Interreg
Balkan-Mediterranean
WetMainAreas

THE GOULANDRIS NATURAL HISTORY MUSEUM
GREEK BIOTOPE/WETLAND CENTRE

Connectivity Assessment

Overview and practical steps of the WetMainAreas approach for territorial ecosystem connectivity assessment

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Overview

In line with Aichi Target 11

"By 2020, at least 17 % of terrestrial and inland water areas and 10 % of coastal and marine areas, **especially areas of importance for biodiversity and ecosystem services, are conserved through** effectively and equitably managed, ecologically representative and **well-connected systems of protected areas** and other effective area-based conservation measures, and integrated into the wider landscape and seascape".

According to EU Habitats (Article 10) and Birds Directives (Article 4) wetlands are stepping stones & key landscape features that improve the coherence, connectivity and resilience of the NATURA 2000 network.

WetMainAreas approach for territorial ecosystem connectivity assessment

Assessment aims to reveal connected natural areas with high potential to provide habitats for biodiversity, and the spatial relationship patterns between them and wetlands and Natura 2000/Emerald sites, within the river basin landscape.

The assessment of wetland ecosystems' role in territorial connectivity of Natura 2000 sites/Emerald sites, has been suggested to follow the conceptual framework developed and tested in H2020 SWOS project for Attica Region in Greece.

Source: Hatziiordanou, L., Fitoka, E., Hadjicharalampous, E., Votsi, N., Palaskas D. (2018). Indicators for the "habitat maintenance" ecosystem service supply by wetland ecosystems, based on EO mapping products and EU biodiversity datasets. The Goulandris Natural History Museum / Greek Biotope-Wetland Centre (EKBY). SWOS Technical publication.

WetMainAreas approach for territorial ecosystem connectivity assessment

- WetMainAreas Project assesses landscape connectivity (regional, national, transnational level), in order to:
  - **Reveal well-connected areas with high importance for biodiversity and ecosystem services** (having potentials to provide habitats for biodiversity).
  - **Locate isolated areas**, but still with potentials to provide habitats for biodiversity.
  - **Examine the spatial relationship patterns** between the well-connected areas and isolated areas, with wetlands and with the network of Protected Areas -PAs (Natura 2000 sites/Emerald sites).
  - **Assess the connectivity of the PAs network and wetlands' role in it.**
  - **Assess and locate areas of the wider landscape**, where 'area-based' conservation measures could be applied, to benefit the PAs network.

Conceptual framework within the state of the art of Ecosystem Services (ES)

The assessment aims to reveal that the policy demands for no net loss and for a coherent N2K/Emerald network can be met by enhancing the delivery of the habitat maintenance Ecosystem Service (ES).

- The Natural Potential of a landscape to provide Ecosystem Services (ES) reflects its condition.
- Assessment of ecosystem condition refers to the analysis of the major pressures on ecosystems and their impact on their condition. If impacts or condition cannot be quantified, pressures are also used as indicators of ecosystem condition.

We assess Natural Potential** as either a) reflection of **nature dominance**, or b) as a **composite of anthropogenic impact (land degradation and population density) and of biodiversity state.

- Additional inputs can act together with the natural potential and enable the spatial identification of areas where the ES is supplied/provided (Service Providing Units – SPUs). These inputs may represent human interventions with a conservation target (i.e. PAs establishment, restoration activities, artificial wetlands, etc.).

***We consider the "level of protection"** (strict, medium, weak/no), as one additional input that can activate the Natural Potential of ecosystems to maintain biodiversity.*

Conceptual framework within the state of the art of Ecosystem Services (ES)

- Natura 2000/Emerald sites benefit from the ES (are the Service Benefit Areas -SBAs)
- Wetlands, are considered stepping stones/key landscape features that improve the coherence, connectivity and resilience of the N2K/Emerald network

*We assess the **structural connectivity** of the Service Providing Units (SPUs), and examine the **spatial relationships** between with the **well-connected SPUs and isolated SPUs**, with both the **N2K/Emerald network (SBAs)** and **wetlands**.*

*We also examine a **distance-based wetland connectivity**, to reveal areas where wetlands can form a connected network, based on their relative distances (edge to edge distances).*

Methodological steps

- **Preliminary step: Creation of Landscape map of the study area.** Map 'Favourable' and 'Hostile' landscape units for species movement and dispersal
- **STEP 1: Creation of 'Landscape mosaic', 'Nature dominance' and 'Land degradation' layers.**
- **STEP 2: Mapping of Natural Potential (ecosystem condition) to provide services.**
- **STEP 3: Mapping of Ecosystem Service Supply**, using as additional input the level of protection, and extraction of the Service Providing Units (SPUs).
- **STEP 4: Structural Connectivity of SPUs** and extraction of network of areas of high biodiversity value (well-connected areas and isolated areas).
- **STEP 5: Wetland Distance Connectivity.**
- **STEP 6: Spatial relationships of well-connected areas, isolated areas, wetlands and N2K/Emerald sites, and evaluation of the N2K/Emerald network connectivity.**

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Preliminary step

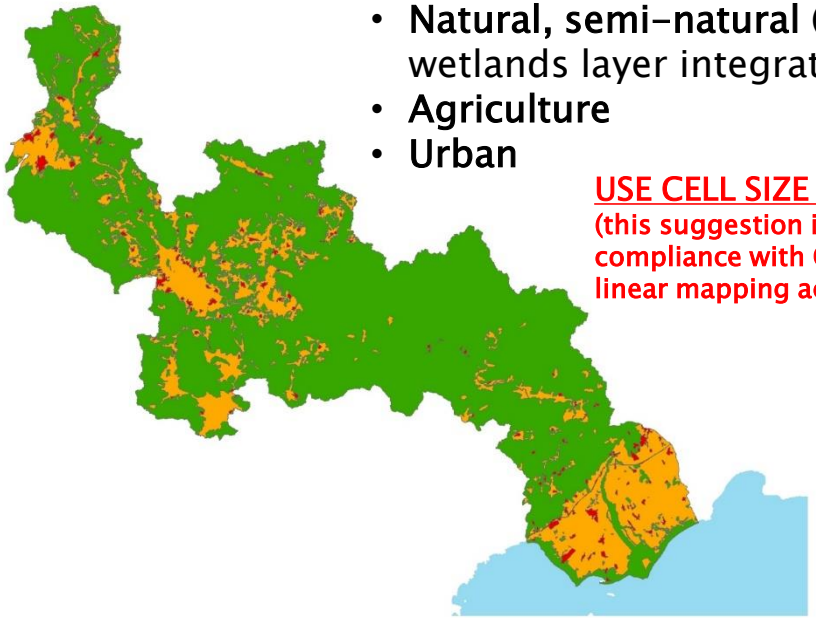
Creation of Landscape map of the study area

