



BIO_SOS

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from Space TO Species

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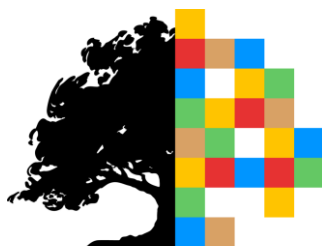


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Abstract	Emerging from the analysis presented in D6.8, the rules for the extraction of the indicators and the evaluation of their trend are presented. The aim of Task 6.7 is the development of an expert system that will combine observation data extracted by the other tasks, in order to design and implement an algorithm for indicator trend evaluation. The various threats specified in D6.8 are rated towards the severity of the imposed impacts on habitats. The correlations between the underlying threats are examined in order to extract the status of biodiversity. Fuzzy logic will be used to develop an expert system based on these rules, where the reliability of each rule as well as the reliability and resolution of each source of information will be taken into consideration. The final goal is the extraction of a warning signal provided in a map form.
Keywords	Threat analysis, quantifying impact, biodiversity status

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1. Executive summary

In the framework of the WP6, with the title “*EO Data for Habitat Monitoring (EODHaM) modeling module development*”, Task 6.7 refers to the *Development of an algorithm for indicator production and their trend (changes) evaluation*. Deliverable D6.11 is the output of WP6-Task 6.7 activity, strictly related to the activity of Tasks 6.2, 6.3, 6.4 and 6.5 and the activity of WP5-Task 5.4 on change detection.

Emerging from the analysis presented in D6.8, the rules for the extraction of the indicators and the evaluation of their trend are presented. The aim of Task 6.7 is the development of an expert system that will combine observation data extracted by the other tasks, in order to design and implement an algorithm for indicator trend evaluation. The various threats specified in D6.8 are rated towards the severity of the imposed impacts on habitats. The correlations between the underlying threats are examined in order to extract the status of biodiversity.

The first part of the deliverable focuses on the identification of the rules for the estimation of the indicators, whereas the second part focuses on the quantification of the magnitude of the threat. Fuzzy logic will be used to develop an expert system based on these rules, where the reliability of each rule as well as the reliability and resolution of each source of information will be taken into consideration. The final goal is the extraction of a warning signal provided in a map form.

The former deliverables acting as inputs to this document are summarized in the following table.

Table I. Overview of former deliverables acting as inputs to this document

Task	Deliverable ID	Deliverable Name
T2.1	D2.1	List of indicators
T5.2	D5.5	Report on RS-IUS second-stage modules software description
T5.4	D5.6	Change detection modules
T6.2	D6.2	Preliminary report on landscape pattern analysis – State of the art
T6.3	D6.4	Landscape pattern analysis
T6.4	D6.7	Report on Ecological Niche Modelling (ENM)
T6.5	D6.8	Developing a methodology to identify locally recognizable pressures and quantify their impact on habitats

2. Introduction

Understanding threats is a critical step in many stages of the conservation process, such as setting up priorities as to where to work and developing strategies to address these problems. As described in D6.8, there is currently no consistent system for measuring the strength, extent, or magnitude of threats either within a project or across projects. On the contrary, there are a number of different variables used for measuring different dimensions of threats with the most common being the TNC's (The Nature Conservancy) 5-S Framework – TNC (2000), the WWF's (World Wildlife Fund for Nature) RAPPAM (Rapid Assessment and Prioritization of Protected Area Management) Methodology, the BSP's (Biodiversity Support Program) Threat Reduction Assessment, the TNC's South-eastern Division's Methodology, the WWF's Root Causes Analysis and the WCS's (Wildlife Conservation Society) Living Landscapes Approach (Salafsky et al., 2003).

As deduced by the review conducted in D6.8, the approach developed by Salafsky for threat classification serves the goals of the BIO_SOS project and therefore is utilized as the basis to build upon the rules for indicator extraction and trend evaluation. Deliverable 6.11 is the implementation of the theory described in D6.8, focusing on the specific rules referring to the methods and input requirements for the estimation of the indicators and the trend evaluation.

3. Indicator estimation

To assess the conservation importance of a site, the magnitude of the threats in the site has to be provided through the calculation of the specified indicators. The basic procedure for measuring the indicators consists of the following steps: a) identify the methods used and b) define the information needs and constraints.

The methods usually consist of well-known techniques such as Landscape Pattern Analysis with already existing tools, e.g., the FRAGSTATS. Tasks 5.4, 6.2, 6.3 and 6.4 are dedicated to the investigation of the proper methods to assess the ecosystem state and its changes and the results are presented in deliverables D5.6, D6.2, D6.4, and D6.7.

Since these methods are focused on monitoring the biodiversity through EO data the requirements on data mainly refer to the type of data, the spatial resolution, and the time span between successive observations. The calculation of most of the indicators requires the existence of habitat maps, LiDAR (Light Detection And Ranging) and other ancillary data. Sometimes field vegetation maps are necessary for the estimation of an indicator, imposing a restriction, as these are not always available to the site managers.

3.1 Correspondence of indicators listed in D6.8 with the CBD indicators

Currently, there is no consistent system for measuring the threats either within a project or across projects. The need for using a common language across projects is apparent; therefore the correspondence of the indicators listed in D6.8 with the three SEBI (Streamlining European Biodiversity Indicators) indicators selected for BIO_SOS (see deliverable D2.1) is attempted in Table 1. As detected from Table 1, there are indicators listed in D6.8 that do not correspond in a well-defined manner to one of the three SEBI indicators. This is due to the fact

that the SEBI indicators were selected based on the criterion that the indicators can be extracted by applying remote sensing. Therefore indicators such as 'Hunting-Fishing' or 'Fire regime' cannot correspond directly to 'Habitats of European interest (extent and change)', 'Abundance and distribution of selected species', or 'Fragmentation of natural and semi-natural areas'.

Table 1. The correspondence of the BIOS_SOS indicators specified in D6.8 with the SEBI bio-indicators selected in deliverable D2.1.

SEBI bioindicators	BIO_SOS indicators as specified in D6.8
Habitats of European interest (extent and change)	Conversion of sedges, reeds and rushes communities to Sarcocornia and other alophytic scrubs communities
	Conversion of salt marshes communities to reed beds
	Broadleaved forest to recreation (Urban)
	Coniferous forest to recreation (Urban)
	Arable land to recreation/industrial/construction sites/built-up (Urban)
	Pastures to recreation/industrial/construction sites/built-up (Urban)
	Pasture to large-scale crops
	Heathland to coniferous forest
	Heathland to grassland
	Inland sand dunes to grassland
	Inland sand dunes to mosses
	Coniferous forest to heathland
	Coniferous forest to inland sand dunes
	Heathland to inland sand dunes
	Encroachment of shrubs and woodlands
	Drainage and conversion to secondary bog
	Encroachment of grasslands
	Change in dominance and evenness values
	Forests to agriculture
	Conversion of salt marshes communities to agricultures
	Native shrubs (maquis) to Pine woods (Pine encroachment)
	Other habitat types to agriculture
	Conversion of temporary ponds to agricultural areas
	Secondary succession or woody encroachment
	Forests to large-scale crops
	Native vegetation to forest plantations
	Native vegetation to perennial crops
	Conversion of salt marshes communities to reed beds
	Meadows and dry grasslands to tall scrub

	Grasslands to agriculture
Abundance and distribution of selected species	Grazing pattern
	Change in tree density
	Loss in species diversity
	Secondary succession or woody encroachment
	Erosion of dunes by human activity and Aeolian forces
	Habitat modification
	Logging
	Intensive practices
Fragmentation of natural and semi-natural areas	Fragmentation
	Decrease in patch size
	Increased inter-patch distance
	Increased edge effects
	Roads (light traffic)
no correspondence to the three indicators above in a well-defined manner	Fire regime
	Tourism
	Water salinization
	Water pollution
	Climate change
	Hunting – Fishing
	Atmospheric deposition

3.2 Indicators estimation in BIO_SOS

In this section the methods and the data requirements for the estimation of the indicators proposed in BIOSOS for each site are presented in Tables 2-12. As expected, the indicators dealing with conversion of land cover, e.g. 'Grasslands to agriculture' can be measured from EO data alone, whereas some indicators, e.g., 'water pollution', are not measurable from EO data alone. In other cases the indicator can be estimated from EO data synergistically with the expert knowledge. For instance, for the UK1 site the experts have designated the "edge effects" as an impact to the target "forest". The use of "Contrast Weighted Edge Density" is proposed as the appropriate index for the estimation of the degree of "edge effects". For the calculation of this index, a table with the contrast weights of the focal class to other classes is needed as input in addition to EO derived LCCS and habitat maps. The contrast weights are expected to be provided by the experts.

