Recovery

RFCS RESEARCH PROJECT

Recovery of degraded and transformed ecosystems in coal mining-affected areas

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Deliverable 2.1

Baseline mapping of relevant ecosystems of Figaredo Mine

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Executive summary

Within this Deliverable, the baseline mapping of relevant ecosystems of Figaredo Mine is developed.

In the first place, and after a description of Figaredo Mine, the adequate boundaries for the study area were defined based on the existing spatial connectivity and functional cohesion. The boundaries selected cover an area of 238 ha, based mainly on geographic limits according to the configuration of the Asturias topography. Wastes heaps cover an area of 67 hectares, reaching 45 m in height.

In the second place, a revision of the European and Spanish online geospatial data available for the Figaredo Mine area was developed. The information was obtained from the Open Data Initiative of the Spanish Government and the downloading centre from the Spanish National Geographic Institute.

The obtained information was: CORINE Land Cover 2018 (land cover), CORINE Land Cover 2018 (land uses), the level of sealed soil (imperviousness), the tree cover density, and forest type, grasslands, wetness and water, and small woody features, COPERNICUS NATURA 2000, 2018, and COPERNICUS CORINE Land Cover 2018. Also, other information coming from COPERNICUS was the European Digital Elevation Model, the EU-Hydro EPSG: 4326 (ETRS89, LAEA) grid width: 25m, and the High-Resolution Imagery False Colour 2015. EPSG: 4326. GSD: 20m.

In the third place, CORINE Land Cover classes (level 3) were used to delineate, categorise and map the different ecosystem types of land cover in the study areas, although detailed field mapping at a higher resolution than in the CORINE programme.

Finally, the information was introduced in the QGIS 3.8 Zanzibar. QGIS (previously known as Quantum GIS) is a free and open-source cross-platform desktop GIS application that supports viewing, editing, and geospatial data analysis.

1 Introduction

Work Package No 2 focuses on mapping and assessing the ecosystems and their services of the project's case-studies.

Specific objectives are:

1. To identify the adequate boundaries of the different case-studies based on existing spatial connectivity and functional cohesion for each coal mining-affected area.

2. To delineate, categorise and map the different ecosystems types of land covers in the study areas, according to CORINE Land Cover classes (Bossard, Feranec, & Otahel, 2000; Barbara, György, Gerard, & Stephan, 2017), although doing detailed field mapping at a higher resolution.

3. To assess the ecosystem services according to the Common International Classification of Ecosystem Services V5.1 (Haines-Young & Potschin, 2018), in order to achieve standardisation and to avoid any overlapping or redundancy within the different categories.

4. To implement a geographic information system (GIS) web interface for each-case study, allowing constructing user desired information thematic maps for viewing purposes.

As the typology of ecosystems and ecosystem services will provide the analytical frame for the project, in order to operationalise this work package, in first place Task 2.1 will focus on the baseline mapping of relevant ecosystems.

Under the coordination of UBER, with a lot of experience in this field, for each case-study the surrounding limits of the different coal mining-affected areas will be defined on the basis of existing spatial connectivity and functional cohesion.

It is critical for establishing an ecosystem services context to determine with accuracy the adequate boundaries of the areas where the impact of the planned activities may produce changes in forms of land use, monetary value of properties, and potential of ecosystem services.

In second place, CORINE Land Cover classes will be used to delineate, categorise and map the different ecosystem types of land cover in the study areas, although doing detailed field mapping at a higher resolution than in the CORINE programme.

In 1985 the CORINE programme was initiated in the European Union. CORINE means 'coordination of information on the environment' and it was a prototype project working on many different environmental issues.

The CORINE databases and several of its programmes have been taken over by the European Environment Agency (EEA). One of these is an inventory of land cover in 44 classes, and presented as a cartographic product, at a scale of 1:100 000. This database is operationally available for most areas of Europe.

Deliverable 2.1 will undergo the baseline mapping of the relevant ecosystems from Figaredo Mine, property of HUNOSA (Spain).

2 Figaredo Mine

Figaredo Mine is a closed underground coal mine property of Hulleras del Norte S.A. (HUNOSA), industrial partner of RECOVERY, which is undertaking nowadays its partial restoration (Figure 2-1).

Figure 2-1. Figaredo mine and waste heaps

This pit is one of the first mines in the Turón valley, dating back to 1867. Famous for having some of the best Spanish coking coal, the first coke batteries were built on this site in 1890. In the early 1930s the pits were built to mine the reserves located under the riverbed, although the projects were delayed because of the Spanish Civil War. The Figaredo pit became part of Hulleras del Norte S.A. in 1998.

After the closing of the mine, restoration activities have started with the refurbishment of the waste heaps area, which is divided in four sectors: Sector one has already been restored; Sector two is undergoing restoration; Sector four is being re-mined for recovering coal; and Sector three is being used to store wastes from coal re-mining of Sector four.

Coal recovered from Sector four is used in a power plant, property of HUNOSA, able to burn waste with some coal content.

The company is also focusing on a new waste heap as Sector three is not big enough to store all the wastes produced by Sector four's re-mining.

Wastes heaps cover an area of 67 hectares, reaching 45 m of height. No restoration or rehabilitation has yet been initiated with the rest of the facilities and terrains of Figaredo Mine, being a good opportunity to propose interesting revitalisation operations.

3 Identifying the adequate boundaries for the case-study area

The surrounding limits of the different coal mining-affected areas will be defined on the basis of existing spatial connectivity and functional cohesion. It is critical for establishing an ecosystem services context to determine with accuracy the adequate but flexible boundaries of the area where the impact of the planned activities may produce changes in forms of land use, monetary value of properties, and potential of ecosystem services.

The area that was selected for the Figaredo Mine is presented in Figure 3-1, and it covers an area of 238 ha.

Figure 3-1. Boundaries of the Figaredo Mine case-study

The boundaries were selected according to the following aspects:

1. All the area of the mine and waste heaps was included in the polygon.
2. The north limit was selected according to the upper part of the mountains/hills.
3. The east limit was selected according to the place in which the hill starts going down to Forniellos, Cabojal and Figaredo, this is, a different valley.
4. The west limit was selected according to the upper limit of the hill that is immediately after the mine.
5. The south limit was selected including the villages and the industrial areas that are at the bottom of the mountain/hills.

4 Geospatial Data Available

A revision of the European and Spanish online geospatial data that was available for Figaredo Mine area was developed.

4.1 CORINE Land Cover 2018

The information was obtained from the following Spanish sites:

- https://datos.gob.es/es/catalogo/e00125901-spaignclc2018, a WPS (web map server) for visualisation.
- http://centrodedescargas.cnig.es/CentroDescargas/catalogo.do?Serie=SIOSE, a downloading centre from the Spanish National Geographic Institute.

Figure 4-1 presents the map of land cover in 2018. The Geodetic Reference datum used is ETRS89 and the UTM projection spindle 30.