CLC CODE	CLC L3 DESCRIPTION	Reclass
111	Continuous urban fabric	Urban
112	Discontinuous urban fabric	Urban
121	Industrial or commercial units	Urban
122	Road and rail networks and associated land	Urban
123	Port areas	Urban
124	Airports	Urban
131	Mineral extraction sites	Urban
132	Dump sites	Urban
133	Construction sites	Urban
141	**Green urban areas**	**Natural, semi-natural**
142	**Sport and leisure facilities**	**Natural, semi-natural**
211	Non-irrigated arable land	Agriculture
212	Permanently irrigated land	Agriculture
213	**Rice fields**	**Natural, semi-natural**
221	Vineyards	Agriculture
222	Fruit trees and berry plantations	Agriculture
223	Olive groves	Agriculture
231	**Pastures**	**Natural, semi-natural**
241	Annual crops associated with permanent crops	Agriculture
242	Complex cultivation patterns	Agriculture
243	Land principally occupied by agriculture, with significant areas of natural vegetation	Agriculture
244	Agro-forestry areas	Natural, semi-natural
311	Broad-leaved forest	Natural, semi-natural
312	Coniferous forest	Natural, semi-natural
313	Mixed forest	Natural, semi-natural
321	Natural grasslands	Natural, semi-natural
322	Moors and heathland	Natural, semi-natural
323	Sclerophyllous vegetation	Natural, semi-natural
324	Transitional woodland-shrub	Natural, semi-natural
331	Beaches, dunes, sands	Natural, semi-natural
332	Bare rocks	Natural, semi-natural
333	Sparsely vegetated areas	Natural, semi-natural
334	Burnt areas	Natural, semi-natural
335	Glaciers and perpetual snow	Natural, semi-natural
411	Inland marshes	Natural, semi-natural
412	Peat bogs	Natural, semi-natural
421	Salt marshes	Natural, semi-natural
422	Salines	Natural, semi-natural
423	Intertidal flats	Natural, semi-natural
511	Water courses	Natural, semi-natural
512	Water bodies	Natural, semi-natural
521	Coastal lagoons	Natural, semi-natural
522	Estuaries	Natural, semi-natural
523	Sea and ocean	Natural, semi-natural

PURPOSE

To locate the 'Favourable' (natural and semi-natural areas) and the 'Hostile' (agriculture, urban) landscape units for species movement and dispersal.

To be used as input for further analysis



Unified CLC classified in 3 classes:

- **Natural, semi-natural** (with wetlands layer integrated)
- **Agriculture**
- **Urban**

USE CELL SIZE 100m
(this suggestion is in compliance with CLC 2018 linear mapping accuracy)

Step 1

CREATION OF: 'Landscape mosaic' 'Nature dominance' and 'Land degradation' layers

CREATING THE LANDSCAPE MAP

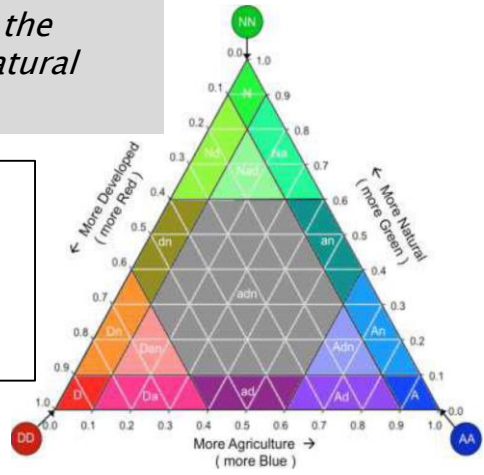
With GuidosToolbox – LM tool

To locate and measure the dominant land cover and the degree of land cover heterogeneity on the land cover map.

In particular, a pattern analysis is run in the GuidosToolbox software, using the Landscape Mosaic (LM) image analysis tool. The result will be a layer (Landscape Mosaic) with 19 mosaic classes indicating the different degrees of land cover heterogeneity.

The analysis identifies the presence (10%), dominance (60%), or uniqueness (100%) of each land cover type, and locates interface zones of natural land cover with agriculture and/or developed (urban) land cover.

For example a neighboring agricultural zone is considered more favourable compared to the transition into developed land cover. On the other hand a totally unique – undisturbed natural unit, indicates absence or minimum anthropogenic impact.



In LM tool, apply a moving window using KERNEL SIZE 9
(given that cell size of input image is 100m, with kernel size 9, we apply the LM tool at moving window with side of 9x100=900m; this distance approximately coincides with the minimum distance of 1km for species dispersal which is reported in research publications).

To be used as input for the 'Nature dominance' layer

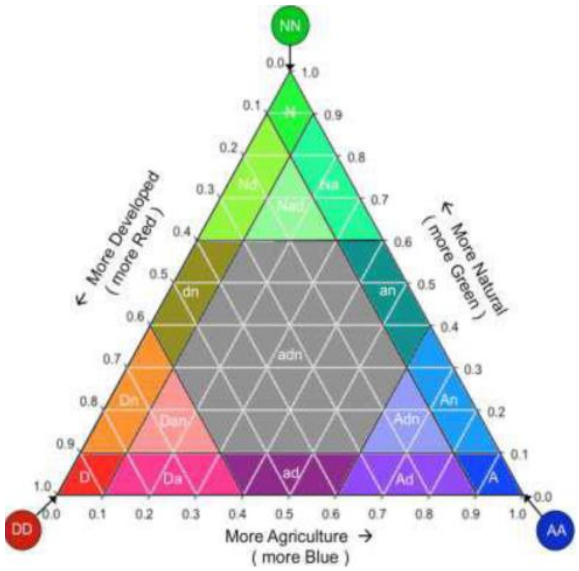
Step 1

CREATION OF: 'Landscape mosaic' 'Nature dominance' and 'Land degradation' layers

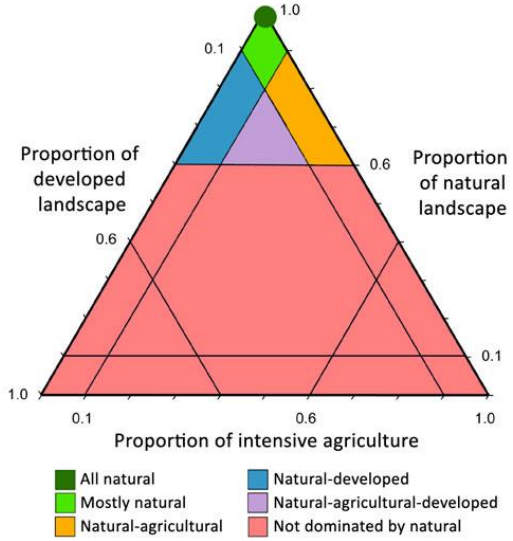
CREATING THE NATURE DOMINANCE MAP

To highlight landscape mosaics within natural background and identify human – natural interface zones *(Riiters, et al., 2010).*

From Landscape mosaic (19 classes)



…to Nature dominance (6 classes)



To be used as input for the 'Natural Potential' or the 'Land degradation'

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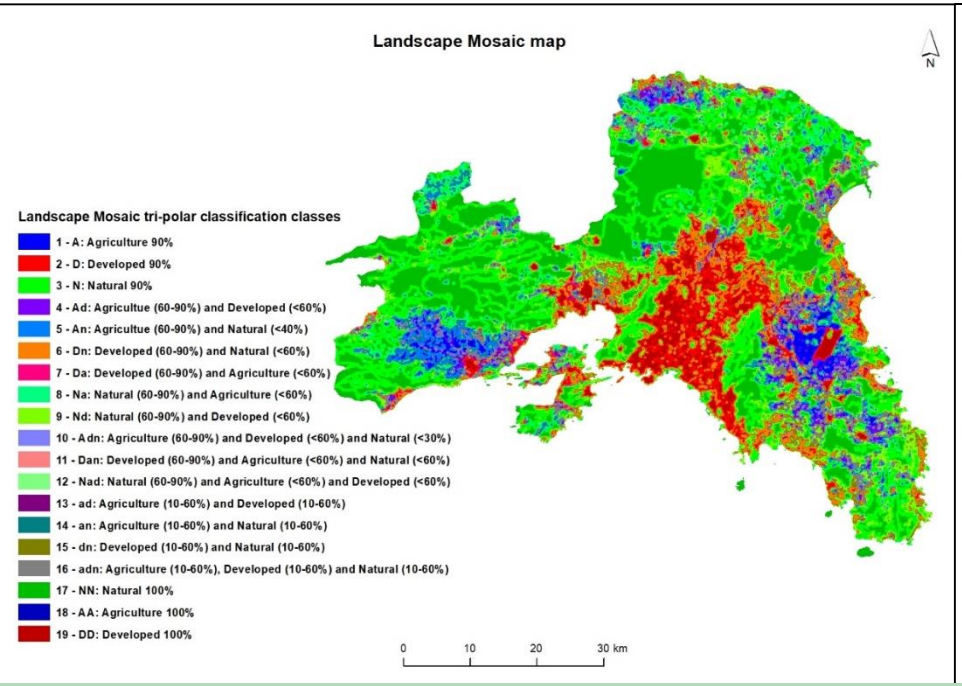
Step 1