3.2.1 Greek sites

Table 2. The methods and data requirements for the estimation of the indicators for the Greek GR1 test site.

Target	Specific habitat	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Salt marshes	A2A6A12B4C2E5-B11E6 LHE/CHE - SCH (Annex I 1410)	Fragmentation	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Changes in spatial connectivity	Class Area (CA)/ Percentage of Landscape (PLAND)/	-	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest	A1A3A10B2XXD1E1F1-B7 FPH/DEC (Annex I 92A0)	Decrease in patch size	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Changes in spatial connectivity	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)/	contrast weight of the focal class to other classes	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed for the contrast weight file
Broadleaved forest	A1A3A10B2XXD1E1F1-B7 FPH/DEC (Annex I 92A0)	Increased inter-patch distance	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or	Changes in spatial connectivity	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)/	contrast weight of the focal class to other classes	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed for the contrast weight file

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			information from LiDAR					
Broadleaved forest	A1A3A10B2XXD1E1F1-B7 FPH/DEC (Annex I 92A0)	Increased edge effects	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices	Changes in spatial connectivity	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)	contrast weight of the focal class to other classes	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest	A1A3A10B2XXD1E2F1-B5/TRS-FPH/DEC (Annex I 9350)	Increased edge effects	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices	Changes in spatial connectivity	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)	contrast weight of the focal class to other classes	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest	A1A4A11B3-A12B14/TRS-TPH/EVR+TRS-FPH/EVR (Annex I 92D0)	Change in dominance and evenness values	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices	Disruption of plant and animal community structure	Class Area (CA)/ Percentage of Landscape (PLAND)/ Indicator species	presence/ absence and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Salt marshes	A2A6A12B4C3-B11/SHY/HEY+EHY/HEL	Change in dominance and evenness values	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices	Disruption of plant and animal community structure	Class Area (CA)/ Percentage of Landscape (PLAND)/ Indicator species	presence/ absence and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed

Table 3. The methods and data requirements for the estimation of the indicators for the Greek GR2 test site.

Target	Specific habitat	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Broadleaved forest	A1A3A10B2XXD1E1 F1-B7/TRS-FPH/DEC (Annex I 92A0)	Decrease in patch size	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Changes in spatial connectivity	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)/	Contrast Weighted Edge Density (CWED)/	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest	A1A3A10B2XXD1E1 F1-B7/TRS-FPH/DEC (Annex I 92A0)	Increased inter-patch distance	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Changes in spatial connectivity	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)/	Contrast Weighted Edge Density (CWED)/	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest	A1A4A11B3-A12B14/TRS-TPH/EVR+TRS-FPH/EVR (Annex I 92D0)	Change in dominance and evenness values	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption of plant and animal community structure	Class Area (CA)/ Percentage of Landscape (PLAND)/ Indicator species	presence/absence and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Salt marshes	A2A6A12B4C2E5F1 - B11E6/SHY/HEY+EHY/HEL (Annex I 7210), A2A6A12B4C3-B11/SHY/HEY+EHY/HEL	Hunting - Fishing	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption/modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/		In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Sclerophyllous	A1A4A11B3C1XXX	Grazing	Change in spatial	Disruption/modification	Class Area		In field data on	Yes but expert

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vegetation	XF1-A12B9/TRS-SCH/EVR (Annex 1 5420), A1A4A10B3XXD1E1 F1/TRS(TRH/EVR)/ TRS(MPH/EVR)/TR S(DCH/EVR)	pattern	coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	cation of ecological regimes	(CA)/ Percentage of Landscape (PLAND)/ Height criterion		vegetation and species composition/ LCCS and habitat maps	knowledge is needed
Continuous urban fabric	A1A4A13A16/URB- ART	Roads (light traffic)	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Fine spatial scale pressures with large spatial impacts	Class Area (CA)/ Percentage of Landscape (PLAND)/		In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broad leaved forest	A1A3A10B2XXD1E2 F1-B7/TRS- FPH/DEC (Annex I 92A0), A1A3A10B2XXD1E2 -B6/TRS-FPH/DEC (Annex I 92D0)	Conversion of forest to agriculture	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ Indicator species	presence/absen ce and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest	A1A4A11B3- A12B14/TRS- TPH/EVR+TRS- FPH/EVR (Annex 1 92D0)	Change in tree density	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Land cover/habitat modification	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)/	Contrast Weighted Edge Density (CWED)/	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest	A1A3A10B2XXD1E2 -B6E4/TRS- FPH/DEC A1A3A10B2XXD1E2 F1-B5/TRS- FPH/DEC A1A3A10B2XXD1E2 F1-B7/TRS- FPH/DEC	Loss in species diversity	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from	Land cover/habitat modification	Class Area (CA)/ Percentage of Landscape (PLAND)/ Indicator species	presence/absen ce and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed

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	A1A4A10B3XXD1E1 F1-B9/TRS- LPH/EVR A1A4A10B3XXD1E1 F1-B8/TRS- MPH/EVR A1A4A11B3XXD1E2 F1-A12B9/TRS- SCH/DEC		LiDAR					
Water courses	A2A5A16B4C3- A8A17B13/SHY- HEL/EHY/HEL (Annex I 3150)	Hunting – Fishing	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption/modifi- cation of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/ Indicator species	presence/absen- ce and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed

Table 4. The methods and data requirements for the estimation of the indicators for the Greek GR3 test site.

Target	Specific habitat	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Broadleaved forest	A1A3A10B2XXD1E 1F1-B7/TRS-FPH/DEC (Annex I 92A0)	Climate change	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption/modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)/	contrast weight of the focal class to other classes	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest	A1A3A10B2XXD1E 1F1-B7/TRS-FPH/DEC (Annex I 92A0)	Hunting - Fishing	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption/modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)/	contrast weight of the focal class to other classes	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Salt marshes	A2A6A12B4C3-B11/SHY/HEY+EHY/HEL	Fire regime	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption/modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/ Indicator species	presence/absence and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Salt marshes	A2A6A12B4C3-B11/SHY/HEY+EHY/HEL	Grazing pattern	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption/modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/ Indicator species	presence/absence and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Salt marshes	A2A6A12B4C3-B11/SHY/HEY+EHY	Hunting - Fishing	Change in spatial coverage of LCCS/GHC	Disruption/modification of ecological	Class Area (CA)/ Percentage of	presence/absence and frequency of	In field data on vegetation and species	Yes but expert knowledge is needed

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	/HEL		category/ change in vegetation indices, in image texture, or information from LiDAR	regimes	Landscape (PLAND)/ Indicator species	indicator species	composition/ LCCS and habitat maps	
Sclerophyllous vegetation	A1A4A10B3XXD1E 1F1-B9/TRS-LPH/EVR	Conversion of forest to agriculture	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ Height criterion		In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Sclerophyllous vegetation	A1A4A10B3XXD1E 1F1/TRS(TRH/EVR)/TRS(MPH/EVR)/TRS(DCH/EVR)	Loss in species diversity	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Land cover/habitat modification	Class Area (CA)/ Percentage of Landscape (PLAND)/ Height criterion		In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Water courses	A2A5A13B4C3XXE 5F2F5F10G2F1-A8A15B11E6G7/HE R-HEL+TRS-TPH (Annex I 3280)	Water pollution- Eutrofication	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Land cover/habitat modification	Class Area (CA)/ Percentage of Landscape (PLAND)/		In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broad leaved forest	A1A3A10B2XXD1E 2F1-B7/TRS-FPH/DEC (Annex I 92A0)	Climate change	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption/modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/ Contrast Weighted Edge Density (CWED)/	contrast weight of the focal class to other classes	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed
Broadleaved forest		Hunting - Fishing	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices,	Disruption/modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/	presence/absence and frequency of indicator	In field data on vegetation and species composition/ LCCS and habitat	Yes but expert knowledge is needed

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			in image texture, or information from LiDAR		Indicator species	species	maps	
Water courses		Fire regime	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Disruption/m odification of ecological regimes	Indicator species	presence/abse nce and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps	Yes but expert knowledge is needed

3.2.2 Italian sites

Table 5. The methods and data requirements for the estimation of the indicators for the Italian IT3 site.

