NewLife4Drylands

LIFE20 PRE/IT/000007

LIFE *Newlife4drylands* PROJECT

April, 18th 2023

Institute of Atmospheric Pollution Research
National Research Council of Italy

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Remote sensing-oriented nature-based solutions towards a NEW LIFE FOR DRYLANDS

LIFE20 PRE/IT/000007 - PREPARATORY PROJECT

Project Information

NEWLIFE4DRYLANDS

Grant Agreement LIFE20 PRE/IT/000007

https://www.newlife4drylands.eu

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OBJECTIVES

- **Establish an approach for mid and long-term monitoring of degradation status and restoration effectiveness through remote sensing techniques**
- **Improve vegetation cover and productivity through Nature Based Solutions in degraded or vulnerable areas where degradation processes are undergoing**
- Provide clear, specific and costless assessment of the restoration process useful for decision-making

CASE STUDIES

Tifaracás | El Bruc | Palo Laziale | Alta Murgia | Nestos | Asterousia

METHODOLOGY

1. Characterization with Driver-Pressure-State-Impact-Response (DPSIheR) Framework
2. Definition of a set of remote sensing indicators for degradation estimation
3. Design of a monitoring procedure for the assessment of NBS effectiveness
4. Design of a good practice protocol for remote sensing based assessment of NBS effectiveness

OUTCOMES

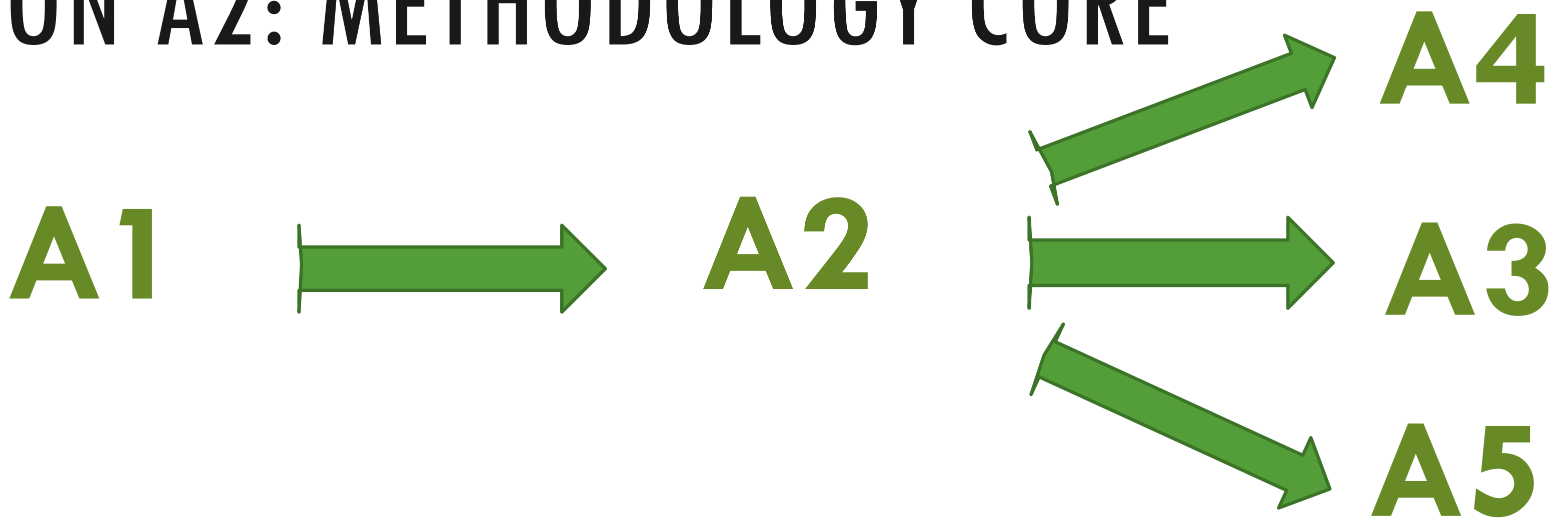
- Monitoring model
- Assessment protocol
- Plan for long term monitoring for Nestos, Palo L. El Bruc, Tifaracás
- Restoration plan with NBS for Alta Murgia and Asterousia

- The 6 study sites represent a wide variety of typical ecosystems in the Mediterranean landscape as drylands, coastal or mountainous, with high or low extension, threatened from different pressures causing LD

Study Site	Location	Ecosystem type	Dominant Ecosystem
Alta Murgia	Southern Italy	Drylands	Grassland
Tifaracas	Gran Canaria, Spain		Shrublands
El Bruc	Catalonia, Spain		Forest
Palo Laziale	Central Italy	Coastal	Forest
Nestos	Greece		Riparian Forest
Asterousia	Greece	Mountain	Shrublands

- The analysis by RS data doesn’t result site-dependent but specific for Mediterranean ecosystems identifying guidelines for the monitoring of their Land Degradation status

ACTION A2: METHODOLOGY CORE



5 ACTIONS:

- **A1: Characterization, main pressures and threads framework for each site**
- **A2: Extraction of indices/indicators from remote sensing data for assessing land degradation status**
- **A3: Monitoring Model for the assessment of NBS effectiveness**
- **A4: Long-Term Monitoring for restoration cases already started within previous projects and Restoration Plan with NBS for Alta Murgia site (southern Italy)**
- **A5: Definition of a good practices protocol for the assessment of NBS effectiveness**

Main challenges addressed:

- Trying to work at a local scale

(free available products, e.g., Copernicus services at a pan-European scale results poorly reliable)

→ to meet the needs of local decision-makers

- do not searching for new methodologies

→ decline on a local scale those well known in literature;

- using free available open satellite data as much as possible.

FREE-AVAILABLE SATELLITE DATA SPECTRAL BANDS

	Sentinel-2A MSI			Landsat 8 OLI		
Band	Spectral region	Wavelength range (nm)	Resolution (m)	Spectral region region	Wavelength range (nm)	Resolution (m)
B1				Blue	435–451	30
B2	Blue	458–523	10	Blue	452–512	30
B3	Green peak	543–578	10	Green	533–590	30
B4	Red	650–680	10	Red	636–673	30
B5	Red edge	698–713	20	NIR	851–879	30
B6	Red edge	733–748	20	SWIR1	1566–1651	30
B7	Red edge	773–793	20	SWIR2	2107–2294	30
B8	NIR	785–899	10			
B8A	NIR narrow	855–875	20			
B11	SWIR	1565–1655	20			
B12	SWIR	2100–2280	20			

SATELLITE REMOTE SENSING CAN GIVE GREAT CONTRIBUTIONS TO LAND DEGRADATION MONITORING

Remote Sensing is based on the extraction of information acquired at a certain distance analysing the reflected or emitted electromagnetic radiation from a target (interaction radiation-matter)

Potentialities:

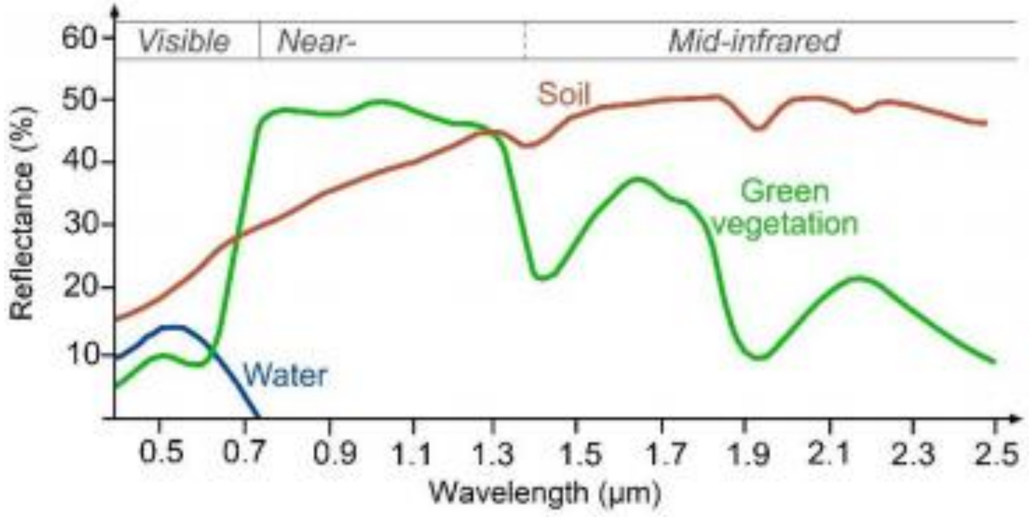
1) collecting the signal from the investigated target within a wide range of wavelengths, not only in the visible spectrum, highlighting properties of matter invisible to the human eye

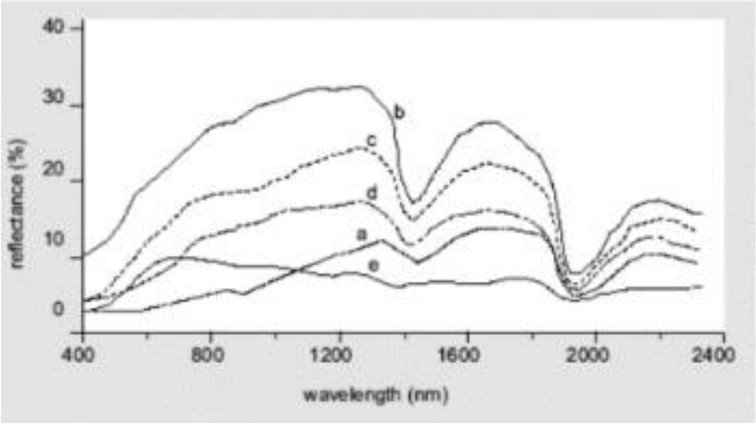
2) acquiring repeated series imagery of the same scene in order to capture changes over time: observations allow for past, present and near-real-time monitoring of Earth processes

3) analysing phenomena at different spatial scales of detail and investigating wide areas (rather than expensive in-situ exploration) seven inaccessible or difficult to reach

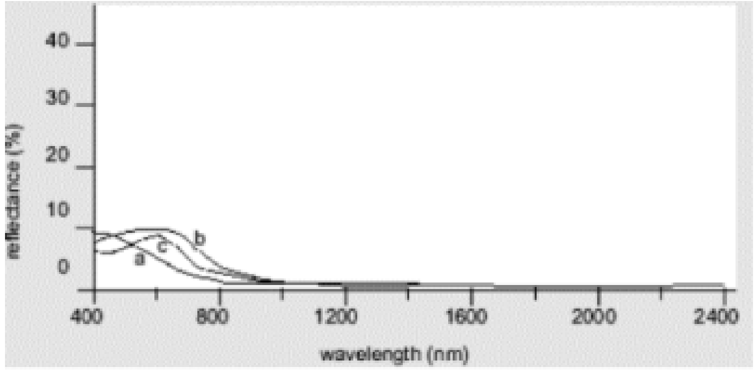
RS can see no more than human eyes but rather better through integration of spatial, temporal and spectral information.