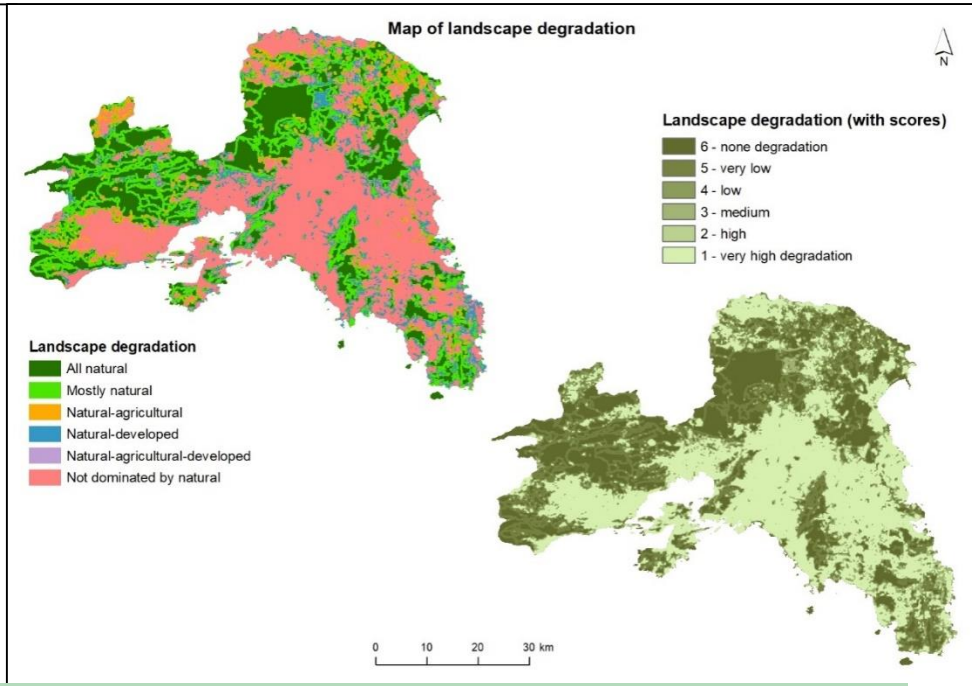
CREATION OF: 'Landscape mosaic' 'Nature dominance' and 'Land degradation' layers

CREATING LAND DEGRADATION MAP

Further interpretation and scoring of the 'Nature dominance' Map

All natural	None degradation	Score: 6
Mostly natural	Very low degradation	Score: 5
Natural-agricultural	Low degradation	Score: 4
Natural-developed	Medium degradation	Score: 3
Natural-agricultural-developed	High degradation	Score: 2
Not dominated by natural	Very High degradation	Score: 1





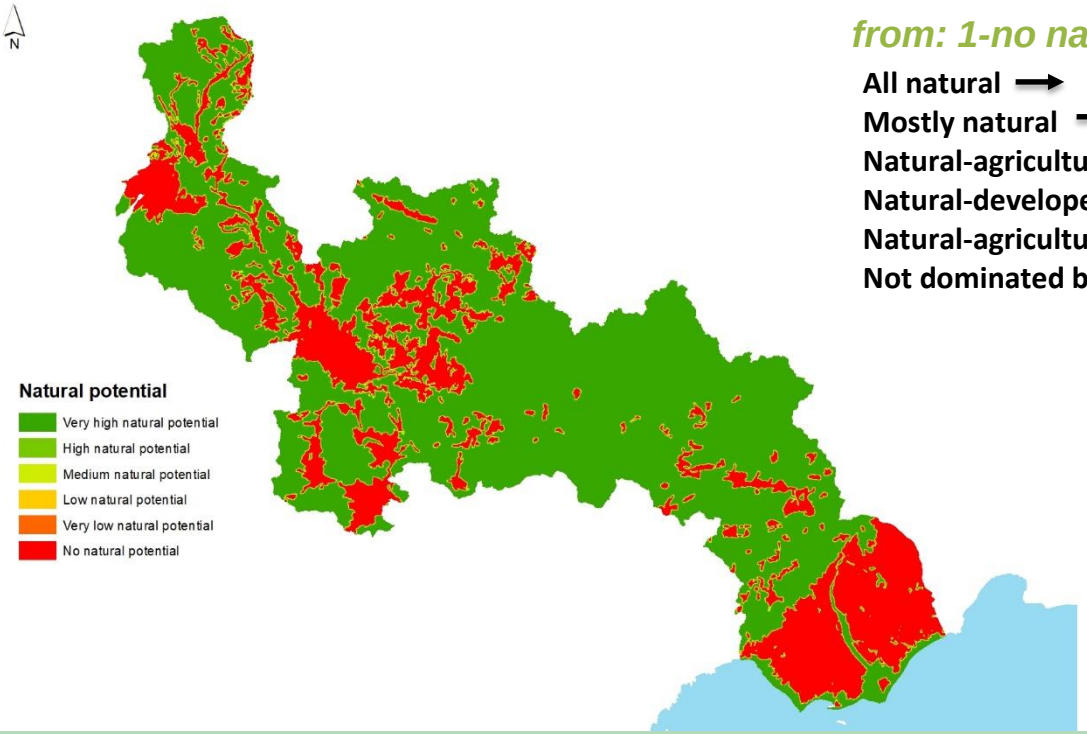
To be used as SUB-INDICATOR for the Anthropogenic Impact

Step 2
Mapping of Natural Potential (ecosystem condition) to provide services.

CASE 1 (simple): From 'Nature dominance' to the 'Natural Potential'

Natural potential to provide ecosystem services as a reflectance of nature dominance.

Further interpretation and scoring of the 'Nature dominance' Map



from: 1-no natural potential, to: 6-very high potential

All natural → Very high natural potential → Score: 6
Mostly natural → High natural potential → Score: 5
Natural-agricultural → Medium natural potential → Score: 4
Natural-developed → Low natural potential → Score: 3
Natural-agricultural-developed → Very low natural potential → Score: 2
Not dominated by natural → No natural potential → Score: 1

To be used for mapping of Service Providing Units –SPUs

Step 2
Mapping of Natural Potential (ecosystem condition) to provide services

CASE 2 (more complex):
Mapping 'Nature dominance' using a composite ecosystem condition indicator

By integrating biodiversity parameters and data on pressures from human influences

Ecosystem Condition Indicator (Natural Potential)	*Pressures and environmental quality composite indicator* **Anthropogenic Impact**	Landscape degradation (*environmental quality*)	SUB - INDICATORS
		Population density (*pressure*)	
	Ecosystem attributes (biological quality composite indicator) **Biodiversity state**	Habitats Condition	
		Species Condition	
		Population trends of breeding birds	
		Habitat Richness	
		Species Richness	
		Habitat Distribution pattern	
		Species Distribution pattern	
		Amount of common bird species	