Target	Specific habitat	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Grasslands, grasslands with trees, pastures	A2.A10.B12.E6 A2.A6.A10.F2.F5.F1 O.G2.B12 A2.A5.A10.B12.E7	Grasslands to agriculture	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/	Individual patch area, landscape area/	LCCS and habitat maps	Yes
Grasslands, grasslands with trees, pastures	A2.A10.B12.E6 A2.A6.A10.F2.F5.F1 O.G2.B12 A2.A5.A10.B12.E7	Secondary succession or woody encroachment	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture related to woody vegetation density and spatial aggregation, in LiDAR canopy height	Land cover/habitat modification	Class Area (CA)/ Percentage of Landscape (PLAND)/ Vegetation indices changes/ Woody vegetation density and height change as per the thresholds in LCCS and GHC manuals	Individual patch area, landscape area/ Vegetation indices/ image texture II order statistics (Grey Level Co-occurrence Matrixes GLCM, Haralick et al., 1973)	LCCS and habitat maps/ RS image	Yes but expert knowledge is needed for GLCM parameters settings and Vegetation index selection
Grasslands, grasslands with trees, pastures	A2.A10.B12.E6 A2.A6.A10.F2.F5.F1 O.G2.B12 A2.A5.A10.B12.E7	Fragmentation	Changes in contagion interspersions metrics, used to assess the degree of fragmentation	Changes in spatial connectivity	Effective mesh size (MESH)	individual patch area, landscape area	LCCS and habitat maps	Yes
Grasslands, grasslands with trees, pastures	A2.A10.B12.E6 A2.A6.A10.F2.F5.F1 O.G2.B12 A2.A5.A10.B12.E7	Edge effects	Changes in edge metrics	Changes in spatial connectivity	Contrast Weighted Edge Density (CWED)	contrast weight of the focal class to other classes	LCCS and habitat maps Contrast weight table for the focal class	Yes but expert knowledge is needed for the contrast weight file

D6.11 Rules for indicator extraction

Pine plantations and semi-natural woodlands	A1.A3.A10.D1.E2.B7 A1.A4.A10.D1.E2.B9 A1.A8.A9.W7 A1.A4.A10.D1.E1.B9	Fire regime	Change in spatial coverage of fire scars/ Decrease in woody vegetation canopy cover	Disruption/Modification of ecological regimes	Class Area (CA) for initial habitat and burnt areas/ Percentage of Landscape (PLAND) initial habitat and burnt areas/ Vegetation indices changes/ Woody vegetation density and height change as per the thresholds in LCCS and GHC manuals	Individual patch area per each class type (i.e. initial habitat and burnt areas), landscape area/ Vegetation indices/ image texture II order statistics (Grey Level Co-occurrence Matrixes GLCM, Haralick et al., 1973)	LCCS and habitat maps/ RS image	Yes but expert knowledge is needed for GLCM parameters settings and Vegetation index selection
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Table 6. The methods and data requirements for the estimation of the indicators for the Italian IT4 site.

Target	Specific habitat	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Mediterranean maquis and relevant mosaics	LCCS: A1A4A10B3XXD1E 1-B9/ A1A4A11B3XXD1E 1-B10 GHC: TRS-MPH/EVR/ TRS-LPH/EVR	Native shrubs (maquis) to Pine woods (Pine encroachment)	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Land cover/habitat conversion	Indicator species/ Class Area (CA)/ Percentage of Landscape (PLAND)/ height criterion	Presence/absence and frequency of indicator species	In field data on vegetation and species composition/ LCCS and habitat maps/ LiDAR	Yes but expert knowledge is needed
Mediterranean maquis and relevant mosaics	LCCS: A1A4A10B3XXD1E 1-B9/ A1A4A11B3XXD1E 1-B10 GHC: TRS-MPH/EVR/ TRS-LPH/EVR	Native shrubs (maquis) to Pine woods (Pine plantations)	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices, in image texture, or information from LiDAR	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ height criterion		LCCS and habitat maps/ LiDAR	Yes
Pine plantations	LCCS: A1B1XXC1D1W7-A8A9B3 GHC: CUL-WOC	Fire regime	Change in spatial coverage of fire scars/ Decrease in Pine forest cover	Disruption/Modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)/ other indicators (texture)		LCCS and habitat maps	Yes but expert knowledge is needed
Dune vegetation	LCCS: A2A5A11B4XXE5-A13B13E7/ A2A6A11B4XXE5-A12B12E6/ A2A6A10B4XXE5-A12B11E6 GHC: HER-THE (Annex I 1210)/ HER-LHE/CHE (Annex 1 2110 and 2120)/	Decrease in area and patch size/ habitat fragmentation	changes in Patch size indices, edge and other metrics	Changes in spatial connectivity	Contrast Weighted Edge Density (CWED)/ PD/ MPS/ CIRCLE/ SHAPE	contrast weight of the focal class to other classes	LCCS and habitat maps	Yes but expert knowledge is needed for the contrast weight file

D6.11 Rules for indicator extraction

	HER-LHE/THE (Annex I 2230)							
Dune vegetation	LCCS: A2A5A11B4XXE5- A13B13E7/ A2A6A11B4XXE5- A12B12E6/ A2A6A10B4XXE5- A12B11E6 GHC: HER-THE (Annex I 1210)/ HER- LHE/CHE (Annex 1 2110 and 2120)/ HER-LHE/THE (Annex I 2230)	Change in species composition/ change in dominance and evenness values	Changes in vegetation indices and species composition	Disruption of plant and animal community structure	Indicator species	Presence/absence and frequency of indicator species	In field data on vegetation and species composition	No
Dune vegetation	LCCS: A2A5A11B4XXE5- A13B13E7/ A2A6A11B4XXE5- A12B12E6/ A2A6A10B4XXE5- A12B11E6 GHC: HER-THE (Annex I 1210)/ HER- LHE/CHE (Annex 1 2110 and 2120)/ HER-LHE/THE (Annex I 2230)	Beaches to urban	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ other indicators (texture)		LCCS and habitat maps	Yes
Salt marshes	LCCS: A2A5A13B4C2E5- B13E7/ A2A6A12B4C2E5- B11E6/ A1A4A12B3C2D3- B10 GHC: THE+SPV/TER (Annex I 1310)/ HEL (Annex I 1410/ TRS-SCH/NLE (Annex I 1420)	Conversion of salt marshes communities to reed beds	Change in spatial coverage of LCCS/GHC category/ change in vegetation indices and species composition	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ indicator species	presence/absence and frequency of indicator species	LCCS and habitat maps/ in field vegetation and floristic data	No
Brackish marshes	LCCS: A2A6A12B4C2E5-	Water salinization	Change in vegetation indices	Land cover/habitat	Indicator species	presence/absence and	In field vegetation and floristic data	No

D6.11 Rules for indicator extraction

	B11E6 GHC: EHY/HEL (Annex I 7210)/ HEL		and species composition	modification		frequency of indicator species		
Brackish marshes	LCCS: A2A6A12B4C2E5- B11E6 GHC: EHY/HEL (Annex I 7210)/ HEL	Conversion of sedges, reeds and rushes communities to Sarcocornia and other alophytic scrubs communities	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ indicator species	presence/abse nce and frequency of indicator species	LCCS and habitat maps	Yes but expert knowledge is needed
Coastal lagoons	LCCS: A2A5A13B4C1E5- A15B12E6 GHC: AQU+TER+SHY+E HY+CHE+LHE/CH E (Annex I 1150)	Water pollution	Change in vegetation indices and species composition	Land cover/habitat modification	Indicator species	presence/abse nce and frequency of indicator species	In field vegetation and floristic data	No
Temporary ponds	LCCS: A2A5A13B4C2E5- B13E7 GHC: THE+GEO+THE/G EO (Annex I 3170)	Conversion of temporary ponds to agricultural areas	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)		LCCS and habitat maps	Yes but expert knowledge and in field data are needed

3.2.3 Welsh site

Table 7. The methods and data requirements for the estimation of the indicators for the Welsh UK1 site.