SPECTRAL RESPONSE OF DIFFERENT TARGET





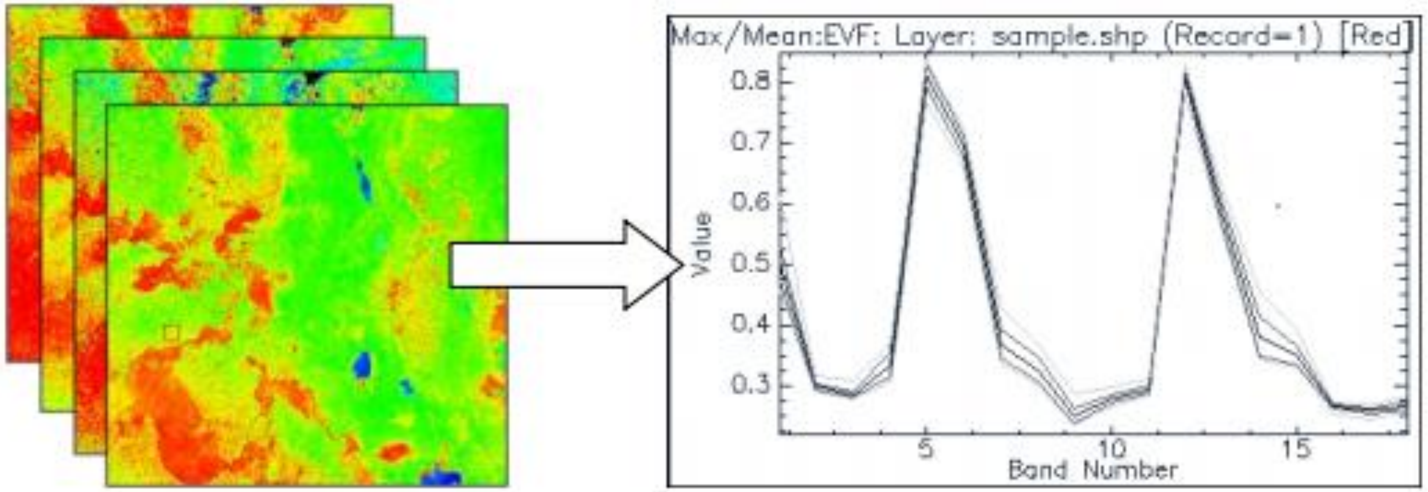
Reflectance spectrum
for 5 different soils:
(a) Predominance of organic matter
(b) Traces of different minerals
(c) Traces of iron
(d) Traces of organic matter
(e) Mainly iron



Reflectance spectrum
for water with clorophyll and sediments:
(a) Oceanic water
(b) Torbid water
(c) Water with clorophyll

The different reflectance response can be used to differentiate different targets

EXTRACTION OF INFORMATION FROM REMOTE SENSED DATA: COMBINATION OF SPECTRAL AND TEMPORAL DOMAIN



Extraction of the phenologic profile from the temporal profile of an NDVI time series

List of Indices/Indicators from Remote Sensed (RS) data useful for assessing soil degradation/desertification status in the NL4DL study sites

Indices (R is the reflectance at the wavelengths (nm) denoted by the subscripts)

Type	Acronym	Description	Generic Formula	Formula by Sentinel-2 bands	Reference	Application	By RS data	Degradation Processes in NL4DL study sites	By CNR-IIA
Vegetation Indices	NDVI	Normalized Difference Vegetation Index	$\frac{R_{800}-R_{670}}{R_{800}+R_{670}}$	$\frac{NIR-Red}{NIR+Red}$	Rouse et al. (1974); Zarco-Tejada et al. (2001)	presence and activity of green vegetation	Yes	Decline in Biodiversity; Decline in Biomass; Decline in vegetation community functioning; Decline in vegetation cover	Yes
	GNDVI	Green Normalized Difference Vegetation Index	$\frac{R_{800}-R_{550}}{R_{800}+R_{550}}$	$\frac{NIR-Green}{NIR+Green}$	Gitelson et al. (1996)				
	$MSAVI_2$	Modified Soil-Adjusted Vegetation Index	$\frac{2R_{800}+1-\sqrt{(2R_{800}+1)^2-8(R_{800}-R_{670})}}{2}$	$\frac{2*NIR+1-\sqrt{(2*NIR+1)^2-8*(NIR-Red)}}{2}$	Qi et al. (1995)				
	OSAVI	Optimized Soil-Adjusted Vegetation Index	$(1+0.16)\frac{R_{800}-R_{670}}{R_{800}+R_{670}+0.16}$	$(1+0.16)\frac{NIR-Red}{NIR+Red+0.16}$	Rondeaux et al. (1996)				
	NDRE	Normalized Difference RedEdge	$\frac{R_{960}-R_{700}}{R_{960}+R_{700}}$	$\frac{NIR_{narrow}-RedEdge1}{NIR_{narrow}+RedEdge1}$	Zhang et al. (2019)				
	ARVI	Atmospherically Resistant Vegetation Index	$\frac{R_{800}-[R_{670}-(R_{450}-R_{670})]}{R_{800}+[R_{670}-(R_{450}-R_{670})]}$	$\frac{NIR-[Red-(Blue-Red)]}{NIR+[Red-(Blue-Red)]}$	Bannari et al. (1995)				
	EVI_2	Enhanced Vegetation Index 2	$2.5\frac{R_{800}-R_{670}}{R_{800}+2.4R_{670}+1}$	$2.5\frac{NIR-Red}{NIR+2.4Red+1}$	Jiang et al. (2008)				
	REP	RedEdge Position	$705+35\frac{\left(\frac{R670+R780}{2}\right)-R700}{R740+R700}$	$705+35\frac{\left(\frac{Red+REdEdge3}{2}\right)-RedEdge1}{RedEdge2+RedEdge1}$	Main et al. (2011)				
	NBR	Normalized Burn Ratio	$\frac{R_{960}-R_{2200}}{R_{960}+R_{2200}}$	$\frac{NIR_{narrow}-SWIR2}{NIR_{narrow}+SWIR2}$	Key et al. (2002)	Burned areas detection		Forest fires	
	NBR_2	Normalized Burn Ratio 2	$\frac{R_{1600}-R_{2200}}{R_{1600}+R_{2200}}$	$\frac{SWIR1-SWIR2}{SWIR1+SWIR2}$	Key et al. (2002)				

	$NDWI_1$	Normalized Difference Water Index 1	$\frac{R_{800}-R_{2130}}{R_{800}+R_{2130}}$	$\frac{NIR-SWIR2}{NIR+SWIR2}$	Gao, 1996	water content of leaves		Decline in vegetation	
Water Indices	$NDWI_2$	Normalized Difference Water Index 2	$\frac{R_{550}-R_{800}}{R_{550}+R_{800}}$	$\frac{Green-NIR}{Green+NIR}$	McFeeters (1996)	water content in water bodies	Yes	Hydrological modifications	Yes
	MNDWI	Modified Normalized Difference Water Index	$\frac{R_{550}-R_{2130}}{R_{550}+R_{2130}}$	$\frac{Green-SWIR2}{Green+SWIR2}$	Xu (2006)				
	NDSI	Normalized Difference Soil Index	$\frac{R_{1650}-R_{560}}{R_{1650}+R_{560}}$	$\frac{SWIR1-Green}{SWIR1+Green}$	Deng et al. (2015)				
Soil Indices	NDBSI	Normalized Difference Bare Soil Index	$\frac{R_{1650}-R_{860}}{R_{1650}+R_{860}+0.001}$	$\frac{SWIR1-NIRnarrow}{SWIR1+NIRnarrow+0.001}$		identify areas where soils are dominant	Yes	Soil quality degradation	Yes
	BI	Bare Index	$\frac{(R_{1650}+R_{670})-(R_{800}+R_{450})}{(R_{1650}+R_{670})+(R_{800}+R_{450})}$	$\frac{(SWIR1+Red)-(NIR+Blue)}{(SWIR1+Red)+(NIR+Blue)}$	Chen et al. (2004)				
	SSI_1	Soil Salinity Index-1	$\sqrt{R_{[520:600]} * R_{[630:690]}}$	$\sqrt{Green * Red}$	Khan et al. (2001); Yahiaoui et al. (2015)				
	SSI_2	Soil Salinity Index-2	$2 * R_{[520:600]}-(R_{[630:690]}+R_{[770:900]})$	$2 * Green-(Red+NIR)$	Douaoui and Lepinard (2010); Yahiaoui et al. (2015)				
Soil Salinity Indices	SSI_3	Soil Salinity Index-3	$\sqrt{R^2_{[630:690]} + R^2_{[520:600]}}$	$\sqrt{Red^2 + Green^2}$	Douaoui et al. (2006); Yahiaoui et al. (2015)	identification of degree of soil salinization	Yes	Soil Salinization	Yes
	SI	Salinity Index	$\frac{R_{[530:590]} * R_{[640:670]}}{R_{[450:510]}}$	$\frac{Green * Red}{Blue}$	Elhag et al. (2016)				
	SASI	Soil Adjusted Salinity Index	$\frac{R_{[630:690]}}{100 * R^2_{[450:520]}}$	$\frac{Red}{100 * Blue^2}$	Yahiaoui et al. (2015)				
Drought/Dryness Indices	NDDI	Normalized Difference Drought Index	$\frac{NDVI-NDWI_1}{NDVI+NDWI_1}$		Gu et al. (2007); Renza et al. (2010)	assessing drought	Yes	Aridification	Yes
	DSI	Desertification Soil Index	$\frac{R_{1648}-R_{498}}{R_{1648}-R_{2203}+0.2}$	$\frac{SWIR1-Blue}{SWIR1-SWIR2+0.2}$	Wu et al. (2010)	highlight the higher reflectance of desertification soil as			

Composite Indicators

Indicator		Sub-indicator	Metric/Measures	Final Formula	Reference				
SDG 15.3.1 (v2 released on March, 29th 2021)	"proportion of land that is degraded over total land area"	Land Cover (LC) change (Trend in LC)	LC Area	*One Out, All Out*	UNCCD (2017; 2018); https://unstats.un.org/sdgs/metadata/files/Metadata-15-03-01.pdf		Yes		Yes
		Land Productivity loss	Net Primary Production (NPP)/Gross Primary Production (GPP)				Yes by proxies from RS		Yes
		Soil Organic Carbon (SOC) decline	SOC				Yes by proxies from RS		Yes
		Further sub-indicators							
		Loss of habitat quality	Habitat cover Area		Assennato et al. (2020)		Partially from RS (LC/habitat map)+InVEST model	Habitat loss; trees encroachment (Very High Resolution RS data); Urban expansion......	Partially (LC)
		Burnt Areas	LC Area				Yes		Yes
		Fragmentation Index	Mesh density				Partially from RS (LC)+spatial rules		Partially(LC)
		Areas of potential impact	LC Area				Partially from RS (LC)+spatial rules		Partially(LC)
		Density of artificial LC	LC Density				Yes		Yes
		Increasing of not sealed areas	LC Area				Partially from RS (LC)+spatial rules		Partially(LC)

MATCHING OF EACH SELECTED INDEX/INDICATOR WITH THE DEGRADATION PROCESSES IN EACH PILOT SITE

Indices			Degradation processes												
Type	Acronym	Description	*Landscape modification*	*Aridification*	*Forest fires*	*Hydrological modification*	*Overgrazing*	*Soil salinization*	*Soil organic matter decline*	*Soil erosion by water and wind*	*Decline in vegetation community functioning*	*Decline in vegetation cover/biomass*	*Habitat loss*	*Increase in invasive species*	*Trees encroachment*
Vegetation Indices	NDVI	*Normalized Difference Vegetation Index*	X		X		X				X	X	X	X	X
	GNDVI	*Green Normalized Difference Vegetation Index*	X		X		X				X	X	X	X	X
	MSAVI$_2$	*Modified Soil-Adjusted Vegetation Index*	X		X		X				X	X	X	X	X
	OSAVI	*Optimized Soil-Adjusted Vegetation Index*	X		X		X				X	X	X	X	X
	NDRE	*Normalized Difference RedEdge*	X		X		X				X	X	X		
	ARVI	*Atmospherically Resistant Vegetation Index*	X				X				X	X	X		X
	EVI$_2$	*Enhanced Vegetation Index 2*	X				X				X	X	X		X
	REP	*RedEdge Position*	X				X				X	X	X		
	NBR	*Normalized Burn Ratio*			X										
	NBR$_2$	*Normalized Burn Ratio 2*			X										
Water Indices	NDWI$_1$	*Normalized Difference Water Index 1*	X			X						X			
	NDWI$_2$	*Normalized Difference Water Index 2*	X			X									
	MNDWI	*Modified Normalized Difference Water Index*	X			X									
Soil Indices	NDSI	*Normalized Difference Soil Index*	X	X			X	X	X				X		
	NDBSI	*Normalized Difference Bare Soil Index*	X	X			X	X	X				X		
	BI	*Bare Index*	X	X			X	X	X				X		
Soil Salinity Indices	SSI$_1$	*Soil Salinity Index-1*	X	X				X							
	SSI$_2$	*Soil Salinity Index-2*	X	X				X							
	SSI$_3$	*Soil Salinity Index-3*	X	X				X							
	SI	*Salinity Index*	X	X				X							
	SASI	*Soil Adjusted Salinity Index*	X	X				X					X		
Drought/Dryness Indices	NDDI	*Normalized Difference Drought Index*	X	X			X	X	X				X		
	DSI	*Desertification Soil Index*	X	X			X	X	X				X		

MATCHING OF EACH SELECTED INDEX/INDICATOR WITH THE DEGRADATION PROCESSES IN EACH PILOT SITE

Indicators			Landscape modification	Aridification	Forest fires	Hydrological modification	Overgrazing	Soil salinization	Soil organic matter decline	Soil erosion by water and wind	Decline in vegetation community functioning	Decline in vegetation cover/biomass	Habitat loss	Increase in invasive species	Trees encroachment
SDG 15.3.1 (v2 released on March, 29th 2021)	"proportion of land that is degraded over total land area"	*Land Cover (LC) change (Trend in LC)*	X	X	X		X		X		X	X	X	X	X
		Land Productivity loss		X	X		X		X		X		X		
		Soil Organic Carbon (SOC) decline		X	X		X		X		X		X		
		Loss of habitat quality	X	X	X		X		X		X	X	X		
		Burnt Areas	X	X	X						X	X	X		
		Fragmentation Index	X		X		X				X	X	X		
		Areas of potential impact	X		X		X				X	X	X		
		Density of artificial LC	X								X	X	X		
		Increasing of not sealed areas	X								X		X		

