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Version	Date	Changes
0	05/10/2018	Structure of the Document (MT)
1	16/10/2018	Contents (MT)
2	20/10/2018	Content/review (EM)
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1 INTRODUCTION

The present report is meant to fulfil the deliverable D28 under Task 1.8.3.4 of the ETC/ULS AP 2018 and was prepared by the ETC/ULS.

This document outlines the progress on the actions to be addressed as part of the support provided by ETC/ULS and the EEA to the Carpathian Convention Secretariat. From 2014, this support is focused on providing information to the Forest Working Group on the development of region-wide indicators of sustainable forest development and on the localisation of virgin and old growth forests in the region. This is key element under this section of the AP18-1.8.3.4 and, as part of this support, from 2017 ETC/ULS is working to facilitate and provide an interactive web interface using the EEA data infrastructure.

Two main interlinked lines of work have been developed during 2018 through different actions aiming to:

- Updating and harmonising the virgin forest inventory
- Developing a proximity analysis based on sustainability indicators for addressing forest restoration and conservation

2 Revision and Harmonization of the Virgin Forest Inventory

2.1 Virgin Forest

During 2017, the Carpathian Convention participating countries have been asked to provide official information about Virgin Forest plots located in their territory.

The information has been provided in a tabular format following the template provided by the Convention itself (table 1) and successively compiled and revised by ETC/ULS.

No.	Name of the virgin forest	Based on		Type of property	Latitude N	Longitude E	Altitudine		(Administrative) Location								
		Forest management plan, edition (year)	Study, edition				minimum	maximum	County	Owner, administrator	Production Unit	basic forest unit (compartment) u.a.	Type of forest	Area (ha)	of which surfaces that do not meet the criterion of naturalness		the level of the forests protection (fully protected, in progress, not protected)
															u.a.	Area (ha)	
0	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16

Table 1: Template of the table which was provided to the participating countries

The data were gathered by ETC/ULS, integrated into a single geodatabase and converted from tabular to point spatial data. A polygon-shaped geodatabase has also been generated, based on the plot extension reported by the countries (except for Poland and Slovakia, for which a shapefile delineating the area of the plots was available).

The point dataset has been published by means of an interactive map created through the EEA infrastructure[1] (Figure 1).

During the previous year, important limitations and gaps of this database were identified (2017AP, 1.8.3.4 milestone report 5[2]), mainly related to the lack of information about privately owned forest, the protection status and to the different codes, languages and classifications used to provide information about forest types.

Hence, country-specific factsheets were prepared with the aim to summarize the status, gaps and shortcomings of the provided inventory information and, through the Convention Secretariat, shared with each participating country to get their feedback.

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[1] http://maps.eea.europa.eu/EEAViewer/?appid=151024dc3c4d43848accc4cf7b5c63e0

[2] https://forum.eionet.europa.eu/etc-urban-land-and-soil-systems/library/8.-action-plan-2017/1.8.3.4-technical-cooperation-partner-regional-conventions/carpathian-convention/milestones/m5-progress-report-support-carpathian-convention-secretariat

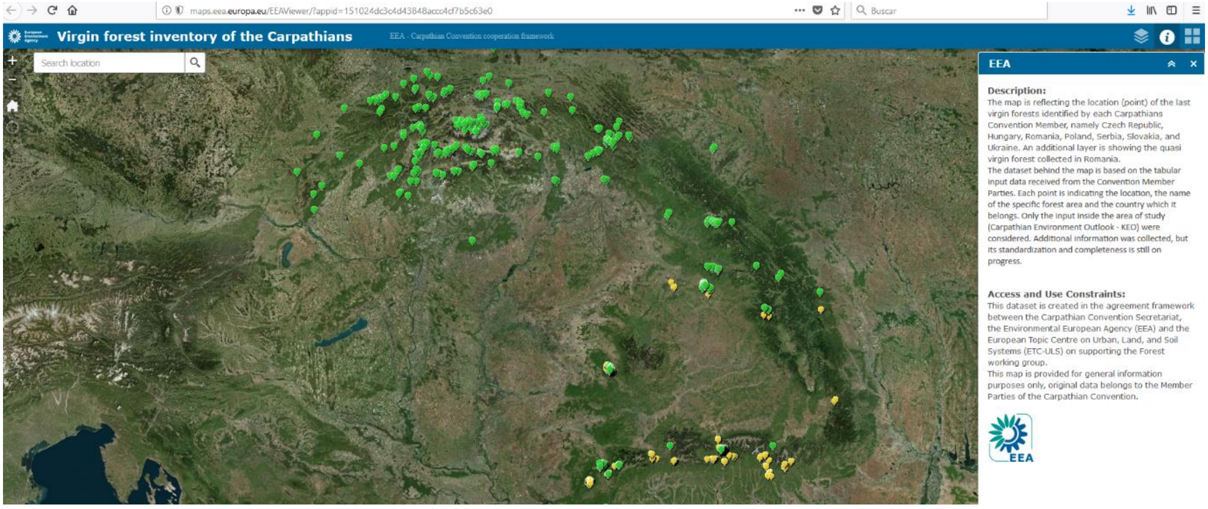

Figure 1: Screenshot of the web application for the integrated data platform (April 2018)

2.1.1 Virgin Forest Type Harmonization

The description of the forest types provided by the participating countries is not harmonized at the international level. The template of the data table proposed by the Convention based on the agreement of the WG members doesn´t define any standard or requirement about the nomenclature of the forest types. For this reason, each country provided this information following different coding schemes (forest types, tree species composition) or languages.