Target	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Forest	Edge effects	changes in edge metrics, used to infer impacts on species population and viability	Changes in spatial connectivity	Contrast Weighted Edge Density (CWED)	contrast weight of the focal class to other classes	1.LCCS and habitat maps 2. Contrast weight table for the focal class	Yes but needs expert knowledge for the contrast weight file
Forest	Fragmentation	Changes in landscape structure and geometry	Changes in area and perimeter of forests	Fragmentation statistics	Area, perimeter and other landscape metrics	LCCS and habitat maps	Yes
Active bog	Encroachment of shrubs and woodlands	Secondary or degraded bog to shrubs and woodland,	Land cover/habitat conversion	LiDAR, Multi-temporal VHR optical	Height, cover & species type	MR and VHR data/ time-series over decadal periods	Yes
Active Bog	Atmospheric deposition	Increase in grasses	Disruption/ modification of ecological regimes	Increase in grass area	Remote sensing indices of non-photosynthetic and photosynthetic material (e.g., Plant Senescence Reflectance Index (PSRI) and Normalised Difference Vegetation Index (NDVI))	MR and VHR data/ time-series over decadal periods	Yes
Active bog	Drainage and conversion to secondary bog	Decrease in surface moisture, decrease in <i>Calluna vulgaris</i> and <i>Molinea caerulea</i>	Changes in hydrological regime	Decrease in surface wetland and changes in plant community composition (e.g., sphagnum)	Remote sensing indices (e.g., Water Band Index, WBI)	MR and VHR data/ time-series over decadal periods	Yes
Active Bog	Encroachment of grasslands	Encroachment of degraded bog vegetation,	Land cover/habitat modification	Increase in grass area	Remote sensing indices of non-photosynthetic and photosynthetic material	MR and VHR data/ time-series over decadal	Yes

D6.11 Rules for indicator extraction

					(e.g., Plant Senescence Reflectance Index (PSRI) and Normalised Difference Vegetation Index (NDVI))	periods	
Salt marsh	Conversion to agriculture	Salt marshes to agriculture,	Land cover/habitat conversion			MR and VHR data/ time-series over decadal periods	Yes
Sand Dune	Erosion of dunes by human activity and Aeolian forces	Vegetation denuded and associated sand dune collapse,	Land cover/habitat modification			MR and VHR data/ time-series over decadal periods	Yes

3.2.4 Dutch sites

Table 8. The methods and data requirements for the estimation of the indicators for the Dutch NL1 site.

Target	Specific habitat	Impact	Indicator	Broad impact category	indicator calculation methodology	Input data requirements	Is it measurable from EO data alone?
Broadleaved forest	(A12) A3.A10.B2.C1.D1.E2.F2.F6.F7.G3.F1-B5F9G8 (H9120, H9190)	Broadleaved forest to recreation (Urban)	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data	Land cover or habitat maps	Yes
Coniferous forest	(A12) A3.A10.B2.C1.D2.E1.F2.F6.F7.G3.F1-B5F9G8	Coniferous forest to recreation (Urban)	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data	Land cover or habitat maps	Yes
Arable land	(A11) (A3.)A4.B1.B5.C1.D1.D9-B4-S7, (A3.)A5.B1.B5.C1.D1.D9-B4-S4, (A3.)A5.B1.B5.C1.D1.D9-B4-S9, (A3.)A5.B1.B5.C1.D1.D9-B4-S3	Arable land to recreation/industrial/construction sites/built-up (Urban)	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data	Land cover or habitat maps	Yes
Pastures	(A11) (A3.)A4.B1.B5.C1D1.D9	Pastures to recreation/industrial/construction sites/built-up (Urban)	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data	Land cover or habitat maps	Yes
Heathland	(A12) A4.A10.B3.C1.D1.E1.F1-B10 (H2310, H4030)	Heathland to coniferous forest	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data/field	Land cover or habitat maps	Yes
Heathland	(A12) A4.A10.B3.C1.D1.E1.F1-B10 (H2310, H4030)	Heathland to grassland	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data/field	Land cover or habitat maps or field data	Yes
Inland sand dunes	(B16, A12), H2330	Inland sand dunes to grassland	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data/field	Land cover or habitat maps or field data	Yes
Inland sand dunes	(B16, A12), H2330	Inland sand dunes to	Change in spatial coverage of	Land cover/habitat	EO data/field	Habitat maps or field data	Yes

D6.11 Rules for indicator extraction

		mosses	LCCs/GHC category	conversion			
Coniferous forest	(A12) A3.A10.B2.C1.D2.E1.F2.F6.F7.G3. F1-B5F9G8	Coniferous forest to heathland	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data	Land cover or habitat maps	Yes
Coniferous forest	(A12) A3.A10.B2.C1.D2.E1.F2.F6.F7.G3. F1-B5F9G8	Coniferous forest to inland sand dunes	Change in spatial coverage of LCCs/GHC category	Change in spatial coverage of LCCs/GHC category	EO data	Land cover or habitat maps	Yes
Heathland	(A12) A4.A10.B3.C1.D1.E1.F1-B10 (H2310, H4030)	Heathland to inland sand dunes	Change in spatial coverage of LCCs/GHC category	Land cover/habitat conversion	EO data	Land cover or habitat maps	Yes
Freshwater	(B27, A12) A1.B1C1.D1-A4 (H6230)	Fresh water extraction for water consumption		Disruption / modification of ecological regimes	Field data	Expert /Field data	No
Freshwater	(B27) A1.B1C1.D1-A4	Pollution of surface water		Disruption / modification of ecological regimes	Field data	Expert /Field data	No
Heathland	(A12) A4.A10.B3.C1.D1.E1.F1-B10 (H2310, H4030)	Soil disturbance		Disruption / modification of ecological regimes	Field data /EO data (dead heather)	Expert /Field data	No (only dead heather with EO)
Forests	(A12) A3.A10.B2.C1.D1.E2.F2.F6.F7.G3. F1-B5F9G8, A3.A10.B2.C1.D2.E1.F2.F6.F7.G3. F1-B5F9G8, A4.A10.B3.C1.D1.E1.F1-B10 (H9120, H9190, H2310, H4030)	Forest Fires	Change in spatial coverage of LCCs/GHC category	Disruption / modification of ecological regimes	EO data	EO data/Expert/Field	Yes

3.2.5 Portuguese sites

Table 9. The methods and data requirements for the estimation of the indicators for the Portuguese PT1 site.

Target	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Evergreen forests and scrublands	Native vegetation to forest plantations	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in species composition	LCCS and habitat maps / thematic data / species records	Yes but species records are needed
Evergreen forests and scrublands	Native vegetation to perennial crops	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in species composition	LCCS and habitat maps / thematic data / species records	Yes but species records are needed
meadows and dry grasslands	Meadows and dry grasslands to tall scrub	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in vegetation composition or types	LCCS and habitat maps/ vegetation data	Yes but vegetation data are needed
Evergreen forests and scrublands	Construction of hydroelectric dams	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in vegetation composition or types	LCCS and habitat maps / thematic data / species records	Yes but species records are needed

Table 10. The methods and data requirements for the estimation of the indicators for the Italian PT2 site.

Target	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Deciduous forests and heathlands	wildfires	Change in spatial coverage of LCCS/GHC category	Disruption/modification of ecological regimes	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in species composition	LCCS and habitat maps / thematic data / species records	Yes but species records are needed
Deciduous forests and heathlands	woody plant invasion	Change in spatial coverage of LCCS/GHC category	Disruption/modification of ecological regimes	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in species composition	LCCS and habitat maps / thematic data / species records	Yes but species records are needed
Meadows, nutrient poor acidic grasslands and heathlands	Grassland and heathlands to tall scrub	Change in spatial coverage of LCCS/GHC category	Land cover/habitat modification	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in vegetation composition or types	LCCS and habitat maps/ vegetation data	Yes but vegetation data are needed
Deciduous forests and heathlands	Native vegetation to forest plantations	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in species composition	LCCS and habitat maps / thematic data / species records	Yes but species records are needed
Deciduous forests and heathlands	Construction of hydroelectric dams	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Landscape Pattern Analysis (LPA) / Morphological Spatial Pattern Analysis (MSPA) / Graph Based Analysis (GBA) / Multivariate statistics	% change in selected indicators of landscape composition, configuration and function / Change in species composition	LCCS and habitat maps / thematic data / species records	Yes but species records are needed

3.2.6 Indian sites

Table 11. The methods and data requirements for the estimation of the indicators for the Indian IN1 site.

