D2.8 es

Report on Web application for ML's management; **Executive Summary**

***MAIL**:* Identifying Marginal Lands in Europe and strengthening their contribution potentialities in a CO_2 sequestration strategy

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[1] **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

[2] **PU** = Public, **PP** = Restricted to other programme participants (including the Commission Services), **RE** = Restricted to a group specified by the consortium (including the Commission Services), **CO** = Confidential, only for members of the consortium (including the Commission Services).

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ABBREVIATIONS

Term	Explanation
API	Application Program Interface
CEN	European Committee for Standardization
CSS	Cascading Style Sheets
DNS	Domain Name System
DSS	Decision Support System
FTP	File Transfer Protocol
GML	Geography Markup Language
GEE	Google Earth Engine
GUI	Graphical User Interface
HTML	HyperText Markup Language
HTTP	Hypertext Transfer Protocol
IP	Internet Protocol
ISO	International Organization for Standardization
ML	Marginal Land
OGC	Open Geospatial Consortium
P2P	Peer to Peer
PHP	Hypertext Preprocessor
SaaS	Software-as-a-Service
SDI	Spatial Data Infrastructure
SGML	Standard Generalized Markup Language
TCP	Transmission Control Protocol

W3C	World Wide Web Consortium
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service
WPS	Web Processing Service
XML	eXtensible Markup Language

Contents

1. Introduction

This document summarises the work done on the task T2.9 “Web application for MLs’ management”. The main objective of this task is the development of a web-GIS portal, which resides together with ***MAIL***’s website. The portal created uses specific sets of previously developed computational algorithms in the WP2 to:

- Generate several semiautomatic classifications of Marginal Lands (ML).
- Produce thematic maps.
- Assist in Decision making for MLs management

This portal is open for public use and allows users (even no experts in remote sensing techniques) to perform a variety of studies on MLs. For this purpose, a Decision Support System (DSS) was designed in the task T3.4, which was embedded in the web-GIS portal to allow end-users to determine the best possible way to visualize, monitor and sustainably utilize MLs, and also to draw conclusions and decision-making, in field of forest management, planting etc.

Moreover, in the ***MAIL*** Map Portal, tools designed and developed within multiple project tasks that also incorporated into the Portal, such as;

- Carbon Sequestration Capacity (CGC) Groups – Task 2.7
- Enhanced marginal land map – Task 2.9
- Carbon prediction – Task 4.2
- Carbon calculations – Task 4.2
- Cost calculator – Task 4.2
- Multi-temporal Analysis – Task 4.4

More details about the project and its deliverables can be found at marginallands.eu.

Also a specified community is opened in Zenodo repository titled “Identifying Marginal Lands in Europe and strengthening their contribution potentialities in a CO2 sequestration strategy”.

2. Marginal Lands Definition According to ***MAIL***

This chapter comes from the Deliverable 2.1 of ***MAIL*** (Abad & Felten, 2020) where the marginality is described from the point of view of ***MAIL*** ***consortium***

Taking into consideration that the definition of marginal land is the basis on which the ***MAIL*** project will be developed, the definition must meet the following objectives:

- Collect the relevant scientific aspects related to marginality as described above.
- Be compatible with, and collect the objectives of the ***MAIL*** project

The definition should include the following aspects:

1. Marginality is caused by various constrains.
2. The definition of marginal lands should integrate environmental, economic and social factors as all of them are causes of marginality. A definition of marginal lands that is only based on environmental parameters (i.e. biophysical factors) is not complete from a theoretical point of view.
3. Dynamic and variability of marginal land should be explicitly included in the definition:
   a) Dynamic from a temporal point of view.
   b) Scale and location dependent.
4. The definition must consider specific restrictions of the ***MAIL*** project, according to the project's goals.
   a) From the full set of marginal lands detected, those more relevant for the emission accounting system as stated in LULUCF regulation, should be considered as ***MAIL's*** marginal land.
   b) Agricultural lands will be excluded from ***MAIL*** marginal lands, avoiding the generation of new pressures on this use.
   c) Protected areas will be excluded from ***MAIL*** marginal lands, to avoid conflicts with environment conservation.
   d) Other local uses should be taken into account (i.e. extensive livestock or tourism).

To sum up, marginal lands for the ***MAIL*** project are:

Lands with significant, either environmental (biophysical variables) or socioeconomic, constraints and with potential to impact national accounting for C stock, excluding agricultural lands and other valuable areas (protected areas,

uses with local importance etc.). Dynamic and variability are key concepts for marginal land identification.

Examples of these areas include, but are not limited to, degraded and / or abandoned lands, lands with naturally low productivity due to biophysical constraints, and other degraded lands that have not (yet) been converted to other uses, e.g., post-industrial and post-mining sites.

In a complement approach, fully consistent with the *MAIL* project objectives, we will consider Marginal Lands those whose land use allows, according to accounting rules referred in the EU commitment and the regulation developed (European Parliament. Regulation (EU) 2018/841**) and land use categories proposed by the 2006 IPCC guidelines (IPCC. (2006)), to maximize the increase of carbon stock. That is, *MAIL* project will focus on areas in which it is possible to convert them to forest lands (Land Converted to Forest Land: *afforested lands*).**

Therefore, it can be considered Marginal Lands, grasslands (including systems with woody vegetation which do not comply with minimum values for the variables specified in the Annex II for each country), abandoned croplands or other lands (bare soil, rock, ice, etc.), excluding from them those with social-economic activity, environmental protection or with legislative restrictions.

The figure below shows the flow chart that represents the transition between marginality and the definition on marginal lands in the framework of ***MAIL*** project.