Hence, it came the need for a common classification of Carpathian forest types to be developed and used for harmonizing the thematic information linked to the virgin forest areas, as also emphasized in the "Strategic action plan for the implementation of the protocol on sustainable forest management to the framework convention on the protection and sustainable development of the Carpathians", Objective 14.f[3].

With this proposal we start addressing the development of a crosswalk scheme which would allow to have a common classification scheme of forest types over the whole Carpathian virgin forest area.

We propose to refer all the submitted forest type information to the EUNIS international classification (EUropean Nature Information System[4]) which, compared to the Habitat Directive one, is periodically subject to updates and revisions based on European vegetation plot data.

For each country, different sources have been used for proposing this draft reclassification scheme, covering at least EUNIS levels 3 or 4. In some cases, more than one reclassification option has been

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[3] http://www.carpathianconvention.org/tl_files/carpathiancon/Downloads/03%20Meetings%20and%20Events/COP/2014_COP4_Mikulov/Follow%20Up/DOC11_Forest%20SAP%20FINAL_26SepCOP4.pdf

[4] https://eunis.eea.europa.eu/

proposed for the same original class while, in others, there was not enough information to identify any class.

Due to the complexity of the information provided, this country-specific crosswalk scheme must be considered as a starting point which requires the revision from national forest experts and the Carpathian Forest WG.

2.1.1.1 Comparison with Vegetation Plots from the Braun-Blanquet database

The data officially reported by the single countries has then been checked against the classification of several vegetation plots which are part of a database compiled for the Blaun-Blanquet project (http://www.sci.muni.cz/botany/vegsci/braun_blanquet.php?lang=en). For its classification, this project adopts a modified EUNIS scheme (EEA Technical Report, No 18/2015).

This database includes various national and regional vegetation databases using a unified taxonomic reference database. A quality check of the single databases has been performed by Alterra (Wageningen University & Research) and Masaryk Universities.

The Braun-Blanquet vegetation plots falling into the virgin forest areas (as officially reported by member countries) are then selected and their EUNIS2015 class compared to the officially reported national forest types together with the proposed harmonized class.

For this purpose, in the case of virgin forests identified by a point, the area is assumed to be circular and with an extension matching the reported tabular value.

In the case of Poland and Slovakia, the extension of the virgin forests has been reported as a polygon.

This comparison aims to provide an alternative source for the validation of both the officially reported forest type classification and the proposed crosswalk scheme to reclassify the national types into a common classification system (EUNIS). In the spreadsheet used to develop the crosswalk classification, a color scheme is used to distinguish between the cases in which there is full, partial or no match between the proposed reclassification and the independent source.

As already mentioned, beside Poland and Slovakia, the assumption that the shape of the virgin forest is circular might lead to the inclusion of vegetation plots which are not part of the considered Forest and so introducing a source of error in the validation. If needed, these cases could be possibly identified and further analyzed.

2.1.1.2 Country-specific issues

For each country we provide the participating countries with both a word and an excel document.

In the word document, we first highlight some open questions related to the submitted tabular data.

Then, background information and methodology about the harmonization and the comparison are presented, highlighting the main results and questions/doubts which would help improving the results.

2.1.2 Status of the review (October 2018)

The proposed cross-walks schemes have been sent last June to the representatives of the Carpathian Convention in order to share them with the countries' representatives for validation together with the open questions about the tabular data.

Due to the total or partial lack of feedback from some of the countries, the revision of the Inventory is incomplete and will need to be finalized next year. The outlook of the current update status is given in Table 2: the revision is complete for Czech Republic and Slovakia and Hungary, only partial for Ukraine and Poland while no feedback has been provided by Romania and Serbia.

Country	Forest Type Harmonization	Tabular Data
CZ	✓	✓
HU	✓	✓
PL	(✓)	(✓)
RO	✗	✗
RS	✗	✗
SK	✓	✓
UA	✗	(✓)

Legend	
✓	Complete
(✓)	Partial
✗	None

Table 2: Current status of the revision of the official Virgin Forest Inventory

Based on this partial revision, a new version of the Virgin Forest Inventory has been produced, with updated information about ownership and shifting/removal of some of the virgin forest points in Czech Republic and Ukraine (Figure 2).

