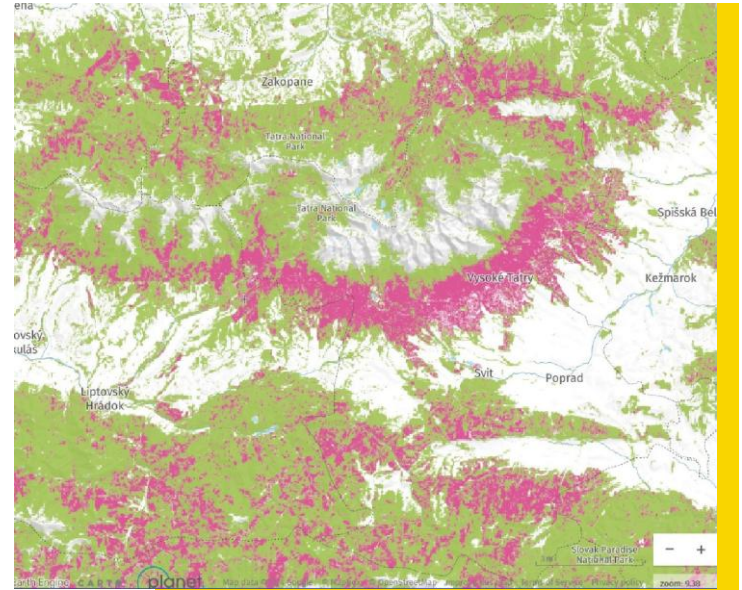


BARK BEETLE OUTBREAKS

Climate change is expected to increase the frequency and severity of bark beetle outbreaks in Europe. These outbreaks negatively impact forest resilience and biodiversity and affect forest structure and composition.

The “red” and “grey” attack stages occur after the new generation of insects has already flown.

Early detection of bark beetle infestation in the “green” stage is key to allowing urgent removal of infested trees.





Project's innovation

Multispectral sensors installed on flying drones

Early Detection

Remote sensing method using UAV equipped with multispectral sensors is able to cover larger areas in a relatively short period

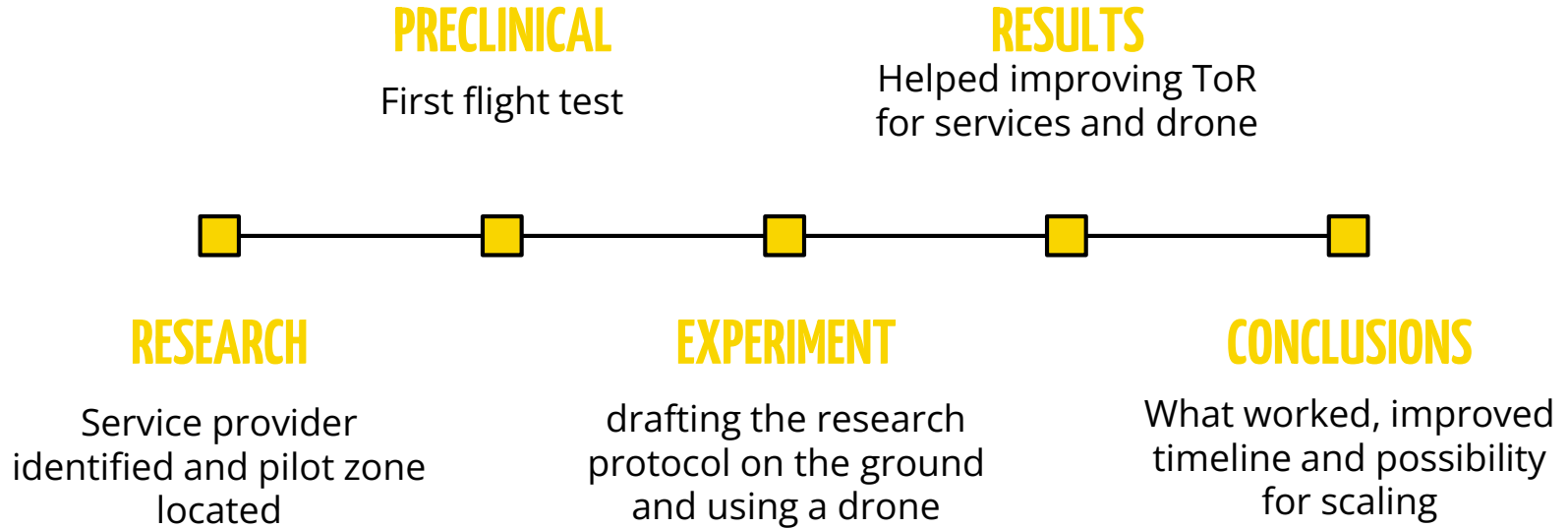
Automatized analysis

Aerial imagery and its automatic interpretation provide objective evidence for justifying salvage logging interventions

