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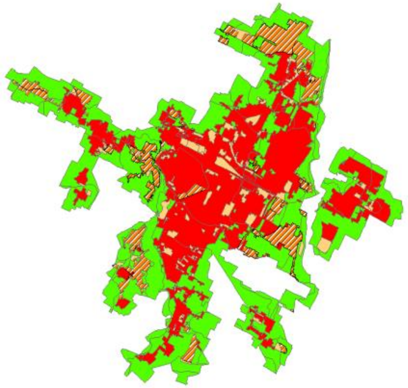
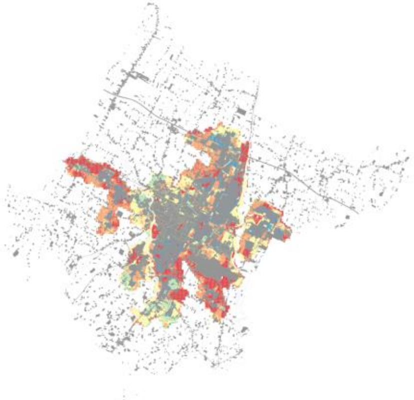

Ecosystem services of urban soils

Fabrizio Ungaro CNR-IBE

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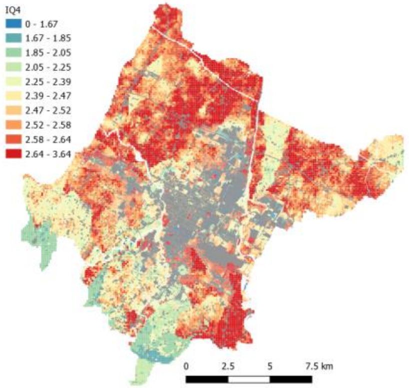


Regione Emilia-Romagna

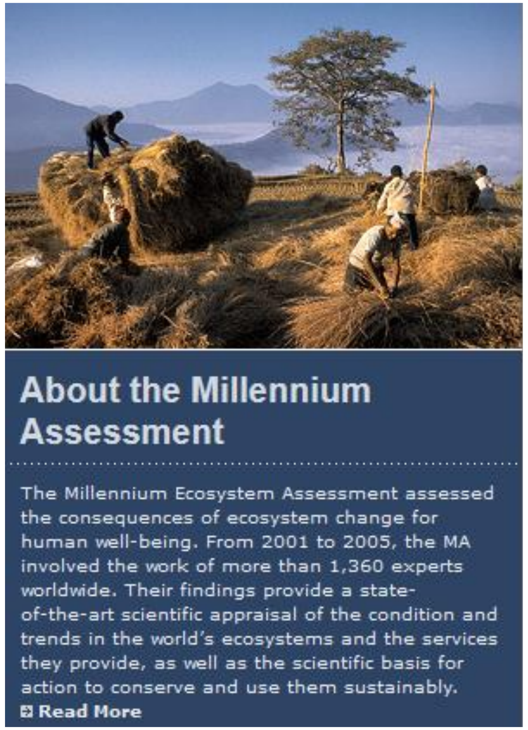
Consiglio Nazionale delle Ricerche
Istituto per la BioEconomia

Comune di Forlì

Ecosystem services of urban soils

The Millennium Ecosystem Assessment (MEA, 2005) provided the first general framework for describing ecosystem services, defined as “***the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly***” (De Groot et al., 2002), or “***benefits people obtain from ecosystems***” (MEA, 2005).

Ecosystem provides a wide range of goods and services to the benefits of human-kind (Costanza et al., 1997; MEA, 2005). There is now broad agreement how these services are to be grouped and classified.



https://www.millenniumassessment.org/en/index.html

Various definitions

“*...the benefits people obtain from ecosystems*” (MA, 2005: 27)

“*...components of nature, directly enjoyed, consumed, or used to yield human wellbeing*” (Boyd and Banzhaf, 2007: 619)

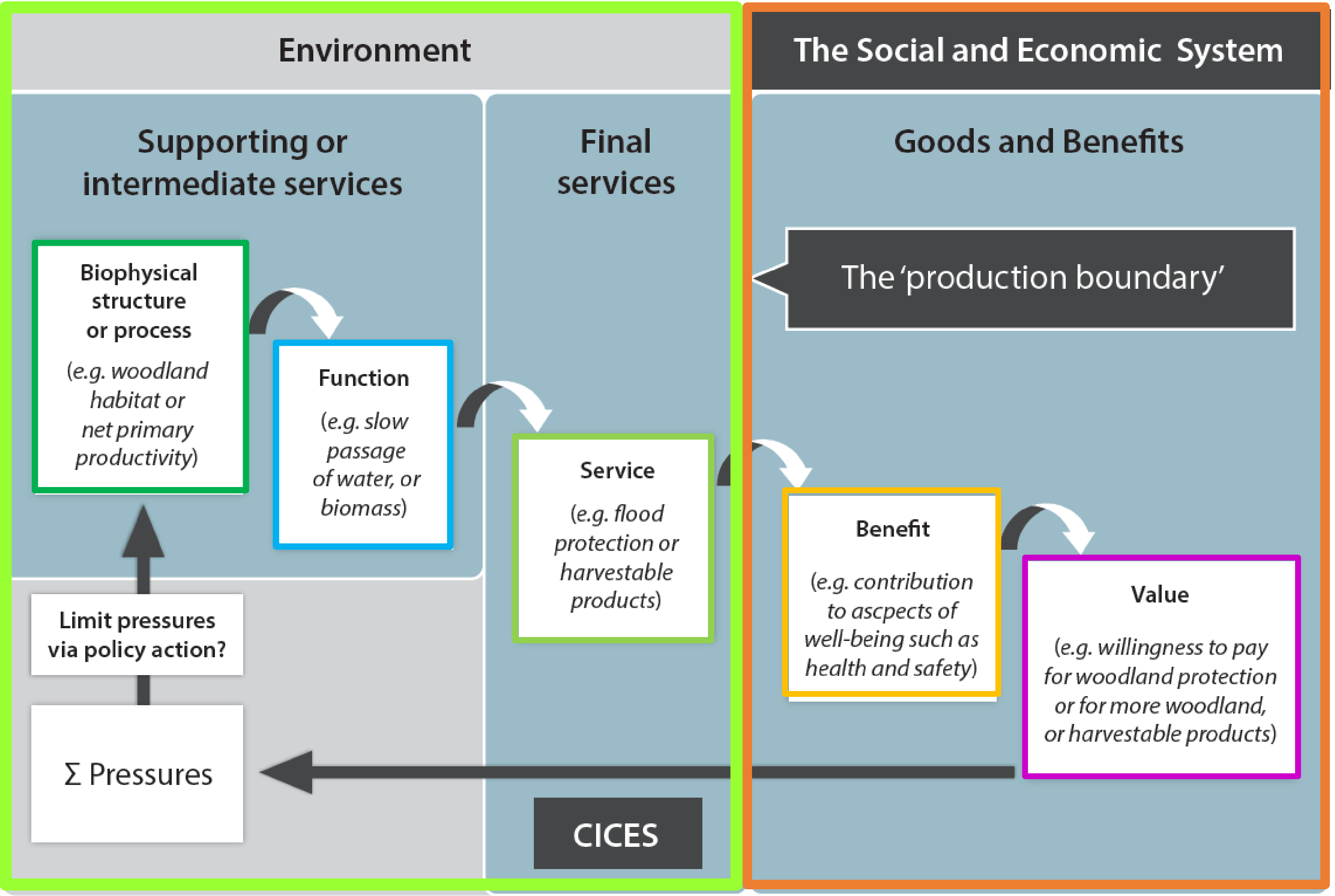
“*...the aspects of ecosystems utilized (actively or passively) to produce* ***human wellbeing***” (Fisher et al., 2009: 645)

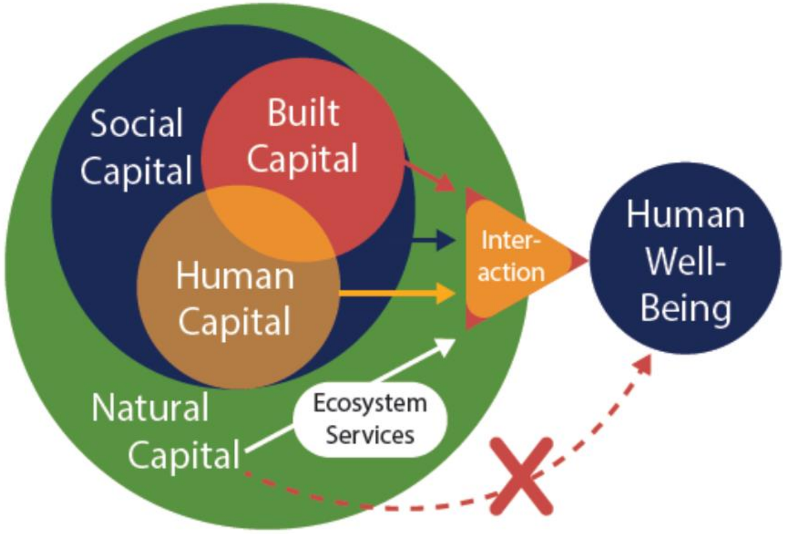
Various classifications

- Pre-MA*: (Daily, 1997; Costanza et al., 1997; de Groot et al., 2002)
- MA*: (MEA, 2005)
- Post-MA*: (Boyd and Banzhaf, 2007; Wallace, 2007; Fisher et al., 2009)

Ecosystem services of urban soils

The cascade model. Credit: Haines-Young and Potschin.





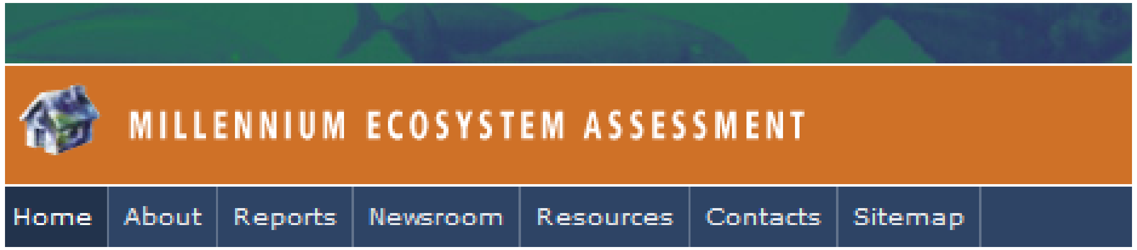
All definitions stress the link between (natural) ecosystems and human wellbeing, and the services are the 'bridge' between the human world and the natural world, with only humans being virtually separated from that natural world

Haines-Young, R., & Potschin, M. (2010). The links between biodiversity, ecosystem services and human well-being. *Ecosystem Ecology: a new synthesis*, 110-139.

Ecosystem services of urban soils

The **2005 Millennium Ecosystem Assessment** grouped ecosystem services into **four categories**:

- **Provisioning services**: direct or indirect food for humans, freshwater, wood, fiber, and fuel;
- **Regulating services**: regulation of gas and water, climate, floods, erosion, biological processes such as pollination and diseases;
- **Supporting services**: nutrient cycling, production, habitat, biodiversity;
- **Cultural services**: aesthetic, spiritual, educational and recreational.



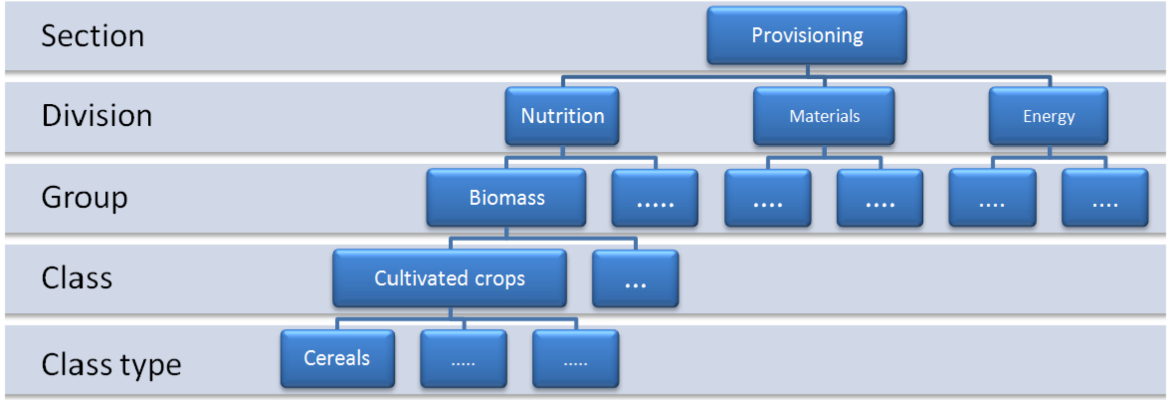
http://www.millenniumassessment.org/en/index.html

Guide to the Millennium Assessment Reports

Ecosystem services of urban soils

The CICES (Common International Classification of Ecosystem Services) classification recognizes **provisioning**, **regulating** and **cultural services**, but it does not cover the so-called supporting services originally defined in the MA.

The supporting services are treated as part of **the underlying structures, process and functions that characterize ecosystems**. Since they are only indirectly consumed or used and may simultaneously facilitate the output of many 'final outputs', it was considered that they were best dealt with in environmental accounts, in other ways.