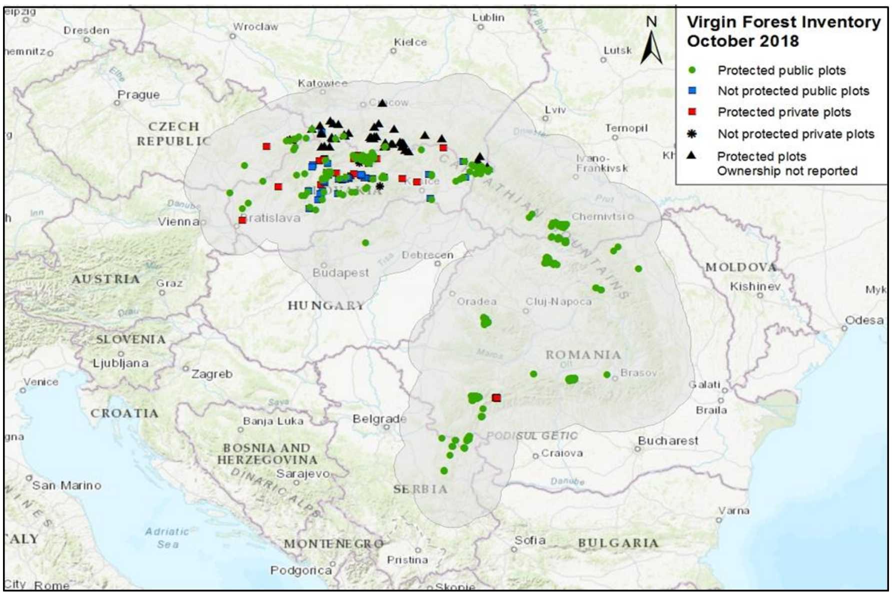

Figure 2 Classification of the Virgin Forest plots in the last version of the Inventory (October 2018) according to protection status and ownership

In general, most of the Virgin Forest sites are protected (Table 3), except for Slovakia where almost 70% of the area doesn´t have any official kind of protection tool in place. On the other side, most of the area is publicly owned, except for Czech Republic, where more than 20% of the Virgin Forest area has private ownership. It has to be noted that the ownership status has not been reported for 55% of the Polish Virgin Forest area.

Country	Number of Plots	Area [ha]	% Protected areas	% Private property
CZ	*15*	*855*	*93,6*	*21,5*
HU	*1*	*43*	*100*	*0,0*
PL	*57*	*9098*	*99,9*	*0,6 **
RO	*515*	*5916*	*100*	*3,2*
RS	*49*	*1902*	*100*	*0,0*
SK	*123*	*22354*	*32,6*	*3,7*
UA	*39*	*16120*	*100*	*0,0*

** Ownership not reported for 55% of the area*

Table 3 Accounting of the extent of virgin forest sites and their protection and ownership status

2.2 ANCILLARY PRIMARY FOREST INFORMATION

In addition to the official virgin forest inventory, there are alternative sources of data that gather information about forests with a well-known conservation status which description may not fully comply with the Protocol of the Carpathian Convention, but are valuable resource to be considered for assessing and/or validating the indicators on sustainable forest development, as alternative and complementary information to the official one. This extended inventory (Figure 3) includes virgin, primeval, quasi virgin and old-growth forest and it can be defined as a Primary Forest Inventory (Buchwald, 2005; Sabatini et al., 2018).

2.2.1 Romania

Two different datasets are available (Table 4). The first one (A), an official inventory of Quasi-Virgin Forest[5] identifies more than 100km^2 of forest of exceptional conservative value. The second one (B) includes forest still classified as "virgin" ("Paduri Virgine") in the project PIN-MATRI[6] and it covers over 2000km^2 of forest.

Forest	Number of Plots	Area [ha]
Virgin	*515*	*5915*
Quasi Virgin (A)	*655*	*11833*
Paduri Virgin (B)	*2889*	*200281*

Table 4: Number of plots and extension of the primary forest inventory of Romania

2.2.2 Ukraine

A complementary database has been included also for Ukraine, gathering from the WWF Ukraine[7] information about high conservation values and old growth forest, and it covers about the same extent of the official virgin forest area (**Error! Reference source not found.**).

Forest	Number of Plots	Area [ha]
Virgin	*39*	*16120*
WWF	*1901*	*19024*

Table 5: Number of plots and extension of the primary forest inventory of Ukraine

[5] http://www.mmediu.ro/articol/prezentarea-catalogului-national-al-padurilor-virgine-si-cvasivirgine-din-romania/2069