Prevents abuses

Objective documentation for the DDS prevents abusive harvesting authorizations and resolve controversial decisions

Project's steps



The team



The University of Agricultural Science and Veterinary Medicine of Cluj Napoca, Faculty of Forestry and Cadaster.

They have experts in entomology and remote sensing data collection and interpretation.



Technical findings were important in drafting a more sustainable MoF for the service contract

Test flight. Lessons learned. Moving forward.

- aerial remote sensing data collection (drone) can collect data from large areas (1,000 ha) at good resolution;
- standardised agricultural settings in terms of multispectral bands and standard NDVI calculation seem not to be the best approach since the results discriminate only between coniferous and broadleaf stands



Pilot site



Location

Altitude between 1067m and 1324m in the Black Sea 1975 elevation system.



Mount "Muntele Mare",
Valea Ierii Village, Cluj
county.

Forest

Surface area 47 ha,
composition 10 MO,
age 75 years,
relatively equien character.

Finding the instrument

Characteristics of the drone used for testing



DJI Mavic 3 Multispectral (or Mavic 3M) drone
Used for agricultural and forestry applications.
It has two cameras

RGB (visible) camera

1/2.8-inch CMOS sensor with an effective resolution of 5 MP.
The field of view is 73.91° ($61.2^\circ \times 48.10^\circ$) and has an equivalent focal length of 25 mm.
F/2.0 aperture, fixed focus



Multispectral camera

Four spectral bands: **Green (G): 560 ± 16 nm;** **Red (R): 650 ± 16 nm;** Red Edge (RE): 730 ± 16 nm; Near Infrared (NIR): 860 ± 26 nm



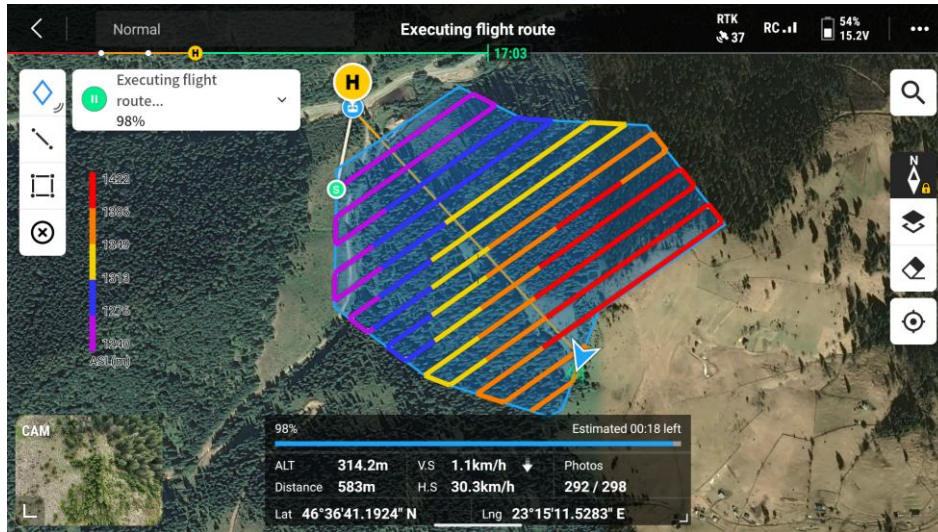
Tree with nameplate

Sample plots



Automatic flight plan

Flights calendar



zbor	data	ziua din an	nr zile intre zboruri
1	12 aprilie	102	-
2	26 aprilie	118	16
3	30 aprilie	122	4
4	10 mai	132	10
5	22 mai	144	12
6	7 iunie	160	16
7	12 iunie	165	5
8	27 iunie	178	13
9	21 iulie	205	27
10	9 septembrie	260	55
durata experimentului 103 zile			