Sites	Landscape modification	Aridification	Forest fires	Hydrological modification	Overgrazing	Soil salinization	Soil organic matter decline	Soil erosion by water and wind	Decline in vegetation community functioning	Decline in vegetation cover/biomass	Habitat loss	Increase in invasive species	Trees encroachment
El Bruc	X	X	X				X	X	X	X	X	X	
Tifaracás		X		X	X		X	X	X	X	X		
Palo Laziale		X							X	X	X		
Nestos	X					X					X	X	
Alta Murgia	X	X	X					X	X	X	X	X	X
Asterousia	X	X		X		X	X	X	X	X	X		
Tot. presence of degradation across sites	4	5	2	2	1	2	3	4	5	5	6	3	1

SDG 15.3.1: *"proportion of land that is degraded over total land area"*

The sub-indicators and their associated metrics (in parentheses) useful for SDG 15.3.1

1. <u>Trend in Land cover</u> (assessed as land cover change)
   → **Action: list of land cover classes** (taxonomy: according to FAO-LCCS)
   → **Action: list of the main changes of interest** (from-to transitions prone to degradation)

2. <u>Trend in Land productivity</u> (assessed as net primary productivity, NPP)
   → after implementation of indices as proxy

3. <u>Trend in Carbon stocks</u> (assessed as soil organic carbon, SOC)
   → measures on ground/any other

4. Extraction of Essential Variables (indices and indicators used as proxies):
   → further sub-indicators (local analysis based on pressures and threats)

ALTA MURGIA

Sub-indicators	Sensor	Spatial resolution (m)	Spatial frame	Temporal frame
NATURAL GRASSLAND COVER MAP;	Landsat	30	N2K +5 km buffer	1990; 2001; 2004; 2011
BURN SEVERITY MAP	Sentinel-2	10		2018; 2021
VEGETATION PHENOLOGY INDEX (MSAVI2)	Landsat	30		2000-2018
PLANT PHENOLOGY INDEX (PPI)	Sentinel-2	10		2017-2020
STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX (SPEI)	3 meteo stations	-----------		2011-2020
SOC*	Sentinel-2; PRISMA	10; 30	Only LC classes with ground data	2020

PALO LAZIALE

Sub-indicators	Sensor	Spatial resolution (m)	Spatial frame	Temporal frame
LAND COVER MAP	Pleiades	2	N2K +1 km buffer	2020; 2021
VEGETATION PHENOLOGY INDEX (NDVI/MSAVI2)	Quickbird	2.4		2002-2009
	Pleiades	2		2014-2021
PLANT PHENOLOGY INDEX (PPI)	Sentinel-2	10		2017-2020
LEAF AREA INDEX (LAI)*				
STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX (SPEI)	1 meteo station	-----------		2000-2020
SOC*	Sentinel-2; PRISMA	10; 30	Only LC classes with ground data	2020

NESTOS

Sub-indicators	Sensor	Spatial resolution (m)	Spatial frame	Temporal frame
LAND COVER MAP*	Landsat	30	N2K	2000; 2005; 2010
	Sentinel-2	10		2017; 2021
VEGETATION PHENOLOGY INDEX (MSAVI2)*	Landsat	30		2000-2018
PLANT PHENOLOGY INDEX (PPI)*	Sentinel-2	10		2017-2020
LEAF AREA INDEX (LAI)*				2017-2020
HYDRO-PERIOD MAP				Oct. 2017 – Sept. 2018; Oct. 2019 – Sept. 2020; Oct. 2020 – Sept. 2021
SOIL SALINITY INDICES*				2017; 2021
STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX (SPEI)*	3 meteo stations	-----------		2011-2020
SOC*	Sentinel-2; PRISMA	10; 30	Only LC classes with ground data	2020

ASTEROUSIA

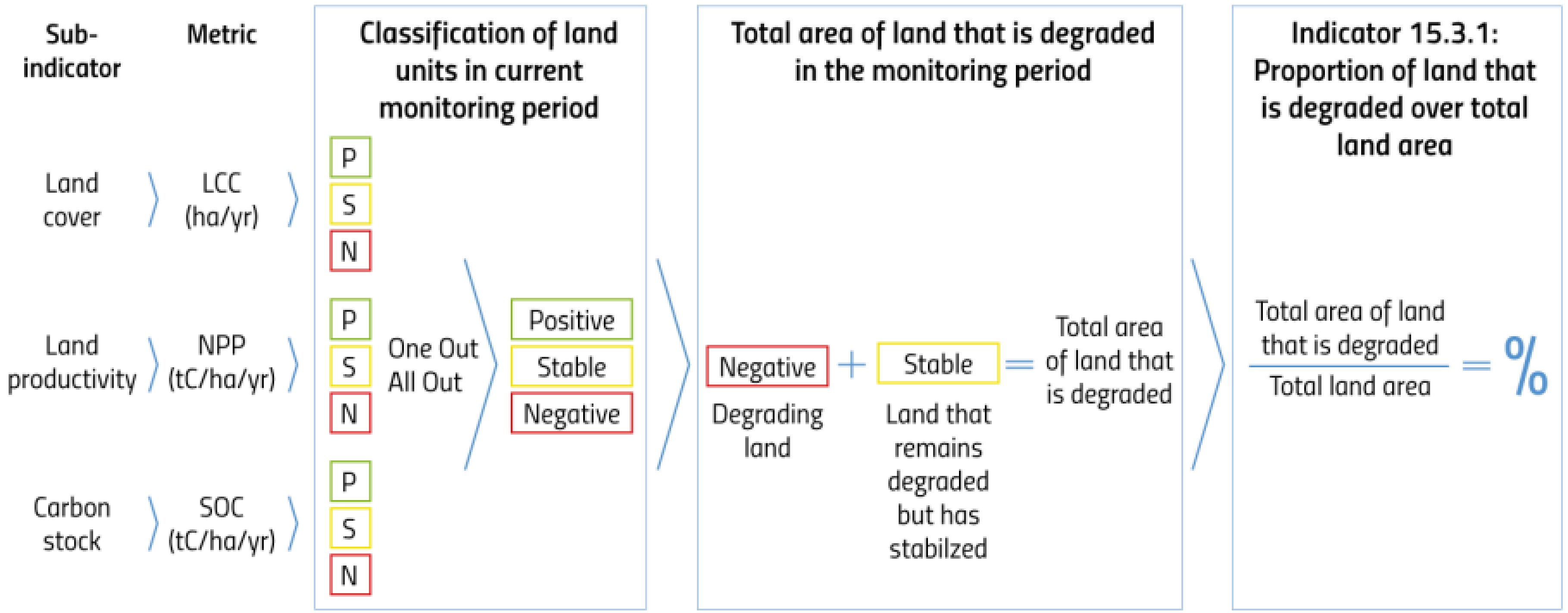
Sub-indicators	Sensor	Spatial resolution (m)	Spatial frame	Temporal frame
LAND COVER MAP*	Landsat	30	N2K +5 km buffer	2000; 2005; 2010
	Sentinel-2	10		2017; 2021
VEGETATION PHENOLOGY INDEX (MSAVI2)*	Landsat	30		2000-2018
PLANT PHENOLOGY INDEX (PPI)*	Sentinel-2	10		2017-2020
BURN SEVERITY MAP*				
SOIL SALINITY INDICES*				2017; 2021
SOC*	Sentinel-2; PRISMA	10; 30	Only LC classes with ground data	2020

EL BRUC				
Sub-indicators	**Sensor**	**Spatial resolution (m)**	**Spatial frame**	**Temporal frame**
LAND COVER MAP	Landsat	30	N2K +5 km buffer	2000; 2005; 2010
	Sentinel-2	10		2017; 2021
VEGETATION PHENOLOGY INDEX (MSAVI2)	Landsat	30		2000-2018
PLANT PHENOLOGY INDEX (PPI)	Sentinel-2	10		2017-2020
BURN SEVERITY MAP				2017-2020
SOC*	Sentinel-2; PRISMA	10; 30	Only LC classes with ground data	2020

TIFARACAS				
Sub-indicators	**Sensor**	**Spatial resolution (m)**	**Spatial frame**	**Temporal frame**
LAND COVER MAP	Landsat	30	N2K +5 km buffer	2000; 2005; 2010
	Sentinel-2	10		2017; 2021
VEGETATION PHENOLOGY INDEX (MSAVI2)	Landsat	30		2000-2018
PLANT PHENOLOGY INDEX (PPI)	Sentinel-2	10		2017-2020
BURN SEVERITY MAP				2017-2020
SOC*	Sentinel-2; PRISMA	10; 30	Only LC classes with ground data	2020

SDG 15.3.1 sub-indicators integration criteria:

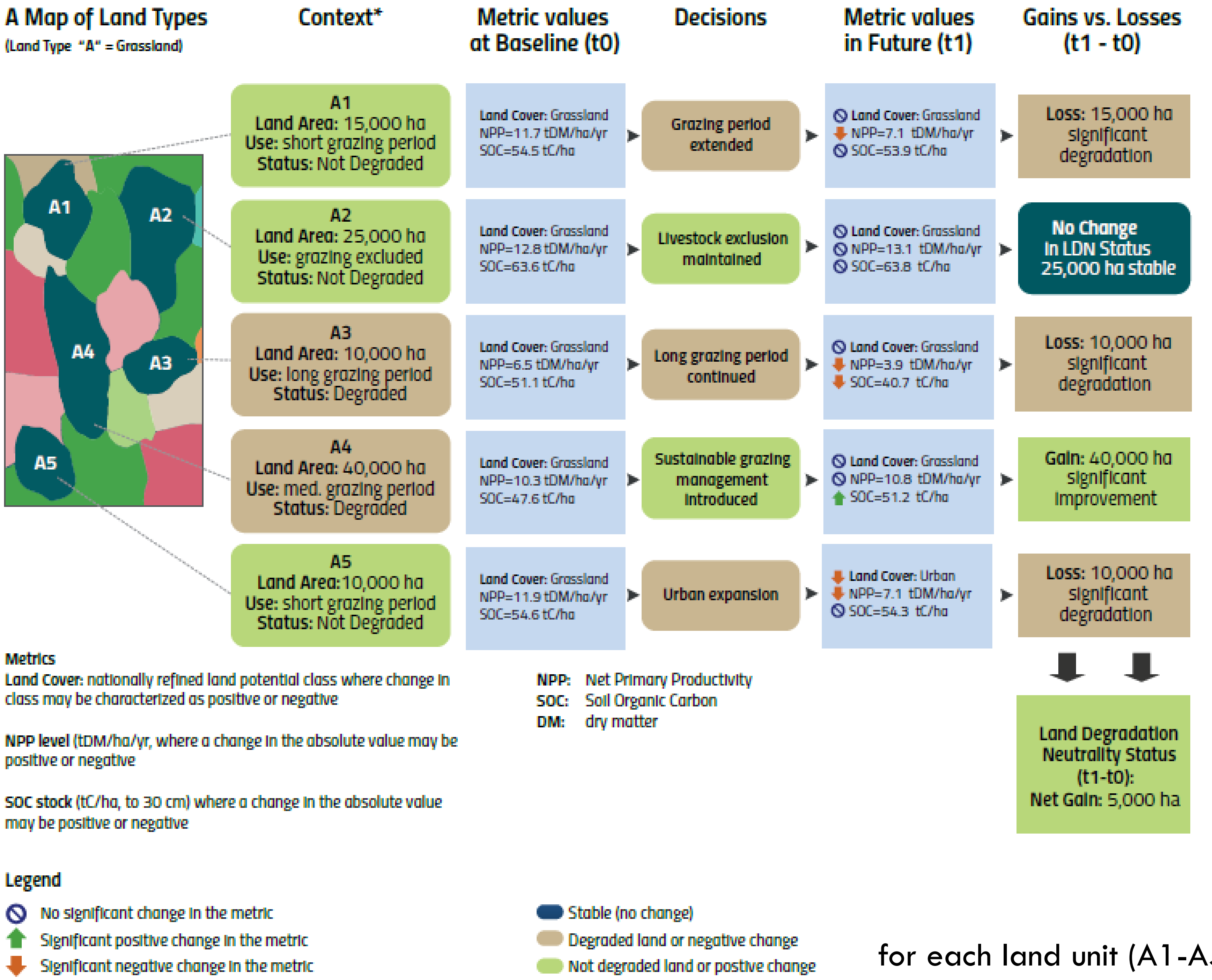
«one-out, all-out»



1. Setting the baseline to determine the initial status of the sub-indicators.
2. Detecting and validating the type of change in each of the sub-indicators per land unit (e.g., pixel, polygon).
3. Deriving the indicator by summing all areas subject to "negative" change (i.e., degraded) and dividing by the total land area using "One Out, All Out" area-based approach where if any of the sub-indicators is determined to show significant negative change, it is considered degraded.