Based on the analytical framework for mapping and assessment of ecosystem condition / MAES 5thTechnical Report (Maes et al., 2018)

To be used for mapping of Service Providing Units –SPUs

Step 2
Mapping of Natural Potential (ecosystem condition) to provide services

CASE 2 (more complex):
Mapping 'Nature dominance' using a composite ecosystem condition indicator

Ecosystem Condition = 0,5 *Anthropogenic Impact + 0.5 *Biodiversity State

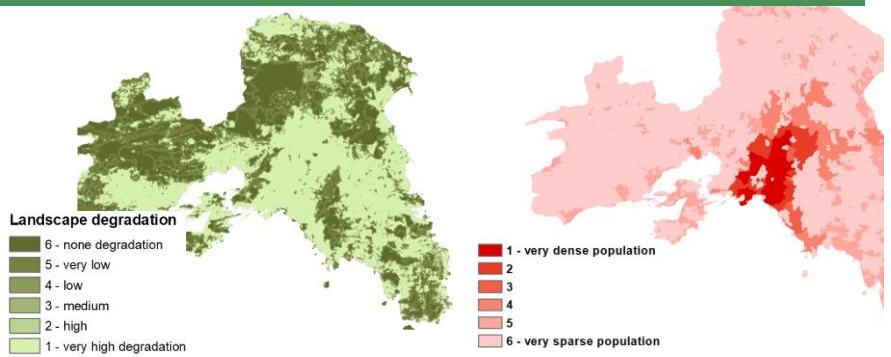
ANTHROPOGENIC

- **Land degradation**

Land degradation based on nature dominance patterns (human-natural interface zones within natural background)

- **Population density**

Use population data (usually reported fir a given land area, eg. municipality) and create density by dividing the number of citizens per sq km for the reported area (i.e. sq km per municipality area).



- ***Land degradation: from 1 to 6, indicating very high to none degradation.***
- ***Population Density: from 1 to 6, indicating dense to sparse population.***

- **Biodiversity state**

Based on biodiversity parameters i.e. habitats/species/birds distribution data and conservation status/population trends derived from National Reports for the implementation of EU Habitat (Art. 17) and Birds (Art. 12) Directives, N2K SDFs, etc).

- ***Biodiversity state:***
- ***from 0 to 5, indicating no biodiversity to excellent biodiversity state.***

Step 2
Mapping of Natural Potential (ecosystem condition) to provide services

CASE 2 (more complex):

Impact of Anthropogenic Pressures Indicator (IAP)

Urbanisation and intensive agriculture, are the main anthropogenic pressures to natural ecosystems, causing biodiversity loss, ecosystem degradation and landscape fragmentation, and suspending species movement and dispersal.

Further, increasing impervious surface coverage affects ecosystem integrity, reduces biological diversity and spreads disturbance (i.e., invasive species).

Population growth is considered as a key driver associated with food and energy consumption patterns, biodiversity loss, degradation of natural ecosystems and water pollution (EEA, 2015).

To this perspective, the IAP can be assessed as a composition of:

- **Landscape degradation**
- **Population density**

Anthropogenic Impact = 0,6 * Landscape degradation + 0.4 * Population density

Step 2

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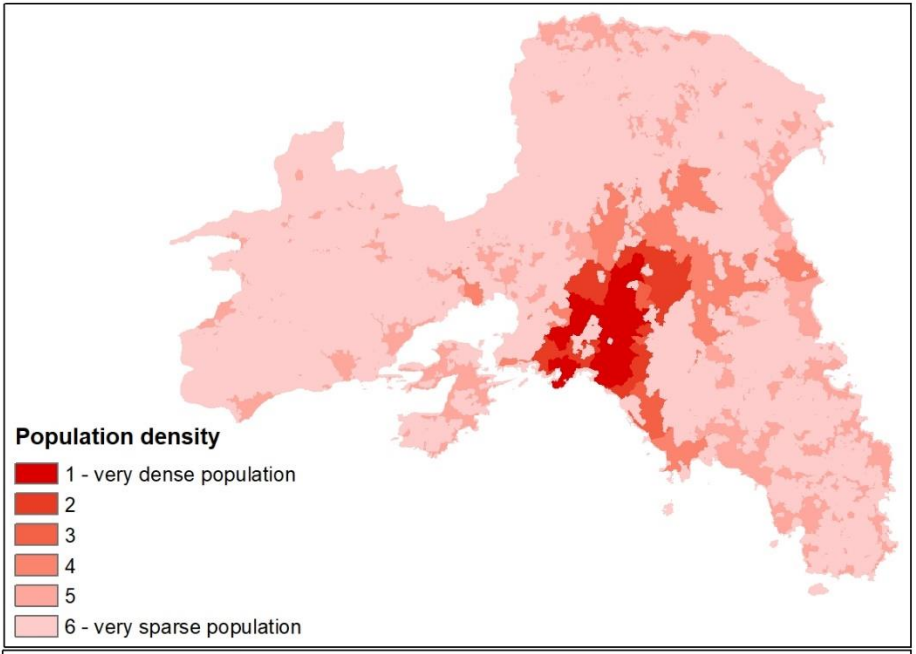
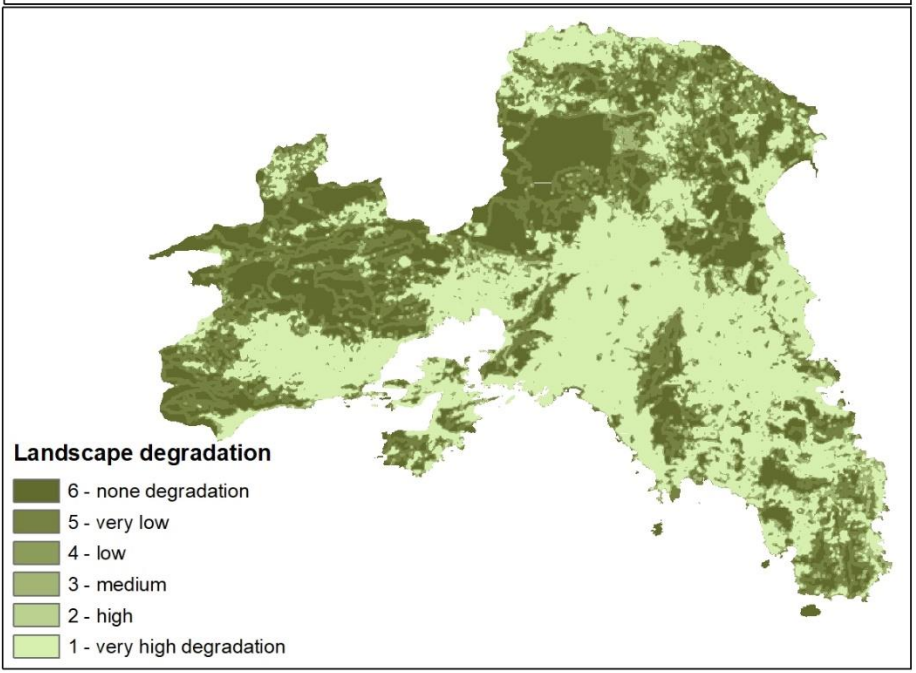
Impact of Anthropogenic Pressures Indicator (IAP)