[6] www.mmediu.ro/articol/proiect-pin-matra-padurile-virgine-din-romania/2068

[7] http://sfmu.org.ua/en/hcvf

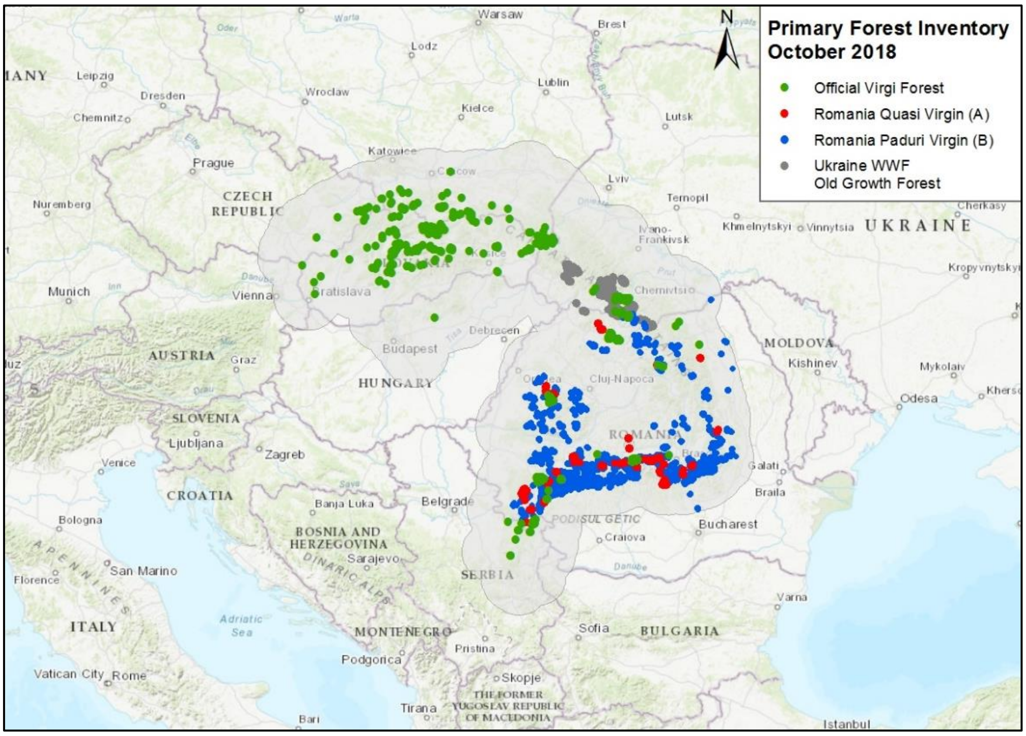

Figure 3: Outlook of the current status of the primary forest inventory

3 PROXIMITY ANALYSIS

Within the initiatives undertaken by the Convention Secretariat, the Environmental European Agency (EEA) and the ETC/ULS under the Carpathian Convention Protocol framework, a proximity analysis has been developed around the primary forest areas included in the extended inventory with the aim to provide input for the improvement of the regional governance of forests in the Carpathian region and providing insights on management efforts needed to conserve, protect and prioritize forest restoration and conservation in the region.

Being the Carpathian Environment Outlook (KEO) region (UNEP, 2007) a pilot study for the European approach, specific spatial indicators have already been produced by EEA-ETC/ULS with the aim to support forest condition monitoring and the identification of High Nature Value (HNV) forest (EEA, 2014) and, ultimately, to develop a governance tool to support international and regional efforts, such as the Carpathian Convention.

For our purposes, also based on preliminary results (Mancosu et al., 2014), a series of sustainable forest indicators, is proposed for assessing conservation and restoration priorities: a) Fragmentation, b) Naturalness and c) Disturbance Indicators (Griffiths et al., 2014).

The integration of the forest indicators and the primary forest locations and their surrounding areas encompass a holistic and comprehensive assessment to support sustainable forest management strategies. At the same time, the proximity analysis offers an insight into the current distribution of forest HNV components also allowing for further assessments of spatial trends, providing key elements in the multicriteria assessment for the identification of HNV forest areas, as expressed in IEEP, 2007.

3.1 BUFFER ZONES

The term "buffer zone" gained international prominence through UNESCO's Man and the Biosphere Programme (1996). According to UNESCO, the definition is "Areas peripheral to a specific protected area, where restrictions on resource use and special development measures are undertaken in order to enhance the conservation value of the protected area".

Buffer zones are areas created to enhance the protection of a specific conservation area, often peripheral to it. Within buffer zones, resource use may be legally or customarily restricted, often to a lesser degree than in the adjacent protected area, so to constitute a transition zone. A buffer zone can also be designated as a protected area and be assigned an IUCN Management Category depending on the conservation objective.

Buffer zones have a two-fold purpose; to reinforce reserves by, e.g., increasing the size of the considered area, and to eliminate or reduce negative influence on the reserves from their surroundings (Batisse, 1997; Groom et al., 1999; Shafer, 1999). The technique of surrounding a protected area with other protected and non-protected areas allows for the creation of a gradient of protection around the core site.

Furthermore, through well-planned projects, buffer zones provide protection for wilderness from human activities and developments (Meffe and Carroll, 1997) and can increase the ratio of rare and common population by softening the edge effect (Martino, 2001).

Buffer zones are therefore an important part of conservation strategies for a wide variety of sites of biodiversity importance.

A variety of spatial patterns and arrangements for buffer zones exist, all following the same principle, but applied under completely different conditions (ecological, political, economic, etc.). Hence, a wide diversity can be observed in the criteria for their creation and management. There are five aspects that are commonly considered in their creation.

These are (Ebregt & Hodgkinson, 2000):

- *Size: determined based on factors such as the objectives for creation of buffer zone*
- *Availability of land, traditional land use systems, threats and opportunities.*
- *Ecology: buffer zones vary depending on their focus on the landscape, habitat and/or species conservation, each of which demands a different approach for their creation.*
- *Economy: this involves appraisals such as cost-benefit analysis, time frame and discount rate, to assess economic viability of establishing a buffer zone.*
- *Legislation: several international treaties and conventions (e.g. Convention on Biological Diversity, World Heritage Convention) and national level guidelines*

In this framework, the ETC/ULS aims to define buffer zones around the reported primary forest points.

3.2 FOREST SUSTAINABILITY INDICATORS

3.2.1 Fragmentation

The fragmentation indicator is developed at 100m resolution and classifies each pixel into one of 5 possible classes: Background, Branch, Edge, Perforation, Islet, Core Forest, Bridge.

For the scope of this analysis, the indicator has been transformed in a "Core Forest" index which quantifies the percentage of Core Forest area over the total forest extent.

3.2.2 Naturalness (Natural species assemblage)

The indicator is based on the calculation of percentage of Natural type of tree species from the EU inventory [1] selected from the habitat suitability [2] and tree distribution [3] per total forest coverage [4]. The indicator calculated in the past by the ETC/SIA, is based on:

1. The tree forest inventory (European Forest Inventory)
2. Forest habitat suitability (JRC, 2011)
3. Tree distribution (Barbati et al., 2013)
4. Corine Forest coverage (CLC 2006)

On these bases a Natural species assemblage indicator has been calculated replacing the input 4 (CLC2012) with the Palsar forest/ no forest product which presents the full coverage of Carpathians Area Of Interest. The result is provided at 1km resolution, where 1 is the maximum value of Natural species, and 0 the minimum value.