Results

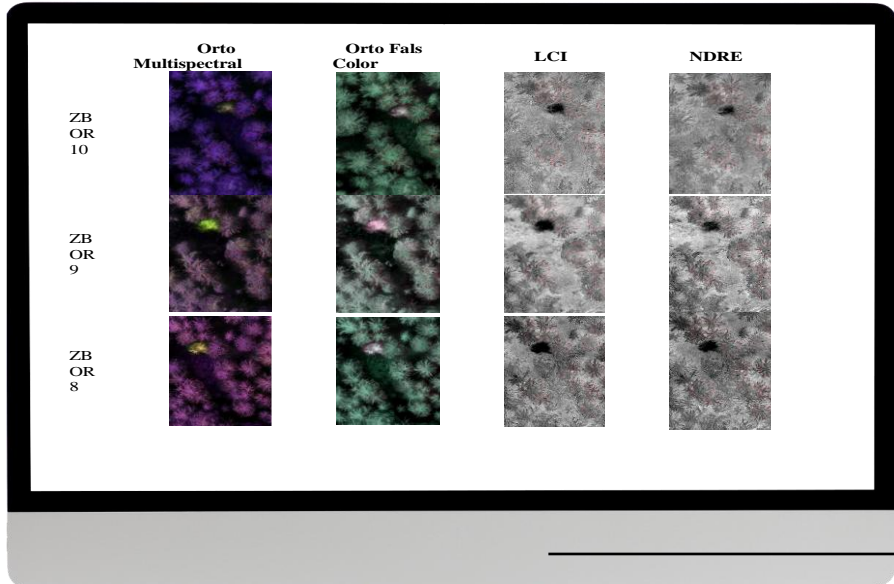
Thus, spectral reflectance values and vegetation indices calculated from orthorectified and radiometrically calibrated images were statistically analyzed by linear discriminant analysis (LDA) using IBM SPSS Statistics software, version 20.

The individual vegetation index values failed to capture significant differences between damaged and healthy trees, especially since they were intended to differentiate by symptoms class

Climatic context for the project period

Ziua	Temperatura medie (°C)	Temperatura maximă (°C)	Temperatura minimă (°C)	Precipitații medii (mm)	Viteza medie a vântului (Km/h)
1	14.7	20.7	11.9	0	15.6
2	9.4	12.6	2	0	8.1
3	5	10.2	0.7	4.83	7.4
4	4.6	7.3	1.9	0.76	5.4
5	8	12.7	3.8	0.25	5.7
6	9.6	13.6	6.2	0	6.7
7	9.7	15.1	6.4	1.52	5
8	10.8	17.6	6.6	0	4.6
9	14.6	20.9	8.7	0	4.1
10	15.1	20.9	11.3	0	5
11	14.3	19.5	11.5	0	4.3
12	13	19.2	8.7	0	4.6
13	11.4	16.7	7.5	0	5.6
14	13.8	19.4	8	0	7.8
15	15.7	21.2	12	0	11.3
16	11.9	18.7	7.5	0	9.6
17	0.7	12.2	-0.6	22.61	3.9
18	-0.9	1.5	-2.5	1.27	6.9
19	-1.5	3	-4.4	2.79	4.3
20	1.4	8.2	-3.9	6.35	4.4
21	2.9	8.9	-0.6	1.78	4.3
22	1.2	4	-0.5	8.64	1.7
23	3.6	10.4	-0.9	1.78	6.3
24	3.8	7.5	1	27.43	5
25	1.8	5.3	-0.3	2.29	2.6
26	3.6	9.6	-0.5	2.54	4.6
27	6.9	13	1.7	0	4.6
28	10.7	17.2	4.6	0	4.3
29	12.1	17.8	7	0	3.3
30	10.5	15.9	5.7	0	3.9
Media	7.9	13.4	4	84.84	5.7

Results



LDA classification of the images Flight 10 - Following cross-validation, **the detectability was 36.7%**