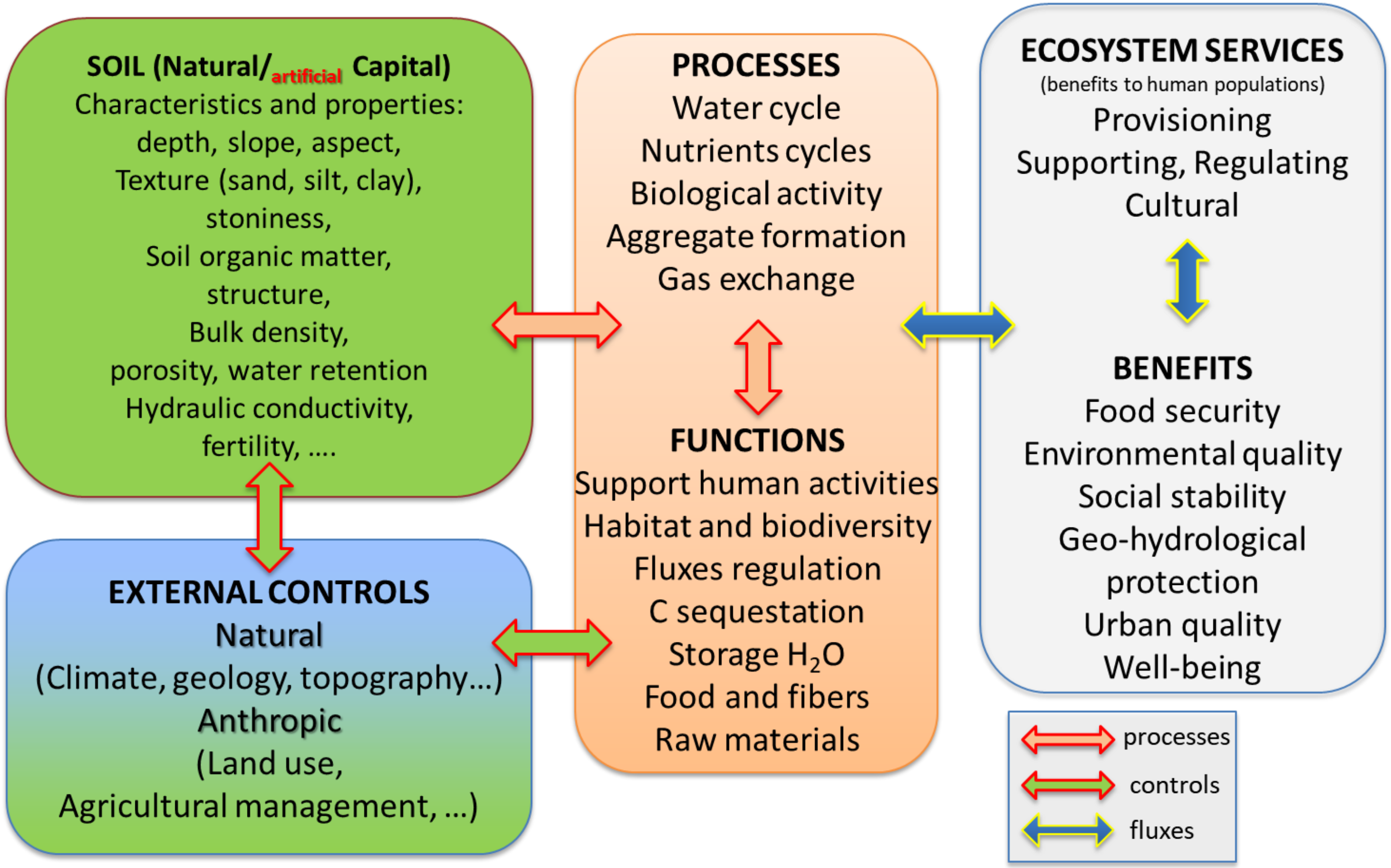


Section	Division	Group
Provisioning	Nutrition	Biomass
		Water
	Materials	Biomass, fibre
		Water
	Energy	Biomass-based energy sources
		Mechanical energy
Regulation &	Mediation of waste, toxics and other nuisances	Mediation by biota
		Mediation by ecosystems
	Mediation of flows	Mass flows
		Liquid flows
		Gaseous / air flows
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection
		Pest and disease control
		Soil formation and composition
		Water conditions
		Atmospheric composition and climate regulation
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions
		Intellectual and representative interactions
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic
		Other cultural outputs

http://www.cices.eu

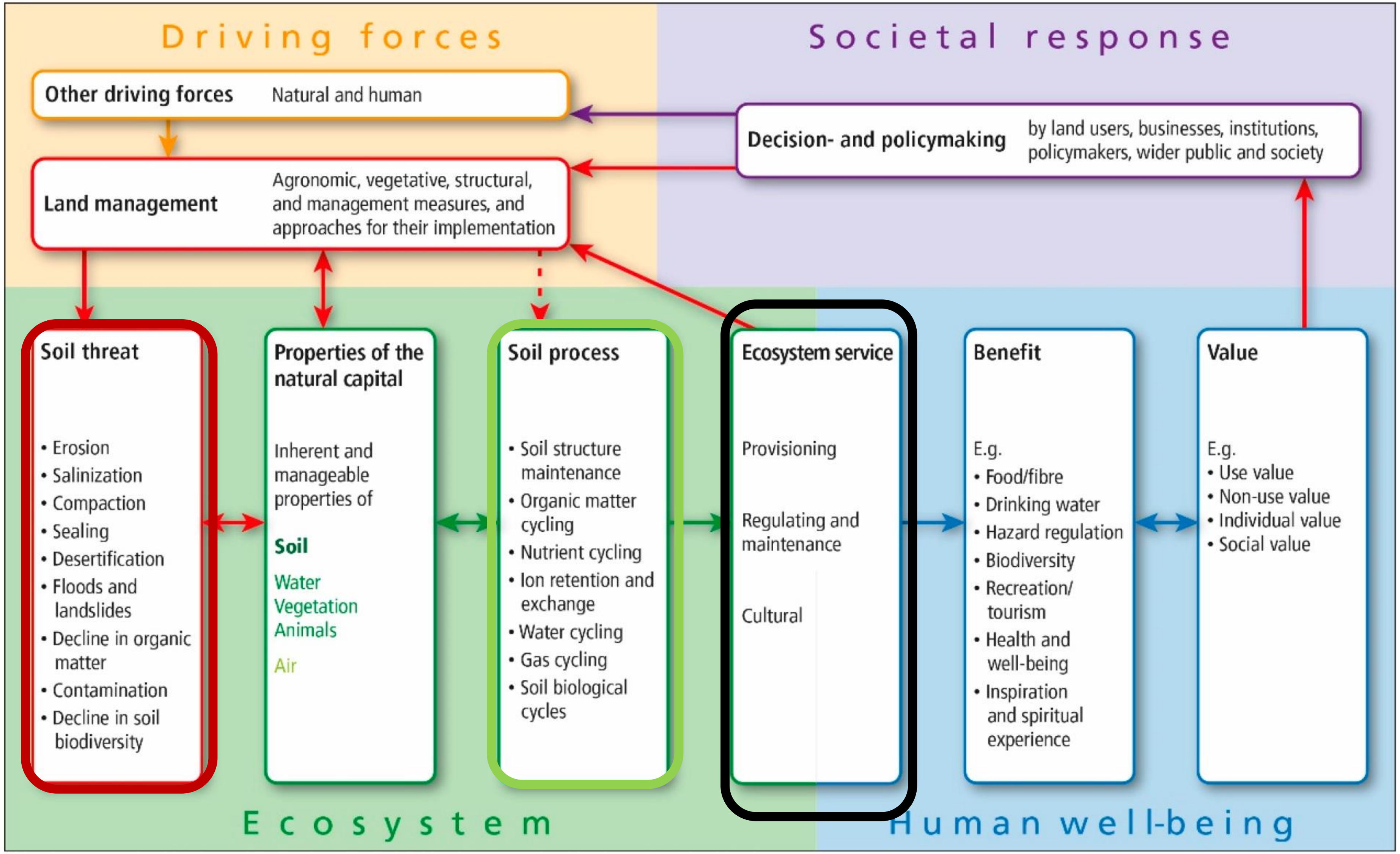
Ecosystem services of urban soils

- ❑ Ecosystem services (ESs) are the benefits people obtain from ecosystems (MEA, 2005)
- ❑ ESs research is currently focusing more and more on (agricultural) soils but few studies have focussed on the **linkages between soil properties and ES provision** and the use of soil data has been often minimal (Adhikari & Hartemink, 2016)
- ❑ Soil is still an **overlooked component in ESs** studies as well as in policy level decisions (Hewit et al., 2015) despite the centrality of its role in ESs supply (Greiner et al., 2017)



- ❑ Few evaluation schemes tailored on soils are available which consider **soil characteristics explicitly** (Adhikari and Hartemink, 2016; Calzolari et al., 2016; Hewitt et al., 2015; Greiner et al., 2018; Vogel et al., 2019).

Ecosystem services of urban soils



Ecosystem service framework for RECARE. Reprinted from Ecological Indicators, Vol. 67, Schwilch et al., Operationalizing ecosystem services for the mitigation of soil threats: A proposed framework, 586–597, 2016,

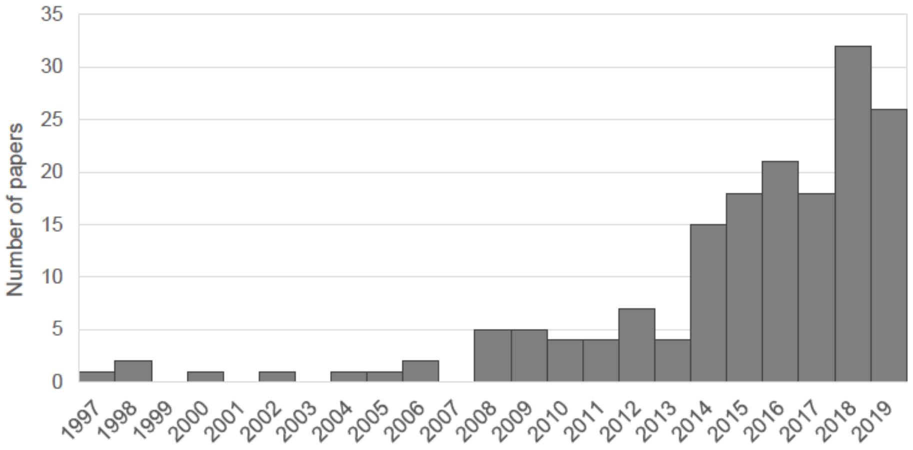
(Schwitch et al., 2018)

Ecosystem services of urban soils

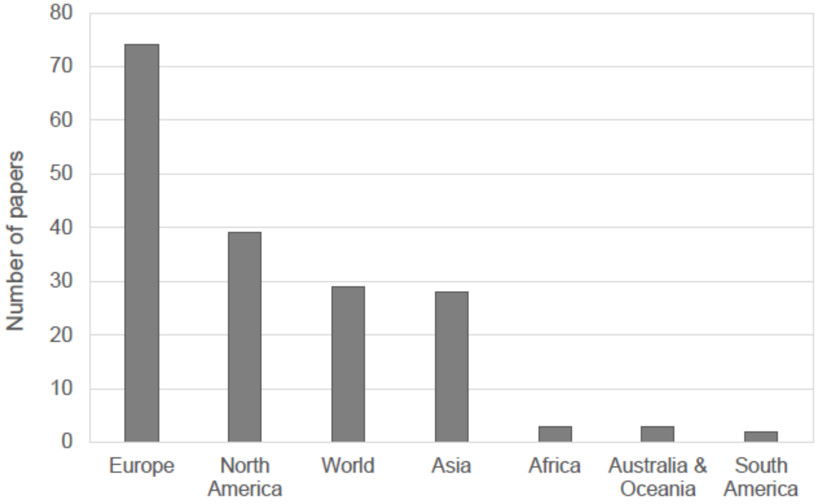
- The explicit assessment of soil-based ecosystem services and their mapping has recently gained more relevance, in order to increase awareness on the importance of soil functions and related services and to highlight their value to society (van der Meulen and Maring, 2018).

- This is mostly due to the recognition of their capacity to trap and stock greenhouse gases from the atmosphere, mitigating the effects of climate change (Ontl and Schulte, 2012; Singh, 2018).

- Nevertheless, as for ecosystem services in the urban environment, Haase et al. (2014) report that "there is a lack of both historic studies and future-oriented studies systematically analysing the dynamics of Urban Ecosystem Services", and in a recent meta-analysis of published literature on urban ecosystem services from six different research perspectives (i.e. ecology, governance, methods, economics, society, planning), not a single reference to soil based ecosystem services is mentioned (Luederitz et al., 2015).

