Interreg CENTRAL EUROPE

Co-funded by the European Union

RE-ENFORCE

Deliverable 2.4.3

Web-based visual display and documentation of Pilot Actions via 3D model from drones

Version 1

05 2026

Introduction

One of the dissemination outputs of the RE-ENFORCE Project is the creation of web-based 3D models of the Pilot Actions (DT2.4.3), with the specific aim of showcasing to the general public the six forest degradation drivers studied, and the restoration actions implemented by the Project Partners to mitigatetheir effects.

These models were created through the digital combination of imagery acquired through Unmanned Aerial Systems (UAS), commonly known as drones. The use of these close-proximity aircrafts enabled a very detailed reconstruction of the Pilot Action Areas, making it possible to focus on the restoration interventions. The process used was Structure-from-Motion (SfM), a well-established method that derives 3D models from overlapping 2D images (see the Methodology section for more details).

A 3D Web viewer was chosen to provide the best usability for the general public. In addition to the 3D models, each Project Partner provided information on the restoration actions implemented in their Pilot Actions, complementing the visual content with relevant scientific information.

Methodology

The Interreg Central Europe Project RE-ENFORCE identified six major drivers of forest degradation in Central Europe: ash dieback caused by *Hymenoscyphus fraxineus* Baral et al. (2014); extreme drought; forest fires; improper management of riparian forests; bark beetle (*Ips typographus* Linnaeus, 1758) outbreaks; and windthrows.

Accordingly, six Pilot Actions (PA) were implemented to study possible interventions to counter forest degradation. For each PA, one or more Pilot Action Areas (PAA) were identified, i.e., forests where the interventions were tested. For each PAA a 3D model was created, for a total of 15 models.

- PA1 Ash dieback, Duna-Drava National Park (HUN), 2 PAAs: Babócsa, Berzence
- PA1 Ash dieback,Trebel (DEU)
- PA2 Drought, Jastrebarsko (HRV)
- PA2 Drought, Plzeň (CZE)
- PA3 Forest fires, Myszyniec (POL)
- PA3 Forest fires, Taibon (ITA)
- PA4 Riparian forest management, Duna-Drava National Park (HUN), 2 PAAs: Dunaszekcső, Bár
- PA5 Bark beetle outbreaks, Horn (AUT), 3 PAAs: Horn 1, Horn 2, Horn 3
- PA6 Windthrows, Torun (POL), 2 PAAs: Rytel 1, Rytel 2
- PA6 Windthrows, Malgonera (ITA)

The process of creating the models is the Structure from Motion[1,2] (SfM), a well-established method to reconstruct 3D models from 2D pictures shot from different locations. In the case of SfM on UAS data, this consists of combining pictures shot at short intervals while the drone flies. All the process is nowadays managed through a flight plan, to ensure a consistent and complete cover of the studied area (i.e., enough overlap between the pictures).

[1] https://en.wikipedia.org/wiki/Structure_from_motion
[2] https://youtu.be/i7ierVkXYa8?feature=shared

Once a sufficient number of images is collected, dedicated software can process them, identifying the common features ("tie points") that allow two images to be matched. The distortion between these two pictures is then further analysed to render the depth, or third dimension, of the surveyed area (Fig. 1).

Fig. 1: Successive pictures shot by UAS. In red, possible tie points (managed internally by the software). In blue, the difference in tree height between pictures-tree length, in 2D-enables its 3D reconstruction.

The software used to process the images was Agisoft Metashape (v. 2.3 Pro). The output were tiled models, that is, 3D models representing the terrain and the vegetation surface, optimised for viewing in browsers. This output was the most relevant for the scope of dissemination. The procedure used is similar to that suggested in the software tutorial , with modifications to meet the project requirements.

The tiled models were then loaded in the ESRI Scene Viewer platform, and diffused as a Web Experience App. This service is particularly useful for storing and managing data, and for creating user-friendly viewers with a good degree of customization.

In addition, Scene Viewer works as a complete GIS, allowing the attachment of additional information (vectorial files, …). This capability was used to showcase the interventions to the users, because often not evident from just the 3D model (Fig. 2).

The geolocation of the 3D models was possible through the GNSS module present in the drone itself, or through the localization of Ground Control Points (GCPs), associating their position with that recorded with a GNSS antenna. In both the cases, the final tiled models of the PAAs had a final reprojection accuracy in the order of 10-2 m. The horizontal resolution of the tiled models was set to 10 cm, as a compromise between visual quality and storage requirements. Most flights were carried out with the DJI Matrice 4T Enterprise3 of PP8 (UNIPD), except for the PAA Jastrebarsko (HRV) and the PAA Trebel (DEU) where the survey was performed with a DJI Mavic 3 Multispectral4 and a DJI Mavic 2 Pro5, respectively. An additional acquisition for PA4 (DDNP) will also be performed with a DJI Mavic Air 3[6] to capture the post-intervention forest structure.