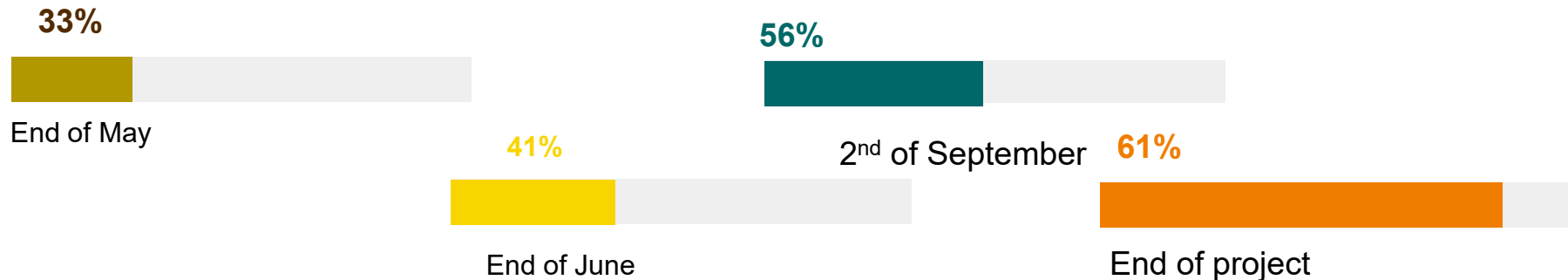
Visual raster analysis 3 operators, with only those trees confirmed by at least 2 of the operators being considered validly identified.

	Orto Multispectral	Orto to Fals color	Indicele de vegetatie LCI	Indicele de vegetatie NDRE
Imagini zbor 10 (2 septembrie 2024)				
Gradul de detectabilitate - GD%	49	59	54	57
Eroarea de detectabilitate -E%	29	27	35	43
Acuratetea detectarii -AC%	24	39	23	17

Results validation

The detectability of infested trees based on their spectral signature was limited primarily by the performance of the equipment used (**PA is directly related to the characteristics of the drone used**), which recorded values of 6% on the flight of May 5 and the percentage increases steadily until September 2 (21%).

The accuracy of the method (UA) - which is directly related to the adequacy of the classification algorithm used on the data set obtained, shows below values
the overall accuracy at this date is 61% (of the trees identified as affected only in this percentage are also validated from the ground)



Lessons

What can we learn and improve further??

Tips for improving the flights. What to avoid:

- shaded areas, as they can affect image quality and lead to errors in data processing.
- areas with substantial differences in level.
- rocky areas have been avoided as they disturb visibility and affect image quality.
- Areas with dense vegetation were avoided, as this can affect visibility and image alignment.
- areas with overhanging trees (canopy). Overlapping images can lead to errors in data processing.

TOOL – to be improved

Performance of the equipment used
Similar studies to the one in question show that increased detectability is achieved in the NIR band at wavelengths between 900 and 1200 nm

Circle of life and climate change

The first Beatles flight was atypical because it started earlier than in other years and was interrupted due to climatic conditions

Adaptability

Not realising the normal flight curve directly influenced the physiology of infested trees and indirectly the possibilities of early detection by specific means of remote sensing.

At the end

WWF's We conclude that better results in terms of both the number of trees detected and the period in which this is done can be obtained under similar conditions (terrain and facilities) in the situation where we are dealing with very strong infestations, characteristic of the progradation phase, when the response of trees is much more uniform, but over a period of about 2 years

TO BE CONTINUED...

Next steps

Identify funds

Improve the instrument

Include in the team with other interested
persons or universities

Extend the periods for performing the analysis



The highly promising
idea for scaling

Communicating the story and results



The Problem: Bark beetle outbreaks

The European spruce bark beetle (Ips spp) causes major economic loss and has a negative impact on forest biodiversity. Additionally, bark beetle outbreaks affect forest structure and composition, nutrient cycling, erosion processes, reduction in carbon uptake, and increase the fire risk. An increase in the frequency and severity of bark beetle outbreaks is also expected due to climate change.



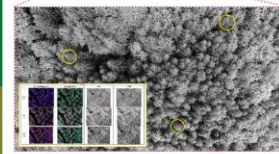
Multispectral sensors mounted on flying drone to detect the "green attack" stage



The Concept: Early detection of the infestation

Early detection of the infestation at the green attack stage, when the trees hold the most generation of beetles, allows for targeted removal of infested trees, preventing further outbreaks while healthy trees may remain in the habitat.