SDG 15.3.1

"proportion of land that is degraded over total land area"



for each land unit (A1-A5)

What has been assessed up to now: Series of Guidelines

- ✓ Analysis of pressures and threats causing land degradation in each site (supported by the expert-knowledge) (context-based approach)
- ✓ Spatial, temporal and spectral domain affect the choice of satellite data:
  - ❑ The spatial framework of the Area of Interest (AOI) and buffer area surrounding:
    - Area > 50 ha (5 km buffer) → HR free available satellite data
    - Area < 50 ha (1 km buffer) → VHR commercial satellite data
  - ❑ The temporal framework (trigger events identification) :
    - Long-term monitoring back before 2015 → Landsat data (30 m)
    - Medium/short-term monitoring after 2015 → Sentinel-2 data (10-20 m)
  - ❑ The spectral response: multi/hyper - spectral
  - ❑ Combination of spectral and temporal domain (i.e., spectral indices time series)
  - ❑ The working scale: local (site-scale)
- ✓ Analysis of free available satellite data and the compromises in their choice: long/mid-term vs. short-term monitoring, global vs. local scale, multi- vs. hyper- spectral investigation
- ✓ Reviewing of scientific and technical literature about identification of a list of well-known remote sensing indicators and spectral indices
- ✓ SDG 15.3.1 indicator computation, according to the United Nations Convention to Combat Desertification (UNCCD) guidelines: integration of further sub-indicators at a local scale for monitoring pressures and threats in each study area according to the “One Out, All Out” criteria.

Guidelines are not site-specific solutions: conceived for whatever site for a local scale approach

Gaps encountered

- Availability of optical satellite data without cloud cover or considering clouds/clouds shadow masking;
- Need of tasking and purchase for VHR satellite data in case of small size of study areas;
- Difficulties in the radiometric and geometric calibration mainly for VHR data and in case of mountainous sites (topographic correction);
- Difficulty in the validation of sub-indicators for the lack of ground truth data mainly in the past: in particular for SOC or NPP or their proxies in-field measures;
- Difficulty in the training of data-driven machine learning algorithms due to the lack of sufficient ground truth data;
- Difficulty in obtaining finer land cover details without ancillary data or sufficient information to discriminate among the classes;
- Possibility to obtain soil salinity indices (soil measures sub-indicator) only for those areas covered by bare soil or herbaceous vegetation (the presence of dense trees does not allow to observe the soil from satellite);
- Lack of validation data for SOC, soil salinity, burned areas and vegetation phenology trend indices for the Greek sites due to slight control of the territory;
- Need to update the list of sub-indicators as the sites change.

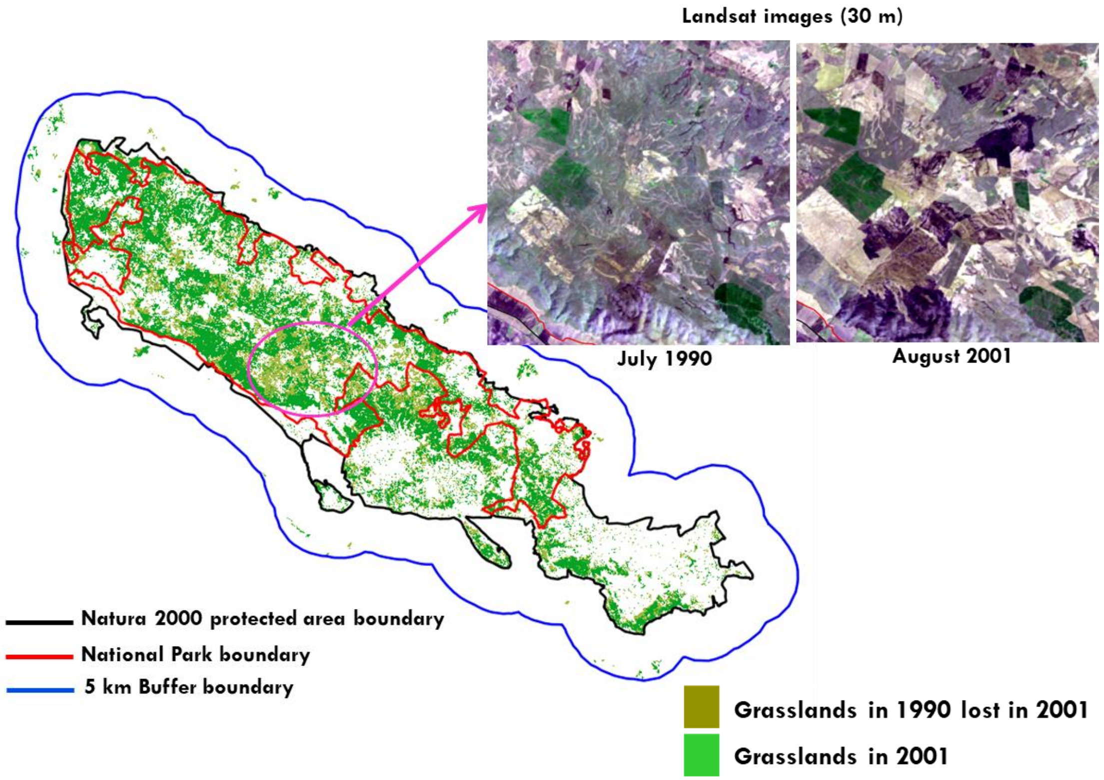
Strenghts

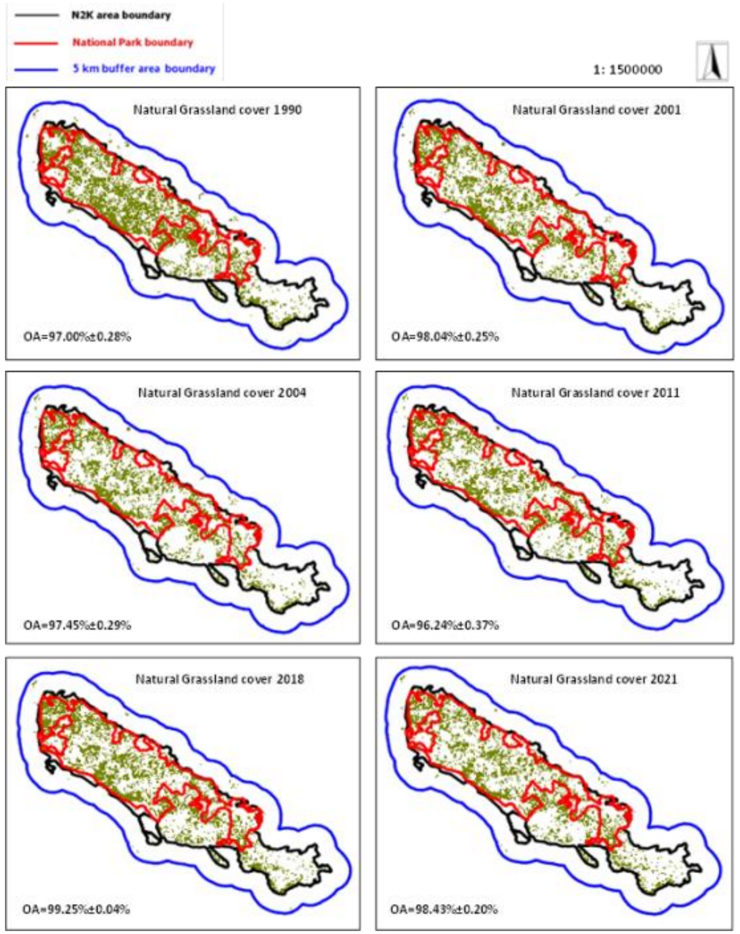
- Starting from an accurate analysis of the main problems affecting the different types of Mediterranean ecosystems;
- Provisioning for local scale detail: HR or VHR satellite data in case of areas > 50 ha or < 50 ha, respectively;
- Increase of sub-indicators to be combined to obtain SDG 15.3.1;
- Calculation of SDG 15.3.1 indicator at local scale overcoming the current Trends.Earth tool available at global scale;
- Usefulness for local decision-makers.

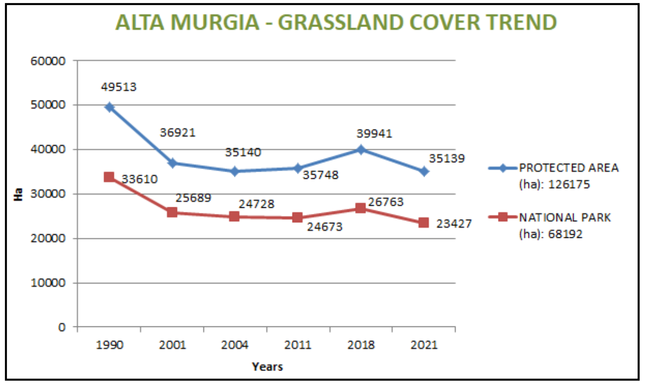
Importance of the local analysis:

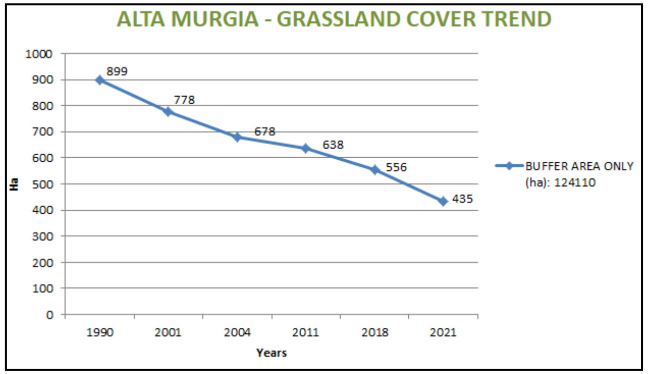
- «Good Practice Guideline» for SDG 15.3.1 suggests changes into cultivated land use is not degradation but in Alta Murgia this is the main cause for biodiversity loss from natural grassland ecosytem
- Decision-makers need of VHR solutions