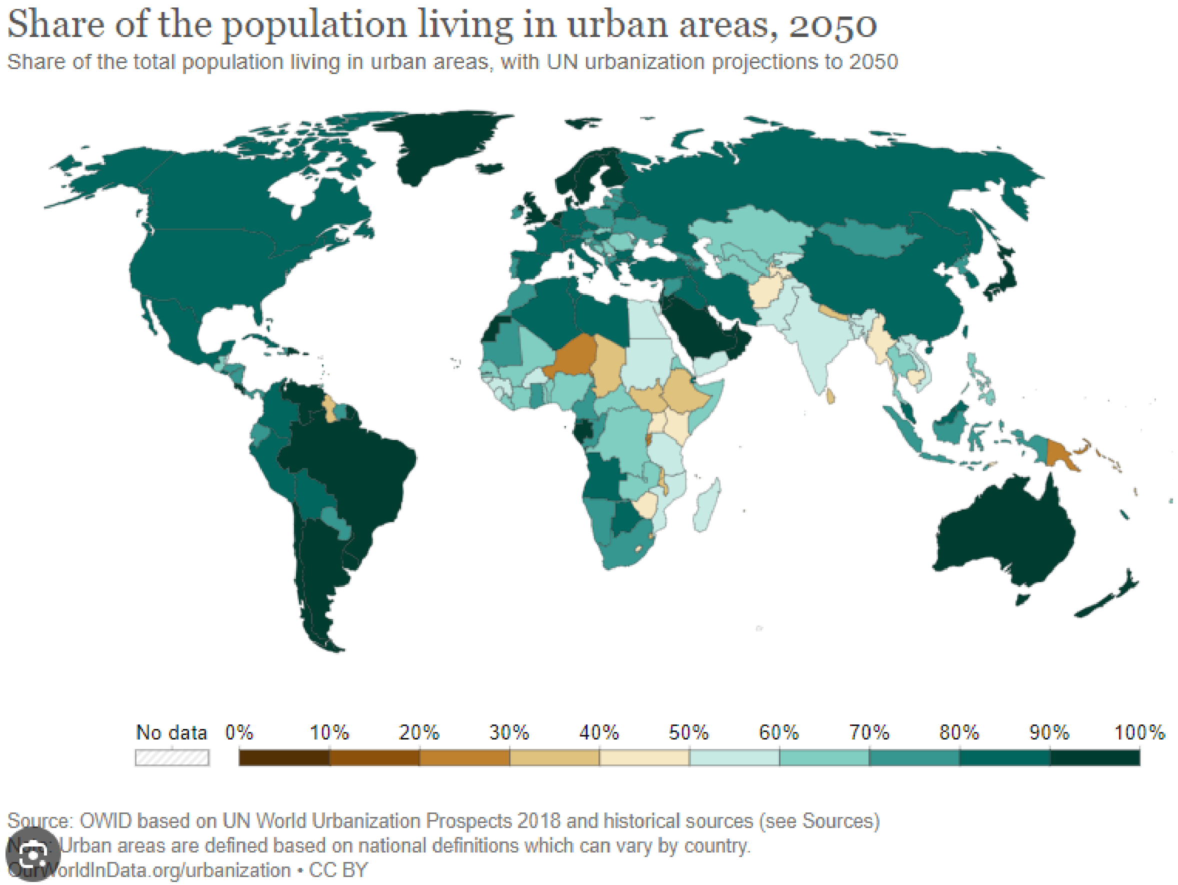


Number of papers published between 1997 and 2019 using the search string for urban soil and ecosystem services



https://doi.org/10.1016/j.geoderma.2021.115076

Ecosystem services of urban soils

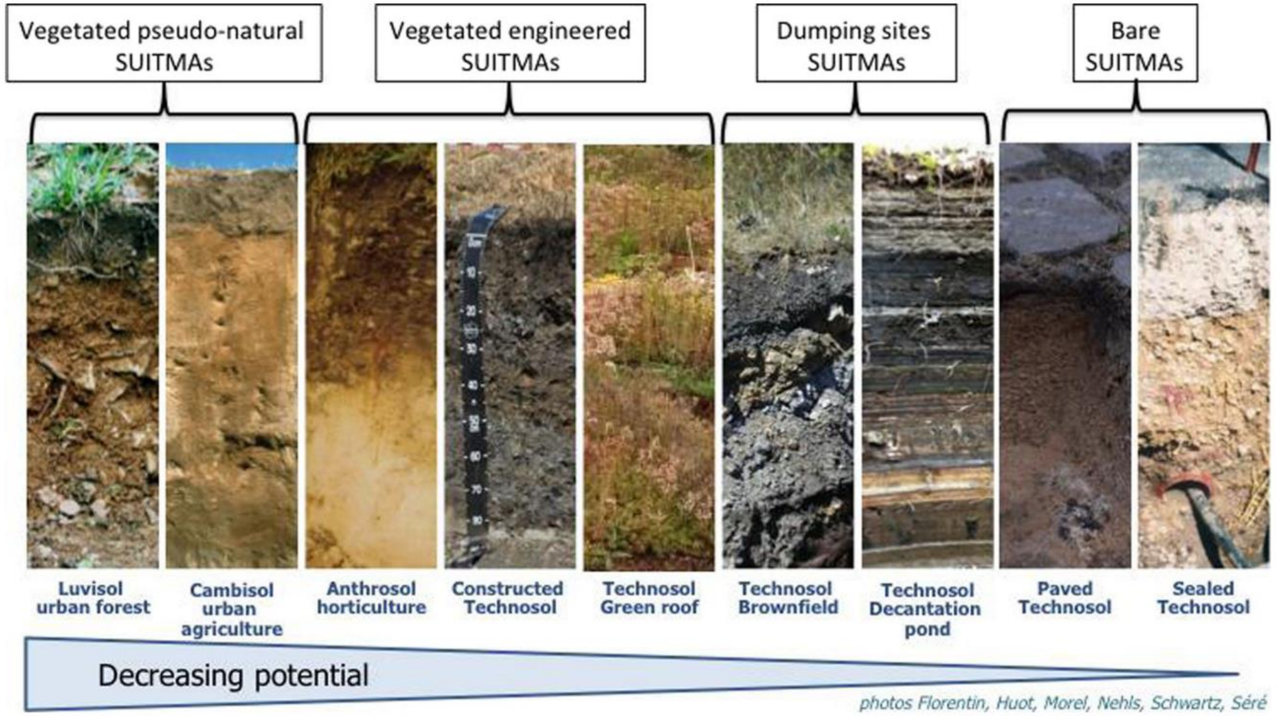


- The expansion of urban areas worldwide is increasing the anthropogenic impact upon soil and highlights the important role of urban areas in supporting a sustainable future.

- As such, urban soils are becoming more important in the delivery of a broad range of ecosystem services (ESs), including carbon storage and climate regulation, biomass provision for food and water flow regulation, and recreational benefits (O'Riordan et al., 2021).

- The contribution of urban soils to human well-being in terms of provision of ecosystem services is largely unknown and very rarely accounted for in urban planning to enhance the sustainable development of urban ecosystem (Morel et al., 2014) and although fundamental soil is considered a secondary compartment beyond vegetation.

Ecosystem services of urban soils

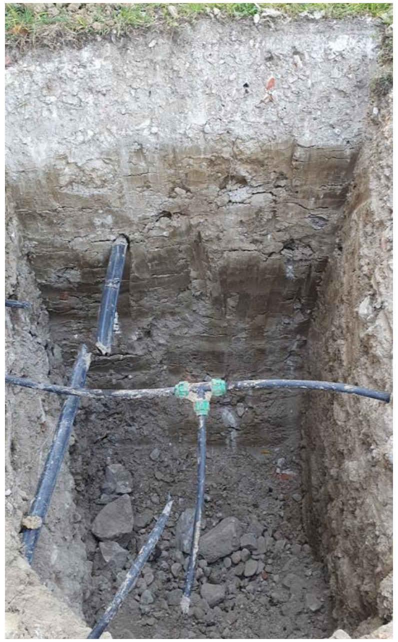


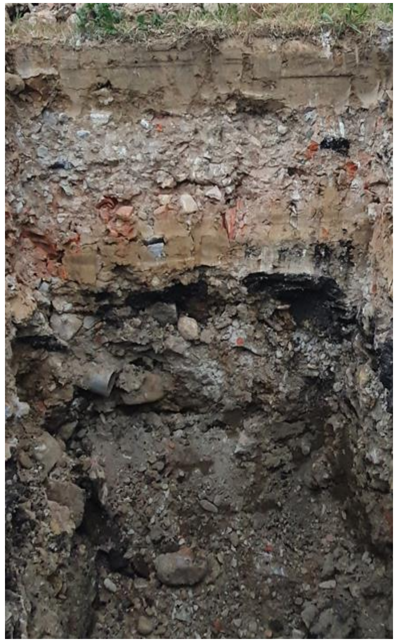
Urban soils are all soils located within urban areas. Urban soils are included within SUITMA (Soils of Urban, Industrial, Traffic, Mining and Military Areas), defined as soils strongly modified by human activities with drastic changes in composition and function, though in urban areas, they can include both highly-transformed soils and pseudo-natural soils (Morel et al., 2015).

- https://doi.org/10.1080/00380768.2015.1054982

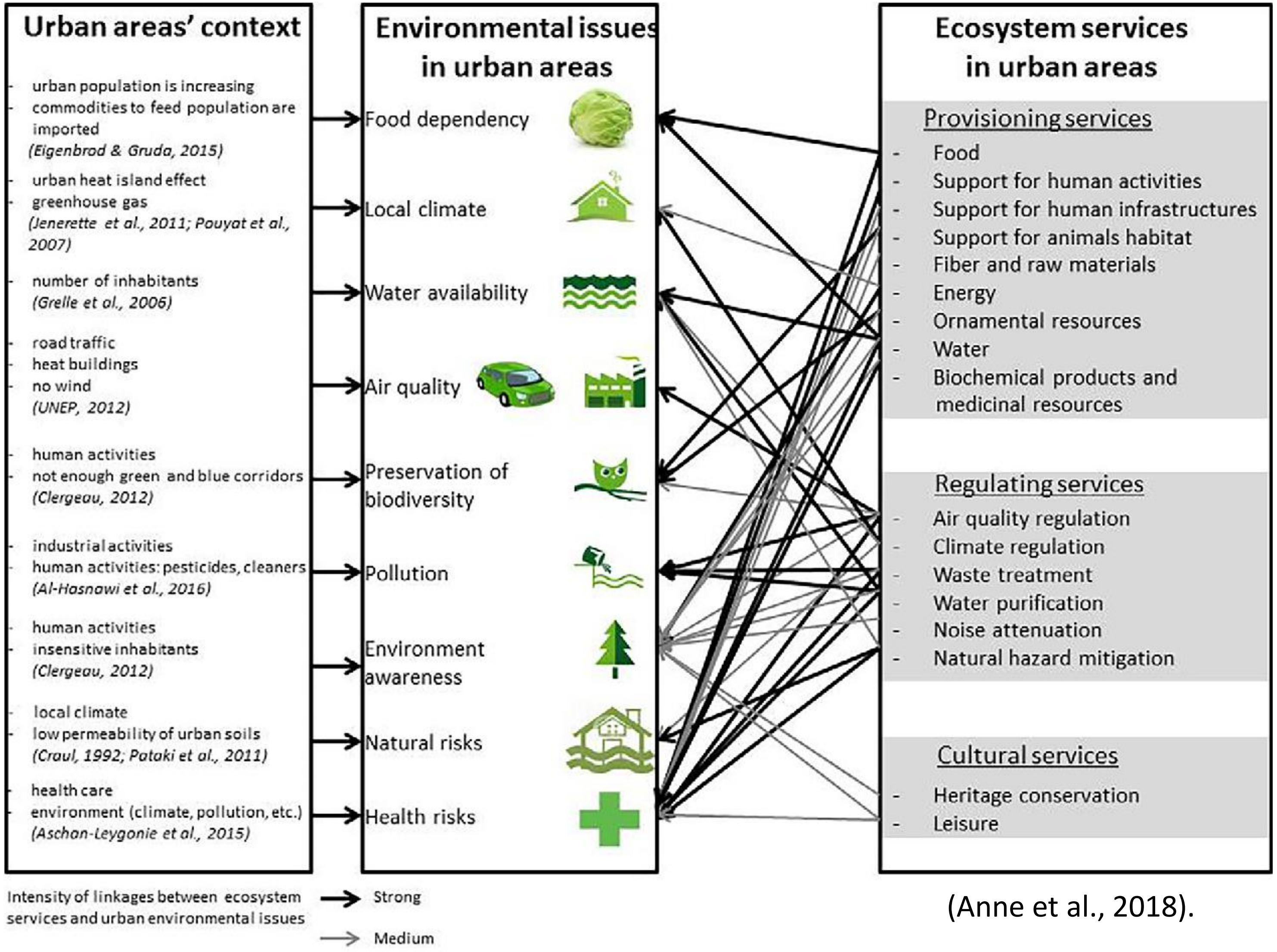
Urban soils are characterized by:

- ❑ An extreme vertical and horizontal variability
- ❑ A more or less pronounced degree of disturbance
- ❑ The presence of allochthonous (soil) material and/or human artifacts
- ❑ A variable amount of diverse contaminants
- ❑ A variable degree of surface sealing (0 to 100%)





Ecosystem services of urban soils

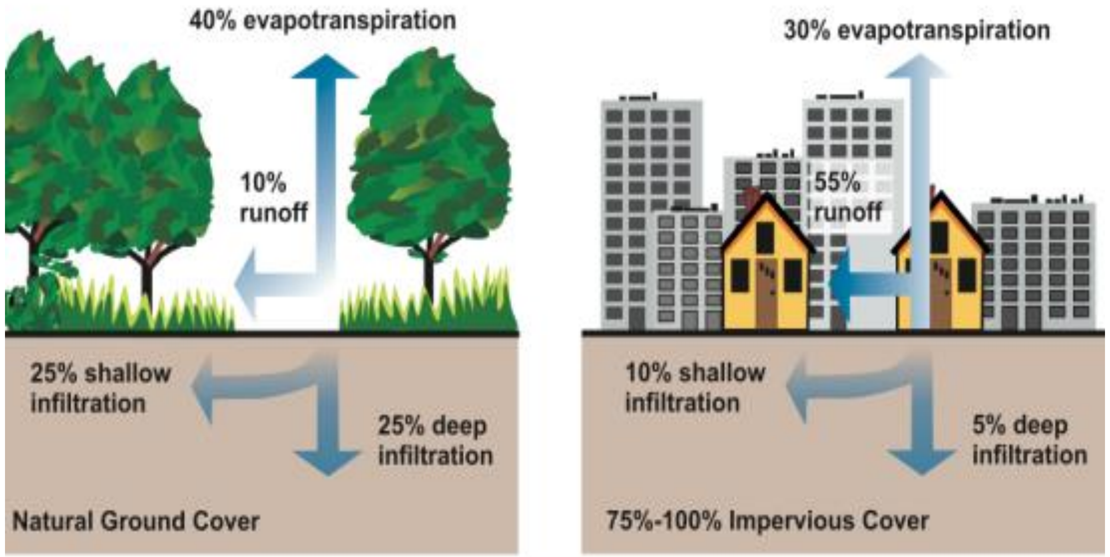


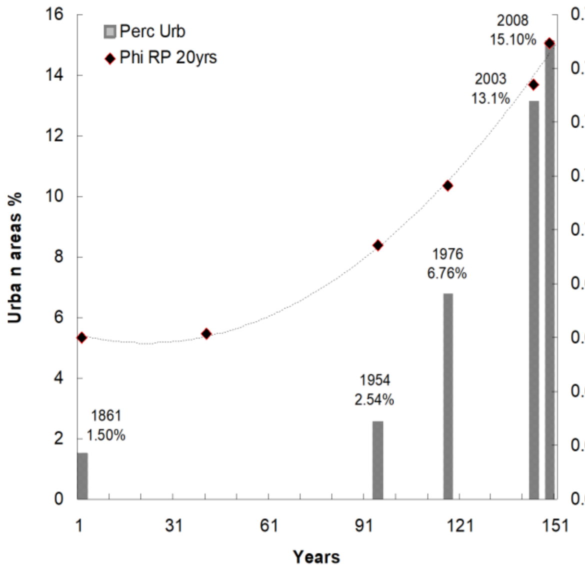
(Anne et al., 2018).