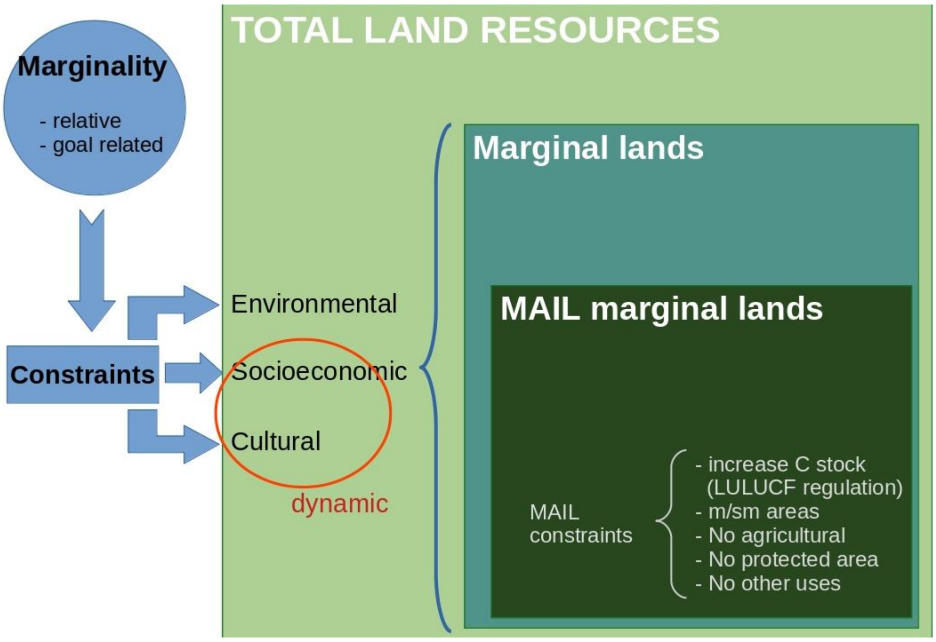

Figure 1: Transition between marginality and the definition on marginal lands in the framework of MAIL project.

3. MAIL MAP PORTAL

As a final solution for the developed Map Portal Google Earth Engine was selected. Due to the extent, size and resolution of the data, as well as for compatibility with the numerous different modules that developed during ***MAIL***'s lifetime geoportal, this task implemented on Google Earth Engine (GEE).

Furthermore, GEE as a cloud-based platform for planetary-scale geospatial analysis and massive computational capabilities allowed multiple developers (***MAIL*** secondees) to collaborate easily and to avoid compatibility issues of different tools.

The final version of ***MAIL*** Map Portal was implemented in Google Earth Engine environment and contains 3 main parts:

1. a searching window
2. map
3. tools panel

In the following subchapter, the main functionality of the portal will be described.

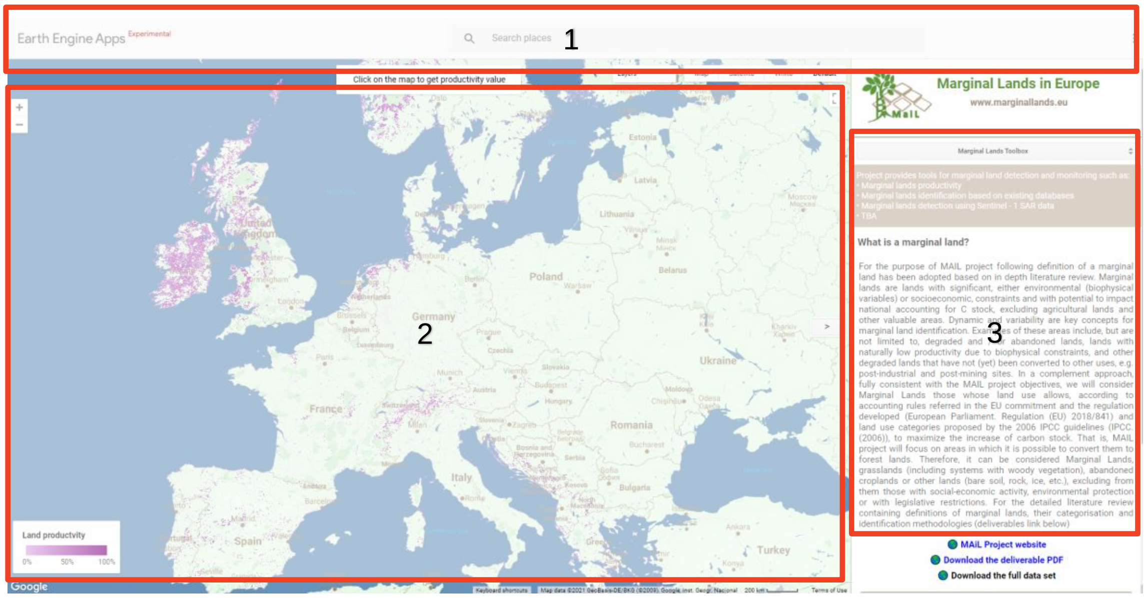

Figure 2. *MAIL* Map Portal components.

3.1 Basic functionality

Following the Panel with Map, the Tools panel and the searching window will be described.

3.1.1 Panel with Map

3.1.1.1 Productivity layer

The default layer which is displayed when user enters our portal contains the layer called “Marginal Lands productivity”. It’s pan-European layer, developed within Task 2.3. The only difference comparing to the original result is that in geoportal, values are scaled to the range 0-100%.

Figure 3. Layers available in *MAIL* Map Portal.

3.1.1.2 Productivity Classes

The second precomputed layer, available in geoportal is called “Productivity classes” with DOI: [***10.5281/zenodo.5809011***](https://doi.org/10.5281/zenodo.5809011).

It contains the layer described in previous chapter, but the values are divided into 3 classes:

- Class 1: areas with high suitability for afforestation
- Class 2: areas with moderate suitability for afforestation
- Class 3: unsuitable areas

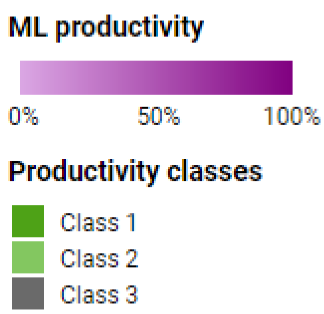

Figure 4. Legend with colours explanation for two layers available in *MAIL* Map Portal.

3.1.1.3 *Carbon Sequestration Capacity Groups*

Carbon Sequestration Capacity (CSC) Groups is the resulting layer from the development of the methodology regarding classification of MLs into CSC groups, as described in D2.6. From Group A to Group E, classification was done from higher to lower sequestration respectively with DOI: [10.5281/zenodo.5808901](https://doi.org/10.5281/zenodo.5808901)

Through this classification we get a better understanding regarding the relative interconnections between groups and each one's potential trend. In Figure 5 the percentage of the five CSC classes of all MLs of Europe are presented in a relative pie chart, followed the histogram.