ALTA MURGIA RESULTS:
GRASSLAND COVER TIME SERIES



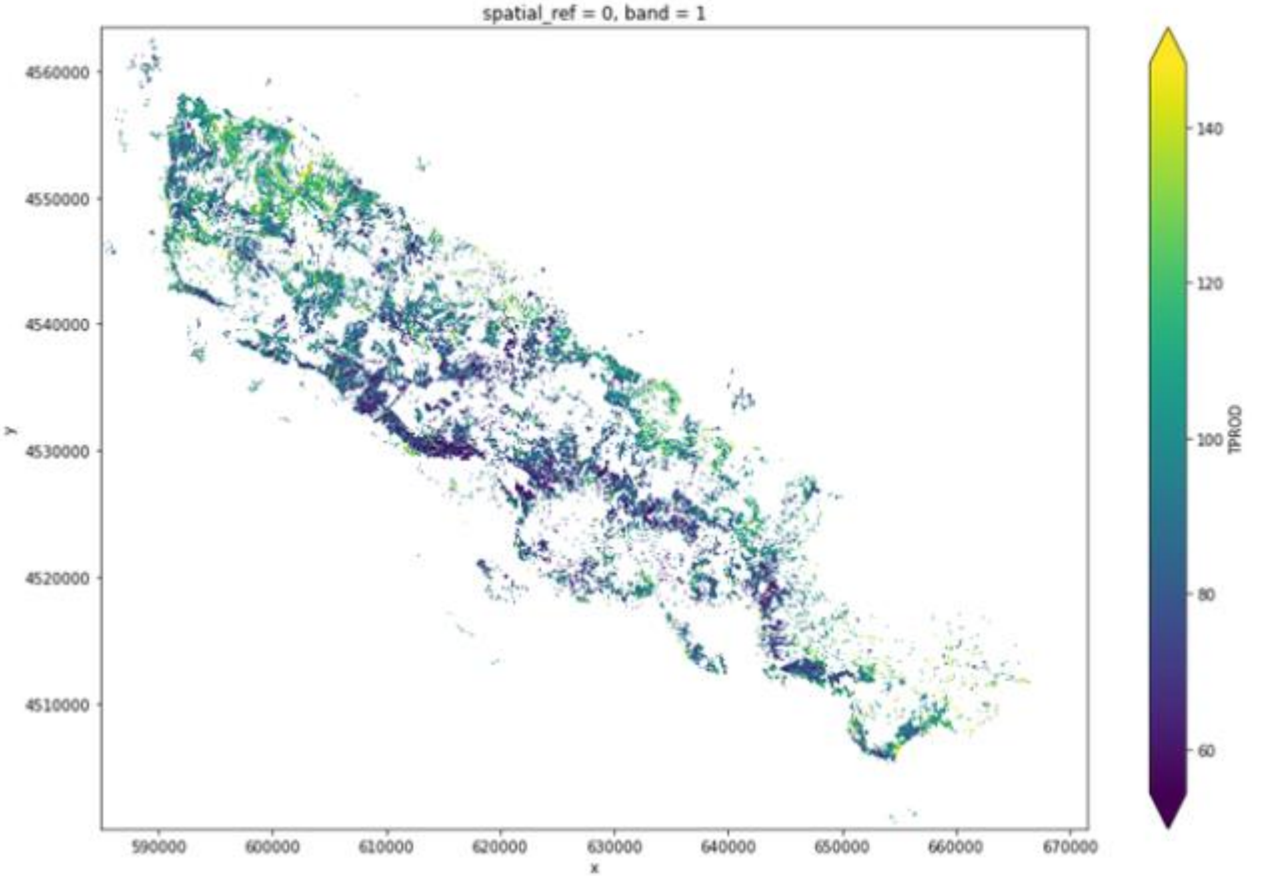






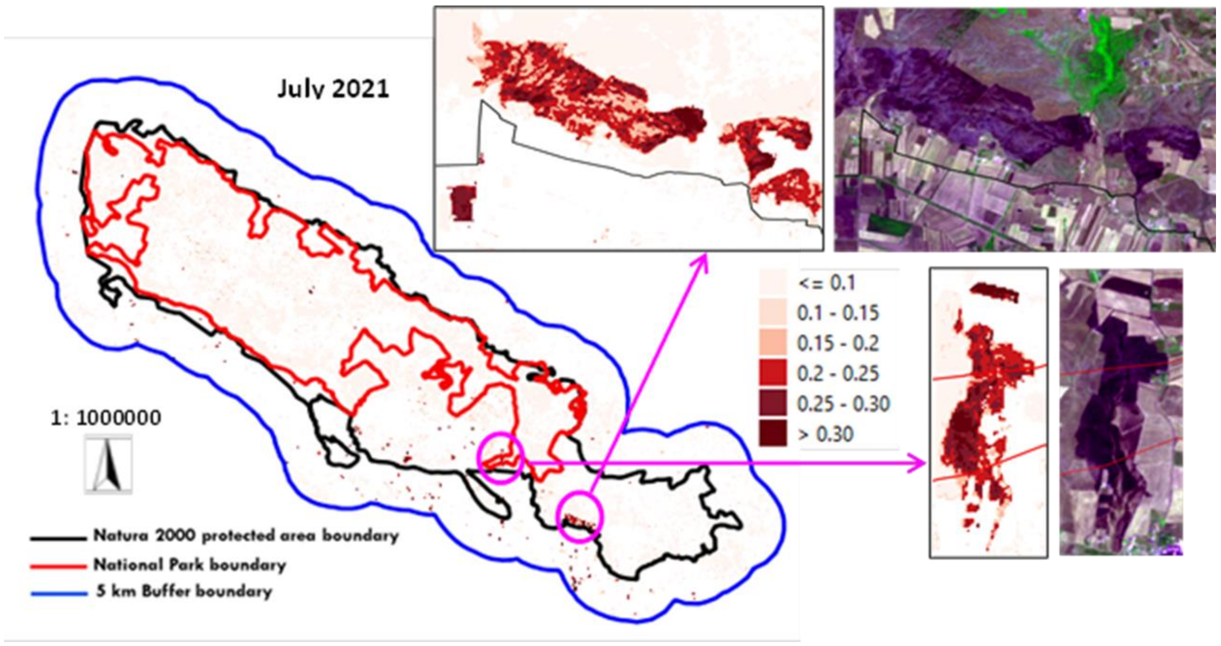
ALTA MURGIA RESULTS:

GRASSLAND PRIMARY PRODUCTIVITY



Grassland has higher productivity on the side of the highlands that look towards Adriatic Sea, while central plateau is less productive.

GRASSLAND BURN SEVERITY



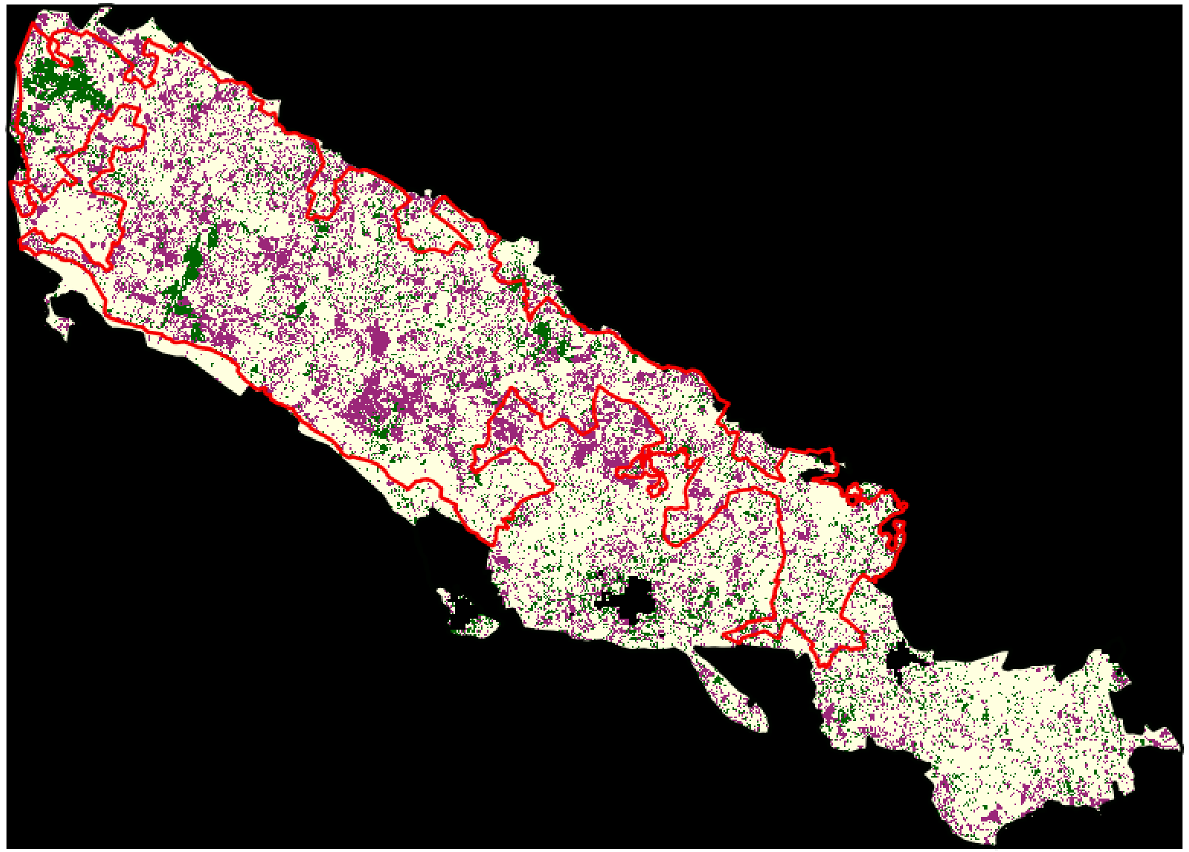
ALTA MURGIA RESULTS:

SOILGRIDS at 250 m for 2016

SOC

Soil organic carbon degradation (1990 to 2021)

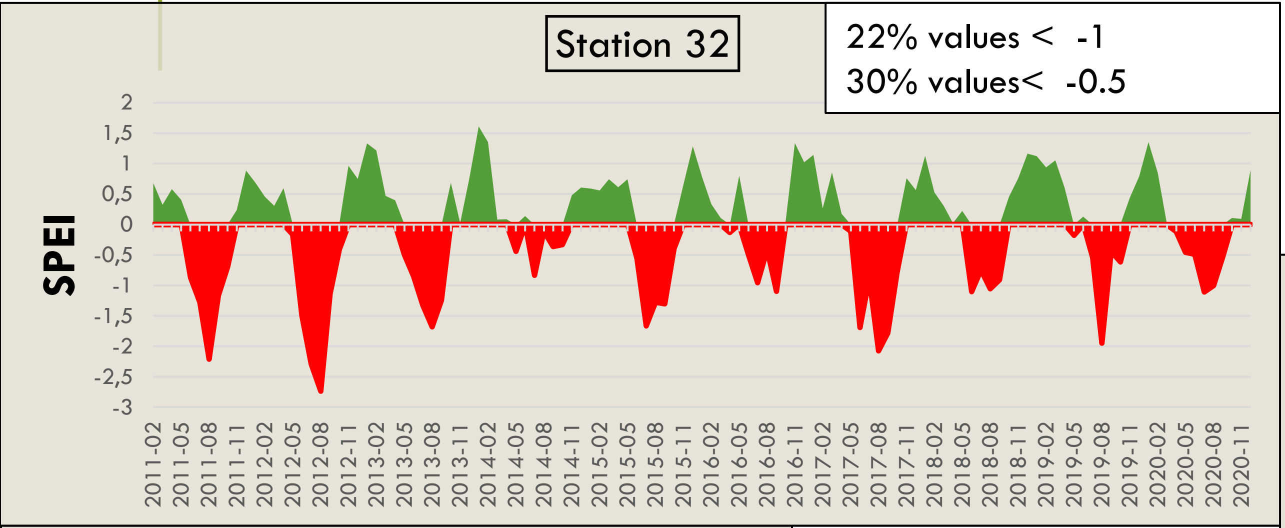
- No data
- Degradation
- Stable
- Improvement

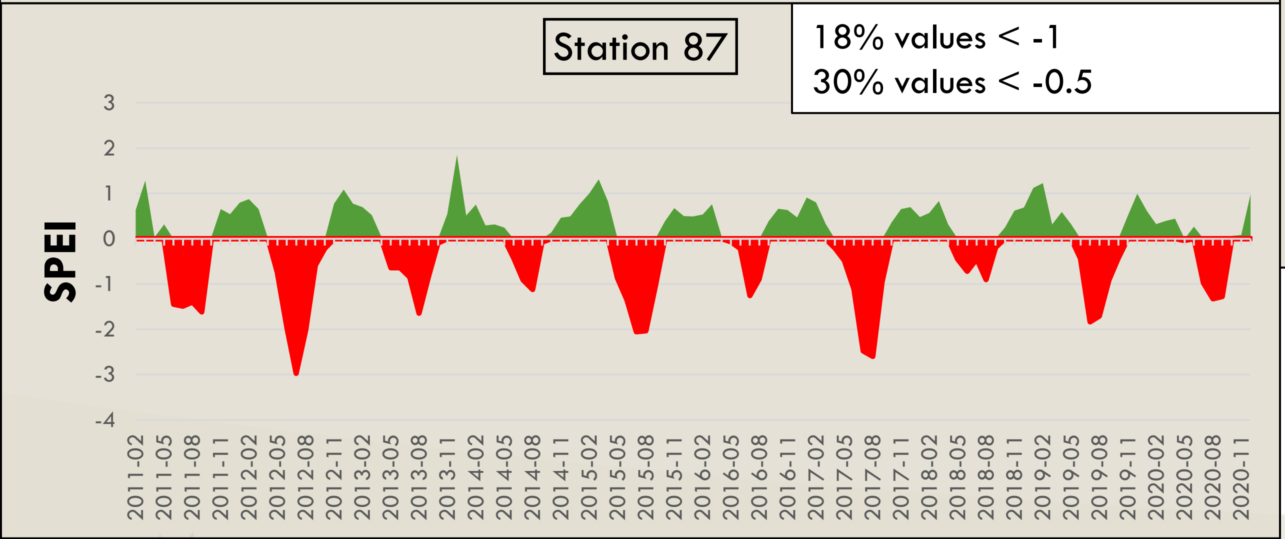


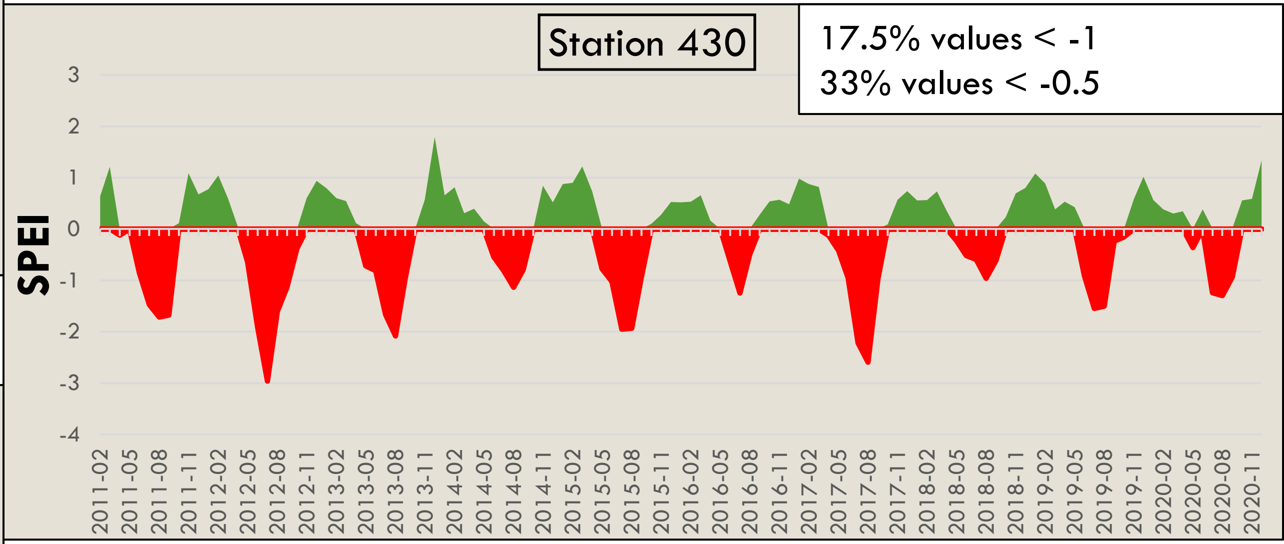
ALTA MURGIA: CLIMATIC ANALYSIS

STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX (SPEI)