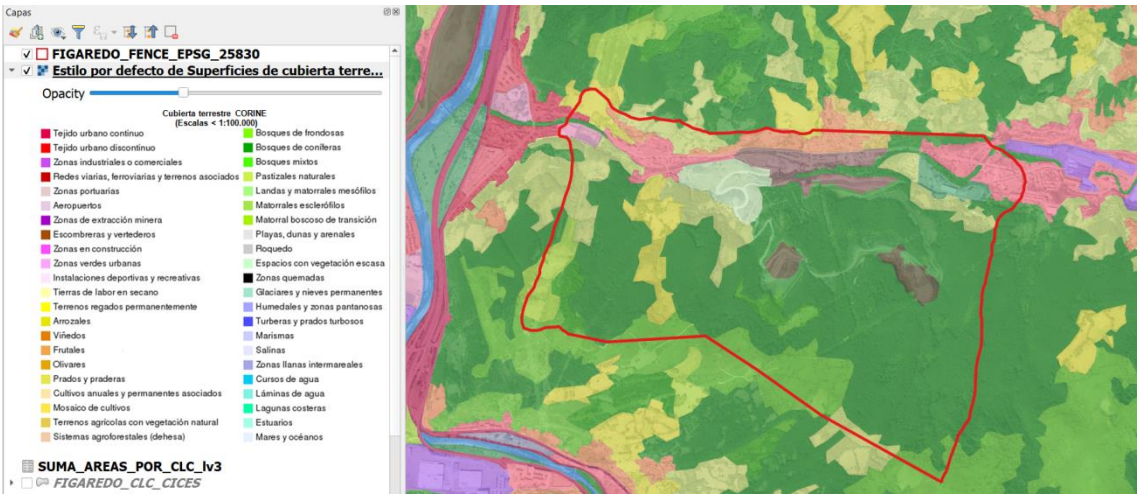

Figure 4-1. CORINE Land Cover 2018 (land cover)

The CORINE Land Cover (CLC) project has been the responsibility of the European Environment Agency since 1995 with the fundamental objective of obtaining a European database of land use at a scale of 1: 100 000, useful for territorial analysis and policy management.

This project is currently included in the COPERNICUS Program whose main objective is to establish an Earth Observation System under the mandate of the European Commission.

On the other hand, Figure 4-2 presents the land uses in 2018.

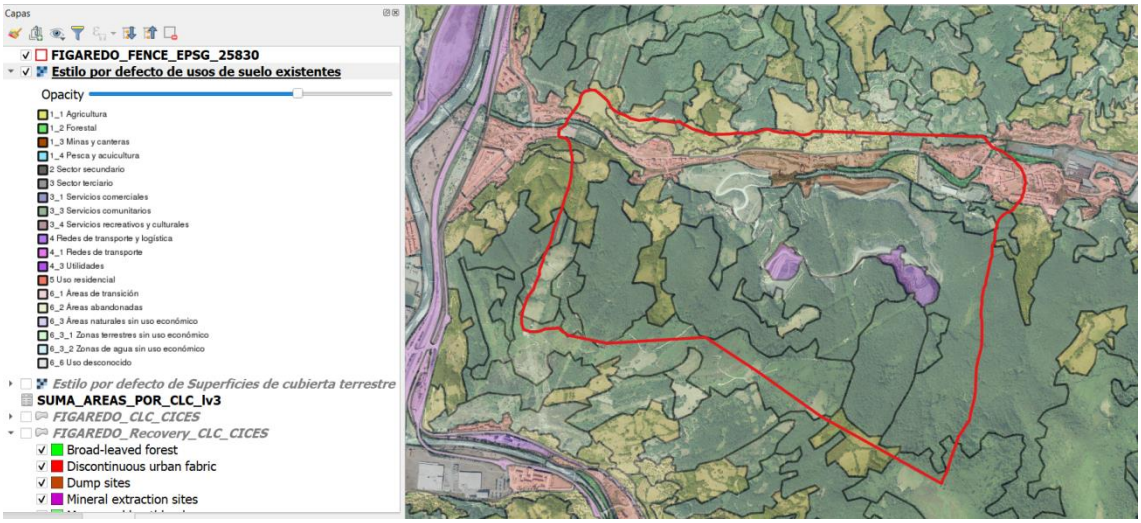

Figure 4-2. CORINE Land Cover 2018 (land uses)

4.2 COPERNICUS Land Monitoring System

Information was obtained from: https://land.copernicus.eu/pan-european/high-resolution-layers

Pan-European High Resolution Layers (HRL) provide information on specific land cover characteristics, and are complementary to land cover / land use mapping such as in the CORINE Land Cover (CLC) datasets.

The HRLs are produced from satellite imagery through a combination of automatic processing and interactive rule based classification. Since the production of the 2015 reference year the production is increasingly based on time series of satellite images from a number of different sensors, including the combination of optical and radar data.

The main sources are the Sentinel Satellites (in particular Sentinel-2 and Sentinel-1). In addition to high resolution (HR) data, since 2015, they also use very high resolution (VHR) imagery for some of the products.

Five themes have been identified so far, corresponding with the main themes from CLC, i.e. the level of sealed soil (imperviousness), tree cover density and forest type, grasslands, wetness and water, and small woody features.

Figure 4-3 presents the imperviousness density in 2015, capturing the percentage and change of soil sealing. Built-up areas are characterised by the substitution of the original (semi-) natural land cover or water surface with an artificial, often impervious cover.

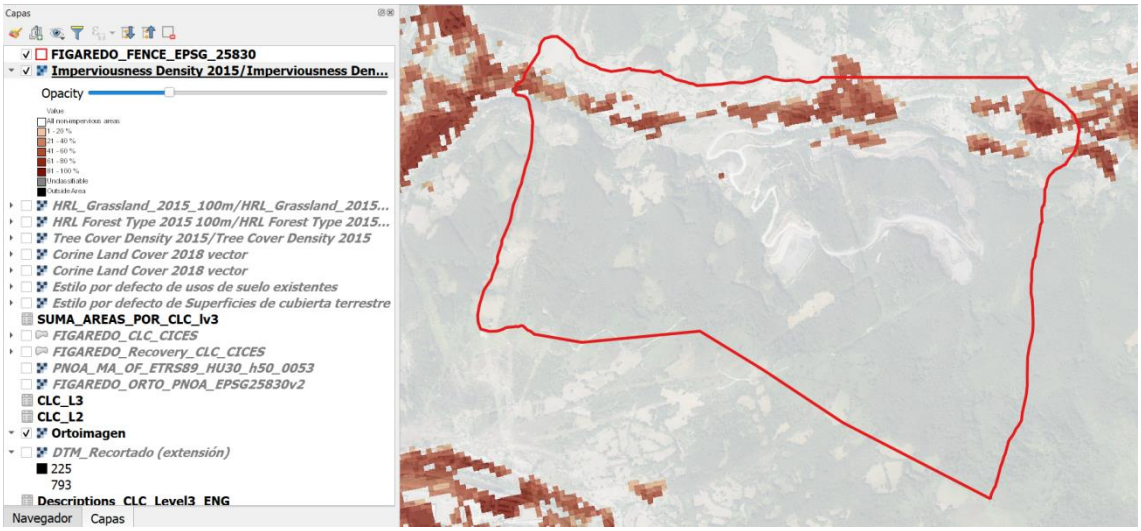

Figure 4-3. COPERNICUS Imperviousness 2015

Figure 4-4 presents the tree cover density in 2015, being the 'vertical projection of tree crowns to a horizontal earth's surface', providing information on the proportional crown coverage per pixel. This information is derived from multispectral High Resolution (HR) satellite data using Very High Resolution (VHR) satellite data and/or aerial ortho-imagery as reference data. Tree cover density is assessed on VHR sources by visual interpretation following a point grid approach and subsequently transferred to the HR data by a linear function.