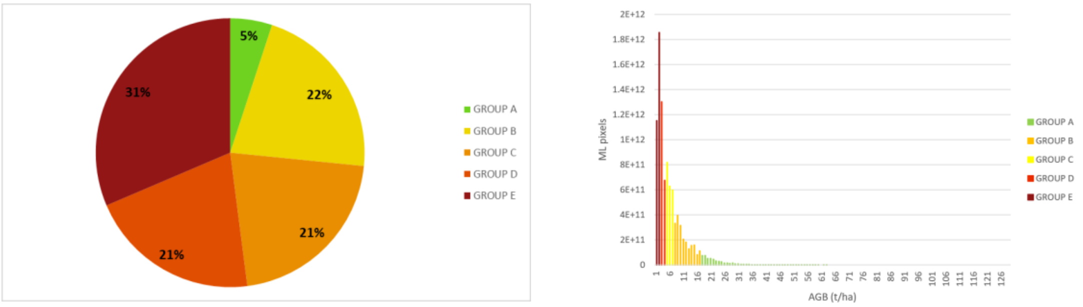

Figure 5. Relative Pie Chart and Histogram of 5 CSC classes for MLs of Europe.

In the Figure 6 the results of an indicative Area of Interest are presented.

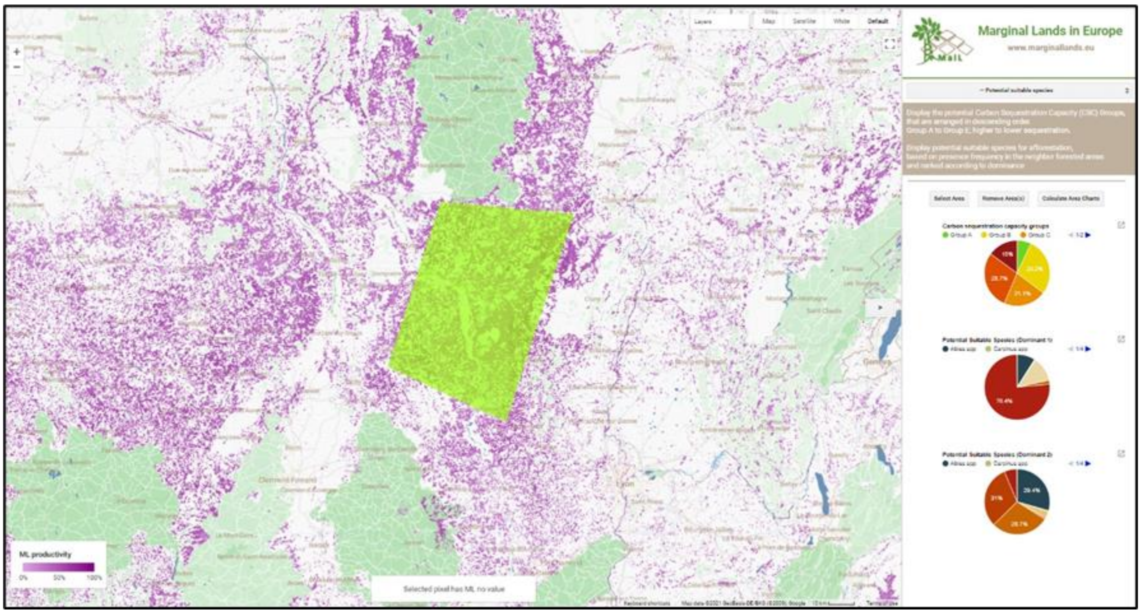

Figure 6. Example of Carbon Sequestration Capacity groups identified for selected Area of Interest.

3.1.2 Panel with Tools

The right part of ***MAIL*** Map Portal is dedicated for the tools related to identification of marginal lands and DSS. In the top-right (Figure 7), list of tools is available. Each tool has short description about its functionality. Detailed explanation how to use them is available in the form of pdf manual.

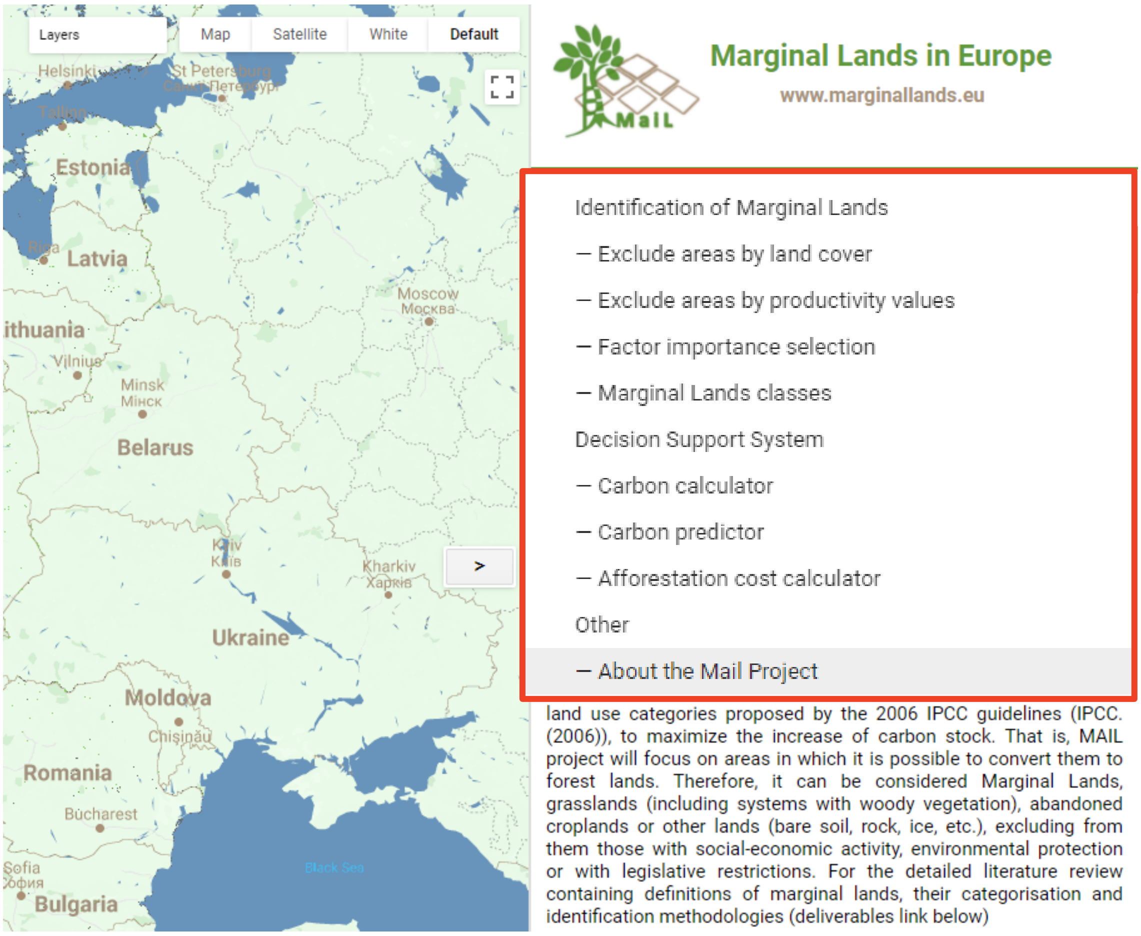

Figure 7. Panel with tools developed within *MAIL* project and available in *MAIL* Map Portal. (Demo mode, December 2021)

3.1.3 Searching window

The default extent of map contains the whole Europe. User can manually zoom into specific area of interest or use searching window (Figure 8) and type geographical name to define the area to be displayed.