Target	Specific habitat	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Forests	A3A14B2XXD1E2F2F4F10G4-A15B7E3G11/ A3A14B2XXD1E2F2F4F10G4-A15B7G11	Forests to agriculture	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/	Individual class area, landscape area/	LCCS and habitat maps	Yes
Forests	A3A10B2XXD1E1F2F6F7G3F1-B5E4F9G9/A2B1XXC2D3D9-B4C3C7C17D6-S13W7	Forests to plantation	Change in spatial coverage of LCCS/GHC category	Land cover/habitat conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/	Individual class area, landscape area/	LCCS and habitat maps	Yes
Forests	A3A11B2XXD1E2F2F6F7G3F2 F4F7G4- B7E3F9G9G11/A3A14B2XXD1E2F2F4F10G4- A15B7E3G11/A3A14B2XXD1E2F2F4F10G4- A15B7G11/A3A10B2XXD1E2F2F6F7G3F1- B6F9G9/A3A11B2XXD1E2F2F6F7G3F2F4F7G4- A12B5E3F9G9F9G12	Habitat modification	Vegetation indices	Land cover/habitat modification	Vegetation indices	Change in vegetation index	EO data+field data	Yes , but also require field data
Forests	/A3A14B2XXD1E2F2F4F10G4-A15B7E3G11/ A3A14B2XXD1E2F2F4F10G4-A15B7G11/ A3A11B2XXD1E2F2F6F7G3F2 F4F7G4-A12B5E3F9G9F9G12/ A3A10B2XXD1E2F2F6F7G3F1-B6F9G9/ A3A10B2XXD1E1F2F6F7G3F1-B5E4F9G9	Disruption of plant and animal community structure	Change in spatial coverage of LCCS/GHC category/ Vegetation Indices	Land cover/habitat modification	Vegetation indices/ RS classification	Change in vegetation index/ change in habitat area	EO data+field data	Yes , but also require field data

3.2.7 Brazilian sites

Table 12. The methods and data requirements for the estimation of the indicators for the Brazilian BR1 site.

Target	Specific habitat	Impact	Indicator	Broad impact category	indicator calculation methodology	Indicator calculation parameters	Input data requirements	Is it measurable from EO data alone?
Rainforest	evergreen broadleaved high trees	Forest to large-scale crops	Deforestation for large-scale crops	Land cover/habitat at conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ Landscape metrics	-	LCCS and habitat maps	Yes
Rainforest	evergreen broadleaved high trees	Forest to large-scale pasture	Deforestation for large-scale pasture	Land cover/habitat at conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ Landscape metrics	-	LCCS and habitat maps	Yes
Rainforest	evergreen broadleaved high trees	Forests to small-scale agriculture	Deforestation to small-scale agriculture	Land cover/habitat at conversion	Class Area (CA)/ Percentage of Landscape (PLAND)/ Landscape metrics	-	LCCS and habitat maps	Yes
Rainforest	evergreen broadleaved high trees	Logging	Tree density	Disruption of plant and animal community structure	Indicator species	Presence/absence of species	EO data and canopy cover/ Field surveys	Yes
Pasture	Permanently Cropped area Graminoids Crop(s), Grassland with shrubs, Scattered Clustered Fields of permanently Cropped Area Graminoid Crop(s), Broadleaved Evergreen Open Woody Vegetation with Herbaceous Layer	Pasture to large-scale crops	Crop expansion on pasture	Land cover/habitat at conversion	Class Area (CA)/ Percentage of Landscape (PLAND)	-	LCCS and habitat maps	Yes

D6.11 Rules for indicator extraction

Pasture	Permanently Cropped area Graminoids Crop(s), Grassland with shrubs, Scattered Clustered Fields of permanently Cropped Area Graminoid Crop(s), Broadleaved Evergreen Open Woody Vegetation with Herbaceous Layer	Grazing pattern	Grazing pattern	Land cover/habitat at modification	Class Area (CA)/ Percentage of Landscape (PLAND)	-	LCCS and habitat maps	Yes
Natural vegetation	Non Linear Built Up Area(s)	Urbanization	Urbanization	Land cover/habitat at conversion	Class Area (CA)/ Percentage of Landscape (PLAND)	-	LCCS and habitat maps	Yes
Crops	Permanently Cropped Area with Herbaceous Crop(s)	intensive practices	intensification	Land cover/habitat at modification	Number of cropping cycles/year	-	LCCS and habitat maps	Yes
Roads	Linear Built Up Area(s)	Roads construction	Roads construction	Fine spatial scale pressures with large spatial impacts	Road detection algorithm	-	LCCS and habitat maps	Yes
Water	Aquatic or Regularly Flooded Area	Water pollution	Water pollution	Disruption/ Modification of ecological regimes	fields surveys	-	Surveys on water quality	No
Water	Aquatic or Regularly Flooded Area	Water change	Water change	Disruption/ Modification of ecological regimes	Class Area (CA)/ Percentage of Landscape (PLAND)	-	LCCS and habitat maps	Yes
Rainforest	evergreen broadleaved high trees	Rainforest to plantations	Plantations	Land cover/habitat at modification			LCCS and habitat maps	Yes

4. Quantifying impacts

The TNC's Southe-astern Division's Methodology is adopted herein for the quantification of impacts, utilizing two variables to measure threats:

- 1) *Severity* is "how severe are the stresses associated with the Source of Stress to the conservation targets?"
- 2) *Extent* is "what percent of eco-regional target occurrences are affected by the threat at this level of severity?"

These variables are assessed using categorical rankings (e.g., > 75%, 50-75%, 25-50%, < 25%). Ranking is then combined using a rule-based system.

Salafsky et al. (2003) proposed 4-point scales for the categorical measurements as these rankings provide sufficient spread, but do not create false precision. For a number of variables, non-linear categories to reflect the non-linear nature of the variable being measured may be recommended, but for the threats assessed in BIO_SOS linear categories are suitable, i.e., low impact extent (rated as 1) corresponds to <25%, medium impact extent (rated as 2) corresponds to 25-50%, high impact extent (rated as 3) corresponds to 50-75%, and very high impact extent (rated as 4) corresponds to >75%. Consequently, the compound variable of *Threat magnitude* is a combination of *Extent* and *Severity*, constructed using a rule-based system. Over time, other compound variables may emerge as being useful.

Once a series of measurements is developed out of different variables pertaining to threats, the next step is to combine or roll-up these variables into overall measurements, as many threats do not act individually in conjunction with other threats, but instead act with synergistic or antagonistic interactions with positive and negative feedbacks, frequently leading to unanticipated outcomes. For instance, grazing can result in the exacerbation of the effects of other types of threats such as habitat degradation, soil depletion, weed invasion and pollution of waterways. Such effects can become more severe during periods of climate change, especially during drought events. Yet, if maintained within moderate intensities, grazing can also have positive effects on habitats, stimulating the growth of native grasses. Such threat categories have high levels of assessment uncertainty, which needs to be flagged during analysis and planning for management, and requiring careful research and monitoring during management.

There are three basic combinations of ranking needed for landscape assessment:

- Rating Type I: How to combine variables to assess a single threat to a single target. For example, what is the magnitude of the threat of the impact "Native shrubs (maquis) to Pine woods (Pine encroachment)" to target "Mediterranean maquis and relevant mosaics"?
- Rating Type II: How to roll-up assessments of the impact of different threats to a single target. For example, if "Mediterranean maquis and relevant mosaics" is threatened by "Native shrubs (maquis) to Pine woods (Pine encroachment)" and "Native shrubs (maquis) to Pine woods (Pine plantations)", what is the overall threat status for this target?
- Rating Type III: How to roll-up assessments of the impact of one threat across multiple targets. For example, if "Land cover/habitat conversion" affects "Mediterranean maquis and relevant mosaics", "salt marshes", "brackish marshes" and "temporary ponds", what is the overall ranking of this threat?

To handle the combination and roll-up of threat measurement a procedure that is meaningful and models real world problems is adopted. There are two basic procedures to roll-up the different measurements:

- Arithmetic Procedures involving mathematical combinations of different variables, e.g., addition, averaging and multiplication. These procedures have the advantage of being relatively simple and transparent. WWF's RAPPAM method (Ervin 2002) represents an example of a multiplicative method for aggregating different threat variables. BSP's Threat Reduction Assessment (Salafsky and Margoluis 1999) represents an example of an additive method. WCS's Living Landscape Approach (WCS 2002) uses a combination of addition and multiplication to combine their threat parameters [*(Urgency + Recovery time) * Proportion of Local Area Affected * Severity * Probability*].
- Threshold Rule-Based Procedures involving specifying rules, as to how different parameters should be combined as shown in the following example. These systems have the advantage of being able to tailor the combinations in ways that reflect real-world threshold effects.

Example:

In BIO_SOS, an explicit rule-based procedure is followed for conducting Type II, III and IV rollups of threat rankings. The procedure begins by ranking threats on the *Extent* and *Severity* variables and then using a Type I rule-based roll-up to combine these variables to produce an overall rank of Very High, High, Medium, or Low for each threat on each focal target as described above. The next step is to create matrices of threats and focal targets as shown in the Tables below where this analysis is performed for all the sites in BIO_SOS. Multiple threats to individual targets and multiple target threat scores are summed together using the 3-5-7 rule adopted from the TNC 5-S Framework as discussed in D6.8. Once multiple threats scores are summed together, the overall threat status for a single target, for a threat, and the overall threat status for each site is calculated.