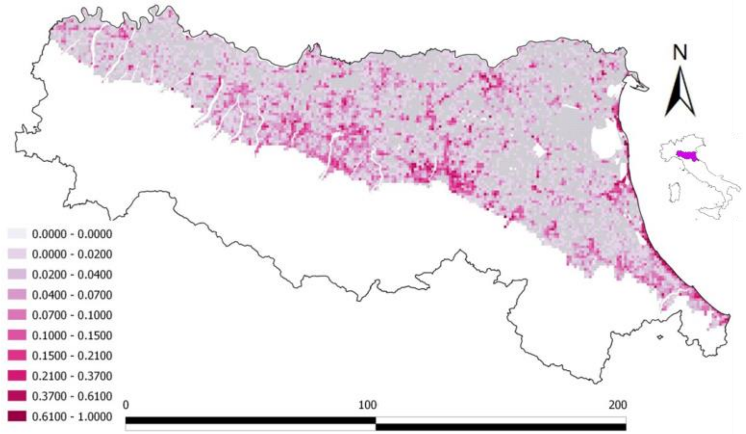
Links between ecosystem services provided by urban soils and major environmetal issues in urban areas

As with nonurban soils, urban soils provide ecosystem services. Because of the close proximity of urban soils with dense human populations, the importance of ecosystem services is especially magnified for (managed) **regulating services** and (managed) cultural services

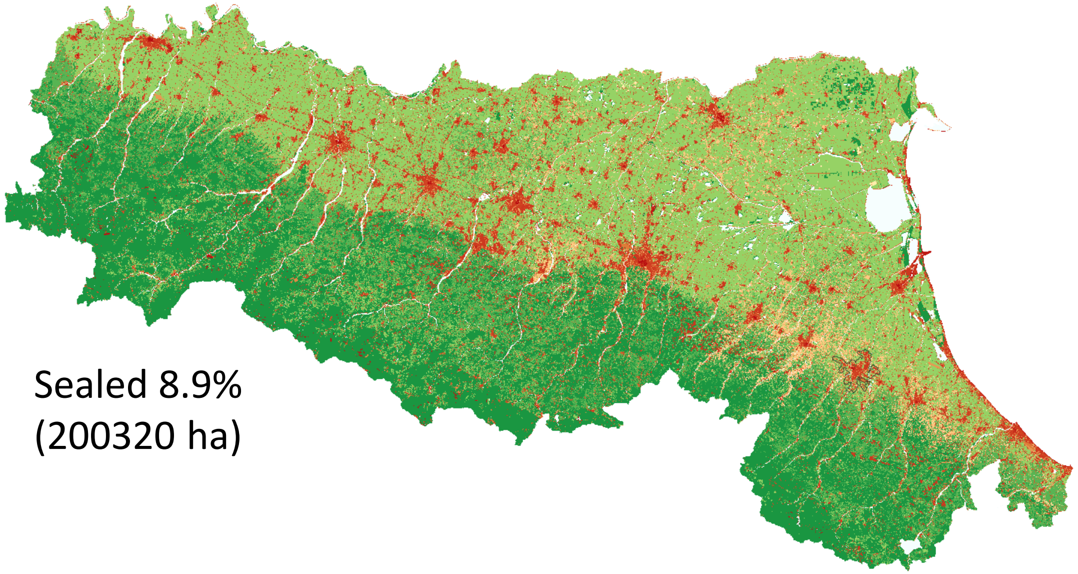
Ecosystem services of urban soils



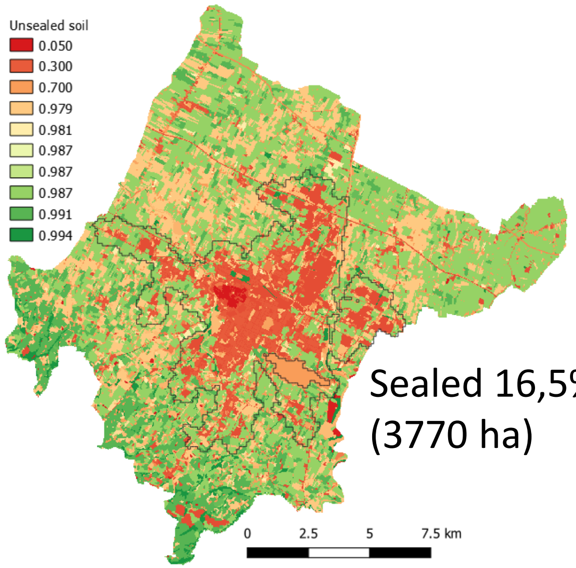




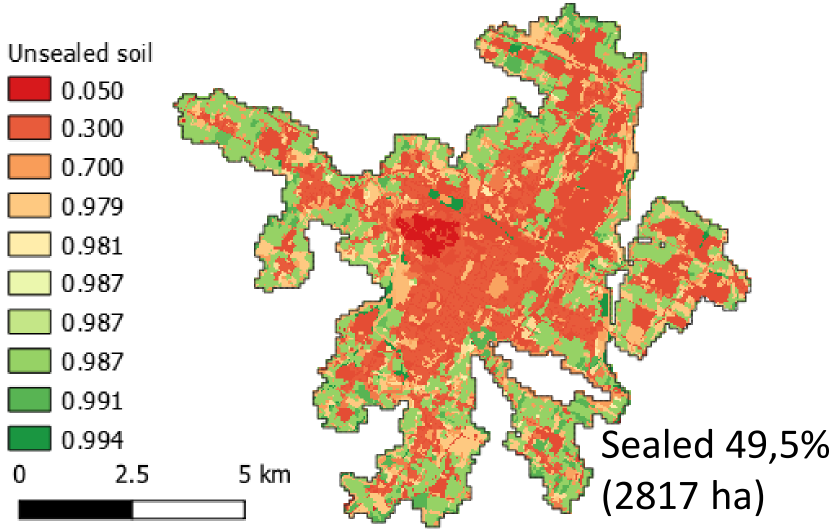
doi: 10.2478/johh-2014-0005



Sealed 8.9%
(200320 ha)

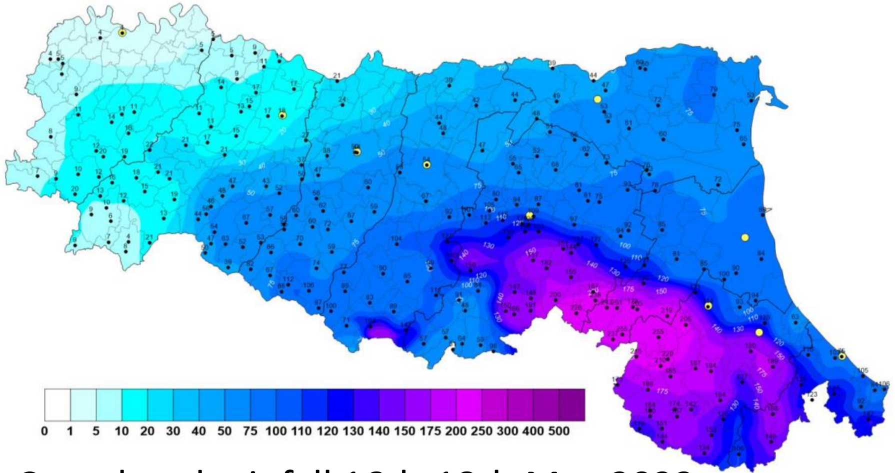


Sealed 16,5%
(3770 ha)

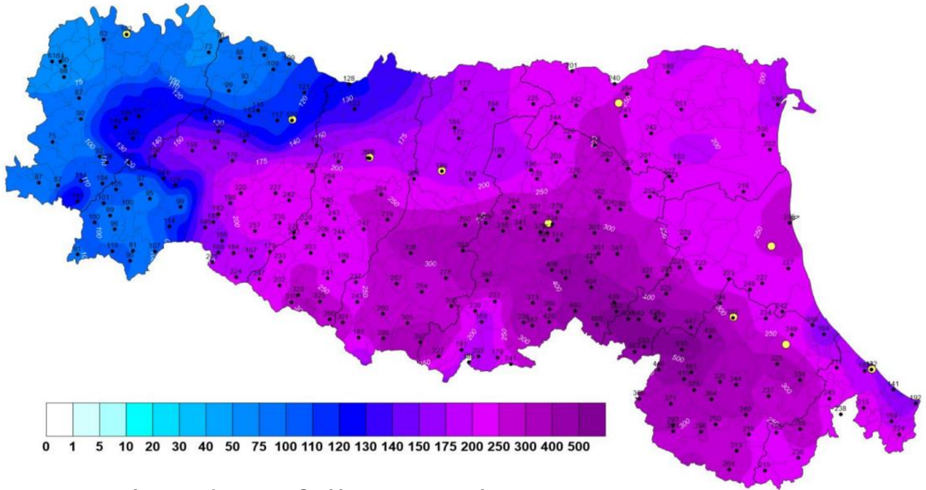


Sealed 49,5%
(2817 ha)

Ecosystem services of urban soils



Cumulated rainfall 16th-18th May 2023



Cumulated rainfall 1st-18th May 2023

https://allertameteo.regione.emilia-romagna.it/aggiornamenti/-/asset_publisher/Nb5jHes0zyRl/blog/id/2302643

Ecosystem services of urban soils

SOS4LIFE
SAVE OUR SOIL FOR LIFE

Guidelines for assessing soil ecosystem services in urban environment

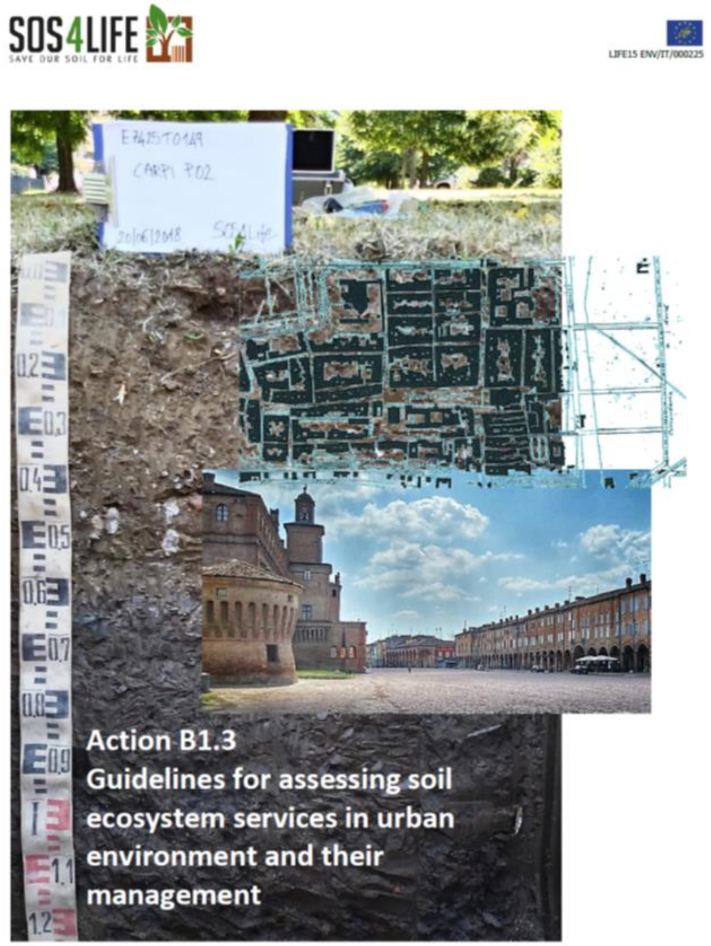
Prior knowledge of soils, of their properties and distribution in space is required to assess and eventually map their ecosystem services. Depending on the goal of the investigation and on resources availability, the necessary soil data can result from *ad hoc* urban soil surveys or from existing soil databases and maps.

Three approaches are possible depending on resources and data availability

1. Ad hoc soil survey: sampling -> analyses -> mapping -> ESs assessment
2. Use existing soil data base and maps (vector format): benchmark soil profiles and analytical data -> ESs assessment
3. Use existing soil properties/functions maps (raster format) -> ESs assessment

<u>In all cases soil data are at the base of the assessment and these are used to build **indicators** of ecosystem service potential provision</u>.

Furthermore, the approach must be coherent with the scale of investigation and implementation.



https://www.sos4life.it/en/documents/

Ecosystem services of urban soils

Various authors tried to identify **biotic and abiotic characteristics** that are correlated, or at least are thought to be correlated, with soil functions and services of interest. These characteristics are generally referred to via several terms, like "*indicator variables*", "*indicators*", "*metrics*", or "*proxies*“.