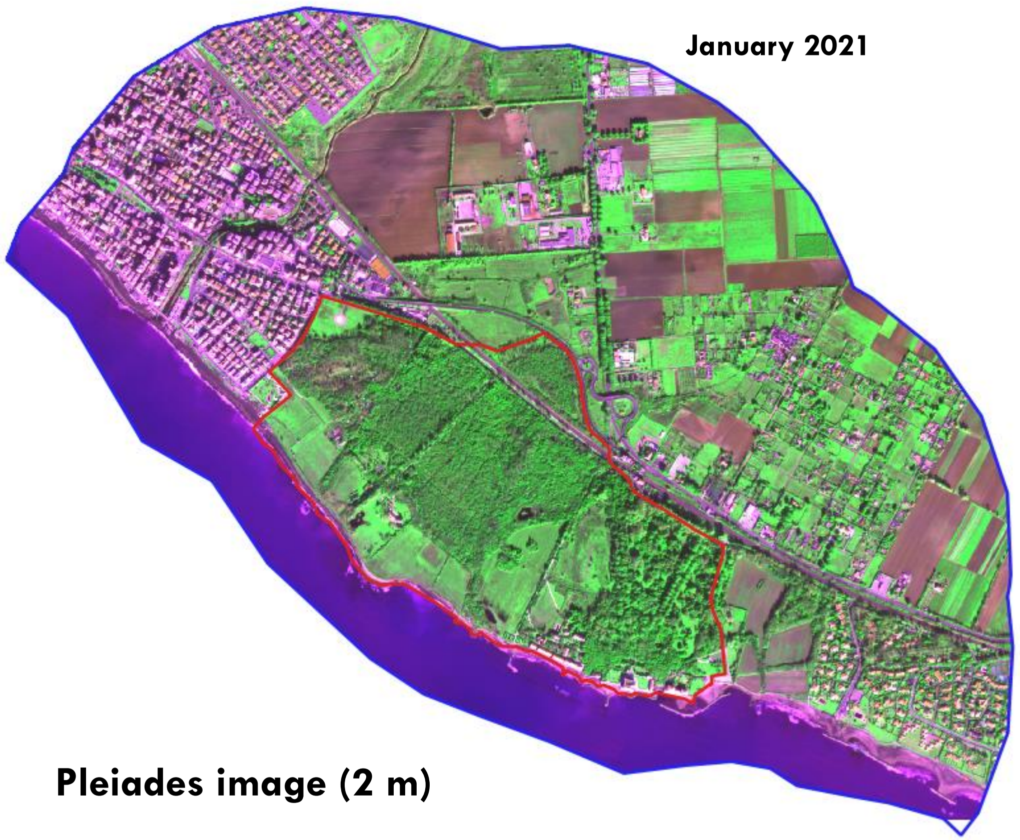
- **Station 32**
Minervino Murge (BT)
502 m a.s.l.
- **Station 87**
Masseria Modesti (BA)
501 m a.s.l.
- **Station 430**
Mercadante (BA)
395 m a.s.l.







PALO LAZIALE RESULTS:
LAND COVER MAPPING



Pleiades image (2 m)

- B_Notvegetated (road,bare soil, sand)
- Unclassified
- B27/B28_Artificial or Natural Waterbodies
- SHADOW
- A24 OR A23_Artificial or Natural Aquatic Vegetation
- A12/A2.A6 OR A11/A3_Natural Terrestrial Vegetation/Herbaceous.Graminoids or Cultivated Land/Herbaceous
- A12/A2.A5_Natural Terrestrial Vegetation/Herbaceous.Forbs
- A12 OR A24/A3.D1.E2_Natural Terrestrial or Aquatic Vegetation/Trees.Broadleaved.Deciduous
- B15_BUILDINGS
- A12 OR A24/A3.D1.E1_Natural Terrestrial or Aquatic Vegetation/Trees.Broadleaved.Evergreen
- A24/A2.A6_Natural Aquatic Vegetation/Herbaceous.Graminoids
- B15_ROAD OR WET SAND

NewLife4Drylands
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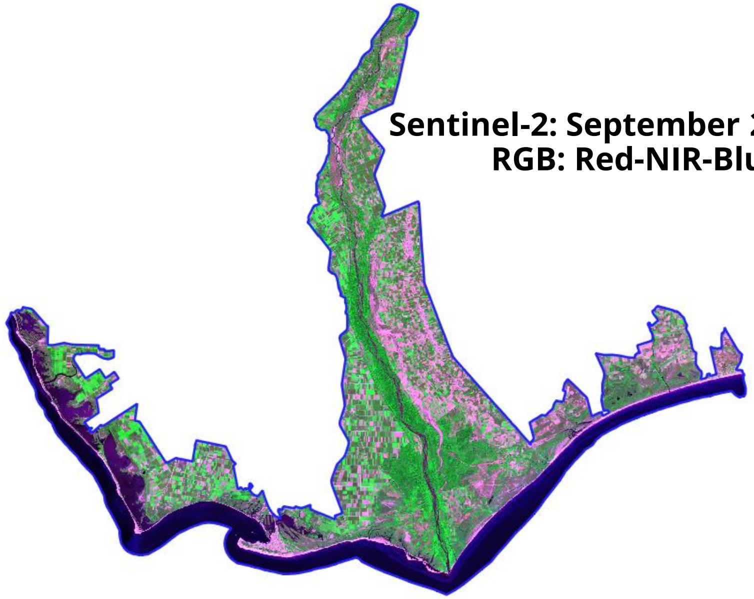
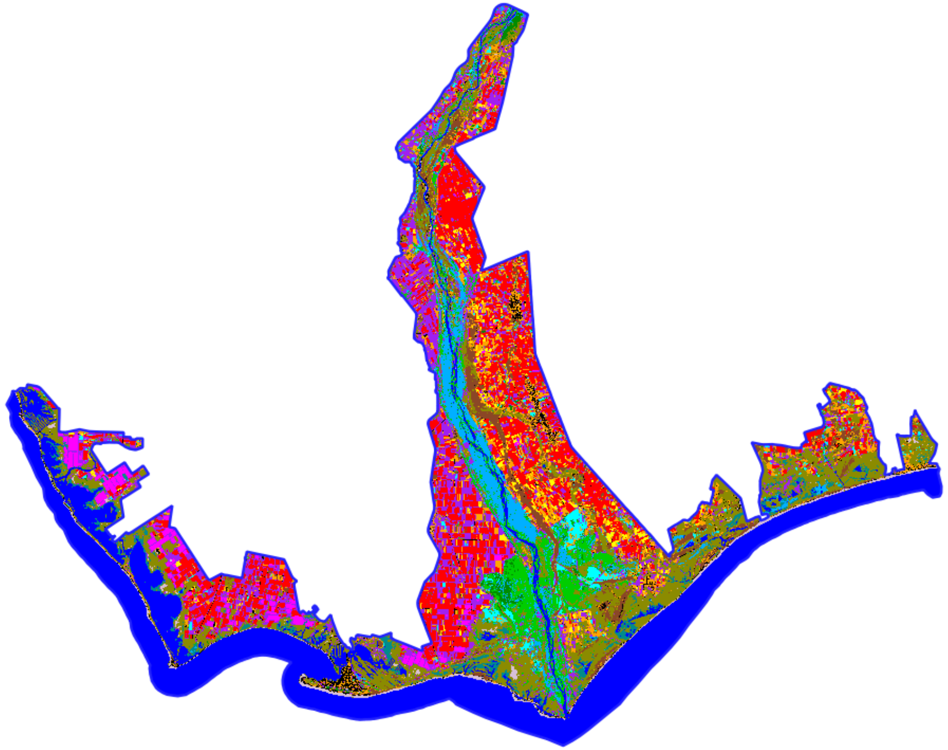
NESTOS: LAND COVER MAPPING

Sentinel-2: September 2nd, 2021
RGB: Red-NIR-Blue

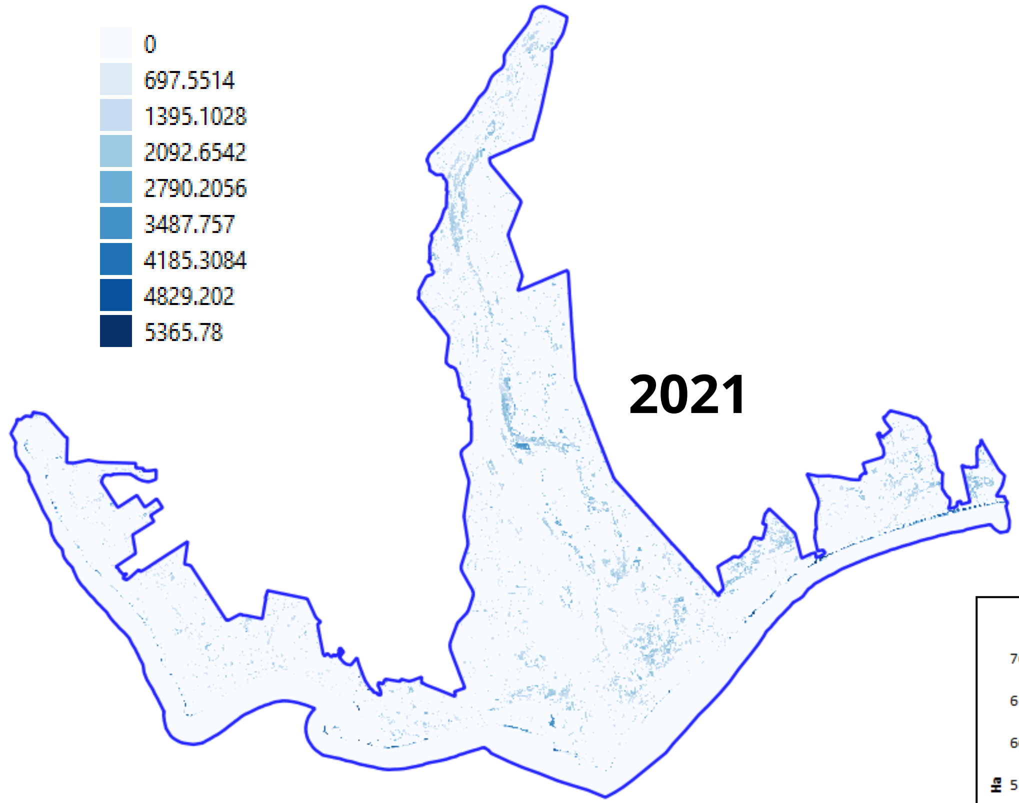




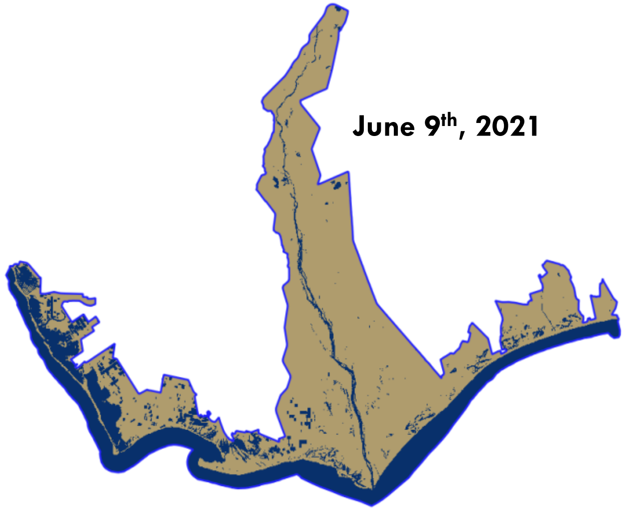
- ARTIFICIAL_AREAS
- ARTIFICIAL_POPLAR_PLANTATIONS
- BARE_AREAS
- CULT1_DMARCH_DMAY_DJUNE_GJULY_GSEPT_asparagus
- CULT2_DMARCH_DMAY_GJUNE_GJULY_DSEPT_corn
- CULT3_DMARCH_GMAY_GJUNE_GJULY_GSEPT_alfalfa
- CULT4_GMARCH_GMAY_DJUNE_GJULY_DSEPT_wheat_soft
- CULT5_BMARCH_BMAY_VJUNE_VJULY_VSEPT
- NATURAL_AQUATIC_VEGETATION_SHRUBS_DECIDUOUS
- NATURAL_TERRESTRIAL_VEGETATION_HERBACEOUS-GRASSLAND
- NATURAL_TERRESTRIAL_VEGETATION_TREES-SHRUBS_DECIDUOUS
- NATURAL_TERRESTRIAL_VEGETATION_TREES-SHRUBS_EVERGREEN
- NATURAL_WATERBODIES
- SANDY_SOIL
- UNCLASSIFIED
- ARTIFICIAL_91E0_PLANTATIONS