[3] https://enterprise.dji.com/en/matrice-4-series/specs
[4] https://https://ag.dji.com/it/mavic-3-m/specs
[5] https://www.dji.com/it/mavic-2/info#specs
[6] https://www.dji.com/air-3/specs

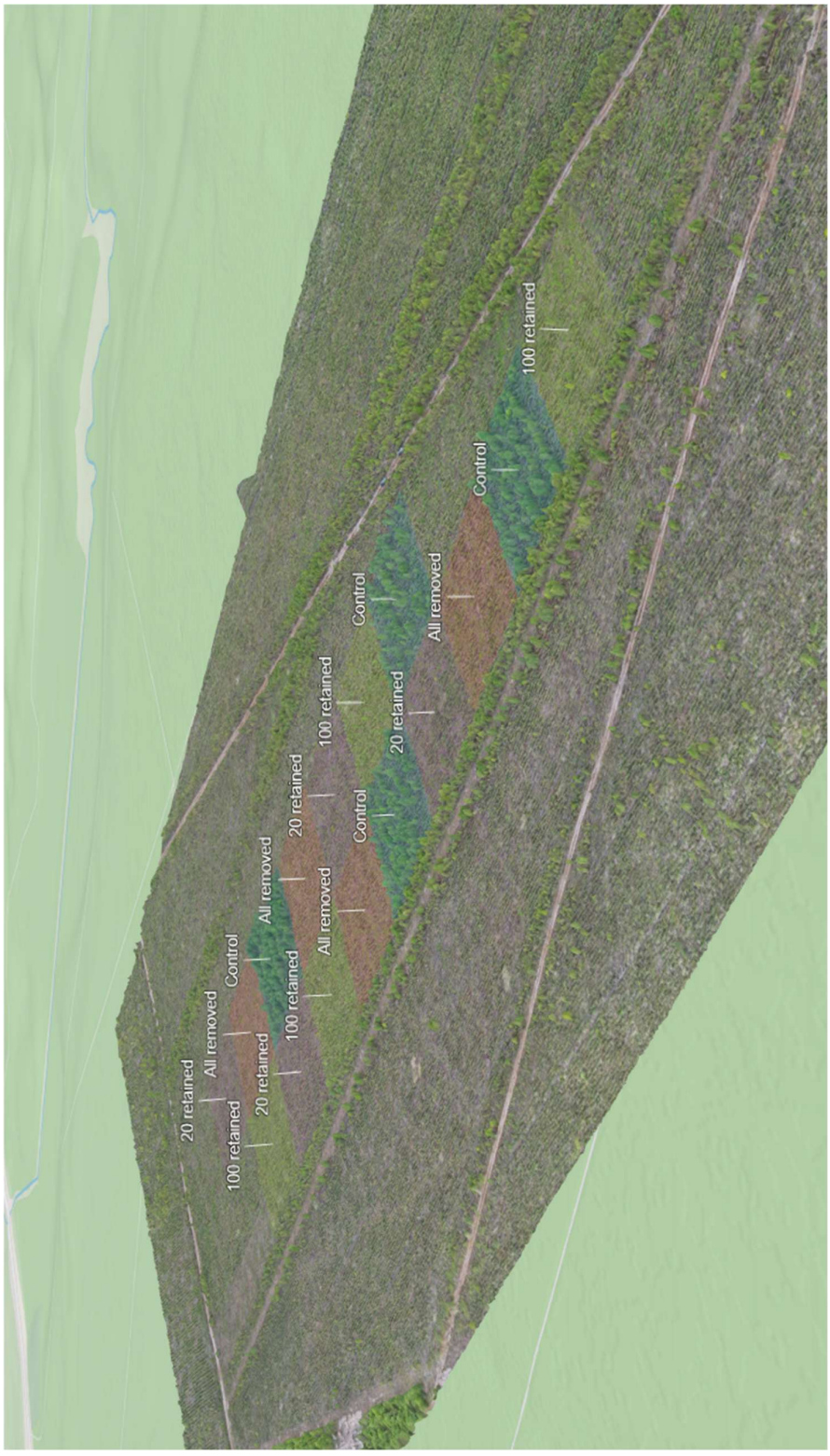

Fig. 2: Not all information can be transferred with the 3D models. Callouts and polygons helped define the type of intervention applied in the Pilot Actions.

The web viewer will be updated and maintained throughout the project duration to improve its functionality. It is planned to implement more detailed 3D models for selected PAAs created using handheld cameras such as smartphones (Fig. 3). This option is considered in case the interventions are not clearly visible from drone pictures, and are single-tree tailored. The results will be disseminated through the same web viewer as attachments to the main 3D models.

Fig. 3: For small details 3D reconstruction (e.g., tree saplings), the pictures used in SfM can be shot with a smartphone at a close distance.

Results

The 3D Web Viewer with all RE-ENFORCE 3D models can be accessed at this link (Fig. 4):
https://experience.arcgis.com/experience/89816b560c344e5caf718b9d983c10a7

In case of problems or difficulties with the web viewer, please contact PP8 for support:
forestdynamics.lab@gmail.com

Acknowledgments

A special thanks goes to the RE-ENFORCE colleagues who autonomously acquired UAV images in their Pilot Action Areas: Robert Bogdanić, Sztellik Endre, Eric Thurm and Wöhlbrandt Anna. The advice of Roberto Rossi (UNIPD-Geoscienze) was fundamental in the fine tuning of the 3D Web Viewer, and in the optimisation of data storage and processing.

Fig. 4: 3D Web Viewer of the Pilot Actions of Re-Enforce.