The first instrument available for an appropriate assessment (DCS Data Diagnosis System) on salvage logging using remote sensing techniques for identification of mature forests affected by bark beetle outbreaks that show a physiological decline.



Innovation of the project

Classical method to inspect forest health involves ground-based forest surveys. These surveys are very laborious, are costly and therefore are not feasible and hard to apply, besides being highly sensitive to weather conditions. The use of flying drones is a more efficient way to inspect forest health, allowing surveying and targeted management interventions.

Appropriate assessment (DCS) of salvage logging using the remote sensing technique for identification of mature forests affected by bark beetle outbreaks is thus contributing to effective decision making for a responsible forest and protected areas management.

Scaling strategy

The project aims to scale out this innovative early detection instrument from the pilot site region to the national level in Romania and also at a larger geographical scale to countries in Central Eastern Europe (CEE) countries who have this same problem and associated risks of salvage logging.



Inspiration Gallery

<https://sites.google.com/impacthub.net/innovation-wwf/inspiration-gallery>

The project was presented by USAMV during the poster presentation, part of the 23rd International Conference "Life Sciences for Sustainable Development", Cluj-Napoca, Romania, between 26th– 28th September 2024

EARLY DETECTION OF BARK BEETLE INFESTATIONS OF SPRUCE STANDS, USING MULTISPECTRAL UAV IMAGERY. CASE STUDY FROM VALEA IERUI, CLUJ COUNTY

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Introduction

Considering the evolution of technology and current concerns in forestry, the use of new UAV technologies is required to help implement forest ecosystem management systems (Kaste et al., 2024). These non-invasive remote sensing techniques can significantly contribute to increasing the efficiency of pest control actions (Hua et al., 2023). The present work aims to highlight the advantages and disadvantages of using multispectral imaging techniques along with UAV platforms, in solving the complex problem of spruce stands caused by bark beetle attacks.

Material and method

The study was carried out in a 25-year-old spruce stand, located in the area of the Mădăc, Mare massif in the Western Carpathians, where seven experimental areas of 30 trees were placed.

Trees were monitored from the ground and from the air with a Mavic 3 Multispectral UAV platform. The study lasted approximately monthly between 12.09.2024 - 10.09.2024.

The monitoring of the bark beetle attacks was carried out by an flight and taking multispectral photographs, simultaneously with the inventory from the ground, according to some well-established criteria.

Results and discussions

The inventory of infested trees, carried out at ground level, identified three according to the degree of damage, using the following scale: 0 - healthy trees, 1 - slightly infested, 2 - moderately infested and 3 - severely infested.

The classification of the images was carried out by a discrimination analysis, an advanced statistical method used to differentiate and classify objects according to the observed variables.

Conclusions

From the analysis of the collected data for the entire sample of 210 control trees, it was observed that, at the end of the monitoring period, 77% of the trees (162 trees) showed signs of infestation. Of these, 37.6% had a poorly highlighted symptomatology, 21.4% were characterized by moderate symptomatology and 18.2% had strong and distinct signs of attack, clearly illustrating multiple symptoms of severe bark beetle infestation.

References

Hua L., Person H.J., Lambert E. (2024). Early detection of forest stress from European spruce bark beetle attack, and a new vegetation index: normalized distance red & SWIR (NDIR). Remote Sens. Environ. 255, 112240.