3.2.3 Disturbance

The measure of disturbance is derived from the indicator developed by Griffiths et al., 2014, on which basis we developed 2 indexes at $1km^2$ resolution, one indicating the percentage of area which suffered from disturbances between 1985 and 2010 and one indicating the percentage of area which recovered from pre-1985 events.

3.2.4 Forest Area Indicator

Time series of forest cover changes are useful to shape the evolution trends in the forest coverage and assess the effectiveness of sustainable management practices applied along the time. Different products are available, and their potentials to support the Carpathians case is in a testing phase:

- *CLC 1990-2012 time-series (2017, EEA/Copernicus)*

- *High Resolution Tree cover density layer, 2012-2015 (2018, Copernicus)*
- *PALSAR Global forest/ no forest coverage, 2015-2017 (2018, JAXA)*

3.3 METHODS

In order to assess the condition of forest in the proximity of primary forest sites, we developed a spatial model based on the indicators described above, especially designed for the assessment of the sustainability of Carpathian forested area. We analysed the spatial trends of the indicators inside the primary forest plots and in the surrounding area up to 10km distance, monitoring changes at steps of 1km distance. We seek to identify the level of forest sustainability as a function of the proximity to primary forest sites and, based on this, to propose a governance scheme for prioritizing the efforts of conservation and restoration policies.

The trends of the indicators have also been put in relation with physical and policy-related factors such as altitude and ecological features (eco-climatic regions) or ownership status.

3.4 RESULTS

Spatial Trends

As a first step, we considered the area of proximity to the primary forest plots over the whole study area and analysed the spatial trends of the indicators between the forest plots and a maximum of 10 km radius (Figure 4). As expected, all indicators have a negative trend while moving from the centre of the primary forest plot towards the hedge of the buffer area. The decrease of naturalness value is about 13% in total, while the change in fragmentation is more evident and steeper, with an extent of core forest reduced of about 27% at 10km distance from the centre of the plot.

This trend is reflected in the behaviour of the disturbance indicators which show a regular increase of the affected area, after a steep increase in the immediate proximity of the primary forest.

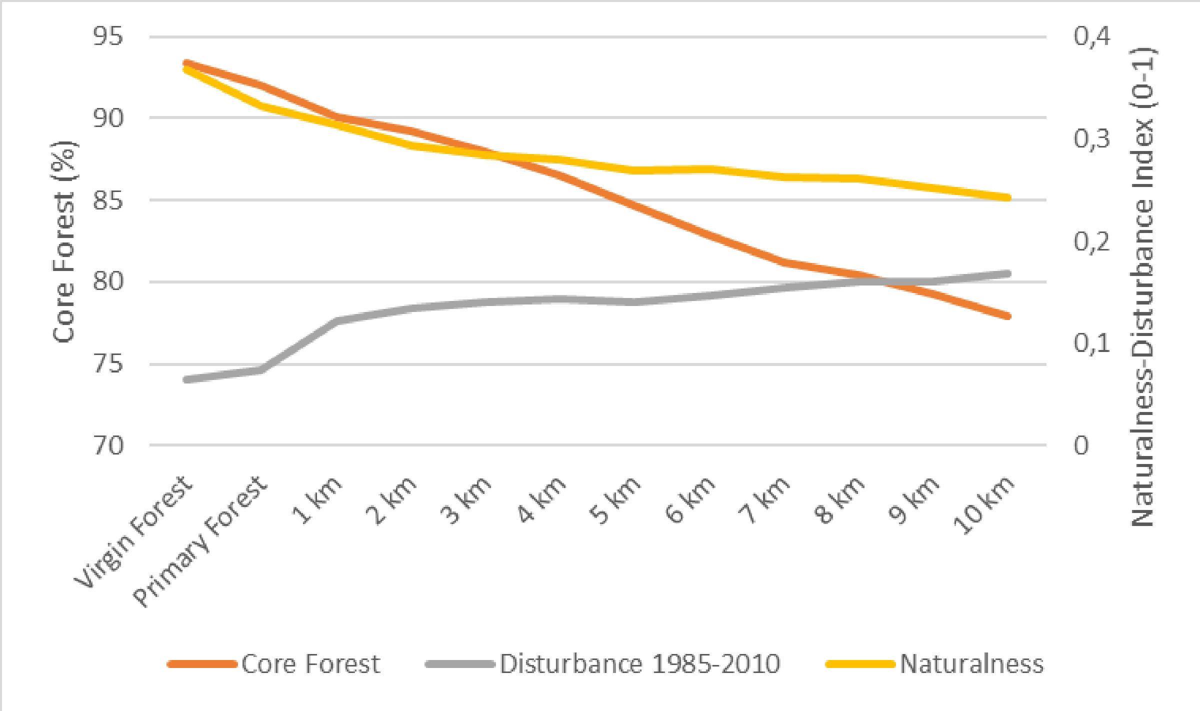

Figure 4: Spatial trends of sustainable forest indicators for the extended primary forest inventory

Although the information on protection status is missing for most of the forest which are not officially Virgin Forests, the proximity analysis reveals a behavior of the indicators similar to what has been observed in Protected Areas (PAs) across the globe (Central and South America, Cuenca, 2017; South-Eastern Asia, Sims, 2017; Northern American Atlantic and Pacific coast, Joppa, 2008; Kroner, 2016): PAs in fact significantly increase average forest patch size and greatest negative changes in fragmentation are observed in their surrounding landscapes. Although it has been shown (Butsic et al., 2017) that in the Carpathians effectiveness of PAs is heterogenous among countries and differences can be broad, it appears that there is a clear pattern of increasing disturbance getting further from primary forests (increase in terms of affected area of about 0.7% per km).