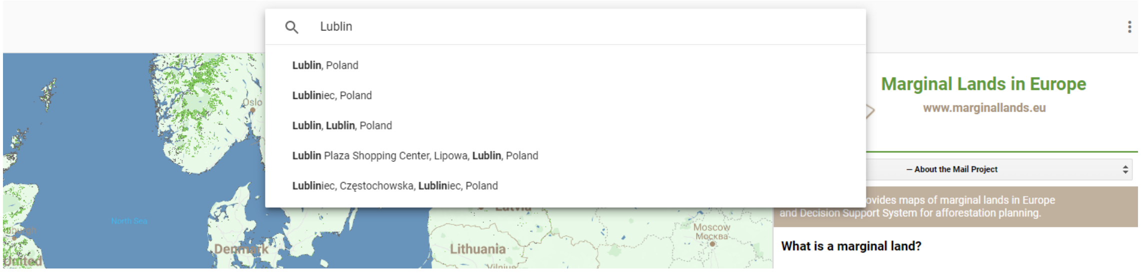

Figure 8. Searching window of *MAIL* Map Portal.

3.2 Identification of Marginal Lands

3.2.1 Exclude regions by land cover

Creating the final map we excluded some land cover land use classes because by definition they can’t contain marginal lands. However, maybe, for some reason, you don’t want to exclude for example protected areas or peatbogs. To change it, just choose the tool called “exclude regions by land cover”.

This section allows for the generation of the “HardLayer mask” based on a list of land covers. The land cover list is composed by: forests, protected areas, changed areas, impervious, marshes, peatbogs, permanent snow-covered surfaces and water bodies. The Hard Layer mask is applied on the Soft layers and it can be dynamically operated using check boxes.

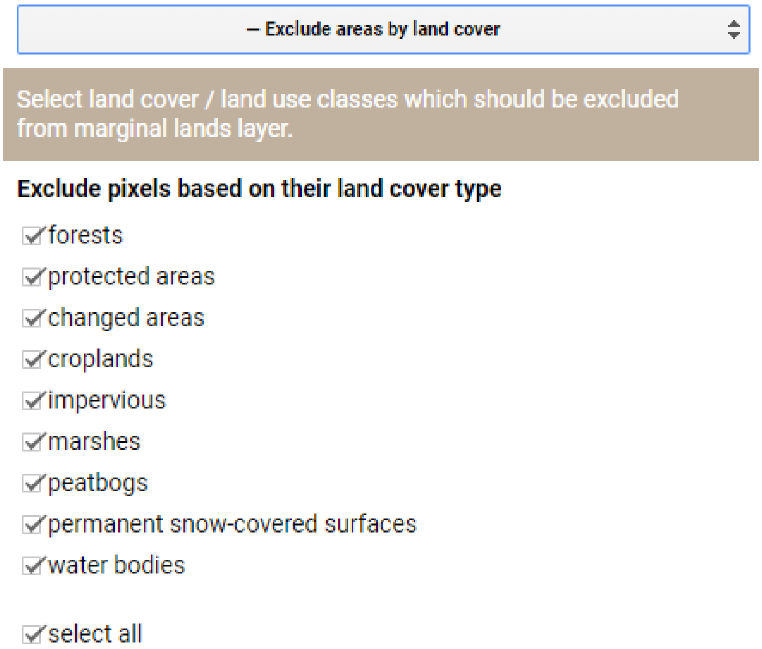

Figure 9. Tool for exclusion of land cover classes.

3.2.2 Exclude regions by value

Allows the user to filter marginal lands based on their productivity value. Productivity is obtained by calculating a weighted overlay for the weights and rankings applied for the soft layer variables. Both the weights and rankings are explained in the deliverable 2.3. Finally, productivity is standardized to get a relative scale (in %).

If you want to display only pixels with high productivity, let's say above 50%. You can do it here. Enter your threshold and click Apply. You can notice that now we can see fewer pixels than previously.

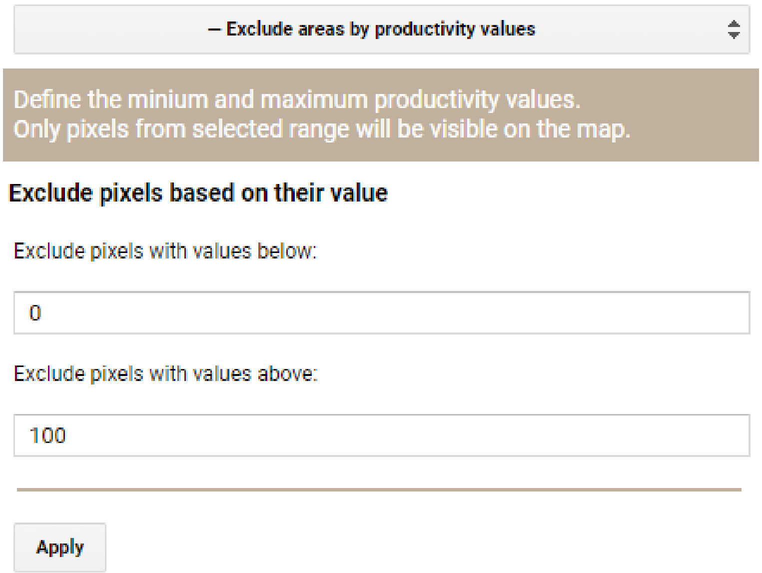

Figure 10. Tool for selection productivity values range.

3.2.3 Factor importance selector

As you know, our product is based on 3 types of factors. First relates to terrain and soil, the second to sustainability and the third to productivity. In each group there is a list of parameters. Here you can decide how important they are for the final value. You can modify them and click Apply or reset to the default values which are adjusted according to our methodology. More detailed explanation of parameters and their weights can be found in D2.3.

Here, the user can assign the weights to each soft layer and evaluate the overall relative importance over the rest of the variables. The value assignment can be done in 2 ways: individually (for each soft layer) or by groups of soft layers. The groups classify the soft layers in Terrain and Soil, Sustainability and Productivity. The default weights used for each variable are collected in Table 1.