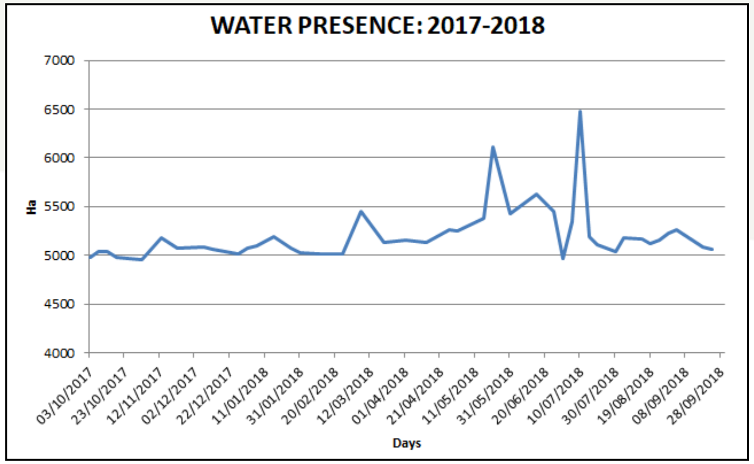
NESTOS: Soil Salinity index

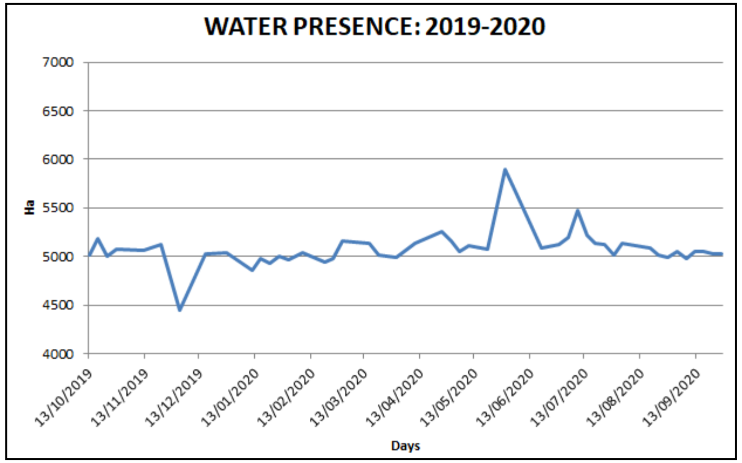
$$SI = \frac{Green * Red}{Blue}$$

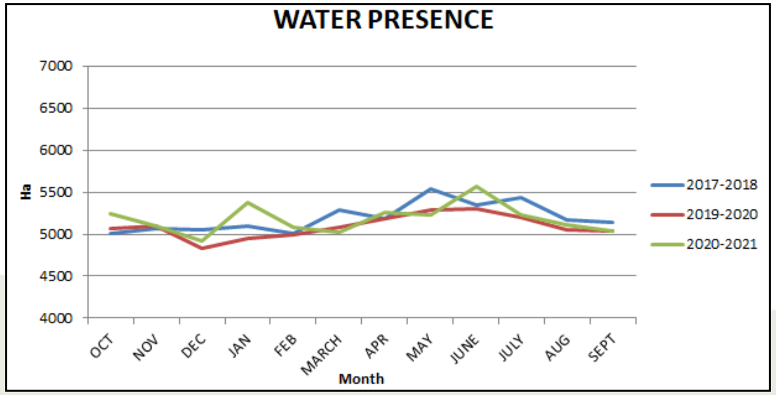


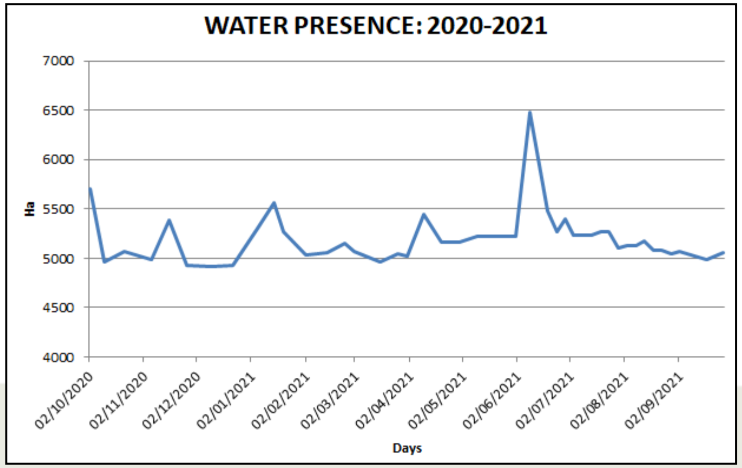
WATER COVER PRESENCE





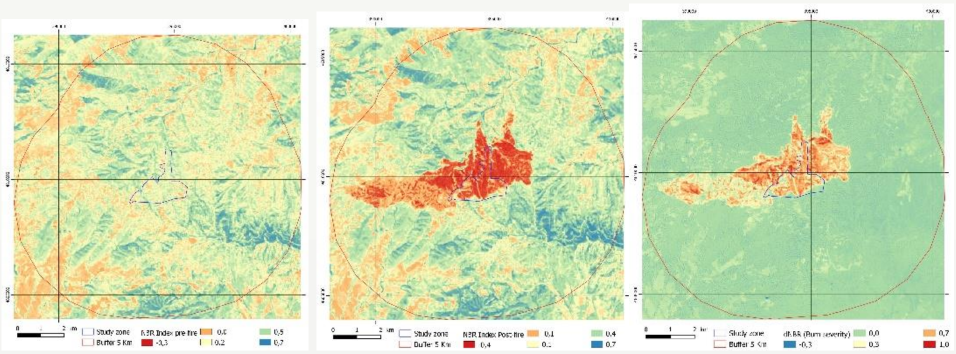




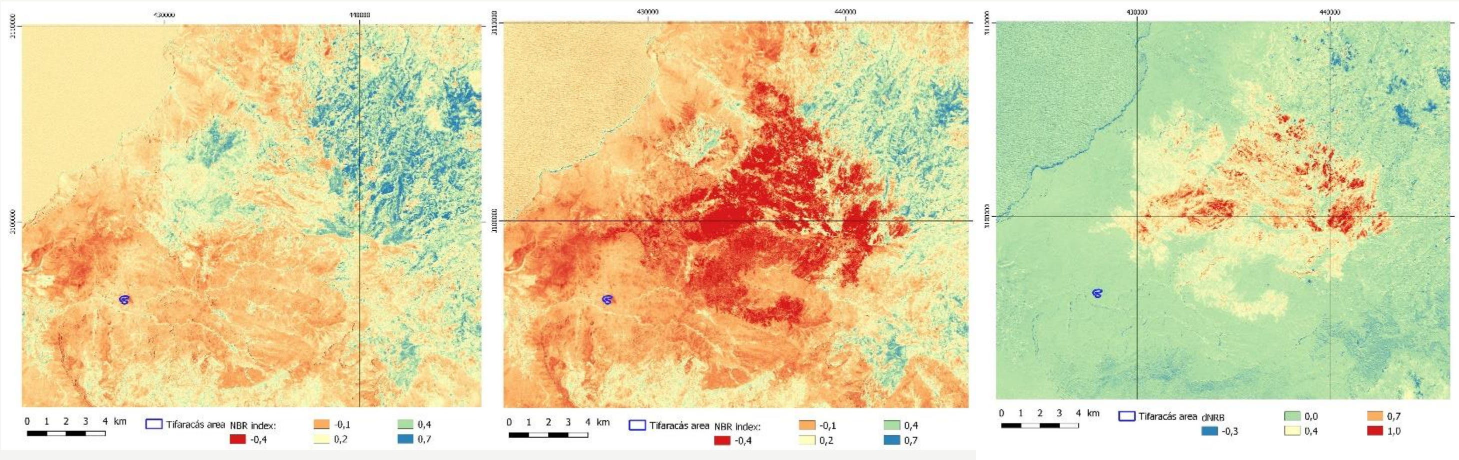


BURNED AREAS INDEX

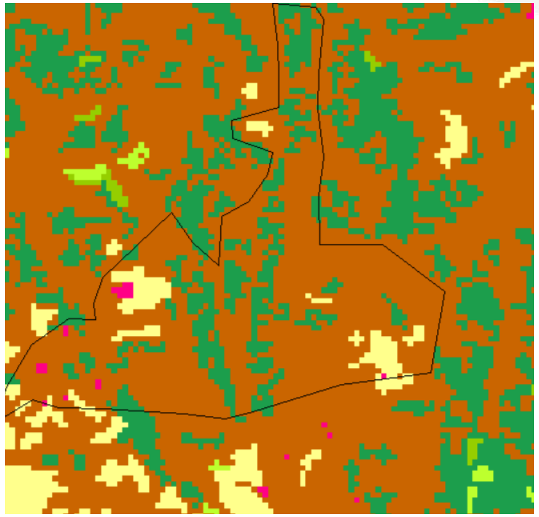
EL BRUC



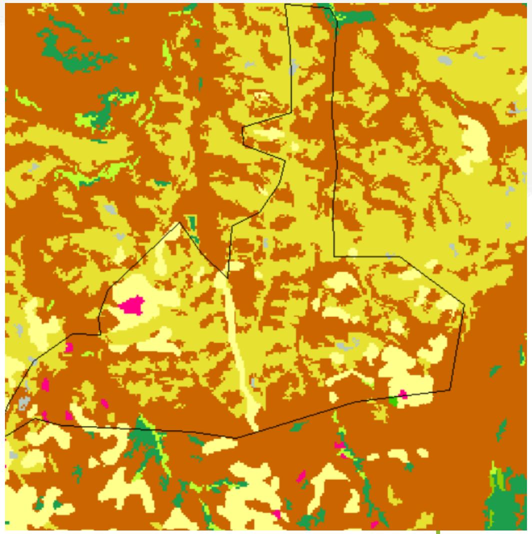
TIFARACÁS



LAND COVER MAP



2012 30 m Landsat



2017 10 m Sentinel-2

NBS effectiveness

Indicators identified will be useful for the monitoring of the effectiveness of NBS recovery :