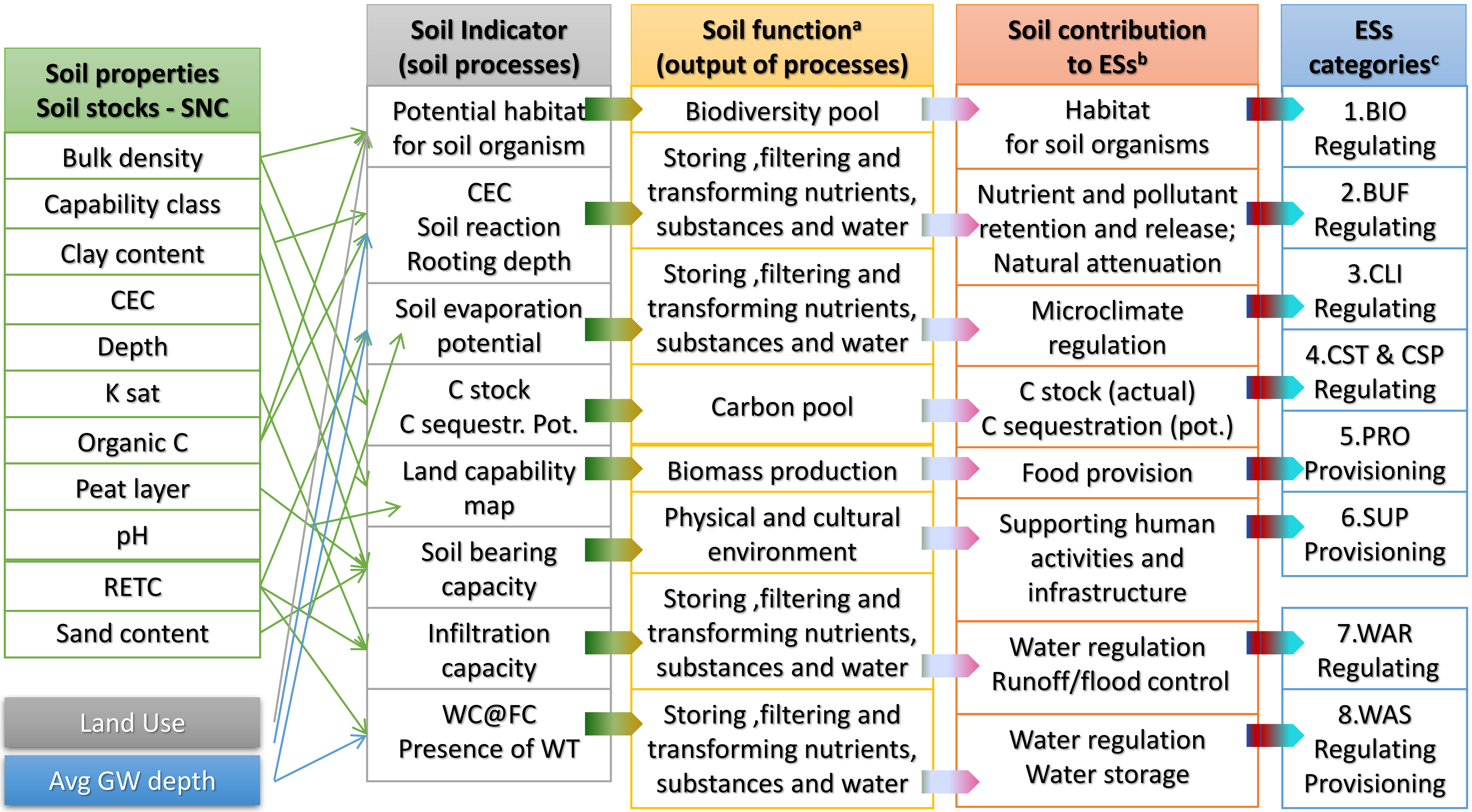
In principle, indicators should satisfy a number of criteria, such as being **easily quantified** and **responding to change in a predictable manner**. Indicators that meet these conditions are believed to afford reliable information with which one can assess how soil functions and services are likely to vary in space and time.

In many case the use of indicators represent the only viable option. Their **robustness** depend on a number of factors: the **data** (properties) used to build the indicators, the **functional link** between properties and processes, and the **relevance** of a (set of) process(es) in describing a (set of) function(s). **Soil indicators must rely on soil data** (despite the huge amount of published literature in which this is just not the case!)

Expert knowledge and **dialogue with stakeholders** must assist this stepwise procedure

Real **data availability**, **objects**, **goals** and **scale** of implementation of the ES framework are again key issues along with the kind of functions/services considered .

Ecosystem services of urban soils



Goal of this framework is estimating the potential contribution of soils to the potential supply of ESs and to compare the potentiality of different soils to support land and urban planning and assess the impact of urban sprawl on soil ESs supply.

Ecosystem services of urban soils

Ecosystem Services[a]	Code CICES 5.1 [b]	Soil contribution to ES[c]	Soil functions[d]	Indicators	Input data	Code
Regulating	2.2.1.1 2.3.3.2	Ritenzione e rilascio dei nutrienti e degli inquinanti Capacità depurativa (potenziale)	Riserva, filtraggio e trasformazione delle sostanze nutritive e dell'acqua	CEC Soil pH	C org % Clay % pH Skel %	BUF
Regulating	2.1.1.2 2.3.3.2	Carbon stock (potential)	Carbon pool	Actual C sequestration	C org % Bulk density	CST
Regulating	2.2.1.1 2.2.1.3	Riduzione delle perdite di suolo per erosione idrica	Support to vegetation	Actual erosion	RUSLE factors C, K, LS, R	ERSPRO
Provisioning	1.1.1.1	Food provision (potential)	Biomass production (food)	Soil cability map	LCC e integrades	PRO
Provisioning	1.1.1.x 1.1.5.x	Biomass provision (potential)	Biomass production	NDVI, mean 2015-2020	NDVI (Landsat 8)	BIOMASS
Regulating	2.2.1.3	Water regulation/runoff and flood control (potential)	Riserva, filtraggio e trasformazione delle sostanze nutritive e dell'acqua	Infiltration capacity	Ksat (mm/h) Psi_e (cm)	WAR
Regulating (Provisioning)	2.2.1.3 (4.2.2.2)	Water regulation – water storage (potential)	Riserva, filtraggio e trasformazione delle sostanze nutritive e dell'acqua	Water content at field capacity	Field capacity (-33 kPa)	WAS
Regulating	2.2.2.3	Habitat for soil organisms	Biodiversity pool	Habitat (potential) for soil organisms	QBS-ar Covariates DSM	BIO

Ecosystem services of urban soils

SES	Input data	Indicators calculation
BUF	CEC (cmolc/kg) as function of OC (%) and clay (%) CEC = 6.332 +0.404 clay + 1.690 OC (R^2 = 0.75) pH Coarse fragments content, sk (%) Shallow water table depth, WT (cm)	$BUF_{0–1}$ = Log CSC (pH; sk)$_{0–1}$ With pH<6.5 reduction by 0.25 or 0.5 depending on CEC and by 0.25 for skel. >30% With shallow water table depth (WT) < 30 cm $BUF_{0–1}$ = Log CSC (pH; sk)$_{0–1}$*WT/30
CST	Organi carbon, OC (%) Bulk density, BD (Mg m^{-3})	$CST_{0\text{-}1}$ = log [OC * BD * (1-SK)]$_{0\text{-}1}$
ERSPRO	Potential soil erosion (Mg ha^{-1} y^{-1}) Actual soil erosion(Mg ha^{-1} y^{-1})	Standardization (0-1) Log10 (Potential erosion – actual erosion)
PRO	Capability class and intergrades	LCC class scaling (0-1)
BIOMASS	NDVI (Normaized Difference Vegetation Index)	Standardization (0-1) NDVI (mean of 2015-2020 median values)
WAR	Saturated hydraulic conductivity, Ksat (mmh^{-1}) Air entry potential PSIe (cm)	$WAR_{0–1} = logKsat_{0–1}–PSIe_{0–1}$
WAS	Field capactity (-33 kPa), WCFC (vol/vol) Average shallow water table depth, WT (cm) Sk, coarse fragments (Ø >2 mm, vol/vol)	$WAS_{0–1}$ = (WC_{FC} * 1–sk)$_{0–1}$ WT depth> 100 cm, and $WAS_{0–1}$ = (WC_{FC} * 1-sk)*WT/100 with WT depth <100 cm
BIO	QBS_{ar} Covariates for Digital Soil Mapping	DSM approach (Quantile Random Forest)

0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1.0

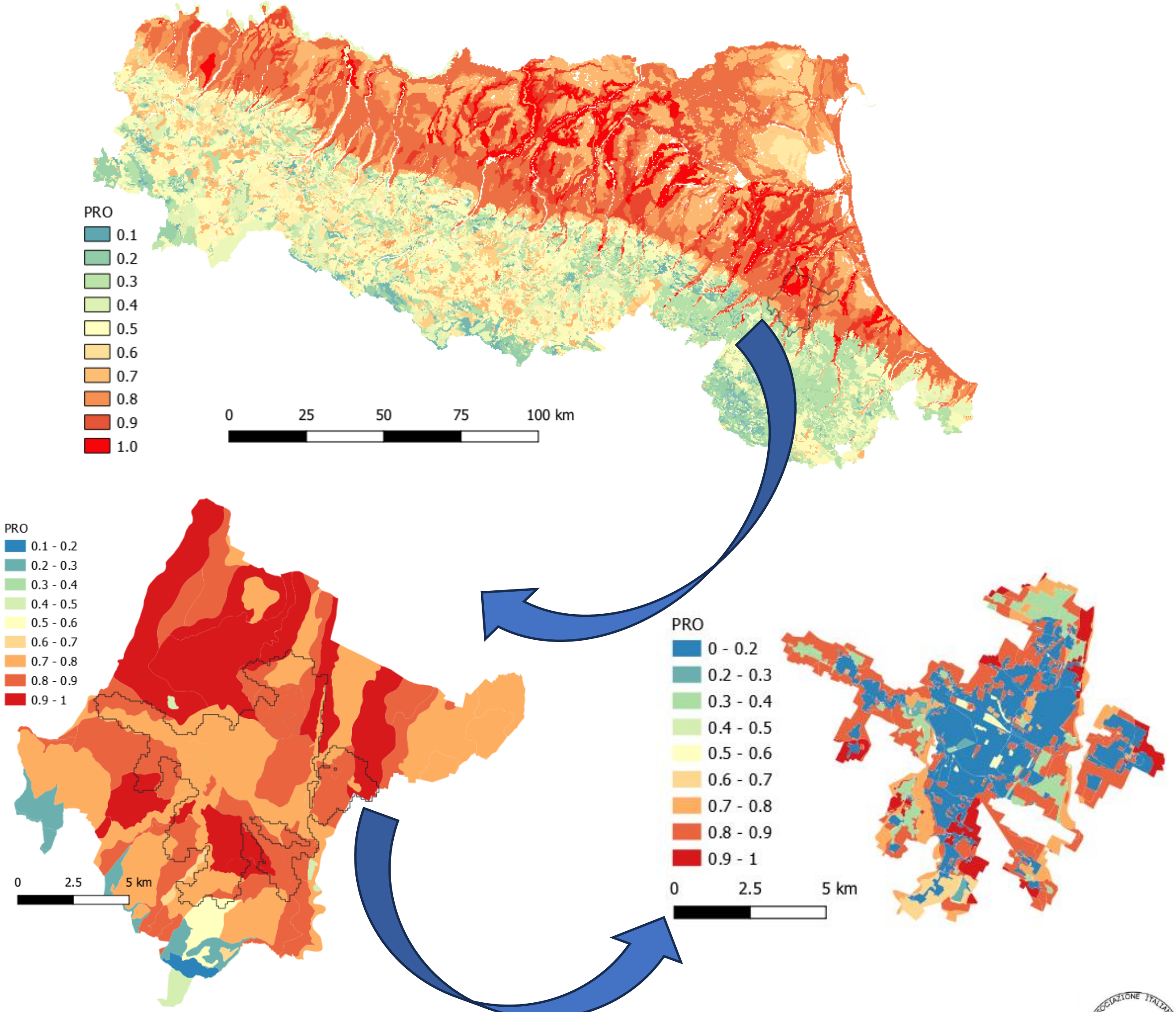
All indicators, with the exception of PRO, are rescaled to the 0-1 interval with the following:

$$X_{i\ 0\text{-}1} = (X_i - X_{min})/(X_{max} - X_{min})$$

Ecosystem services of urban soils

LCC as a proxy for PRO (food production; update 2023)