Table 1: List of soft layers and associated weights applied for the area of Europe.

Groups	Variables	Weight
Terrain and Soil	Slope	0.17
	Depth available roots	0.18
	Stoniness (subsoil)	0.03
	Stoniness (topsoil)	0.03
	Texture (subsoil)	0.045
	Texture (topsoil)	0.045
	Clay (subsoil)	0.015
	Clay (topsoil)	0.015
	Sand (subsoil)	0.015
	Sand (topsoil)	0.015
	Total available water (subsoil)	0.02
	Total available water (topsoil)	0.02
Sustainability	Soil acidity	0.09
	Soil erosion	0.06
	Flooding	0.04
	Sodicity	0.03
	Toxicity contamination	0.03
	Natural toxicity	0.02
	Dryness	0.02
Productivity	Soil organic matter (subsoil)	0.03
	Soil organic matter (topsoil)	0.03

Groups	Variables	Weight
	Caption exchange capacity	0.03
	Productivity (forest)	0.01
	Productivity (grass)	0.01

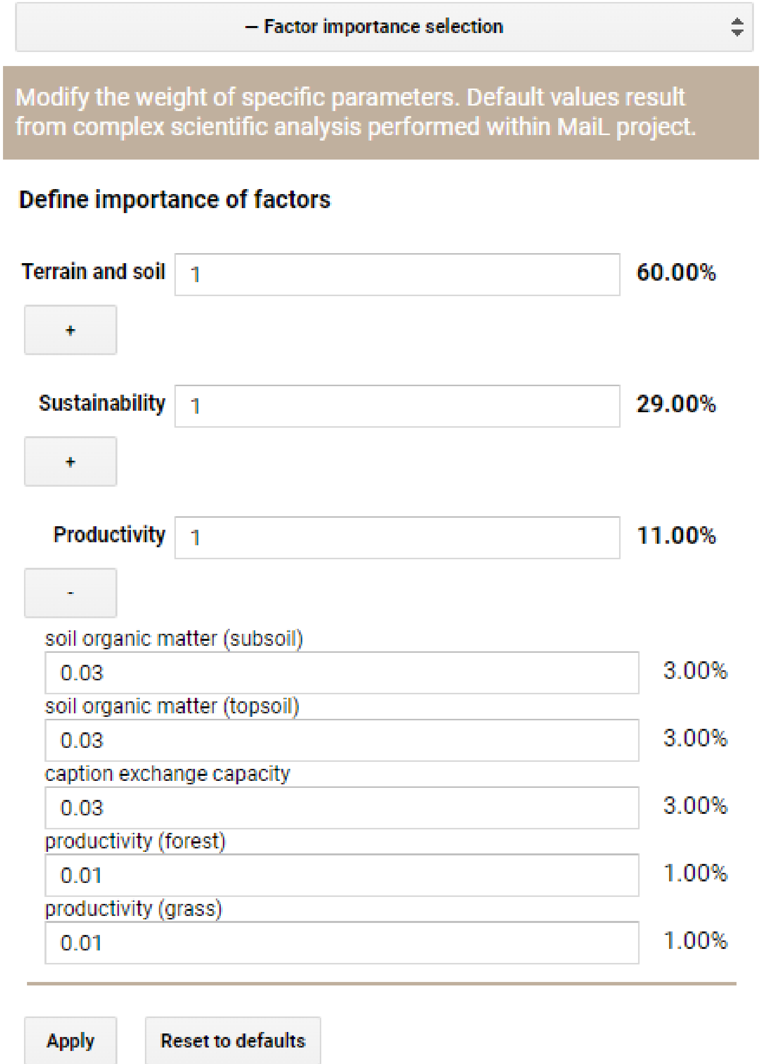

Figure 11. Factors importance selection tool. Layers are grouped into 3 categories.

3.2.4 Productivity classification

Here you can choose how our final values are divided into 3 classes. You can enter the threshold values manually, use the percentiles in two ways or divide it equally into three zones. In this tool we have additional options. We can perform the division for a specific country or even specific region of the selected country. If our area of interest differs from official borders, we can draw it manually using an option called “select area”.

You draw one or more polygons and click Apply. One additional feature is the histogram for the area which you selected.

On this figure you can see how often specific productivity values occurred in the area of interest. The plot can be downloaded as a vector or raster image or in the form of a table with values.

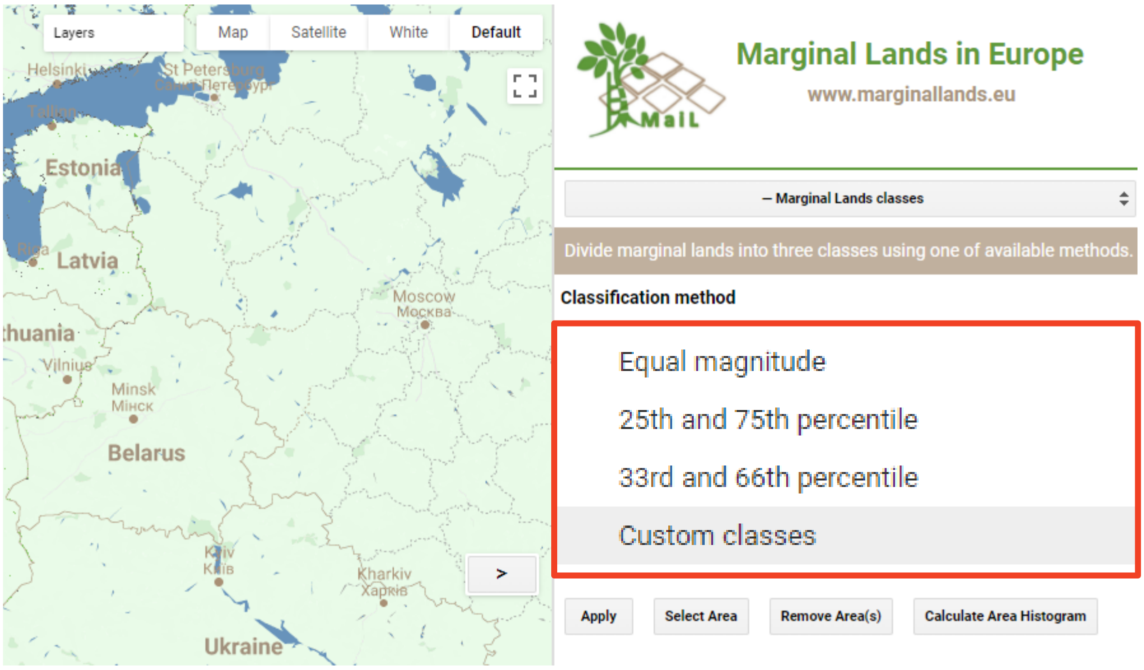

Figure 12. Classification of marginal lands tool.