This can be considered a sign that the high nature value of Carpathian primary forest sites is well preserved, and it is an indication about the possibility of setting priorities for restoration measures in the proximity area of primary forests based on the sharp increase of fragmentation with distance.

Temporal trends

When looking at the trend in forest cover change it appears that, for both of the considered time periods (2012-2015, Figure 5, and 2015-2017, Figure 6), the increase of forest cover density is higher when getting further from the primary forest plot.

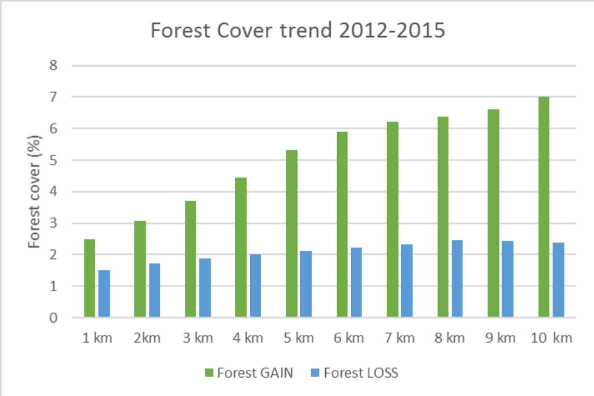

Figure 5: Forest Cover trend of gain and loss between 2012 and 2015

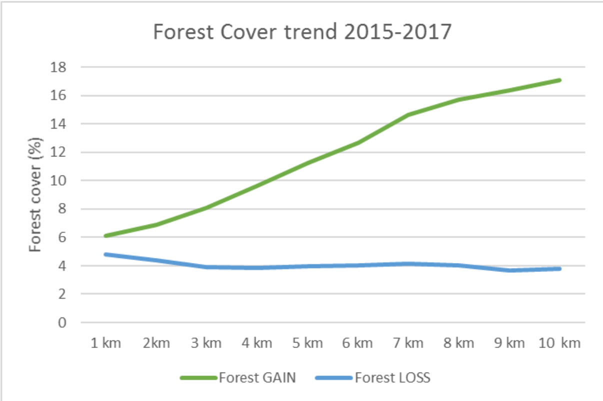

Figure 6: Forest Cover trend of gain and loss between 2015 and 2017

As already shown for the polish Carpathians (Kozak et al., 2018), forest expansion may not necessarily lead to more homogenous forested landscape, due to complex land-ownership and land-use legacy patterns. With our analysis we confirm that although the cover density increases with the distance, the percentage of core forest becomes lower.

3.4.1 Stratification of the spatial trends

3.4.1.1 Country

There are important differences in both number of plots and extent of primary forest between countries. Hungary has only one plot of about 0.5 km^2 while the extent of Romanian virgin and quasi-virgin forest is over 2000 km^2.

The trend in naturalness at general level is reflected at country level (Figure 7), remaining quite constant across the 10km buffer area except for Czech Republic which sees an important gap at 6 kilometres distance from the plots.

In terms of absolute value of the index, the countries with the smallest extent of forest (Hungary and Serbia) have also the lower value of naturalness while an exceptionally high value is evident for Czech

Republic. The increasing trend in fragmentation is also confirmed but with substantial differences between countries. In particular, Poland and Czech Republic suffer a loss of about 2,5% of core forest every kilometre.