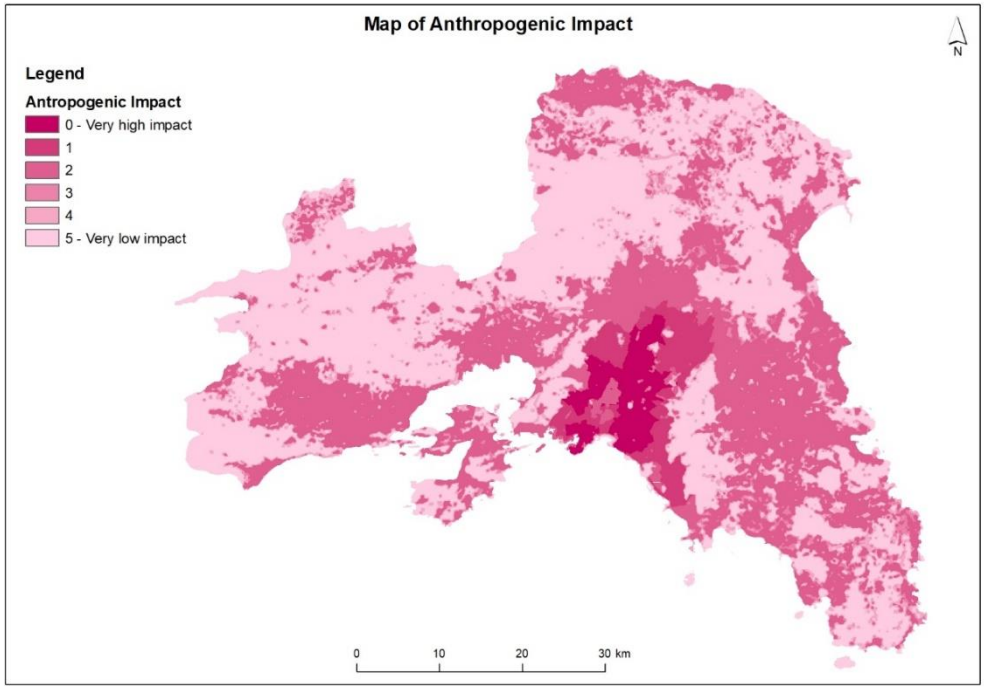
Anthropogenic Impact = 0,6 * Landscape degradation + 0.4 * Population density

IAP ranked in 6 classes:

from 0 (very high impact) to 5 (very low impact)





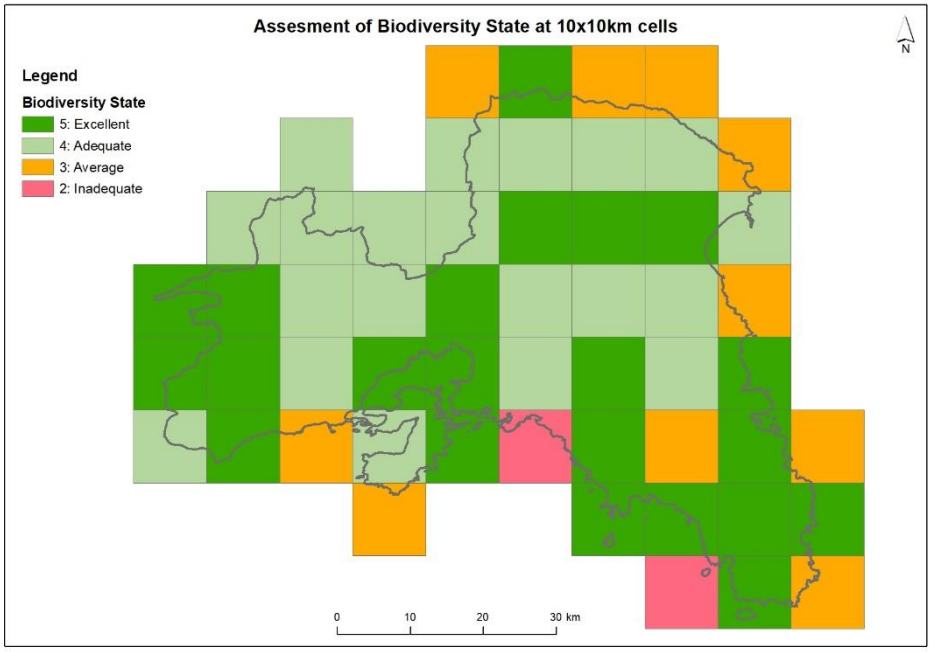


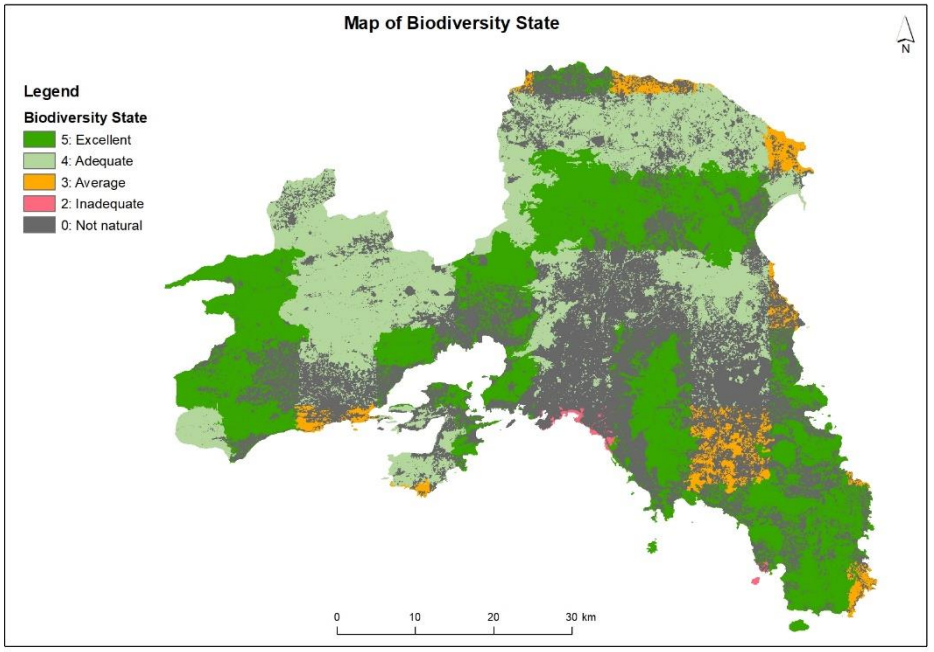
Step 2

Biodiversity State Indicator (BS)

Downscaling from grids to natural – semi-natural areas

Not natural – semi-natural areas are excluded and are assigned with the value “0: Not natural”