Marginal land Classes: Divides the marginal land productivity values in 3 classes assigning 2 thresholds defined in 4 different ways:

- Equal magnitude: takes the maximum productivity value and divides it by 3 and classifies the rest, using this value as the amplitude for each class
- 25th and 75th percentiles: uses as threshold values the 25th and 75th percentile of the productivity value distribution
- 33rd and 66th percentiles: uses as threshold values the 33rd and 66th percentile of the productivity value distribution

- Custom classes: the user inputs percentage values that will be use as the breaking values for the classes definition.

Moreover, the classification can be run for all Europe or for custom areas, such as countries, or NUT 2 regions. After the classification is run, the user can evaluate the area of each class for the target area with the Calculate Area Histogram button.

3.3 Decision Support System

The Decision Support System is presented as a framework inside the tool in order to filter and select the most suitable marginal lands for a reforestation project. The selection is based on user inputs that defines the area of interest and the distances from or to land cover areas to carry out the reforestation.

First, the DSS work flow starts by defining an Area of interest. The user is given two options to select the area: the first one is selecting a NUTS3 area defined by a GAUL level 2 or defining a polygon.

Next step in the DSS is the identification of the marginal lands in the user defined area. at this step the user can choose between two options: The Marginal lands identified by the methodology proposed in task 2.3 (the output of the exclude by land cover areas and exclude by productivity values tools) and the MLs Enhanced Classification (task 2.8).

Continuing with the workflow in the DSS, after identifying the marginal lands distance filters are applied (to key land covers) to select target MLs suitable for reforestation. The user must select a type of reforestation and indicate the distance value close to a land cover type where the reforestation is to be performed. Additionally, it is given a checkbox to indicate that the distance introduced is regarded as distance further than the land cover of choice. Depending on the reforestation objective two sort of filters are applied: for protective reforestations feasibility and biodiversity filters are applied, whereas in the productive reforestation only feasibility filters are applied. The feasibility filters consider the distance to roads, crops and urban areas, on the other hand the biodiversity filters contemplate the distance to forest and protected areas. Considering the user defined distances, a distance mask is generated to mask the Marginal Lands

Once the reforestation areas are identified then these areas passed to the carbon tools to asses both a present carbon content (carbon content) or a future carbon content (carbon predictor).

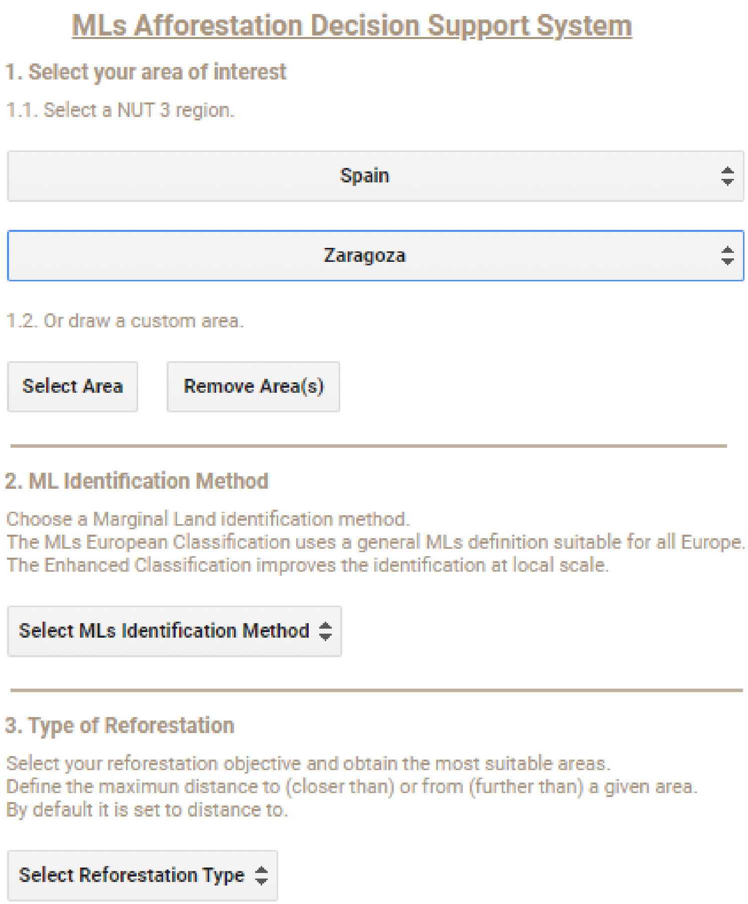

Figure 13. Overview of DSS tool within MAIL Map Portal.

3.3.1 Carbon Calculator

The Carbon Calculator Tool aim is to provide a carbon estimation for the aboveground biomass components of a given area representing a forest plot of known density (number of trees per hectare) and mean breast height dimeter (in cm). Alternatively, it can be used to assess the Carbon fixed by a reforestation when a given diameter is reached. This tool performs the calculation for a mixture of maximum 3 species.

The carbon estimation is based on a compendium of generalized diameter-dependent aboveground biomass equations proposed by Forrester et al. 2017.