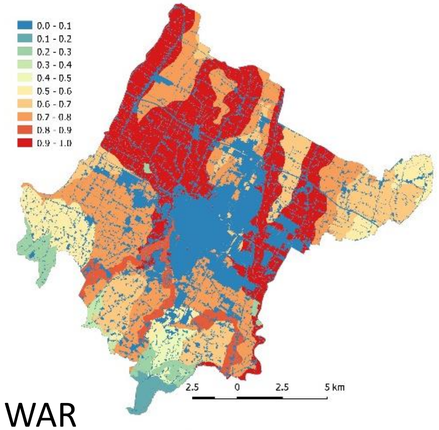
LCC	PRO [0- 1]	LCC	PRO [0- 1]	LCC	PRO [0- 1]	LCC	PRO [0- 1]
I	1.000	III/VI/II	0.538	IV/VIII/VI	0.314	VII/III	0.400
I/II	0.936	III/VI/IV	0.538	V	0.429	VII/III/VI	0.366
I/II/III	0.885	III/VI/VII	0.404	V/I	0.686	VII/III/VIII	0.300
I/III	0.871	III/VI/VIII	0.438	V/II	0.621	VII/IV	0.336
I/V	0.743	III/VII	0.457	V/VI	0.364	VII/IV/VIII	0.252
I/VI	0.679	III/VII/VI	0.423	V/VIII	0.236	VII/VI	0.207
II	0.857	III/VII/VIII	0.357	VI	0.286	VII/VI/III	0.323
II/I	0.921	III/VIII	0.393	VI/II	0.543	VII/VI/VIII	0.157
II/III	0.793	III/VIII/VI	0.376	VI/III	0.479	VII/VIII	0.079
II/III/IV	0.742	IV	0.571	VI/III/II	0.561	VII/VIII/III	0.228
II/III/VI	0.676	IV/II	0.700	VI/III/IV	0.495	VII/VIII/VI	0.128
II/IV	0.729	IV/II/III	0.699	VI/III/VII	0.395	VIII	0.000
II/IV/III	0.728	IV/II/VI	0.599	VI/III/VIII	0.362	VIII/III	0.321
II/IV/VI	0.628	IV/III	0.636	VI/IV	0.414	VIII/III/IV	0.371
II/V	0.664	IV/III/II	0.685	VI/IV/I	0.547	VIII/III/VI	0.304
II/VI	0.600	IV/III/VI	0.552	VI/IV/III	0.480	VIII/IV	0.257
III	0.714	IV/V	0.507	VI/IV/VII	0.347	VIII/IV/VI	0.257
III/I	0.843	IV/VI	0.443	VI/IV/VIII	0.314	VIII/VI	0.129
III/II	0.779	IV/VI/I	0.576	VI/VII/III	0.338	VIII/VI/III	0.262
III/II/IV	0.728	IV/VI/III	0.509	VI/VII/IV	0.304	VIII/VI/IV	0.228
III/II/VI	0.661	IV/VI/VII	0.376	VI/VII/VIII	0.171	VIII/VI/VII	0.128
III/IV	0.650	IV/VI/VIII	0.343	VI/VIII	0.157	VIII/VII	0.064
III/IV/VI	0.566	IV/VII	0.379	VI/VIII/III	0.290	VIII/VII/III	0.214
III/IV/VIII	0.533	IV/VIII	0.314	VI/VIII/IV	0.257	VIII/VII/IV	0.181
III/VI	0.521	IV/VIII/III	0.414	VII	0.143	VIII/VII/VI	0.114



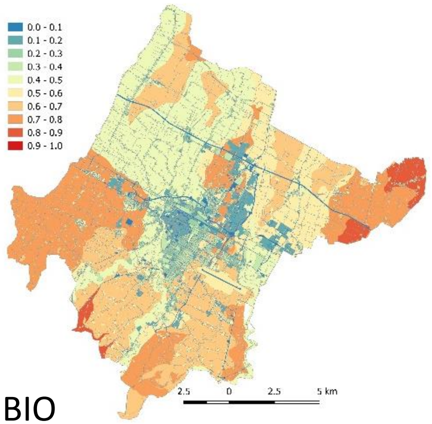
Ecosystem services of urban soils

Assessing and mapping SESs in urban environment using regional soil data bases (soil benchmark profiles)

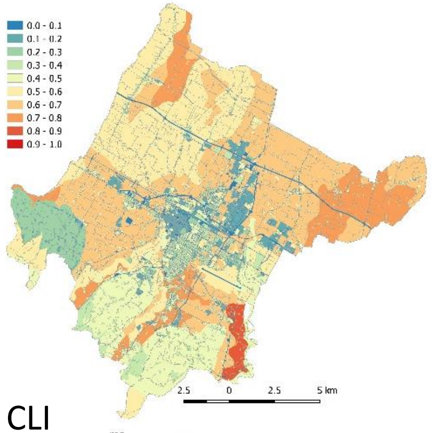
PRO



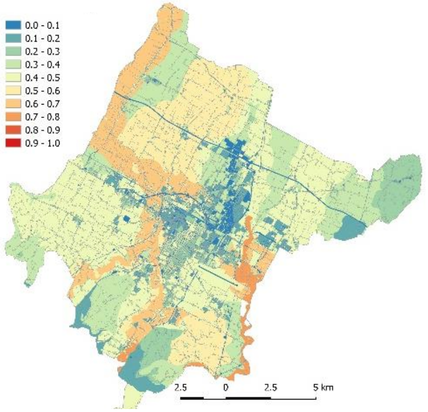
BUF



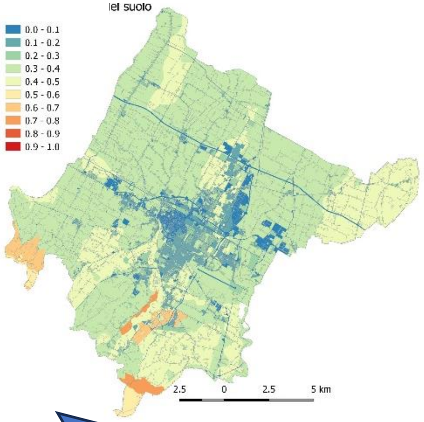
CST



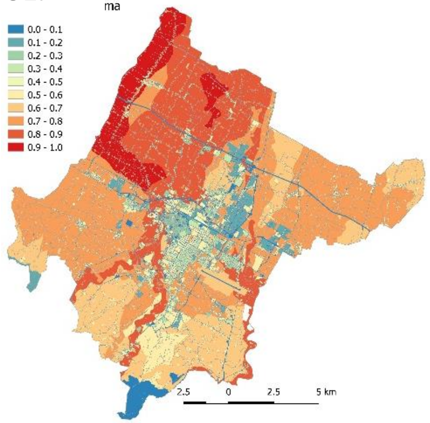
WAR

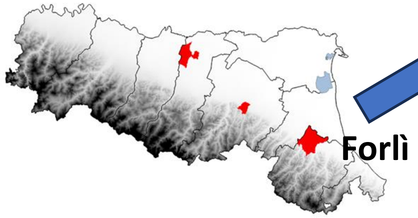


BIO

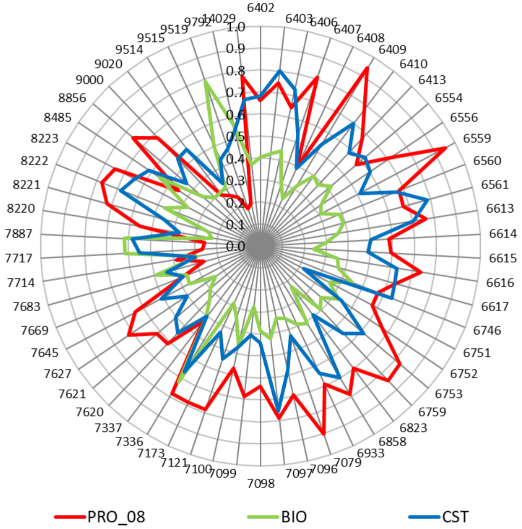


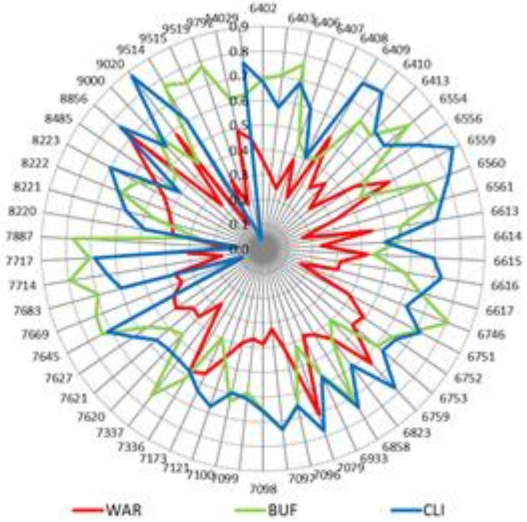
CLI





Elevation 34 m s.l.m.
Area 228,2 km²
Inhabitants 117 978 (31-10-2019)
Pop. Density 516,99 ab./km²





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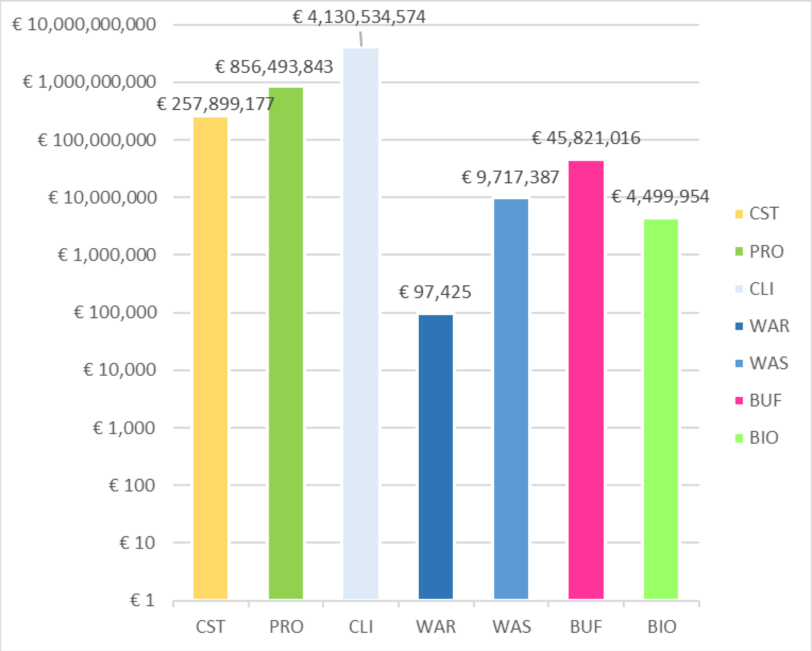
Ecosystem services of urban soils

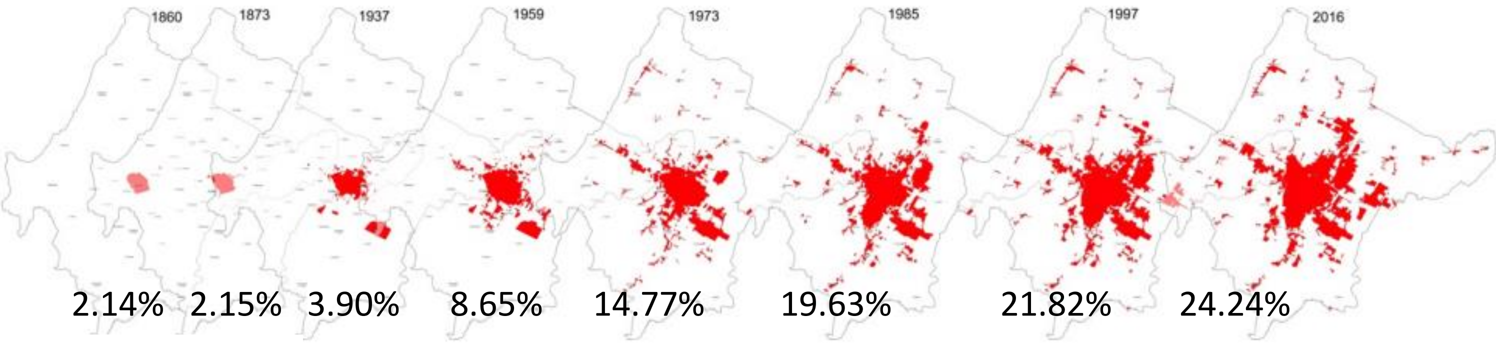
SOS4LIFE
SAVE OUR SOIL FOR LIFE



SE	Description/Units	2016	VALUE	VALUE/ha
CST	C stock (Mg) Market prize	2123500.8	€ 48,840,519.24	€ 2,479.21
CST	C stock (Mg) Social cost	2123500.8	€ 257,899,176.58	€ 13,091.33
PRO	VAM, euro	594028017.5	€ 594,028,017.49	€ 30,153.71
	Wheat, q	1274415.3	€ 262,465,825.69	€ 13,323.14
CLI	AWC, m^3	29446626	€ 4,130,534,574.35	€ 209,671.81
WAR	m^3 infiltration	11881.1	€ 97,425.22	€ 4.95
WAS	AWC, m^3	29446626	€ 9,717,386.57	€ 493.27
BUF	min	17294.2	€ 7,177,098.23	€ 364.32
	max	17294.2	€ 84,464,934.31	€ 4,287.56
BIO		17294.2	€ 4,499,954.12	€ 228.42
SUP. unsealed soil 19700 ha				
TOTAL			€ 5,353,903,895.53	€ 271,771.77

*Metodologia: *Consumo di suolo, dinamiche territoriali e servizi ecosistemici*. Edizione 2018 ISPRA.