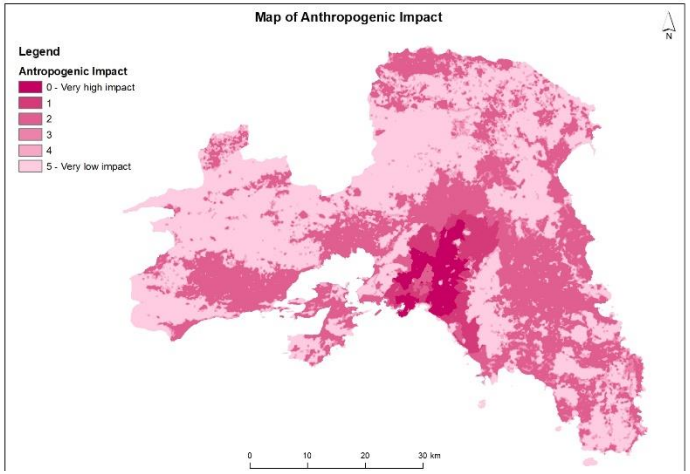


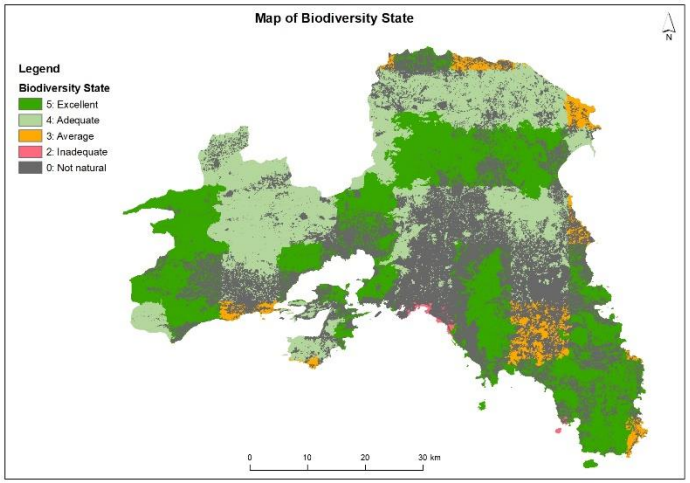


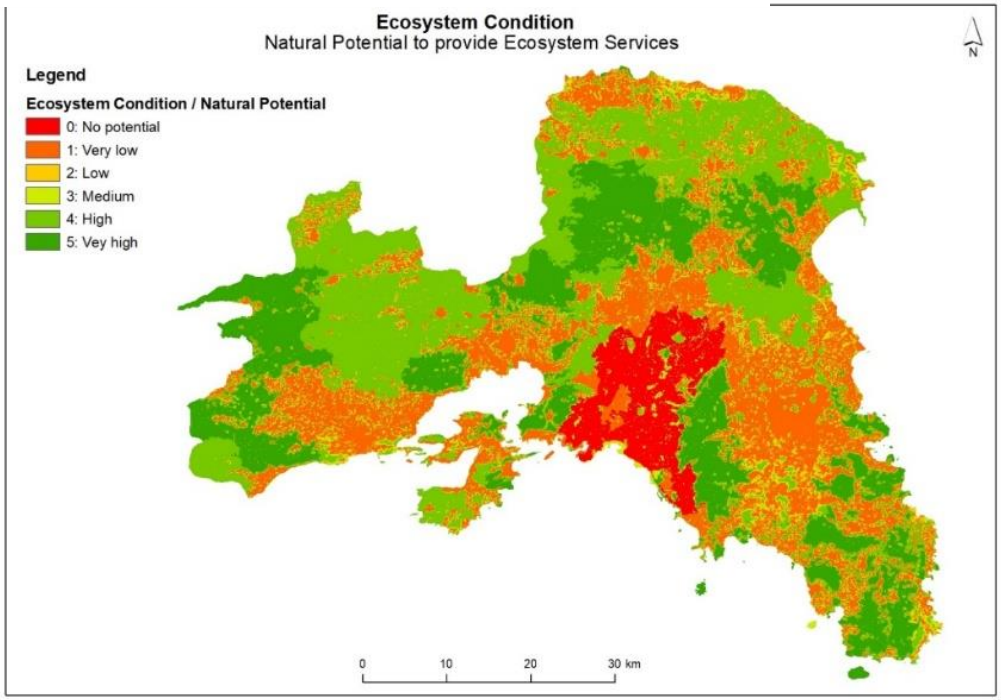
Step 2
Mapping of Natural Potential (ecosystem condition) to provide services

CASE 2 (more complex):
Mapping 'Nature dominance' using a composite ecosystem condition indicator

Ecosystem Condition = 0,5 *Anthropogenic Impact + 0.5 *Biodiversity State







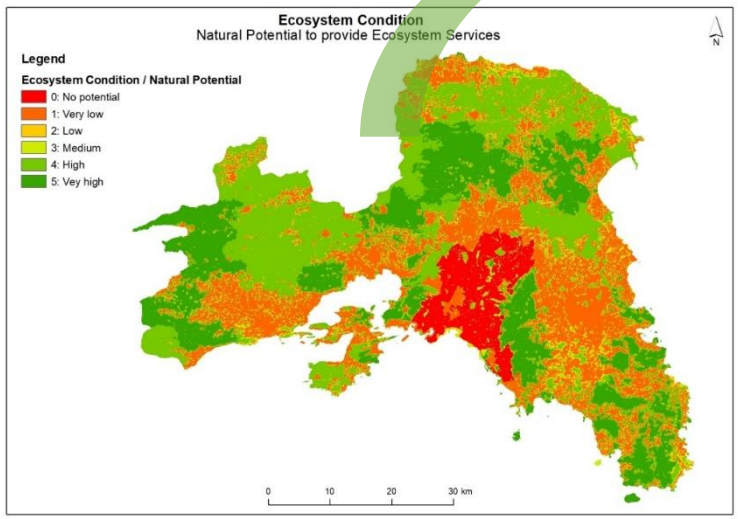
Ecosystem condition/Natural Potential is finally ranked in 6 classes:

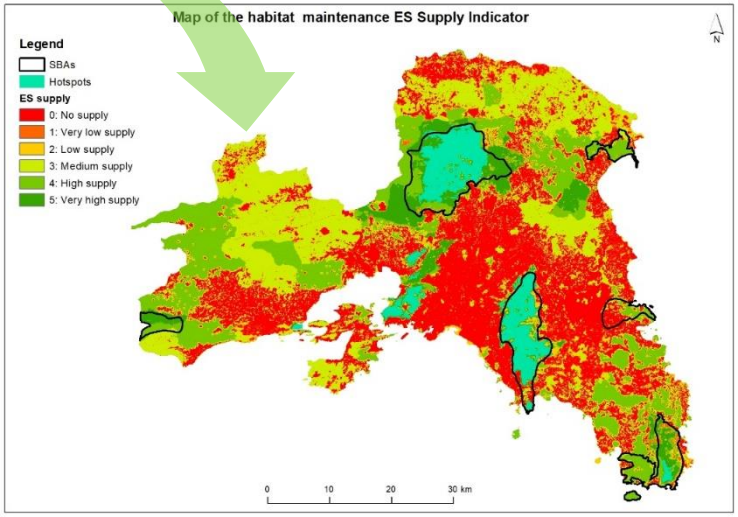
from 0 (no natural potential) to 5 (very high potential)

Step 3
Mapping of Ecosystem Service Supply

Extraction of the Service Providing Units (SPUs), by using as additional input the level of protection

ES Supply Matrix						
Protection level	Natural Potential					
	0 No potential	1 Very low	2 Low	3 Medium	4 High	5 Very high
High	0	2	3	4	5	5
Medium	0	1	2	3	4	5
Weak/No	0	1	1	2	3	4





PROTECTION LEVEL

Strict (High):
IUCN categories Ia, Ib, II
Ia Strict Nature Reserve
Ib Wilderness Area
II National Parkus

Medium:
IUCN categories III, IV, V, VI
III Natural Monument or Feature
IV Habitat/Species Management Area
V Protected Landscape/ Seascape
VI Protected area with sustainable use of natural resources

Weak/No:
Not related to nature conservation (not applicable to IUCN categories), or no protection status