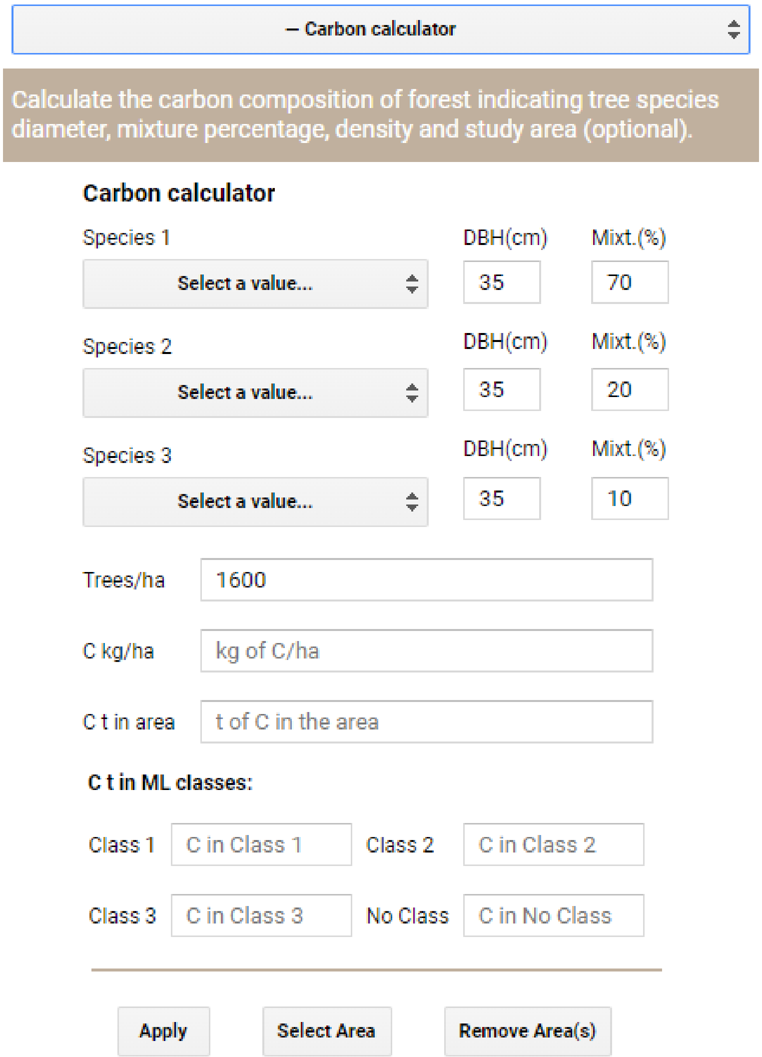

Figure 14. Carbon calculator tool.

3.3.2 Carbon Prediction

The carbon predictor tool main objective is to estimate the future carbon stock in a reforested plot. It can be applied both to a user delimited area or to a general area. If a user defined area is used then a diameter at breast height (hereafter as DBH) increment model is applied, if not mean species increment coefficient is estimated. The tool uses one DBH increment model for each species that is parameterized using forest inventory, climatic and topographic data. Therefore, these models are area sensitive and the DBH increment will change depending on the user delimited area. The DBH increment models were extracted from (Schelhaas, Hengeveld, & Heidema, 2018) Having estimated the growth and DBH for each species then generalized biomass equations from the carbon tool are applied to obtain biomass that is then converted to carbon using a 50% conversion factor.

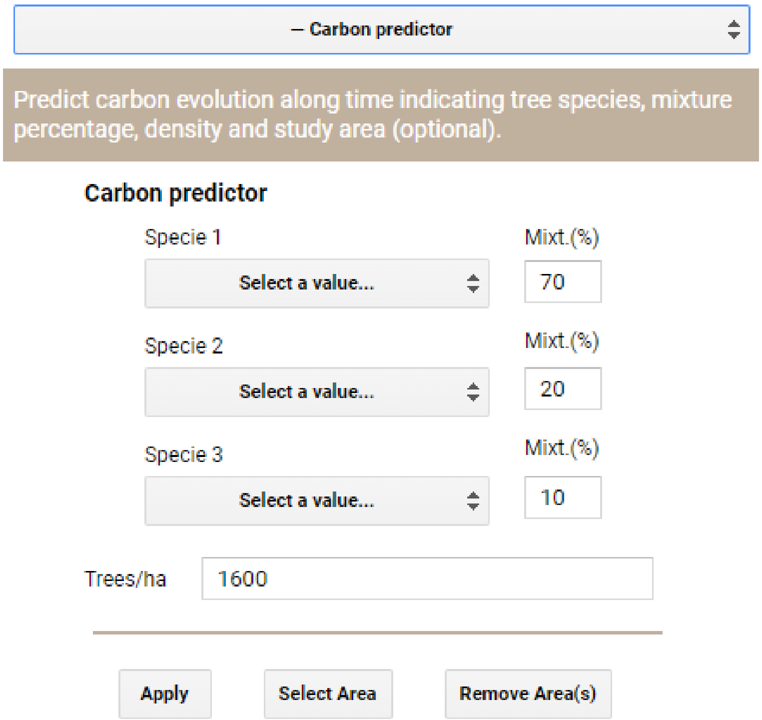

Figure 15. Carbon predictor tool.

3.3.3 Afforestation Cost Calculator

This tool applies an economical model created for calculating the cost of plantation of one single tree in Europe. This model takes into account specific factors that influence the cost of the plantation such as the soil texture, the slope of the area, the manual or the mechanical way of the plantation, the accessibility to cities and the labour cost level of the countries in Europe. The model calculates default base prices for forest plantation practices using as reference site the Spanish website ‘Tarifas Tragsa’. For the definition of the default base prices three basic operations as the opening a hole on the ground (manually or mechanically), the plantation of one tree and the covering of the ground hole were taken into account.

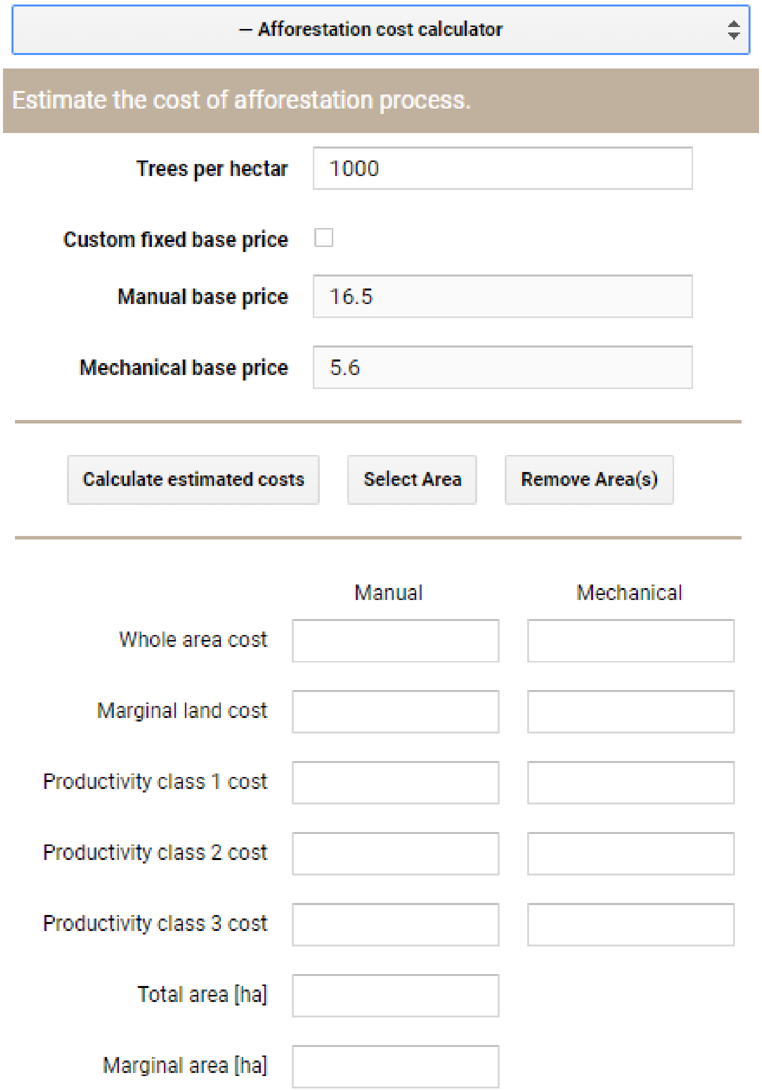

Figure 16. Afforestation cost calculator tool.