Between 1985 and 2016 we estimated an average loss in soil ESs equal to -172,085,036.185 € due to soil sealing (land take +4.61%)



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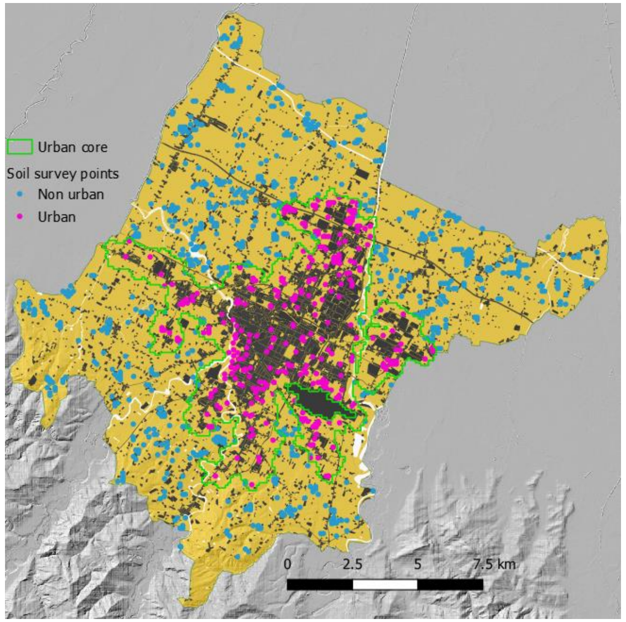
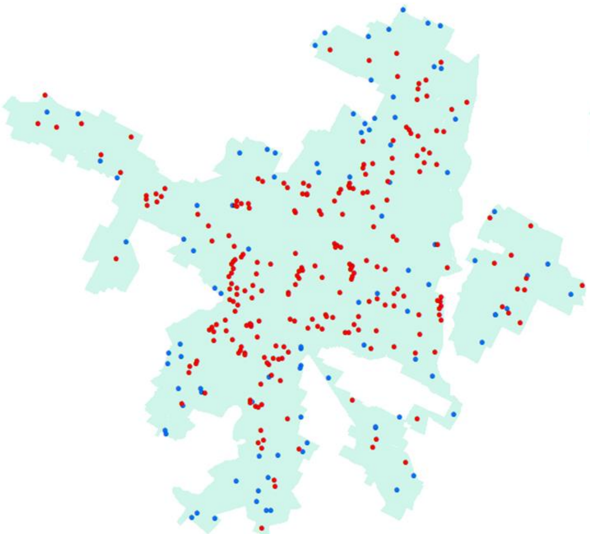
Ecosystem services of urban soils

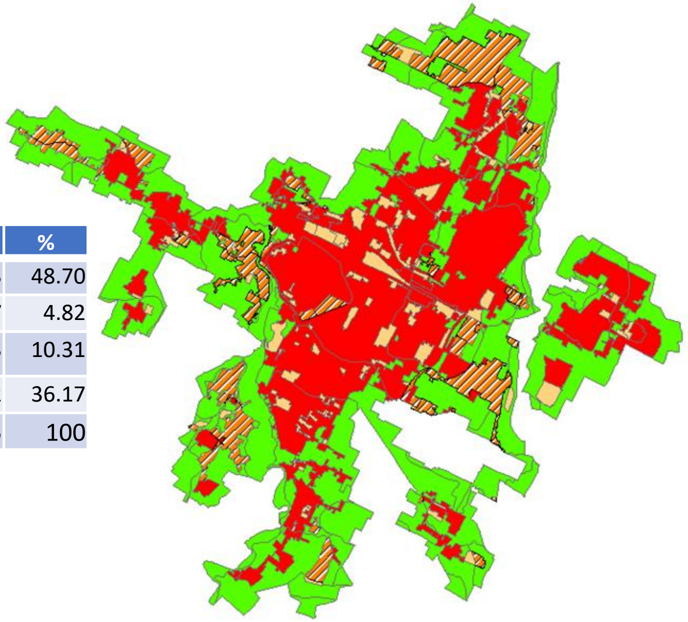
Assessing and mapping SESs in urban environment: *ad hoc* survey of urban soils





Area: 22836 ha (228,36 km^2)
Sampling points: 762 (3/km^2)

Soil disturbance	ha	%
Undisturbed soils	2771.43	48.70
Disturbed soils	274.37	4.82
Urbanized/disturbed soils	586.43	10.31
Urbanised	2058.42	36.17
Total	5690.65	100

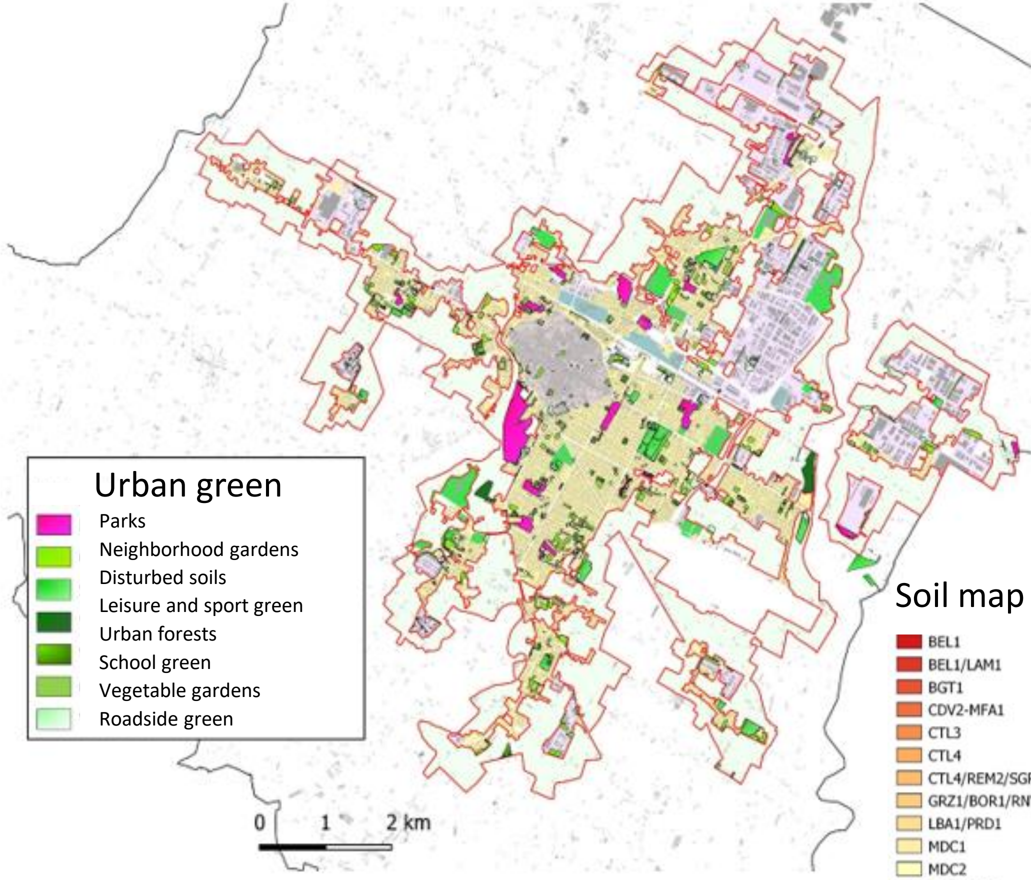


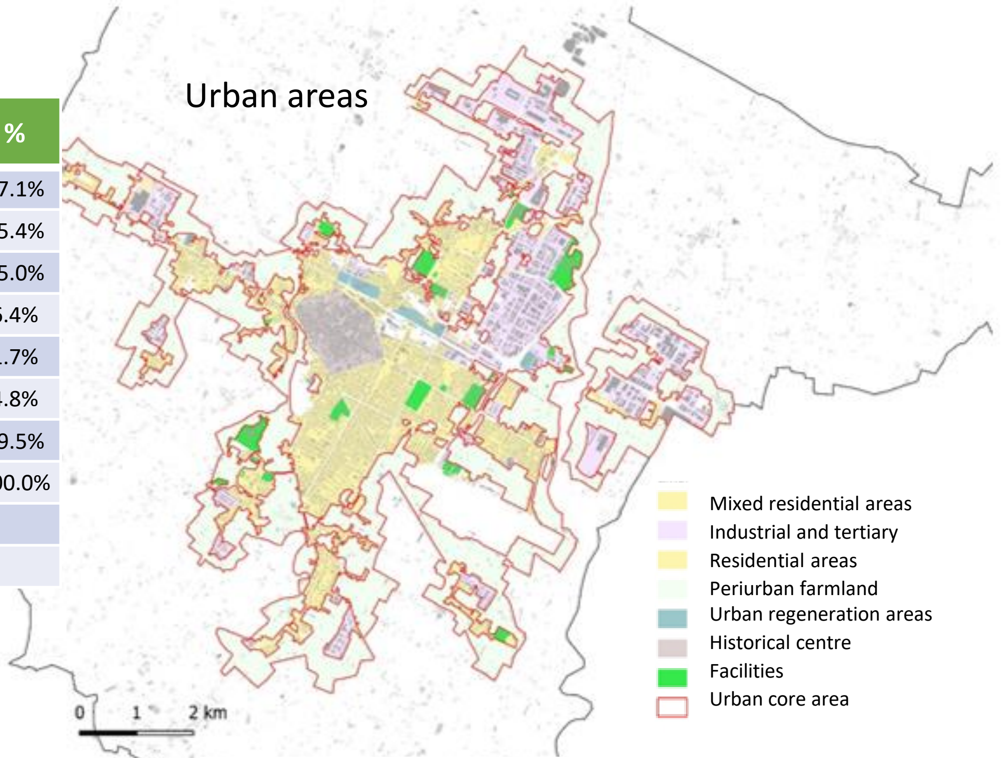
MICROCLIMATE VULNERABILITY AND ECOSYSTEM SERVICES OF URBAN SOILS FUNCTIONAL TO THE GENERAL URBAN PLAN

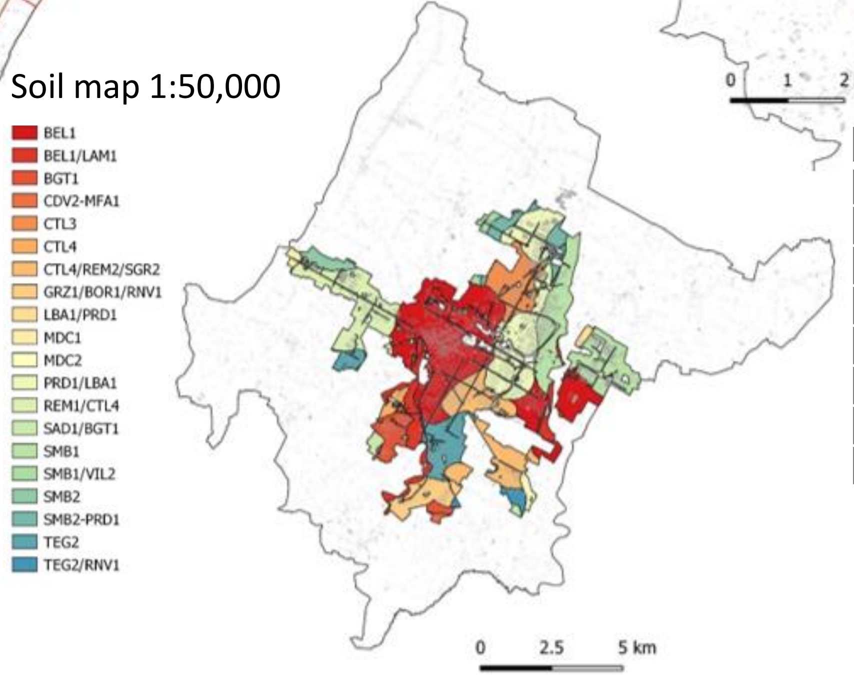
Comune di Forlì
Regione Emilia-Romagna
Consiglio Nazionale delle Ricerche
Istituto per la BioEconomia

Ecosystem services of urban soil

Urban green typologies	N	Area ha	%
Neighborhood gardens	208	81.54	27.1%
Parks	19	76.28	25.4%
Roadside green	192	45.04	15.0%
School green	76	19.28	6.4%
Vegetable gardens	22	5.21	1.7%
Urban forests	13	14.51	4.8%
Sport and leisure green	38	58.77	19.5%
Sub total	568	300.65	100.0%
Periurban farmland		2775.66	
Total		3076.31	