4.1 Greek sites

Table 13. Rating the threats based on the variables Extent and Severity for the Greek GR1 test site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Salt marshes	Fragmentation	Changes in spatial connectivity	Low	Low	Low
Broadleaved forest	Decrease in patch size	Changes in spatial connectivity	Low	Low	Low
Broadleaved forest	Increased inter-patch distance	Changes in spatial connectivity	Low	Low	Low
Broadleaved forest	Increased edge effects	Changes in spatial connectivity	Low	Low	Low
Broadleaved forest	Change in dominance and evenness values	Disruption of plant and animal community structure	Low	Low	Low
Salt marshes	Change in dominance and evenness values	Disruption of plant and animal community structure	Low	Low	Low

Table 14. Roll-up of the different measurements towards the Rating Type I for the Greek GR1 test site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Impact 3	Magnitude of impact 3	Rating Type I
Changes in spatial connectivity	Broadleaved forest	Decrease in patch size	Low	Increased inter-patch distance	Low	Increased edge effects	Low	Low

Table 15. Roll-up of the different measurements towards the Rating Type III for the Greek GR1 test site

Threat	Target 1	Rating Type I	Target 2	Rating Type I	Rating Type III
Changes in spatial connectivity	Broadleaved forest	Low	Salt marshes	Low	Low

Table 16. Roll-up of the different measurements towards the Rating Type II for the Greek GR1 test site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Rating Type II
Broadleaved forest	Changes in spatial connectivity	Low	Disruption of plant and animal community structure	Low	Low

Table 17. Rating the threats based on the variables Extent and Severity for the Greek GR2 test site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Broadleaved forest	Decrease in patch size	Changes in spatial connectivity	Low	Low	Low
Broadleaved forest	Increased inter-patch distance	Changes in spatial connectivity	Low	Low	Low
Broadleaved forest	Change in dominance and evenness values	Disruption of plant and animal community structure	Low	Low	Low
Salt marshes	Hunting - Fishing	Disruption/modification of ecological regimes	Low	Low	Low
Sclerophyllous vegetation	Grazing pattern	Disruption/modification of ecological regimes	Medium	Medium	Medium
Continuous urban fabric	Roads (light traffic)	Fine spatial scale pressures with large spatial impacts	Low	Low	Low
Broad leaved forest	Conversion of forest to agriculture	Land cover/habitat conversion	Low	Low	Low
Broadleaved forest	Change in tree density	Land cover/habitat modification	Medium	Medium	Medium
Broadleaved forest	Loss in species diversity	Land cover/habitat modification	Medium	Low	Low
Water courses	Hunting - Fishing	Disruption/modification of ecological regimes	Low	Low	Low

Table 18. Roll-up of the different measurements towards the Rating Type I for the Greek GR2 test site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Rating Type I
Changes in spatial connectivity	Broadleaved forest	Decrease in patch size	Low	Increased inter-patch distance	Low	Low
Land cover/habitat modification	Broadleaved forest	Change in tree density	Low	Loss in species diversity	Low	Low

Table 19. Roll-up of the different measurements towards the Rating Type III for the Greek GR2 test site

Threat	Target 1	Rating Type I	Target 2	Rating Type I	Target 3	Rating Type I	Rating Type III
Disruption/modification of ecological regimes	Salt marshes	Low	Sclerophyllous vegetation	Medium	Water courses	Low	Low

Table 20. Roll-up of the different measurements towards the Rating Type II for the Greek GR2 test site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Threat 3	Rating Type I	Threat 4	Rating Type I	Rating Type II
Broadleaved forest	Changes in spatial connectivity	Low	Disruption of plant and animal community structure	Low	Land cover/habitat conversion	Low	Land cover/habitat modification	Low	Low

Table 21. Rating the threats based on the variables Extent and Severity for the Greek GR3 test site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Broadleaved forest	Climate change	Disruption/modification of ecological regimes	Low	Low	Low
Broadleaved forest	Hunting - Fishing	Disruption/modification of ecological regimes	Low	Low	Low
Salt marshes	Fire regime	Disruption/modification of ecological regimes	Low	Low	Low
Salt marshes	Grazing pattern	Disruption/modification of ecological regimes	Low	Low	Low
Salt marshes	Hunting - Fishing	Disruption/modification of ecological regimes	Low	Low	Low
Sclerophyllous vegetation	Conversion of forest to agriculture	Land cover/habitat conversion	Low	Low	Low
Sclerophyllous vegetation	Loss in species diversity	Land cover/habitat modification	Medium	Medium	Medium
Water courses	Water pollution-Eutrofication	Land cover/habitat modification	Low	Low	Low
Water courses	Fire regime	Disruption/modification of ecological regimes	Low	Low	Low

Table 22. Roll-up of the different measurements towards the Rating Type I for the Greek GR3 test site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Impact 3	Magnitude of impact 3	Rating Type I
Disruption/modification of ecological regimes	Broadleaved forest	Climate change	Low	Hunting - Fishing	Low			Low
Disruption/modification of ecological regimes	Salt marshes	Fire regime	Low	Grazing pattern	Low	Hunting - Fishing	Low	Low

Table 23. Roll-up of the different measurements towards the Rating Type III for the Greek GR3 test site

Threat	Target 1	Rating Type I	Target 2	Rating Type I	Target 3	Rating Type I	Target 1	Rating Type I	Rating Type III
Disruption/modification of ecological regimes	Broadleaved forest	Low	Salt marshes	Low	Water courses	Low	Temporary ponds	Very high	Low
Land cover/habitat modification	Sclerophyllous vegetation	Medium	Water courses	Low					Medium

Table 24. Roll-up of the different measurements towards the Rating Type II for the Greek GR3 test site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Rating Type II
Sclerophyllous vegetation	Land cover/habitat conversion	Low	Land cover/habitat modification	Medium	Medium
Water courses	Land cover/habitat modification	Low	Disruption/modification of ecological regimes	Low	Low

4.2 Italian sites

Table 25. Rating the threats based on the variables Extent and Severity for the Italian IT3 site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Grasslands, grasslands with trees, pastures	Grasslands to agriculture	Land cover/habitat conversion	Medium	Very high	High
Grasslands, grasslands with trees, pastures	Secondary succession or woody encroachment	Land cover/habitat modification	Low	Low	Low
Grasslands, grasslands with trees, pastures	Fragmentation	Changes in spatial connectivity	-Not applicable	High	High
Grasslands, grasslands with trees, pastures	Edge effects	Changes in spatial connectivity	-Not applicable	High	High
Pine plantations and semi-natural woodlands	Fire regime	Disruption/Modification of ecological regimes	Medium	High	High

Table 26. Roll-up of the different measurements towards the Rating Type I for the Italian IT3 site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Rating Type I
Changes in spatial connectivity	grasslands, grasslands with trees, pastures	Fragmentation	High	Edge effect	High	High

No roll-up for the Rating Type III needs to be done, as there is not any threat affecting more than one habitat for this site.

Table 27. Roll-up of the different measurements towards the Rating Type II for the Italian IT3 site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Threat 3	Rating Type I	Rating Type II
Grasslands, grasslands with trees, pastures	Land cover/habitat conversion	High	Land cover/habitat modification	Low	Changes in spatial connectivity	High	High

Table 28. Rating the threats based on the variables Extent and Severity for the Italian IT4 site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Mediterranean maquis and relevant mosaics	Native shrubs (maquis) to Pine woods (Pine encroachment)	Land cover/habitat conversion	High	High	High
Mediterranean maquis and relevant mosaics	Native shrubs (maquis) to Pine woods (Pine plantations)	Land cover/habitat conversion	Very high	Very high	Very high
Pine plantations	Fire regime	Disruption/Modification of ecological regimes	Medium	Medium	Medium
Dune vegetation	Decrease in area and patch size/ habitat fragmentation	Changes in spatial connectivity	Very high	High	High
Dune vegetation	Change in species composition/ change in dominance and evenness values	Disruption of plant and animal community structure	-Not applicable	High	High
Dune vegetation	Beaches to urban	Land cover/habitat conversion	Very high	High	High
Salt marshes	Conversion of salt marshes communities to reed beds	Land cover/habitat conversion	Very high	Very high	Very high
Brackish marshes	Water salinization	Land cover/habitat modification	Very high	High	High
Brackish marshes	Conversion of sedges, reeds and rushes communities to Sarcocornia and other alophytic scrubs communities	Land cover/habitat conversion	High	Medium	Medium
Coastal lagoons	Water pollution	Land cover/habitat modification	-Not applicable	High	High
Temporary ponds	Conversion of temporary ponds to agricultural areas	Land cover/habitat conversion	Very High	Very high	Very high