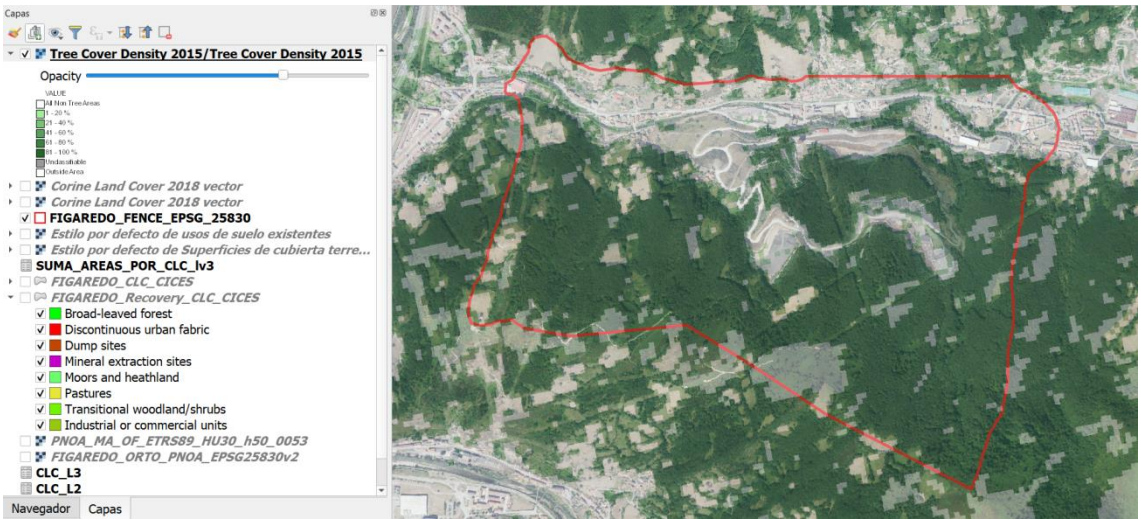

Figure 4-4. COPERNICUS Tree Cover Density 2015

Figure 4-5 presents the tree cover layer with two categories: broadleaved forest in light green and coniferous forest in dark green. White color represents non-forest areas.

Figure 4-5. COPERNICUS Forest Type 2015

Figure 4-6 presents the grassland layer, a binary status layer. This grassy and non-woody vegetation baseline product includes all kinds of grasslands: managed grassland, semi-natural grassland and natural grassy vegetation.

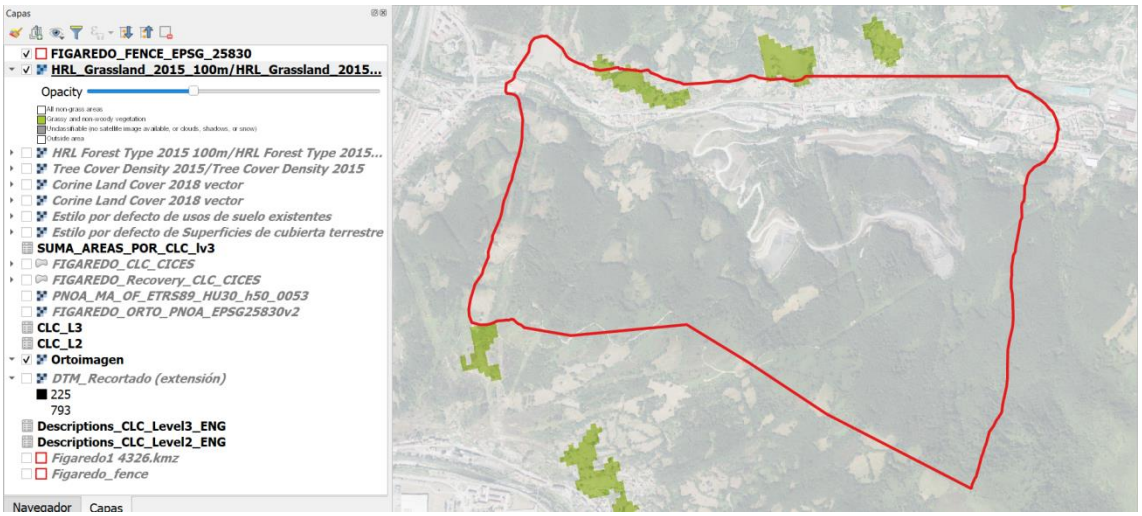

Figure 4-6. COPERNICUS Grassland 2015

Figure 4-7 presents the water and wetness layer, showing the occurrence of water and wet surfaces over the period from 2009 to 2015.

This layer has defined classes of (1) permanent water, (2) temporary water, (3) permanent wetness and (4) temporary wetness.

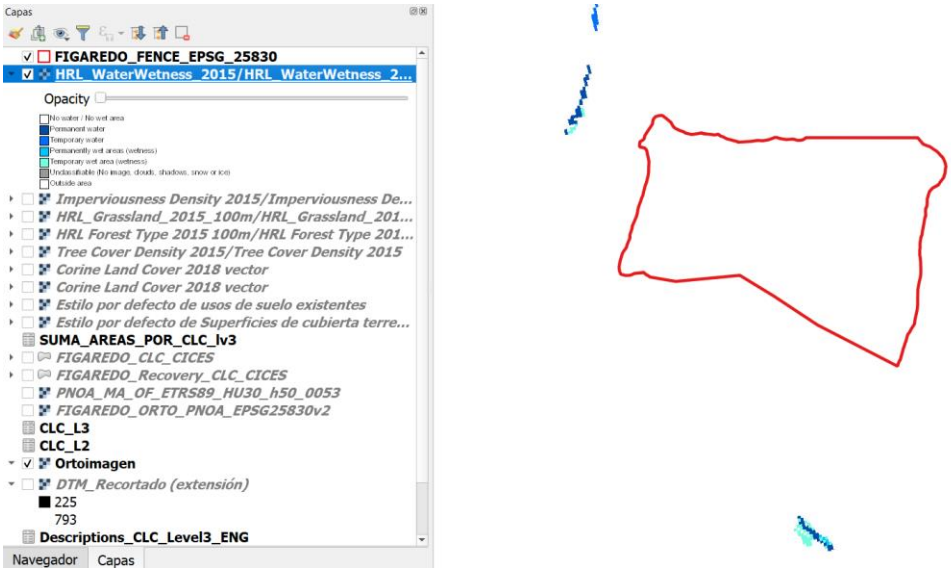

Figure 4-7. COPERNICUS Water and Wetness 2015

On the other hand, Natura 2000 is a network of core breeding and resting sites for rare and threatened species, as well as for some rare natural habitat types which are protected in their own right. The aim of the network is to ensure the long-term survival of Europe's most valuable and threatened species and habitats that are listed under the Birds Directive and the Habitats Directive.