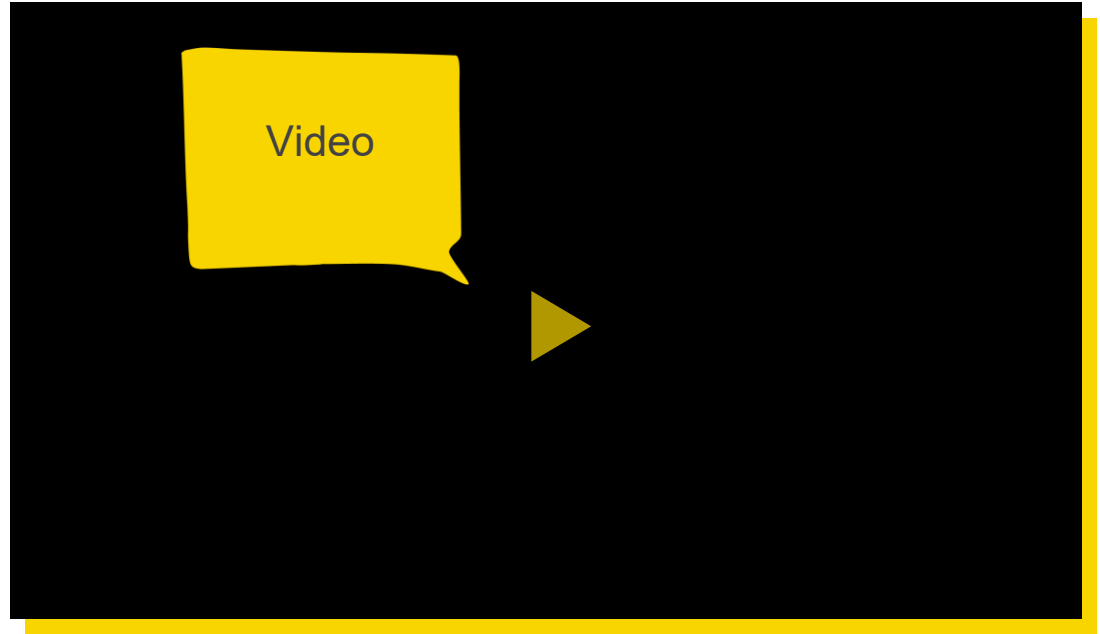
Kaste M., Fiebig P. Aides 2024. Early detection of bark beetle (Ips typographus) infestations by remote sensing-A critical review of recent research. Forest Ecology and Management. Elsevier.

Acknowledgements

This research was funded by the WWF Romania.

THIS IS A VIDEO!

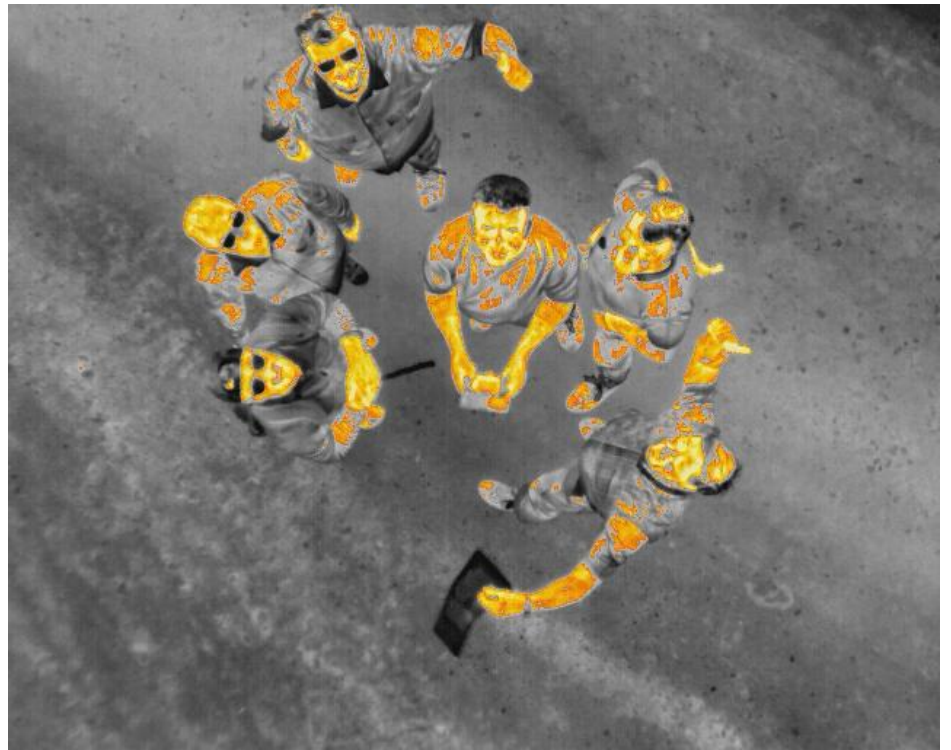
Apart from the 2 workshops organized by WWF Romania, the project team together with Innovation team managed to finalise





**Bark
Beetle**

Thank you!



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