Table 29. Roll-up of the different measurements towards the Rating Type I for the Italian IT4 site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Rating Type I
Land cover/habitat conversion	Mediterranean maquis and relevant mosaics	Native shrubs (maquis) to Pine woods (Pine encroachment)	High	Native shrubs (maquis) to Pine woods (Pine plantations)	Very high	Very high
Disruption of plant and animal community structure	Dune vegetation	Change in species composition	High	Change in dominance and evenness values	High	High

Table 30. Roll-up of the different measurements towards the Rating Type III for the Italian IT4 site

Threat	Target 1	Rating Type I	Target 2	Rating Type I	Target 3	Rating Type I	Target 4	Rating Type I	Rating Type III
Land cover/habitat conversion	Mediterranean maquis and relevant mosaics	Very high	Salt marshes	Very high	Brackish marshes	High	Temporary ponds	Very high	Very high
Land cover/habitat modification	Brackish marshes	Very high	Coastal lagoons	High	Dune vegetation	High			High

Table 31. Roll-up of the different measurements towards the Rating Type II for the Italian IT4 site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Threat 3	Rating Type I	Rating Type II
Mediterranean maquis and relevant mosaics	Land cover/habitat conversion	High	Land cover/habitat conversion	Very high			Very high
Brackish marshes	Land cover/habitat conversion	High	Land cover/habitat modification	Very high			Very high
Dune vegetation	Changes in spatial connectivity	High	Disruption of plant and animal community structure	High	Land cover/habitat modification	High	High

4.3 Welsh sites

Table 32. Rating the threats based on the variables Extent and Severity for the Welsh UK1 site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Forest	Edge effects	Changes in spatial connectivity	Low	Low	Low
Forest	Fragmentation	Changes in area and perimeter of forests	Low	Low	Low
Active bog	Encroachment of shrubs and woodlands	Land cover/habitat conversion	High	High	High
Active Bog	Atmospheric deposition	Disruption/ modification of ecological regimes	Low	Very high	Medium
Active bog	Drainage and conversion to secondary bog	Changes in hydrological regime	Very high	Low	High
Active Bog	Encroachment of grasslands	Land cover/habitat modification	Very high	High	High
Salt marsh	Conversion to agriculture	Land cover/habitat conversion	Low	Low	Low
Sand Dune	Erosion of dunes by human activity and aeolian forces	Land cover/habitat modification	Low	Low	Low

Table 33. Roll-up of the different measurements towards the Rating Type I for the Welsh UK1 site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Rating Type I
Changes in spatial connectivity	Forest	Edge effects	Low	Fragmentation	Low	Low
Land cover/habitat modification	Active bog	Encroachment of shrubs and woodlands	High	Encroachment of grasslands	High	High

Table 34. Roll-up of the different measurements towards the Rating Type III for the Welsh UK1 site

Threat	Target 1	Rating Type I	Target 2	Rating Type I	Rating Type III
Land cover/habitat modification	Active bog	High	Sand Dune	Medium	High
Land cover/habitat conversion	Active bog	High	Salt marsh	Low	Medium

Table 35 Roll-up of the different measurements towards the Rating Type II for the Welsh UK1 site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Threat 3	Rating Type I	Threat 4	Rating Type I	Rating Type II
Active bog	Land cover/habitat conversion	High	Disruption/ modification of ecological regimes	Medium	Changes in hydrological regime	High	Land cover/habitat modification	High	High
Forest	Changes in spatial connectivity	Low	Changes in area and perimeter of forests	Low					Low

4.4 Dutch sites

Table 36. Rating the threats based on the variables Extent and Severity for the Dutch NL1 site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Broadleaved forest	Broadleaved forest to recreation (Urban)	Land cover/habitat conversion	Very high	Very high	Very high
Coniferous forest	Coniferous forest to recreation (Urban)	Land cover/habitat conversion	Very high	Very high	Very high
Arable land	Arable land to recreation/industrial/construction sites/built-up (Urban)	Land cover/habitat conversion	High	Medium	Medium
Pastures	Pastures to recreation/industrial/construction sites/built-up (Urban)	Land cover/habitat conversion	Medium	Medium	Medium
Heathland	Heathland to coniferous forest	Land cover/habitat conversion	Very high	Very high	Very high
Heathland	Heathland to grassland	Land cover/habitat conversion	Medium	High	Medium
Inland sand dunes	Inland sand dunes to grassland	Land cover/habitat conversion	High	High	High
Inland sand dunes	Inland sand dunes to mosses	Land cover/habitat conversion	Medium	Medium	Medium
Coniferous forest	Coniferous forest to heathland	Land cover/habitat conversion	High	High	High
Coniferous forest	Coniferous forest to inland sand dunes	Change in spatial coverage of LCCs/GHC category	Very high	Very high	Very high
Heathland	Heathland to inland sand dunes	Land cover/habitat conversion	Low	Low	Low
Freshwater	Fresh water extraction for water consumption	Disruption / modification of ecological regimes	Medium	Medium	Medium
Freshwater	Pollution of surface water	Disruption / modification of ecological regimes	Medium	Medium	Medium
Heatlands	Soil disturbance	Disruption / modification of ecological regimes	Medium	Medium	Medium
Forests	Forest Fires	Disruption / modification of ecological regimes	Low	Low	Low

Table 37 Roll-up of the different measurements towards the Rating Type I for the Dutch NL1 site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Impact 3	Magnitude of impact 3	Rating Type I
Land cover/habitat conversion	Broadleaved forest	Broadleaved forest to recreation (Urban)	Very High	Broadleaved forest to heathland	Medium	Broadleaved forest to inland dunes	Very High	Very High
Land cover/habitat conversion	Heathland	Heathland to coniferous forest	Very High	Heathland to grassland	Medium	Heathland to inland sand dunes	Low	Very High
Land cover/habitat conversion	Arable land	Arable land to recreation/industrial/construction sites/built-up (Urban)	Medium	Arable land to pasture	Medium	Arable land to forest	Medium	Medium
Land cover/habitat conversion	Pastures	Pastures to recreation/industrial/construction sites/built-up (Urban)	Medium	Pastures to arable	Medium	Pasture to forest	Medium	Medium
Land cover/habitat conversion	Coniferous forest	Coniferous forest to recreation (Urban)	Very High	Coniferous forest to heathland	High	Coniferous forest to inland dunes	Very High	Very High
Land cover/habitat conversion	Inland sand dunes	Inland sand dunes to grassland	High	Inland sand dunes to mosses	Medium	Inland sand dunes to forest	Very High	Very High
Disruption / modification of ecological regimes	Freshwater	Fresh water extraction for water consumption	Medium	Pollution of surface water	Medium			Medium

Table 38. Roll-up of the different measurements towards the Rating Type III for the Dutch NL1 site

Threat	Target 1	Rating Type I	Target 2	Rating Type I	Target 3	Rating Type I	Target 4	Rating Type I	Target 5	Rating Type I	Target 6	Rating Type I	Rating Type III
Land cover/habitat conversion	Broadleaved forest	Very High	Heathland	Very High	Arable land	Medium	Pastures	Medium	Coniferous forest	Very high	Inland sand dunes	Very high	Very High
Disruption / modification of ecological regimes	Freshwater	Medium	Heatlands	Medium	Forest	Low							Medium

Table 39. Roll-up of the different measurements towards the Rating Type II for the Dutch NL1 site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Rating Type II
Broadleaved forest	Land cover/habitat conversion	Very high	Forest Fires	Low	Very high
Heathland	Land cover/habitat conversion	Very high	Soil disturbance, fires	Medium	Medium
Pastures	Land cover/habitat conversion	Medium	Fresh water extraction for water consumption	Medium	Medium
Coniferous forest	Land cover/habitat conversion	Very high	Forest Fires	Low	Very high

4.5 Portuguese sites

Table 40. Rating the threats based on the variables Extent and Severity for the Portuguese PT1 site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Evergreen forests and scrublands	Native vegetation to forest plantations	Land cover/habitat conversion			Medium
Evergreen forests and scrublands	Native vegetation to perennial crops	Land cover/habitat conversion			High
meadows and dry grasslands	Meadows and dry grasslands to tall scrub	Land cover/habitat conversion			Medium
Evergreen forests and scrublands	Construction of hydroelectric dams	Land cover/habitat conversion			High

Table 41. Roll-up of the different measurements towards the Rating Type I for the Portuguese PT1 site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Impact 3	Magnitude of impact 3	Rating Type I
Land cover/habitat conversion	Evergreen forests and scrublands	Native vegetation to forest plantations	Medium	Native vegetation to perennial crops	High	Construction of hydroelectric dams	High	High

Table 42. Roll-up of the different measurements towards the Rating Type III for the Portuguese PT1 site

Threat	Target 1	Rating Type I	Target 2	Rating Type I	Rating Type III
Land cover/habitat conversion	Evergreen forests and scrublands	High	meadows and dry grasslands	Medium	High

No roll-up for the Rating Type II needs to be done, as there is not any habitat is affected from more than one threat for this site.