The mapping product offers a detailed LC/LU product applying a hierarchical nomenclature with 55 thematic LC/LU classes. Figure 4-8 presents the NATURA 2000 mapping in the study area, obtained from https://land.copernicus.eu/news/natura-2000-lc-lu-product-now-updated.

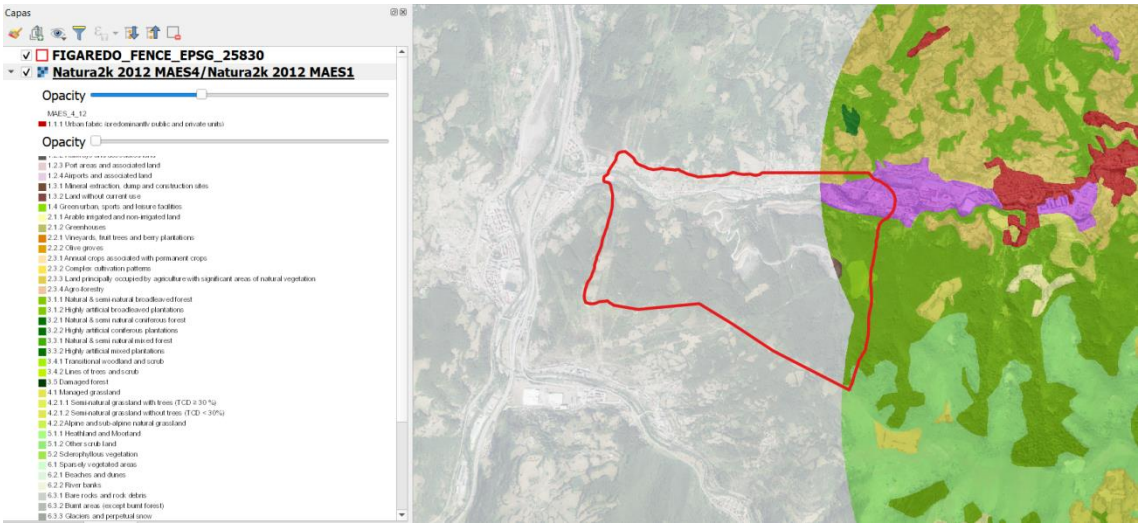

Figure 4-8. COPERNICUS NATURA 2000, 2018

Finally, as CORINE Land Cover (CLC) is also a part of the COPERNICUS Land Monitoring Service, developed with a minimum mapping unit (MMU) for status layers is 25 hectares - minimum width of linear elements is 100 meters - minimum mapping unit (MMU) for Land Cover Changes (LCC) for change layers is 5 hectares (Figure 4-9).

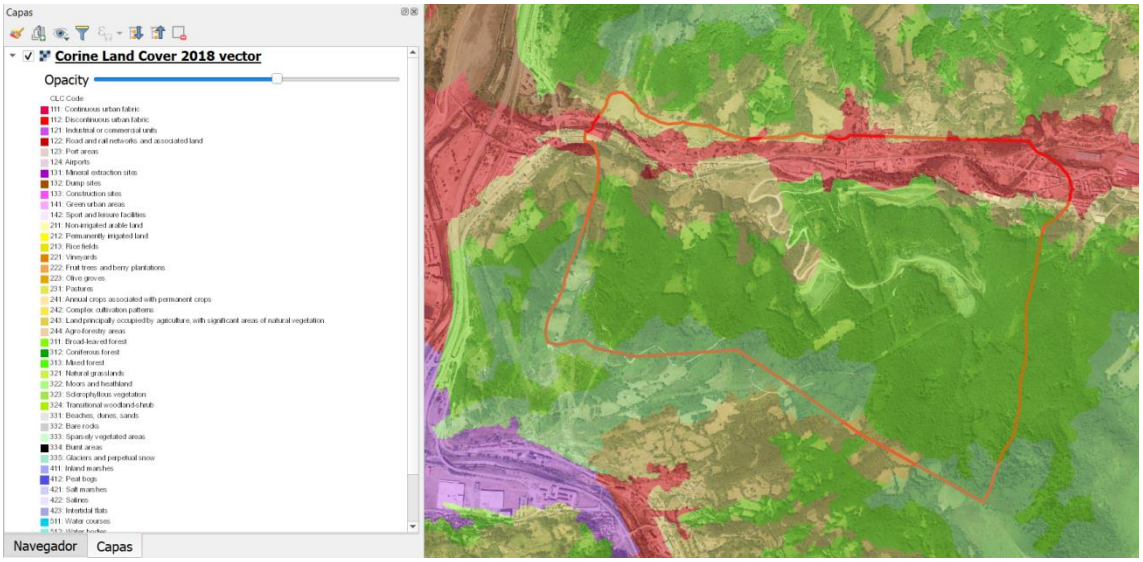

Figure 4-9. COPERNICUS CORINE Land Cover 2018

4.3 COPERNICUS imagery and reference data

Other intermediate products coming from COPERNICUS are the European Digital Elevation Model that is presented in Figure 4-10.

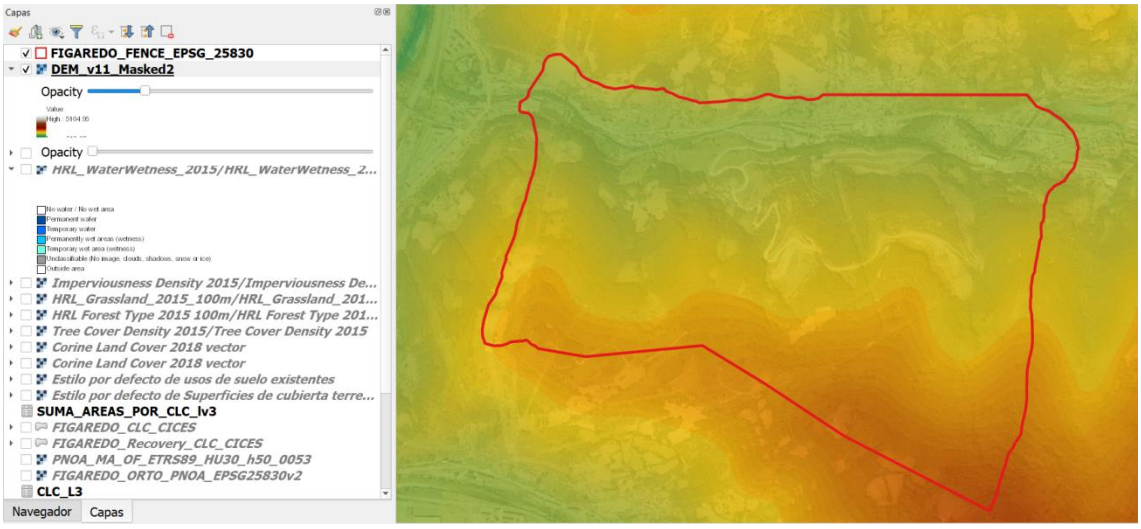

Figure 4-10. European Digital Elevation Model (EU-DEM), version 1.1. EPSG: 4326 (ETRS89, LAEA) grid width: 25m