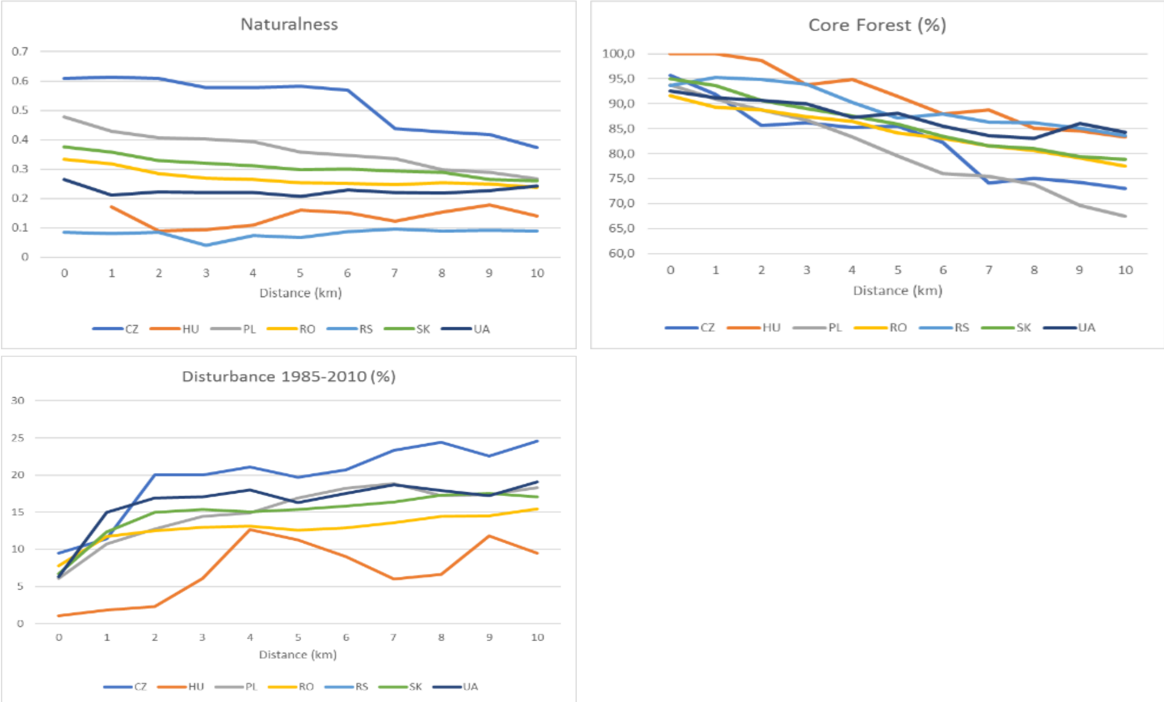

Figure 7: Spatial trends of the sustainable forest indicators by country

3.4.1.2 Altitude

The range of altitude for each grid cell in the buffer areas has been divided in 5 classes (equal intervals) to highlight any specific behaviour of the indicators possibly related to this factor (Figure 8).

Figure 8: Spatial trends of the sustainable forest indicators by altitude

As one could expect, both naturalness and extent of core forest increase with altitude. Nonetheless, while fragmentation increases with distance for most classes, it stays relatively stable for the highest class of altitude.

3.4.1.3 Ownership

The trend of the indicators has been analysed for the officially reported virgin forest plots which report information about the status of ownership (**Error! Reference source not found.**). It can be seen how no difference appears in terms of naturalness while, although the spatial trend is similar, public forest, at any distance from the forest plot, have a 5% higher percentage of core forest than the private ones. The trend for disturbance is also different between the two groups: while the public forest has a quite constant percentage of disturbed forest, the private one has much lower values close to the virgin forest plots, but the extent of affected area becomes almost the triple at 10km distance.

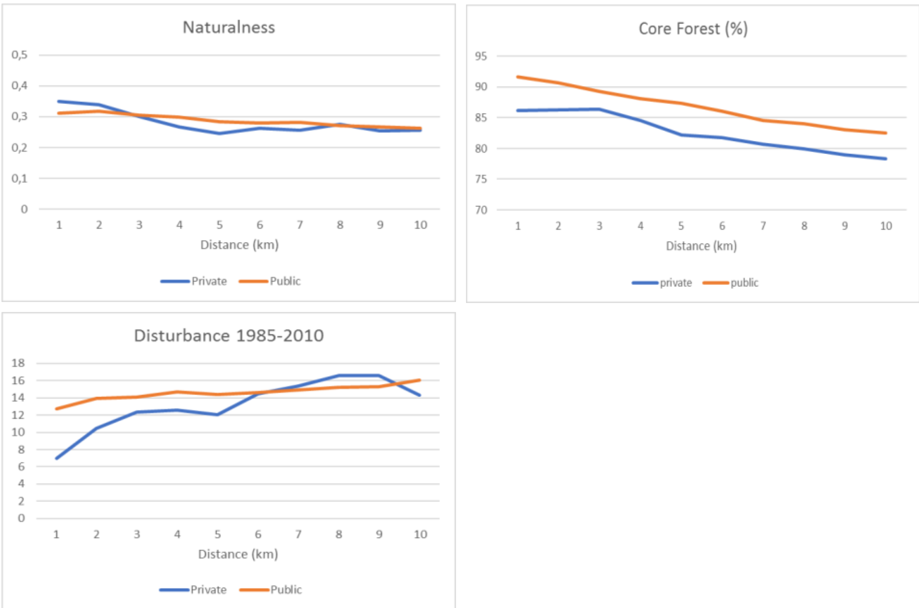

Figure 9: Spatial trends of the sustainable forest indicators by ownership status

3.4.1.4 Eco-climatic regions

The spatial trends of the indicators have then been assessed for eco-climatic regions (Figure 10), as defined by Metzger et al., 2005.

The Carpathian area is interested by three ecoregions: Continental, Pannonian and Southern-Alpine zones. The Pannonian region shows very low values of naturalness but also has very low and spatially constant disturbance. On the contrary, the Southern Alpine region has very high naturalness values which doesn´t decrease with the distance and the lowest levels of fragmentation, but it is also the most disturbed region.