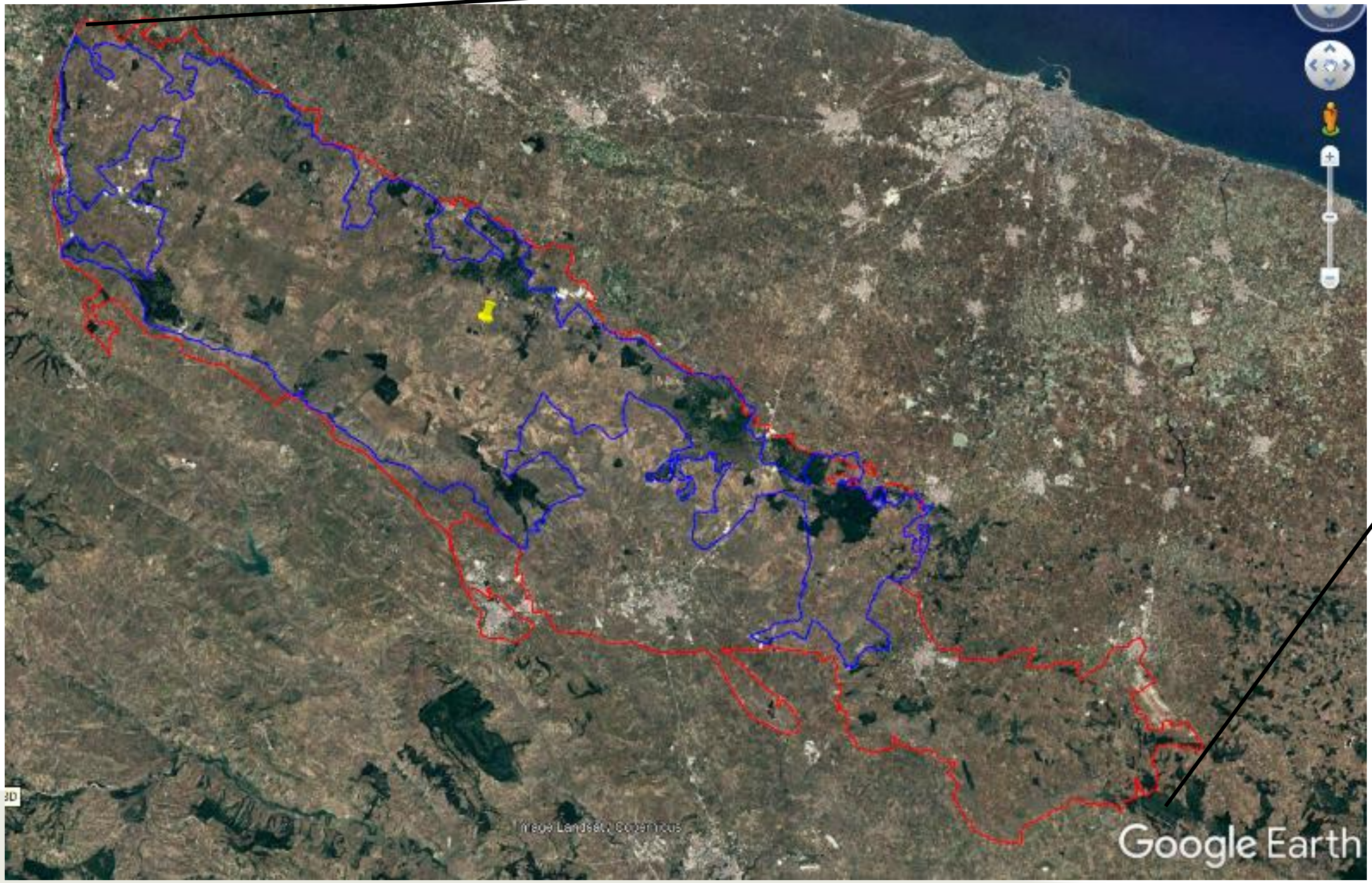
1) In the medium/long term for those actions already applied in the framework of previous LIFE project

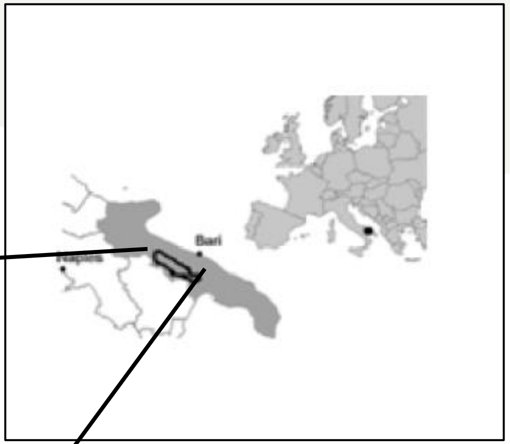
2) In the short term for those actions will be applied during NewLife4Drylands

-> **Alta Murgia**

ALTA MURGIA….ON SITE

ALTA MURGIA….FROM SPACE





Strong interaction with:

- local decision makers: National Park
- Socio-economic actors: network of "park-friendly" farms available to collaborate with good practises

«Alta Murgia» Protected Area

National Park from 2004

Typical Mediterranean agro-pastoral landscape with millennial land-use history mainly occupied by semi-natural rocky dry grasslands, traditionally used as extensive pastures, while forest vegetation consists only of residual patches of downy oak (Quercus pubescens s.l.) woodlands and Aleppo pine (Pinus halepensis) plantations.

MURGIA ALTA SITE OF COMMUNITY IMPORTANCE (SCI) MURGIA ALTA IT9120007

Protected area: 126,000 ha

National Park: 68,192 ha

PICTURES FROM ALTA MURGIA

PICTURES FROM
ALTA MURGIA

NewLife4Drylands
LIFE20 PRE/IT/000007

SEMI-NATURAL GRASSLANDS IN ALTA MURGIA

Semi-natural grasslands of the Western Palaearctic region are considered among the most species-rich habitats in the world (Dengler et al. 2012),

This is a site for: Falco Biarmicus Feldeggi and Falco Naumanii (Bird Directive)

62A0 Eastern sub.Mediterranean dry grasslands (Scorzoneratalia villosae)

6210* Semi-natural dry grasslands on calcareous substrates (Festuco-Brometalia), orchid site

6220* Pseudo-steppe with grasses and annual of Thero-Brachypodietea

9250 Quercus Troiana;

8210 Calcareus rocky slope with chasmophytic vegetation

PRESSURES ON SEMI-NATURAL GRASSLANDS IN ALTA MURGIA

Today, many of these semi-natural grassland ecosystems of high conservation value are threatened by dramatic land use changes inducing processes of habitat fragmentation and contamination both within and at its borders by a number of combined pressures :

- ✓the Common Agricultural Policy (CAP) drove transformation of grassland pastures into agricultural (cereal crops) areas by stone graining,or harrowing which also induced soil erosion and sediment deposition in aquifer, contamination;
- ✓ illegal waste and toxic mud dumping on transformed areas causing heavy metal contamination of soils and aquifer system;
- ✓increasing of traditional legal and illegal mining activities; wind farms infrastructures.
- ✓below-average precipitation and fires due to illegal activities. The extension of burnt surfaces has dramatically increased in the last three years (2017-2020);
- ✓*15 Jan. 2021: Suitable site for Single national **nuclear** waste deposit!!!!!*

NBS RESTORATION EXPERIMENT IN ALTA MURGIA

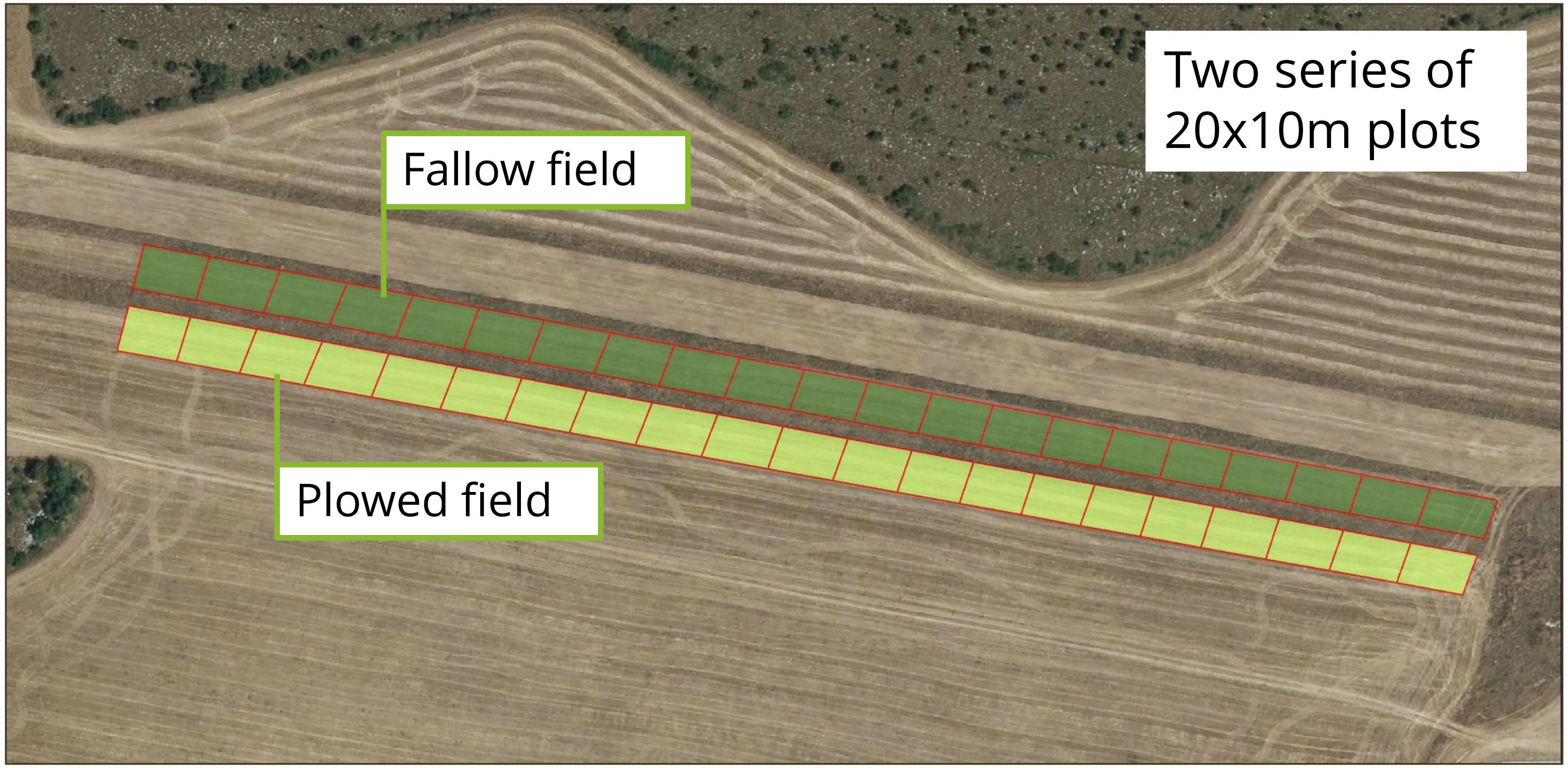
- Previous experiments on grasslands but not in the Mediterranean

(LIFE18 NAT/IT/000803 LIFE DRYLANDS or LIFE10 NAT/IT/000243 LIFE MAGREDI GRASSLANDS)

- Little experience and references were found on the restoration of *xeric semi-natural grasslands* in Mediterranean environment. This is especially truth for the **sub-Mediterranean *xeric grassland*** in Alta Murgia, subject to stonecutting and rock graining

- Indirect restoration techniques will be tested (limited budget available), through the setting up of several experimental and control plots

GRASSLAND RESTORATION



Assessing constraints:

- Small surface
- Short time
- Handwork management

GRASSLAND RESTORATION

Planning protocols:

Fallow field

Combinations of:

- Sod cutting or turf stripping
- Seed sowing
- Hay transfer + jute net
- Chamaephyte sowing

Plowed field

Combinations of:

- Topsoil inversion + soil pressing
- Seed sowing
- Hay transfer + jute net

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PAPERS PUBLISHED

remote sensing

MDPI

Article

Sentinel-2 remote sensed image classification with patchwise trained ConvNets for grassland habitat discrimination

Paolo Fazzini[1], Giuseppina De Felice Proia[2], Maria Adamo[3,*], Palma Blonda[3], Francesco Petracchini[1], Luigi Forte[4] and Cristina Tarantino [3]

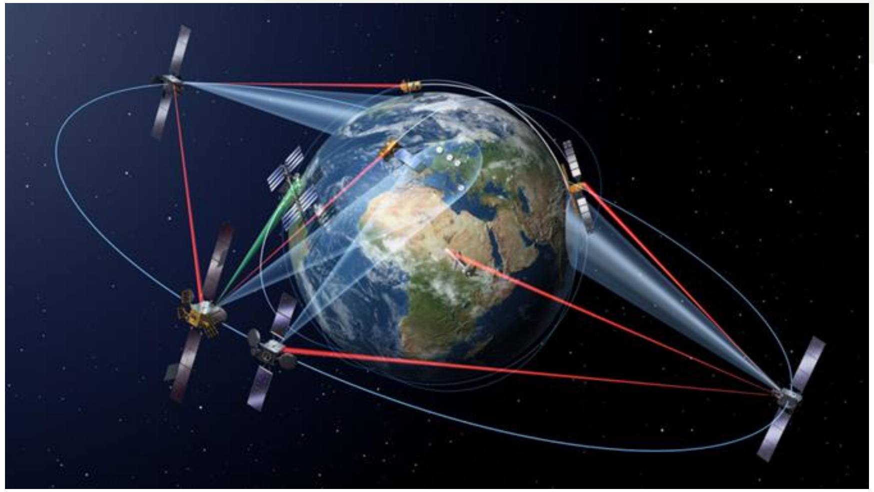
remote sensing

MDPI

Article

Time Series of Land Cover Mappings Can Allow the Evaluation of Grassland Protection Actions Estimated by Sustainable Development Goal 15.1.2 Indicator: The Case of Murgia Alta Protected Area

Cristina Tarantino, Mariella Aquilino *, Rocco Labadessa and Maria Adamo



THANKS FOR YOUR ATTENTION