Also the EU-Hydro, a dataset for all EEA39 countries providing photo-interpreted river network, consistent of surface interpretation of water bodies (lakes and wide rivers), and a drainage model (also called Drainage Network), derived from EU-DEM, with catchments and drainage lines and nodes (Figure 4-11).

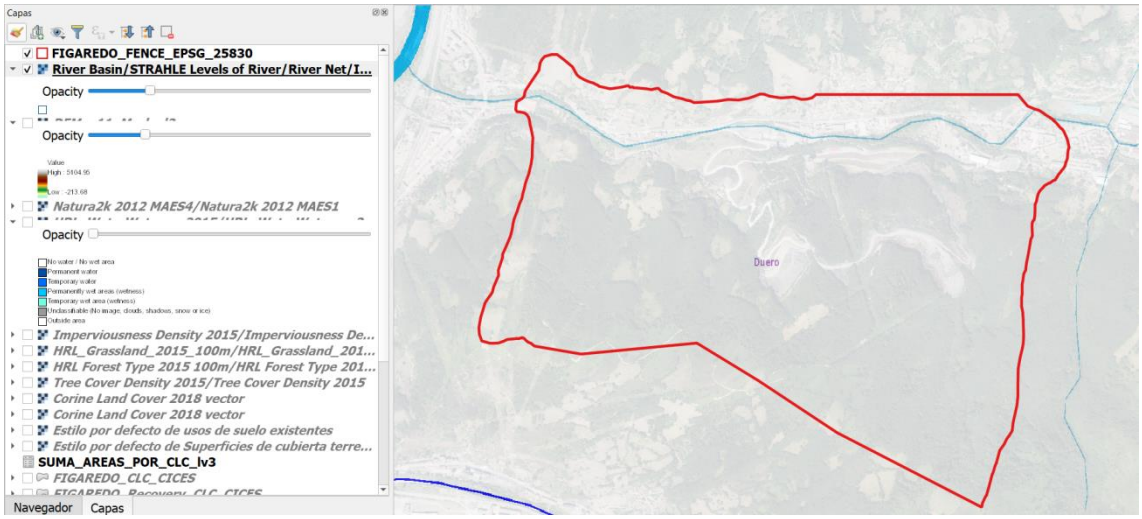

Figure 4-11. EU-Hydro EPSG: 4326 (ETRS89, LAEA) grid width: 25m

Finally, a cloud-free HR corresponding to the vegetation season in 2014-2015, representing in false colour the vegetative zone (Figure 4-12).

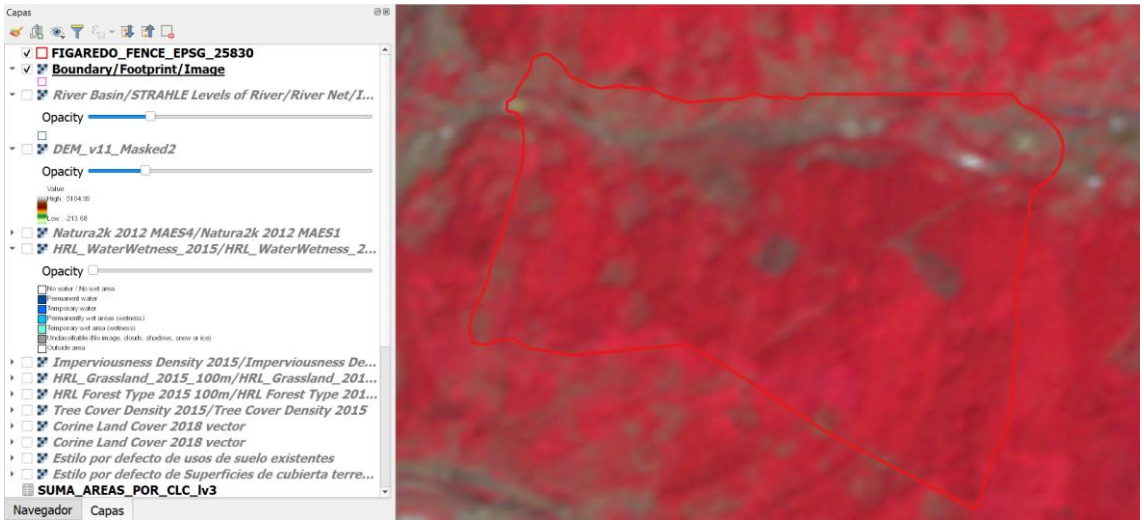

Figure 4-12. High Resolution Imagery False Colour 2015. EPSG: 4326. GSD: 20m

5 Mapping of relevant ecosystems

CORINE Land Cover classes (Bossard et al., 2000) were used to delineate, categorise and map the different ecosystems types of land cover in the study areas (Figure 5-1).

CLC Level 1	CLC Level 2	CLC Level 3	Ecosystem types level 2
1. Artificial surfaces	1.1. Urban fabric	1.1.1. Continuous urban fabric	Urban
		1.1.2. Discontinuous urban fabric	
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units	
		1.2.2. Road and rail networks and associated land	
		1.2.3. Port areas	
		1.2.4. Airports	
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites	
		1.3.2. Dump sites	
		1.3.3. Construction sites	
	1.4. Artificial non-agricultural vegetated areas	1.4.1. Green urban areas	
		1.4.2. Sport and leisure facilities	
2. Agricultural areas	2.1.Arable land	2.1.1. Non-irrigated arable land	Cropland
		2.1.2. Permanently irrigated land	
		2.1.3. Rice fields	
	2.2. Permanent crops	2.2.1. Vineyards	
		2.2.2. Fruit trees and berry plantations	
		2.2.3. Olive groves	
	2.3. Pastures	2.3.1. Pastures	Grassland
	2.4. Heterogeneous agricultural areas	2.4.1. Annual crops associated with permanent crops	Cropland
		2.4.2. Complex cultivation patterns	
		2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation	
		2.4.4. Agro-forestry areas	
3. Forests and semi-natural areas	3.1. Forests	3.1.1. Broad-leaved forest	Woodland and forest
		3.1.2. Coniferous forest	
		3.1.3. Mixed forest	
	3.2. Shrub and/or herbaceous vegetation association	3.2.1. Natural grassland	Grassland
		3.2.2. Moors and heathland	Heathland and shrub
		3.2.3. Sclerophyllous vegetation	
		3.2.4. Transitional woodland shrub	Woodland and forest
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, and sand plains	Sparsely vegetated land
		3.3.2. Bare rock	
		3.3.3. Sparsely vegetated areas	
		3.3.4. Burnt areas	
		3.3.5. Glaciers and perpetual snow	
4. Wetlands	4.1. Inland wetlands	4.1.1. Inland marshes	Wetlands
		4.1.2. Peatbogs	
	4.2. Coastal wetlands	4.2.1. Salt marshes	Marine inlets and transitional waters
		4.2.2. Salines	
		4.2.3. Intertidal flats	
5. Water bodies	5.1 Inland waters	5.1.1 Water courses	Rivers and lakes
		5.1.2 Water bodies	
	5.2 Marine waters	5.2.1 Coastal lagoons	Marine inlets and transitional waters
		5.2.2 Estuaries	
		5.2.3 Sea and ocean	Marine