3.3.4 Potential Suitable Species

The purpose is to provide a general overview regarding Carbon Sequestration Capacity Groups (CSC Groups) and to suggest Potential Suitable Species for afforestation. The CSC groups are calculated based on the methodology applied for the whole Europe and Potential Suitable Species on presence frequency in the neighbour forested areas, ranked according to dominance.

The analysis occurs at a user's defined level (student, stakeholder, etc.) by drawing or inserting a specified Area Of Interest (AOI; *.geojson). The AOI information is displayed on three relative pie charts, one for CSC Groups and another two for species, dominant

1 and dominant 2. In each relative pie chart, the results illustrate the participation percentages in the AOI.

There is specified limit in the AOI extend. However, the tool designed for parcel scale analysis. Therefore, it is suggested not to exceed 100,000 ha, as the accuracy is inversely proportional to the AOI.

The tool scope is a broader approach in European level. Thus, by no means can substitute an in situ analysis, that takes into account more aspects such as micro-climate, ecological zone, elevation, soil attributes, etc.

3.4 Identification of MLs using satellite images

Default map of potential marginal land areas in Europe is based on GIS analyses of various database and presents information from 2017-2018 year. Using satellite images from Copernicus programme (Sentinel-1 and Sentinel-2), user can generate an enhanced map for selected moment in time. Enhanced map is generated for selected area of interest. It means that it’s better adjusted to local conditions, comparing to pan-European approach. For farther analyses using Decision Support System, user can choose which of two maps will applied – MLs European Classification or ML Enhanced Classification.

3.5 Multi-temporal Analysis

Marginal lands are very dynamic phenomenon. For this reason, monitoring of their changes is very valuable. For multi-temporal analysis of marginal lands in Europe, we used the implementation of Change Mapper Application. It allows for change monitoring over last 20 years. Three of possible scenarios which can be monitored this way are:

- deforestation detection (identification of year of occurrence and magnitude of change) – example on Figure 17
- forest areas monitoring
- afforestation/reforestation projects monitoring – example on Figure 18

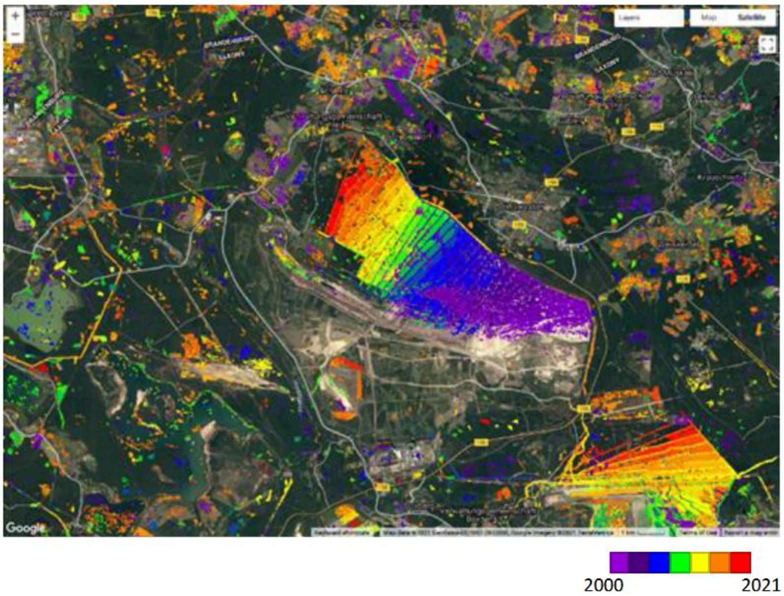

Figure 17. Detection of deforestation. Area of pit mine in Saxony (Germany). Different colours represent the time (year) of the biggest loss of vegetation. Personal compilation of Marta Milczarek

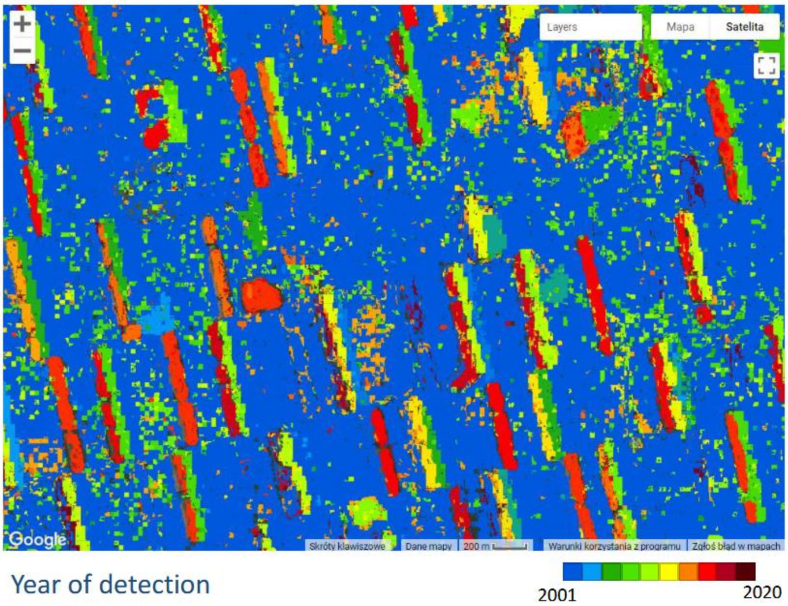

Figure 18. Example of afforestation activities monitoring. Different colours represent years of the biggest gain of vegetation. Location: Poland. Personal compilation of Marta Milczarek

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ANNEX I: TABLE OF FIGURES

ANNEX II: LIST OF TABLES