Step 4
Structural Connectivity of SPUs

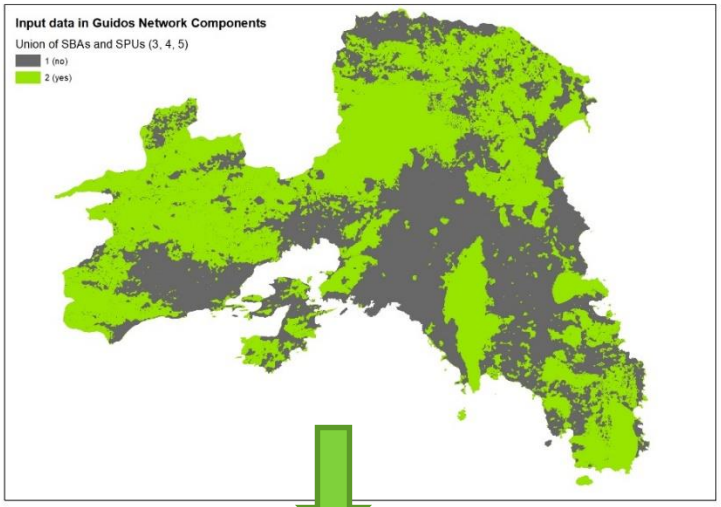
Extraction of network of areas of high biodiversity value (well-connected areas and isolated areas)

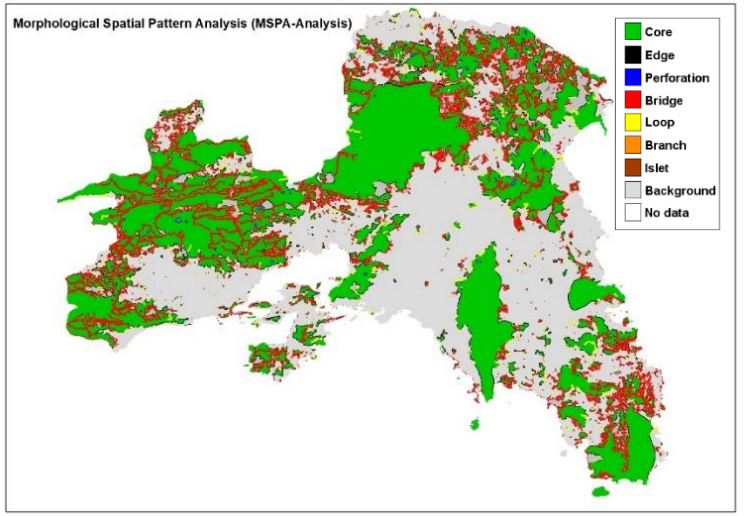
With GuidosToolbox – MSPA-analysis and NW tools

Input data: 8-bit GeoTiff raster map of the study area, with 0, 1, 2 cell values.

- 0: missing values/no data
- 1: **Background**
- 2: **Foreground (= core analysis area)**

Step A: Apply a Morphological Spatial Pattern Analysis (MSPA-analysis) in GuidosToolbox.





USE the following settings:

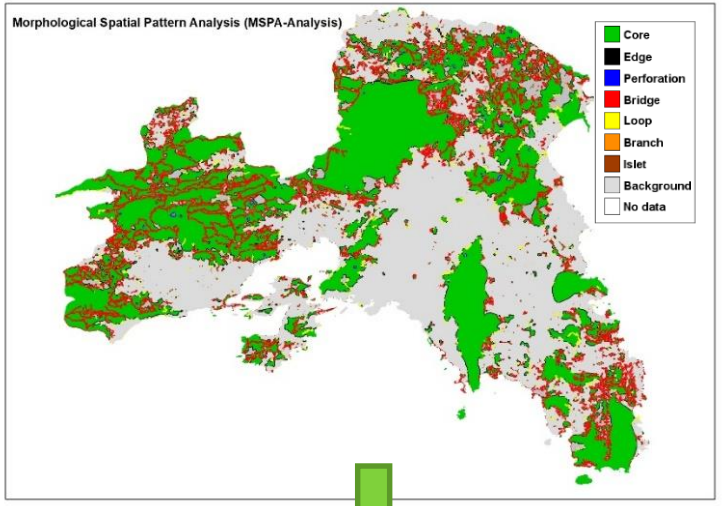
- Check the FGConn [8/4] box (this means that FGConn=8)
- EdgeWidth = 10 (this value corresponds to a 1km zone around each pixel, in compliance to the minimum 1km distance of specie dispersal applied also in the selection of the moving window for the LM computation)
- Check the Transition box (this means that Transition = 1)
- Check the Intext box (this means that Intext = 1)

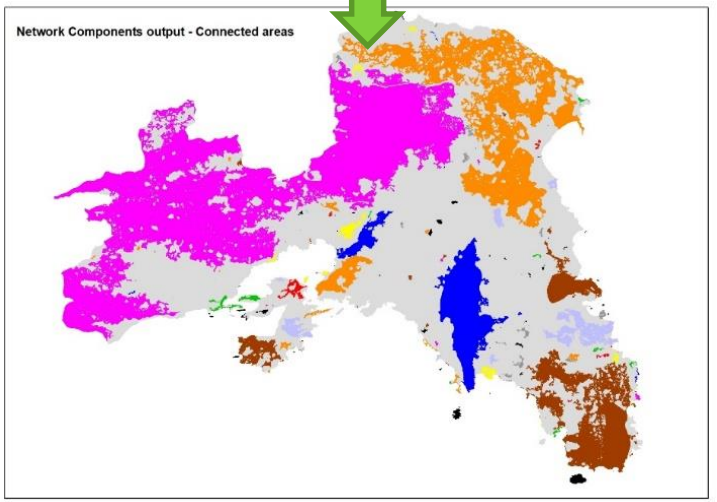
Step 4
Structural Connectivity of SPUs

Extraction of network of areas of high biodiversity value (well-connected areas and isolated areas)

With GuidosToolbox – MSPA-analysis and NW tools

Step B: Convert the MSPA-analysis output into a Network for further analysis, using the NW Components image analysis of GuidosToolbox.





A *Network* is composed of *Nodes* and *Links*.

What happens to MSPA classes when converted to NW…..

Nodes (↔ MSPA class: **Core**)

Links (↔MSPA class: **Bridge** = connectors between different Cores)

The remaining MSPA classes are neglected from the *Network*.

NETWORK INCLUDES THE FOLLOWING:

- NW Components: connected sets of Nodes and Links = Well-connected areas.
- Isolated cores (or isolated areas) are cores that have 0 links (unconnected)

Step 5
Distance-based wetland connectivity

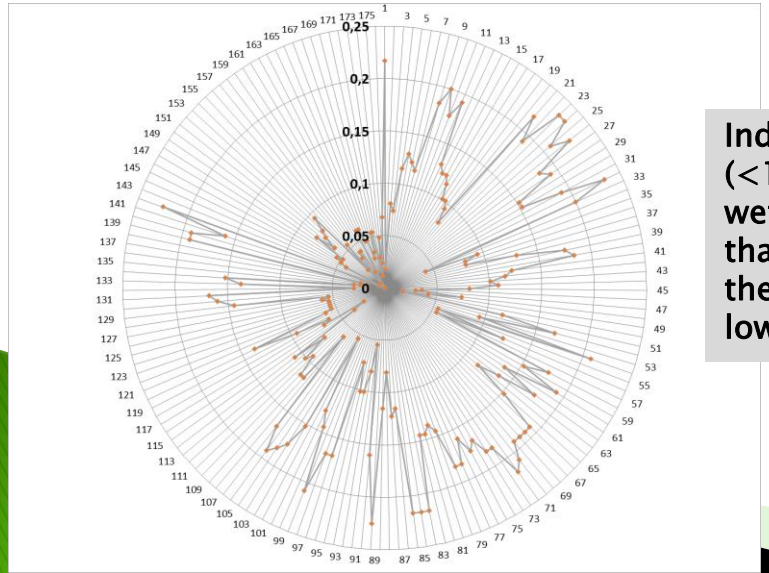
Examine the distance-based wetland connectivity indicator* to assess the potential of wetlands to form a connected network.