Figure 5-1. Correspondence between CLC Classes and ecosystem types

As resented in Figure 5-1, the number of ecosystem types level 2 is much lower than CLC level 3 (Maes et al., 2013), but as the area that is going to be studied is small, CLC level 3 seems to be much more appropriate in order to analyse future changes in the land cover classes and, subsequently, in their ecosystem services provision.

Moreover, Figure 5-2 presents the specific colours of CLC were used in order to develop the mapping of relevant ecosystems (Source: http://www.gisandbeers.com/descarga-corine-land-cover-2018/).

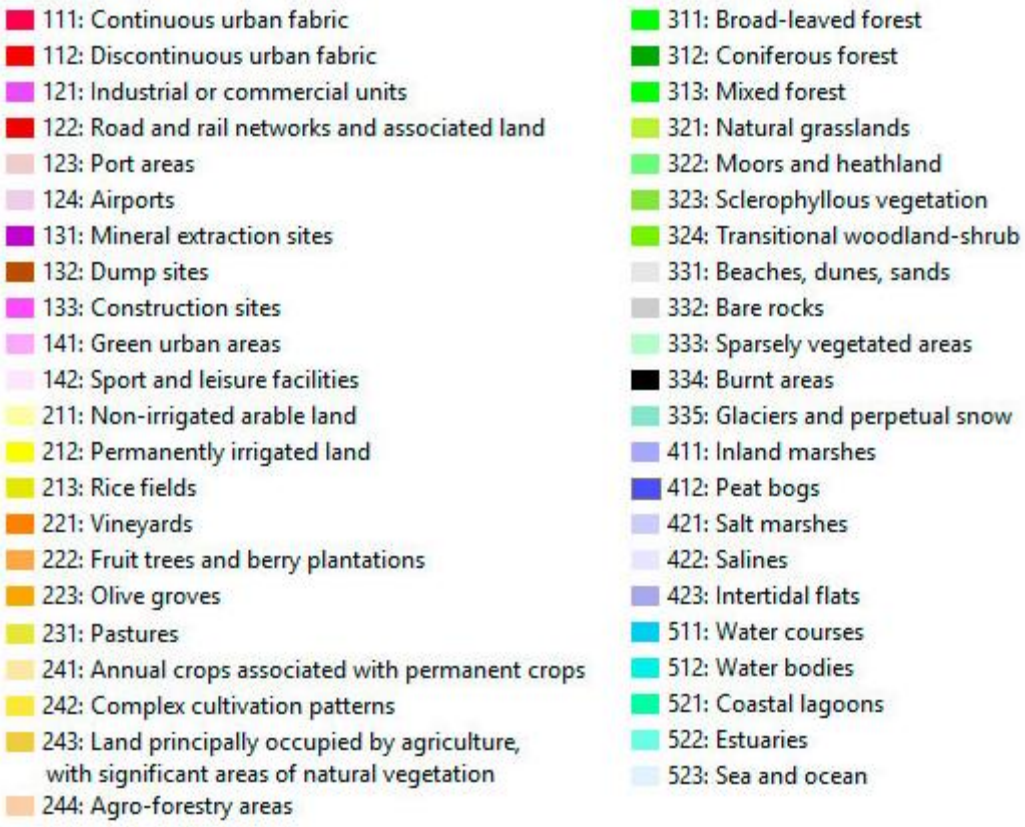

Figure 5-2. CORINE Land Cover pantone

Figure 5-3 presents the GIS aspect of CLC classes in Figaredo that was developed with QGIS 3.8 Zanzibar. QGIS (previously known as Quantum GIS) is a free and open-source cross-platform desktop GIS application that supports viewing, editing, and analysis of geospatial data. On the other hand, Figure 5-4 presents the same image but over imposed to the orthoimage of the area.

Finally, Figure 5-5 presents an example of the polygon information that is available within the GIS: area (ha), perimeter (km), CLC class level 2 and level 3, and the total surface of this specific CLC class level 3 in the whole case-study.