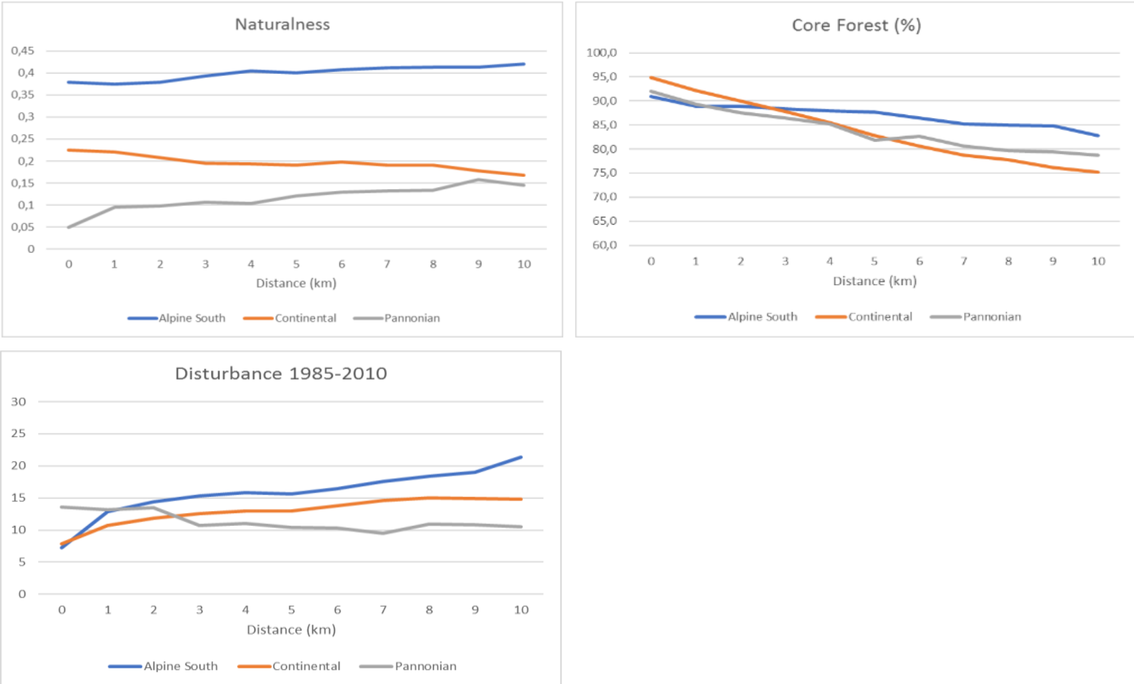

Figure 10: Spatial trends of the sustainable forest indicators by eco-climatic regions

3.5 ASSESSMENT OF RESTORATION AND CONSERVATION POTENTIALS

In the framework of the assessment of sustainable forest indicators, we propose a simple approach to support forest managers and policy makers to prioritize forested areas in need of conservation or restoration measures.

On the basis of reference values of naturalness and fragmentation, it can be possible to identify areas which have very good values of naturalness but high fragmentation and to target them for restoration measures.

We computed reference values of naturalness and fragmentation in the primary forest plots for each of the considered eco-climatic region. These reference values, which can be used as thresholds for defining priority areas, are defined as:

Nat_t (Threshold for Naturalness): $(Nat_{mean} + Nat_{stdv})_{ecoregion}$

$Frag_t$ (Threshold for fragmentation): $(Frag_{mean} - Frag_{stdv})_{ecoregion}$

We would then consider as specific target for restoration/protection purposes all the forested area in one ecoregion which have naturalness values higher than Nat_t and fragmentation values higher than $Frag_t$.

The extent of forested area which results to be a target, based on the previous definition, is reported in Table 6 per ecoregion, where it is highlighted the percentage of this priority areas which is in the 10km proximity of the primary forest.

Consistently with the results highlighted in the previous chapter, the Southern Alpine region would be the one with the least amount of area to prioritize for restoration measures. In both the Southern Alpine region and the Continental one, about half of the area to restore is in the 10km proximity of the primary forest and, for the Southern Alpine region, the 25% in a radius of 4km.

Ecoregion	*Area to prioritize for restoration [km2]*	*Area to prioritize for restoration in 10km proximity of the primary forest plots[km2]*	*%*
ALS	694	358	51.6
CON	1630	748	45.9
PAN	2044	166	8.1

Table 6: Extent of forest area per eco-climatic region to be prioritized for restoration measures

4 CONCLUSIONS AND NEXT STEPS

Main conclusions:

- *Trends of Forest Sustainability indicators in primary forest of the Carpathians are similar to the general ones of Protected Areas: the values of sustainability indicators, and hence their high Nature Value, is higher in the primary forest plots than in their surroundings.*
- *An increase of Forest cover doesn´t imply better forest horizontal structure*
- *Spatial dynamics are similar across different decades*
- *Highlighted spatial trends can be used as input for restoration and conservation efforts*
- *It has been shown how, for some specific eco-climatic regions, a large part of the area which would be in need of restoration efforts is in the proximity of primary forest plots*

Next steps:

- *Virgin Forest Inventory harmonization:*
    - *Plot data, and gap filling review from the countries;*
    - *missing info for Forest type harmonization from Romania and Serbia and, partially for Poland and Ukraine*
    - *Improve primary forest inventory extent with local data (Forum Carpaticum outcomes)*
- *Validation of the forest cover change products through new EEA/Copernicus products, e.g. CLC2018 and HRL Forest Tree Cover Density 2018, supported by ancillary datasets (e.g. Sentinel data and derived products)*
- *Analysis of the indicators in protected vs non-protected areas*
- *Publication of revised and harmonized version of the Virgin Forest Inventory (+other indicators)*
- *The Web viewer developed in 2017 and 2018 will be updated according to the new layers developed*
- *SCC-EEA-ETC/ULS efforts will be following up the work on identification and protection, data integration of Carpathians forest in a European framework*

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