Table 43. Rating the threats based on the variables Extent and Severity for the Portuguese PT2 site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Deciduous forests and heathlands	Wildfires	Disruption/modification of ecological regimes			High
Deciduous forests and heathlands	woody plant invasion	Disruption/modification of ecological regimes			Medium
Meadows, nutrient poor acidic grasslands and heathlands	Grassland and heathlands to tall scrub	Land cover/habitat modification			Medium
Deciduous forests and heathlands	Native vegetation to forest plantations	Land cover/habitat conversion			Medium
Deciduous forests and heathlands	Construction of hydroelectric dams	Land cover/habitat conversion			High

Table 44. Roll-up of the different measurements towards the Rating Type I for the Portuguese PT2 site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Rating Type I
Disruption/modification of ecological regimes	Deciduous forests and heathlands	Wildfires	High	woody plant invasion	Medium	Medium
Land cover/habitat conversion	Deciduous forests and heathlands	Native vegetation to forest plantations	Medium	Construction of hydroelectric dams	High	High

No roll-up for the Rating Type III needs to be done, as there is not any threat affecting more than one habitat for this site.

Table 45. Roll-up of the different measurements towards the Rating Type II for the Portuguese PT2 site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Rating Type II
Deciduous forests and heathlands	Land cover/habitat conversion	High	Disruption/ modification of ecological regimes	Medium	High

4.6 Indian sites

Table 46. Rating the threats based on the variables Extent and Severity for the Indian IN1 site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Forests	Forests to agriculture	Land cover/habitat conversion	Medium	High	Medium
Forests	Forests to plantation	Land cover/habitat conversion	Medium	High	Medium
Forests	Habitat modification	Landcover/habitat modification	Low	Low	Low
Forests	Disruption of plant and animal community structure	Landcover/habitat modification	Low	Low	Low

Table 47. Roll-up of the different measurements towards the Rating Type I for the Indian IN1 site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Rating Type I
Land cover/habitat conversion	Forest	Forests to agriculture	Medium	Forests to plantation	Medium	Medium
Land cover/habitat modification	Forest	Habitat modification	Low	Disruption of plant and animal community structure	Low	Low

No roll-up for the Rating Type III needs to be done, as there is not any threat affecting more than one habitat for this site.

Table 48. Roll-up of the different measurements towards the Rating Type II for the Indian IN1 site

Target	Threat 1	Rating Type I	Threat 4	Rating Type I	Rating Type II
Forest	Land cover/habitat conversion	Medium	Land cover/habitat modification	Low	Low

4.7 Brazilian sites

Table 49. Rating the threats based on the variables Extent and Severity for the Brazilian BR1 site.

Target	Impact	Broad impact category	Extent	Severity	Magnitude
Rainforest	Forest to large-scale crops	Land cover/habitat conversion	Very high	Very high	Very high
Rainforest	Forest to large-scale pasture	Land cover/habitat conversion	High	Very high	High
Rainforest	Forests to small-scale agriculture	Land cover/habitat conversion	High	Very high	High
Rainforest	Logging	Disruption of plant and animal community structure	Medium	High	Medium
Pasture	Pasture to large-scale crops	Land cover/habitat conversion	High	High	High
Pasture	Grazing pattern	Land cover/habitat modification	High	High	High
Natural vegetation	Urbanization	Land cover/habitat conversion	High	High	High
Crops	intensive practices	Land cover/habitat modification	Low	Low	Low
Roads	Roads construction	Fine spatial scale pressures with large spatial impacts	Medium	Medium	Medium
Water	Water pollution	Disruption/Modification of ecological regimes	Low	-Not applicable	Low
Water	Water change	Disruption/Modification of ecological regimes	Low	-Not applicable	Low
Rainforest	Rainforest to plantations	Land cover/habitat modification	Very High	Very High	Very High

Table 50 Roll-up of the different measurements towards the Rating Type I for the Brazilian BR1 site

Threat	Target	Impact 1	Magnitude of impact 1	Impact 2	Magnitude of impact 2	Impact 3	Magnitude of impact 3	Rating Type I
Land cover/habitat conversion	Rainforest	Forest to large-scale crops	Very high	Forest to large-scale pasture	High	Forests to small-scale agriculture	High	High
Disruption/Modification of ecological regimes	water	Water pollution	Low	Water change	Low			Low

Table 51. Roll-up of the different measurements towards the Rating Type III for the Brazilian BR1 site

Threat	Target 1	Rating Type I	Target 2	Rating Type I	Target 3	Rating Type I	Rating Type III
Land cover/habitat modification	Rainforest	Very high	Crops	Low			High
Land cover/habitat conversion	Rainforest	High	Pasture	High	Natural vegetation	High	High

Table 52. Roll-up of the different measurements towards the Rating Type II for the Brazilian BR1 site

Target	Threat 1	Rating Type I	Threat 2	Rating Type I	Threat 3	Rating Type I	Rating Type II
Rainforest	Land cover/habitat conversion	High	Disruption of plant and animal community structure	Medium	Land cover/habitat modification	Very high	High
Pasture	Land cover/habitat conversion	High	Land cover/habitat modification	High			High

5. Discussion and conclusions

Assessing biodiversity is a very complex task, consisting of many disciplines and techniques for the selection and estimation of the proper indicators per target and site, the identification of pressures and the quantification of threats. Based on the approach proposed by Salafsky (2003), each threat can be measured through two variables, the extent and the severity, which combined give the magnitude of the threat. These variables are calculated with a categorical approach, since continuous measurements, though more precise, are more difficult and cost effective to obtain. The use of categorical measurements, on the other hand, induces a level of uncertainty regarding the thresholds chosen for the categorical rankings. Additionally, the combination is conducted through a rule based system, trying to model the real world. The uncertainty in the rules modelling the real world imposes additional uncertainty to the total procedure. Thus, the use of fuzzy methods to the final quantification of the threats and the evaluation of the state of biodiversity becomes crucial. The Dempster-Shafer theory, adopted in BIO_SOS to handle uncertainty arising from missing information and ambiguities in the methods and measurements and described in detail in D5.5, may be embodied to enhance threat quantification. The method offers great flexibility in incorporating fuzzy logic in order to deal with uncertain and inaccurate thresholds in both expert rules and calculated indices, thus facilitating the applicability of the methods in different bio-geographical regions.

The final output is expected to be a warning signal map focused on habitats, built on the Rating Type II, where the synergies of all threats imposed on a specific habitat are taken into account. Each one of the rating scales, i.e. low, medium, high and very high, is assigned to a colour, i.e., green, yellow, orange and red, respectively. These maps are anticipated to be a very valuable tool for the conservation managers at regional level, as they will provide an illustration of the state of biodiversity pressure/threat, indicating the points where mitigation actions need to be taken.

6. References

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7. Abbreviations and Acronyms

BIO_SOS	BIOdiversity Multi-Source Monitoring System: from Space TO Species
EO	Earth Observation
CA	Class Area
CWED	Contrast Weighted Edge Density
GBA	Graph Based Analysis
GHC	General Habitat Categories
GR	BIO_SOS Greek sites
IN	BIO_SOS Indian sites
IT	BIO_SOS Italian sites
LCCS	Land Cover Classification System
LiDAR	Light Detection And Ranging
LPA	Landscape Pattern Analysis
MSPA	Morphological Spatial Pattern Analysis
NDVI	Normalized Difference Vegetation Index
PLAND	Percentage of Landscape
PSRI	Plant Senescence Reflectance Index
PT	BIO_SOS Portuguese site
TNC	The Nature Conservancy
UK	BIO_SOS Welsh site
VHR	Very High Resolution
WBI	Water Band Index