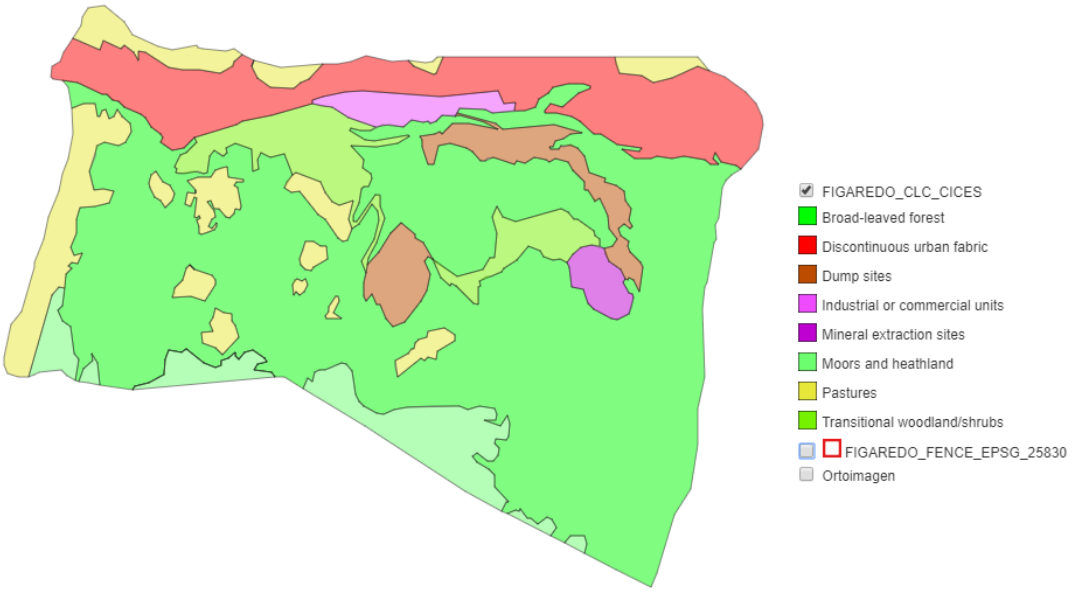

Figure 5-3. GIS presentation of CLC classes in Figaredo Mine

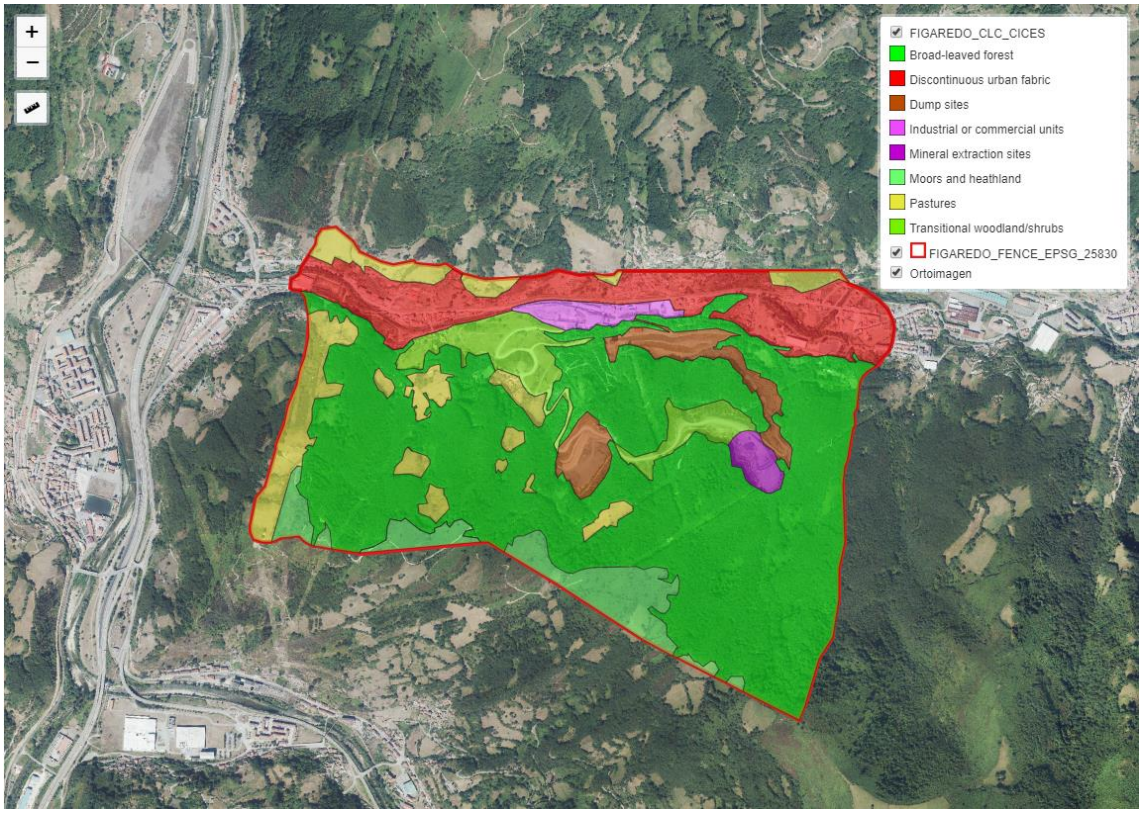

Figure 5-4. GIS presentation of CLC classes in Figaredo Mine over the orthoimage of the area

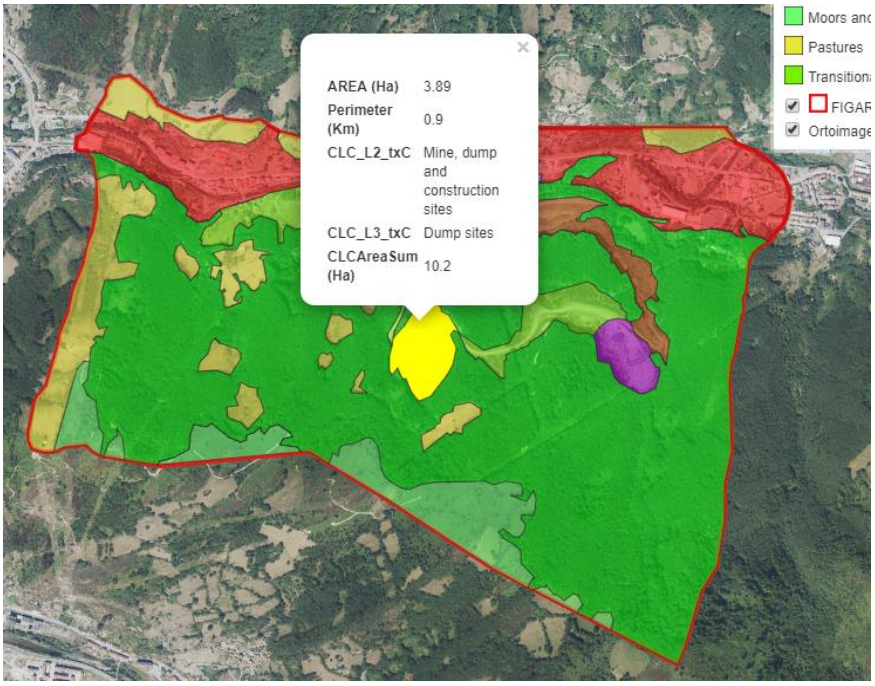

Figure 5-5. Polygon description in the GIS

This information will be used afterwards to develop the calculations concerning the ecosystem services valuation.

The explanation of the different CLC classes used in Figaredo Mine is the following (Bossard et al., 2000):

5.1 Artificial areas (Main Class 1)

In case of cultivated areas inter-mixed with built-up areas within a patchwork system, the minimum threshold to be considered to classify in discontinuous urban fabric is 30 % (at least 30 % of the small parcels are urban fabric). Otherwise, the area should be classified as complex cultivation patterns.

5.1.1 Discontinuous urban fabric (112)

Most of the land is covered by structures. Building, roads and artificially surfaced areas associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces. Between 30 to 80 % of the total surface should be impermeable.

The discrimination between continuous and discontinuous urban fabric is set from the presence of vegetation visible illustrating either single houses with gardens or scattered apartment blocks with green areas between them.

The density of houses is the main criteria to attribute a land cover class to the built-up areas or to the agricultural area (242). In case of patchwork of small agricultural parcels and scattered houses, the cut-off-point to be applied for discontinuous urban fabric is 30 % at least of urban fabric within the patchwork area.

5.1.2 Industry or commercial units, public services and military installations (121)

Artificially surfaced areas (with concrete, asphalt, tarmacadam, or stabilised, e.g. beaten earth) without vegetation occupy most of the area, which also contains buildings and/or vegetation.