Using Conefor tool for ArcGIS or else

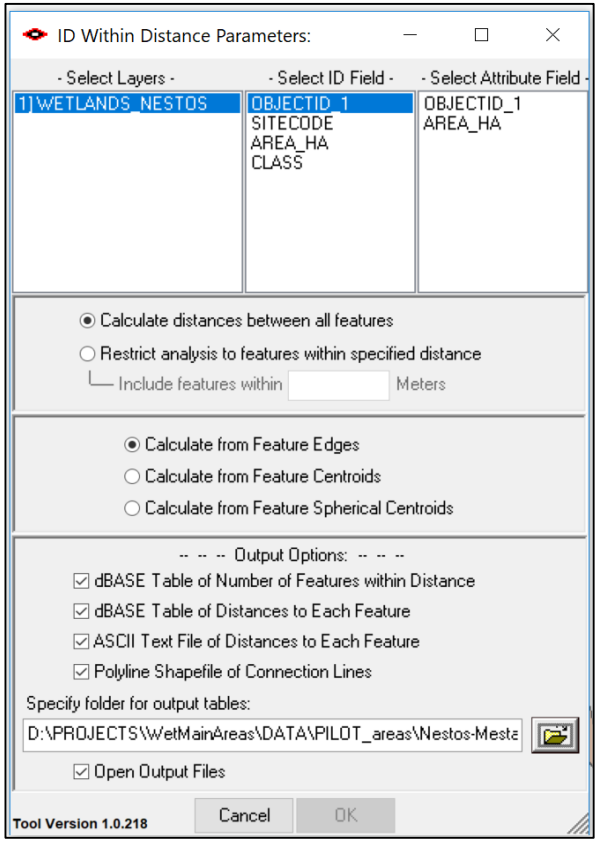
- Find distances between wetlands (edge to edge) *(Using Conefor tool for ArcGIS or else).*
- Find the count of wetlands that are found at distance below 10km from each wetland, and the count found above 10km from it.
- Calculate per wetland ID the following indicator:

http://www.conefor.org

Distance-based wetland connectivity (WetConn) = Number of wetlands that are found at distance below 10km / Number of wetlands that are found at distance above 10km



Indicator values below one (<1) mean that more wetlands are far (>10 km) than close (<10 km) from the examined one, indicating low connectivity.

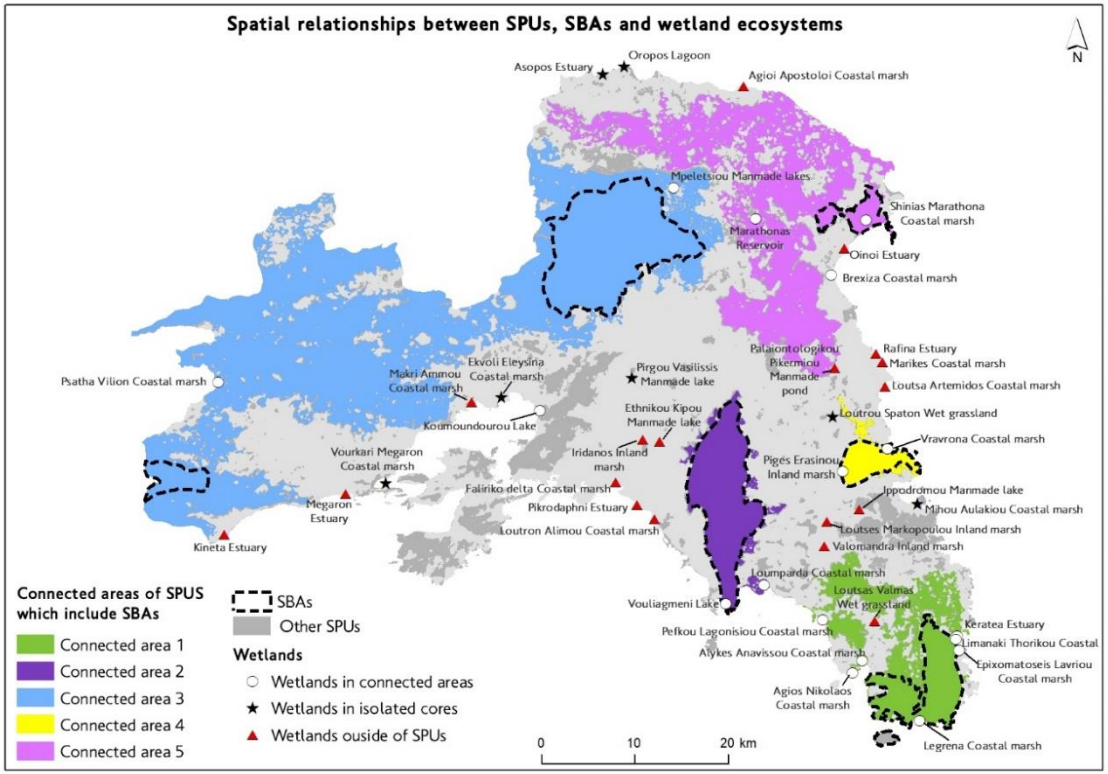


** Indicator proposed by the 5th MAES report* ***(Maes et al., 2018)***

Step 6
Spatial relationships

Spatial relationships of well-connected areas, isolated areas, wetlands and N2K/Emerald sites, and evaluation of the N2K/Emerald network connectivity

Different spatial relationship patterns are examined to evaluate the N2K network connectivity and wetlands contribution to it, and to identify/locate areas for conservation or restoration. Also, to create content (graphs, statistics, results) to feed your reports.



Step 6
Spatial relationships

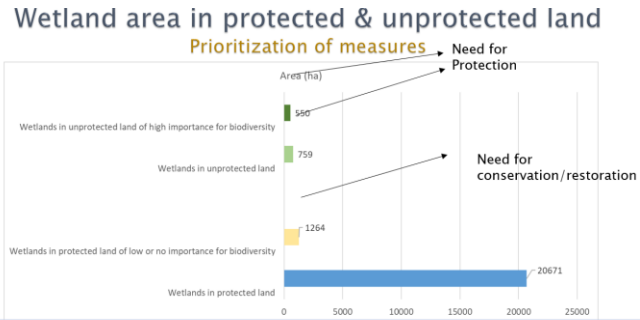
Spatial relationships of well-connected areas, isolated areas, wetlands and N2K/Emerald sites, and evaluation of the N2K/Emerald network connectivity

- **Examine the spatial relations of wetlands with the connected /isolated areas of SPUs and N2K, with unconnected land, with unprotected land and other of findings.**
  - Wetlands found in well-connected areas
  - Wetlands found in isolated
  - Wetlands found in unprotected land
  - Wetlands found in bad/excellent ecosystem condition
  - PPOPOSE OTHER….

- **Examine the well-distance connected wetlands spatial relations (as above)**

- **Generate statistics and examine the results of your work.**
  - Proportion of study area covered by N2K
  - Proportion of study area covered by isolated_N2K
  - Proportion of study area covered by connected_N2K
  - Proportion of N2K area found in well-connected areas
  - Proportion of N2K area found in unconnected land
  - PPOPOSE OTHER….

Think of a way that the above findings could be useful to a policy/decision maker.



Messages and spatial data for conservation, restoration, protection measures:

- ✓ 759 ha of wetland ecosystems need policy measures (to be legally protected); 550 ha of them fall in unprotected land of high importance for biodiversity.
- ✓ 1264 ha of wetland ecosystems in protected land need restoration and conservation measures.

Interreg
Balkan-Mediterranean
WetMainAreas

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Thank you for your attention!

Get some practice at the upcoming working session!

For any questions or guidance please contact:

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