5.1.3 Mineral extraction sites (131)

Areas with open-pit extraction of construction material (sandpits, quarries) or other minerals (opencast mines). Includes flooded gravel pits, except for riverbed extraction.

This class includes flooded gravel pits surface of which is less than 25 ha and temporary mining pools.

5.1.4 Dump sites (132)

Public, industrial or mine dump sites. This class includes dump sites of raw materials or liquid wastes.

5.2 Agricultural areas (Main class 2)

5.2.1 Pastures (231)

Dense grass cover, of floral composition, dominated by graminacea, not under a rotation system. Mainly for grazing, but the fodder may be harvested mechanically. Includes areas with hedges (bocage). Grazing used by cattle.

Pastures can be described as extensively used grasslands with presence of farm structure such as fences, shelters, enclosures, watering places, drinking trough, or regular agricultural works: mowing, drainage, hay making, agricultural practices, manuring.

5.3 Forest and semi-natural areas (Main class 3)

5.3.1 Broad-leaved forest (311)

Vegetation formation composed principally of trees, including shrub and bush understoreys, where broad-leaved species predominate.

This class includes areas with a crown cover of more than 30 % or a 500 subjects/ha density for plantation structure, broad-leaved trees represent more than 75 % of the planting pattern. In case of young plants or seedlings, the proportion of broad-leaved plants to be considered is at least 75 % of the total amount of plants.

5.3.2 Moors and heathland (322)

Vegetation with low and closed cover, dominated by bushes, shrubs and herbaceous plants (heather, briars, broom, gorse, laburnum, etc.).

This class includes temperate shrubby area vegetation (climax stage of development): includes dwarf forest trees with a 3 m maximum height in climax stage.

5.3.3 Transitional woodland/shrub (324)

Bushy or herbaceous vegetation with scattered trees. Can represent either woodland degradation or forest regeneration/recolonisation.

Areas of natural developmental forest formations (young broad–leaved and coniferous wood species with herbaceous vegetation and dispersed solitary trees) for instance; in abandoned meadows and pastures or after calamities of various origin, part of this class may be also various degenerative stages of forest caused by industrial pollution, etc.

6 Three-dimensional view

Finally, Figure 6-1 presents a 3D image of the study area with the CLC classes over impressed.

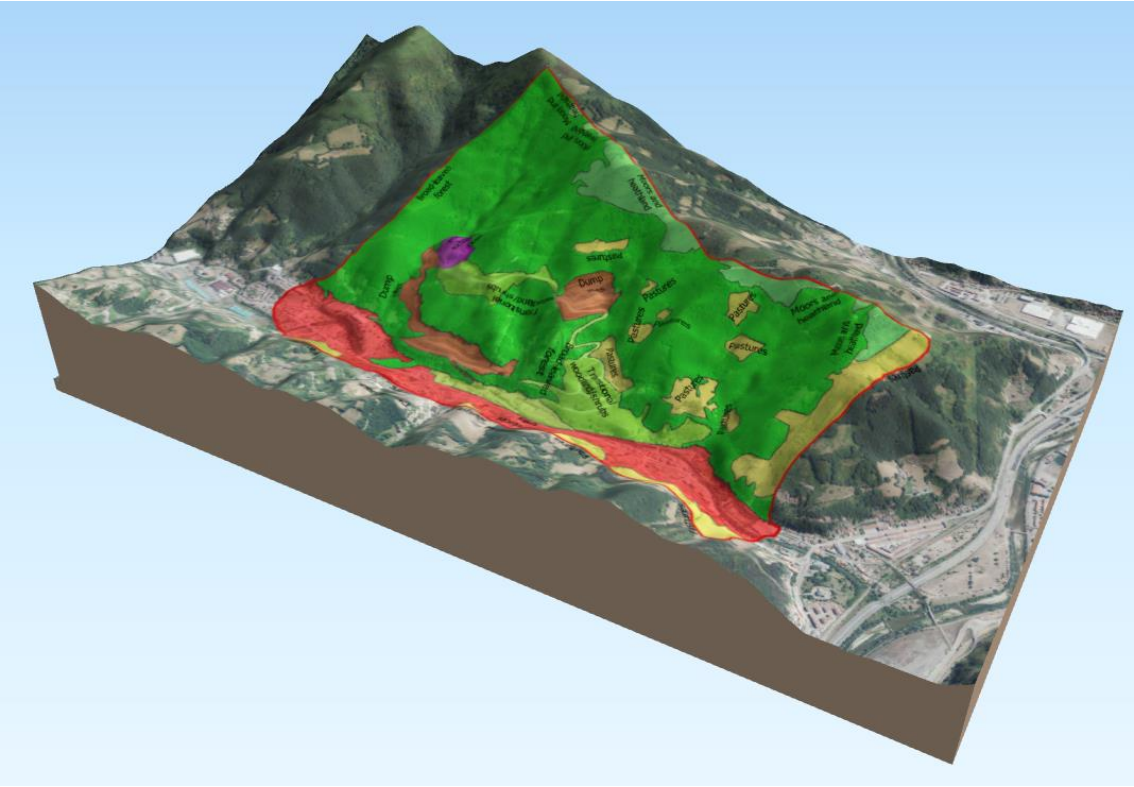

Figure 6-1. 3D image of the CLC classes

7 Conclusions and lessons learnt

In the case of the Figaredo Mine, identifying the adequate boundaries was quite an easy task as including all the mine area and selecting the limits according to the geography of the mountainside and the valley in which the mine is located was enough. This is since Asturias' land covers are pretty homogeneous and repetitive in the central area.

As the number of ecosystem types level, 2 is much lower than CLC level 3, CLC level 3 was considered appropriate to analyse future changes in the land cover classes and, subsequently, in their ecosystem services provision. On the other hand, the large amount of data available in different repositories helped develop the baseline mapping of ecosystems.

The lessons relevant to RECOVERY from the baseline mapping of relevant ecosystems of Figaredo Mine can be summarised as follows:

1. Identifying the reasonable boundaries of the case study based on existing spatial connectivity and functional cohesion of a coal mining-affected area may be challenging to develop. Selecting a considerable size within the boundaries will end in many work-related to mapping. Choosing a small site may risk not selecting representative land covers and potential ecosystem services.

2. There is a considerable amount of geospatial data available, mainly from CORINE Land Cover, from COPERNICUS Land Monitoring System, from COPERNICUS imagery and reference data, and national repositories. In combination with information provided by Google Earth, all of these facilitate the task of categorising and mapping the relevant ecosystems at a higher resolution than in the CORINE programme.

3. The mapping of a study area can be quickly done even by people without experience with GIS. Google Earth polygons are easy to build and easy to export to almost any GIS.

8 Glossary

CLC - CORINE Land Cover

CORINE - Coordination of information on the environment

EEA - European Environment Agency

GIS - Geographic information system

HUNOSA - Hulleras del Norte S.A.

UNIOVI - University of Oviedo

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