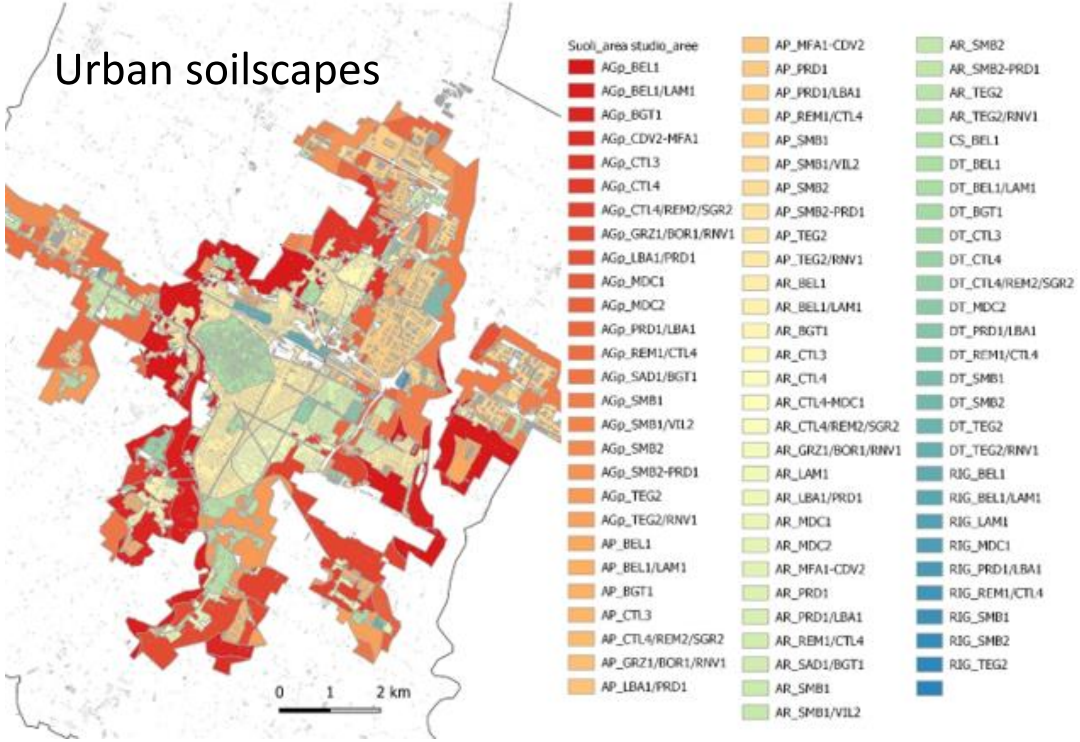


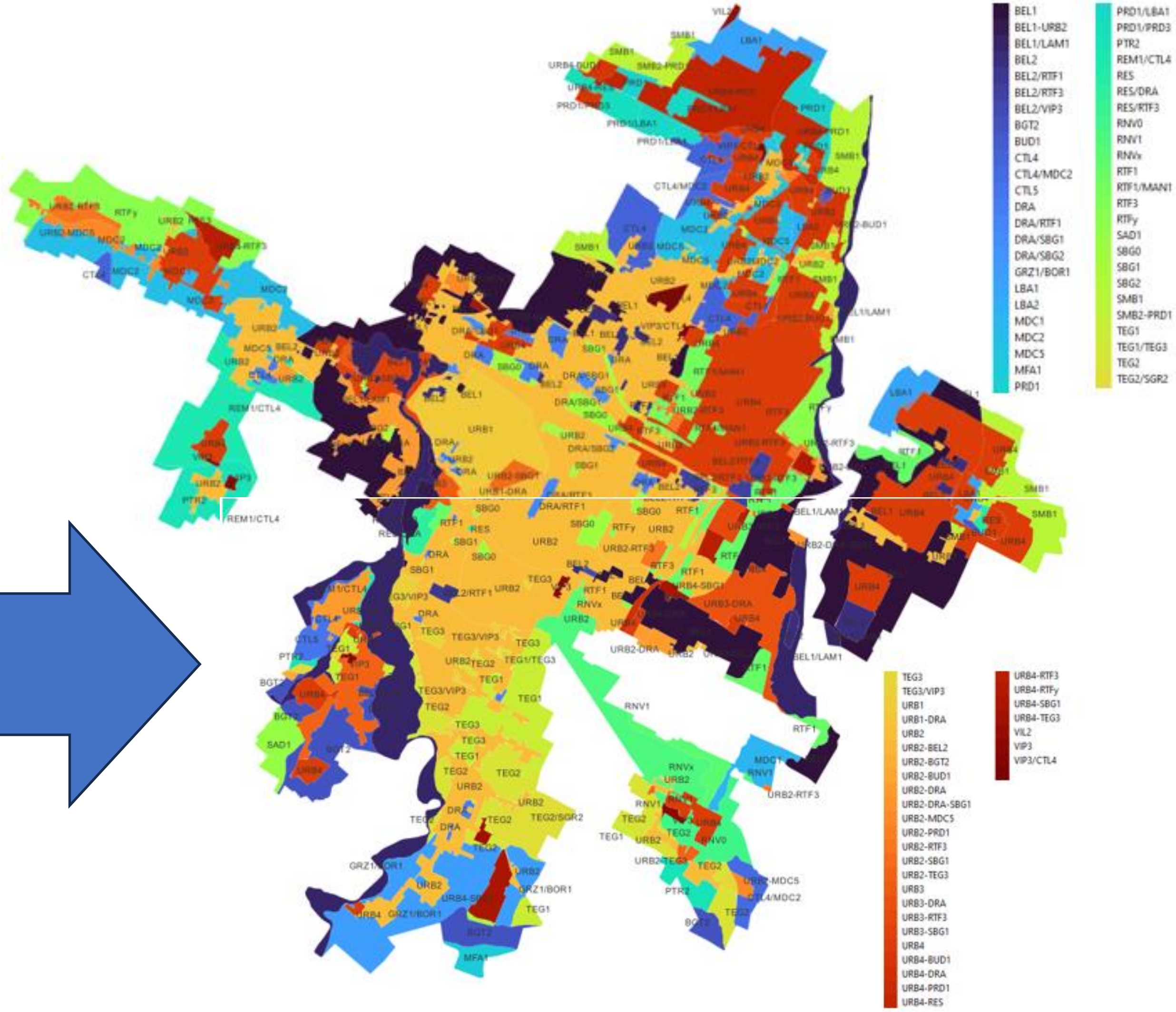


Urban areas	Area, ha	%
Periurban agricultural land	2775.7	50.9
Mixed residential area	1470.1	27.0
Industrial and tertiary urban areas	855.4	15.7
Residential areas	7.5	0.1
Urban regeneration areas	50.0	0.9
Historical centre	156.3	2.9
Facilities	137.1	2.5
Total	5452.0	100.0

Samples were allocated in urban green areas after the identification of preliminary urban pedolandscapes based on soil map units and urban area typologies

Ecosystem services of urban soils





As a results 83 urban soilscapes were identified, proportionally allocating samples in the different green areas of the most relevant ones. The description of soil features from hauger holes and profiles and the analysis of soil samples allowed to define the urban soil units and to draw them on a map

Urban soils map 1:10,000
79 mapping units

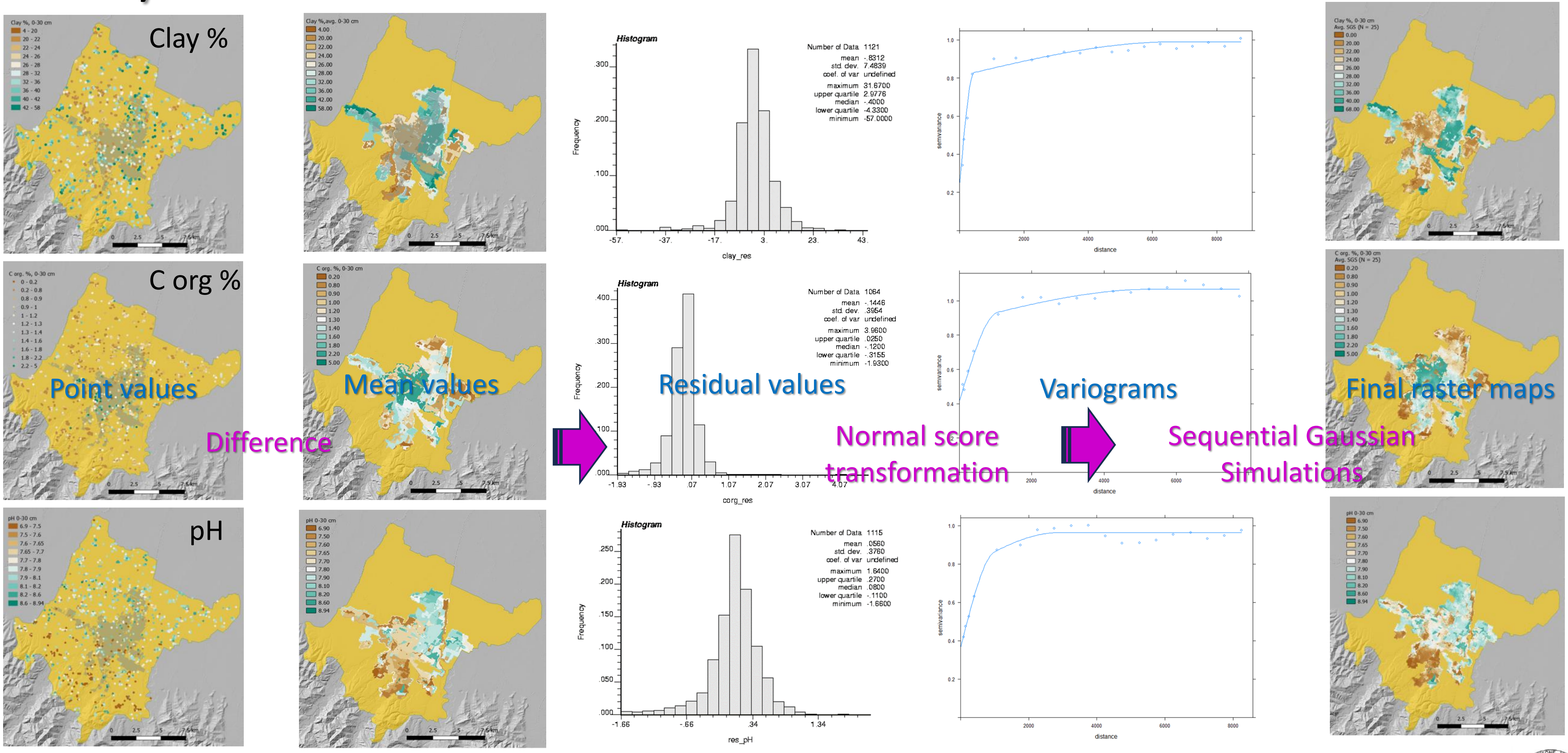
Ecosystem services of urban soils

As for the urbanized areas, four units have been identified, based on the relevance of artificially sealed soil surfaces but not only:

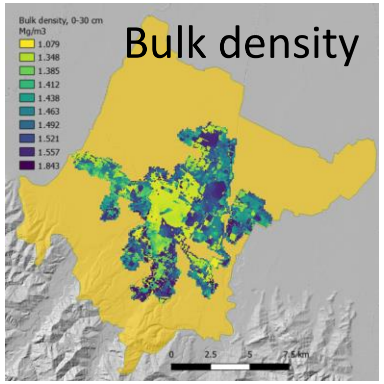
- URB1: historic centre. The occurrence of free soils is variable, but in total rather low.
- URB2: residential areas generally characterized by single houses or buildings with small gardens. Urban greenery has generally been separated, where dimensions allow it, and mostly falls into the category of disturbed soils.
- URB3: urbanized comparable to URB2 in terms of sealing but located in areas at greater risk of flooding (floodplain areas);
- URB4: industrial areas. Here too the sealing percentage is very high, higher than the URB2 and URB3 units. The not built areas have mostly been mapped; they are mostly private green areas (lawns or gardens).

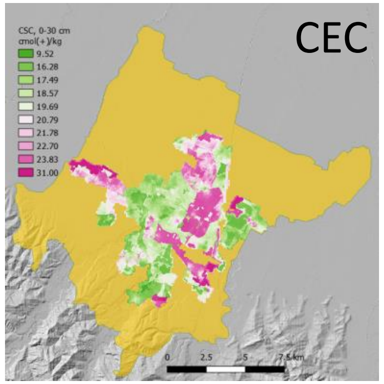
Urbanised areas soil units		
SMU	Ha	%
URB1	134.26	2.36
URB2	1177.15	20.67
URB3	11.45	0.20
URB4	728.39	12.79
	2051.25	36.02

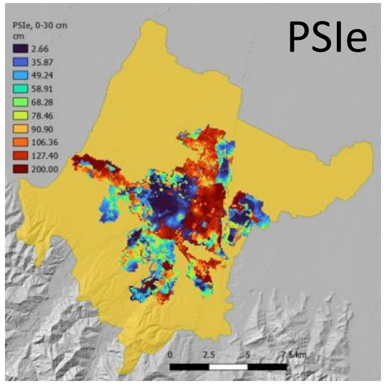
Ecosystem services of urban soils

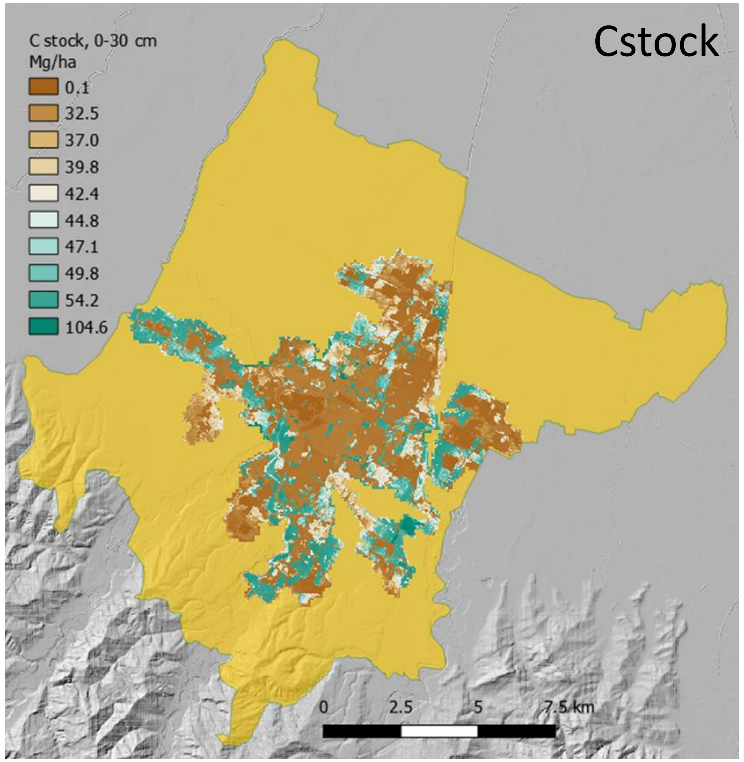


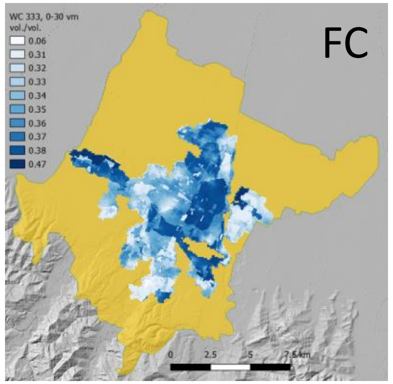
Ecosystem services of urban soils

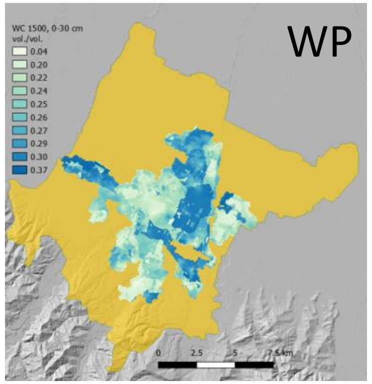


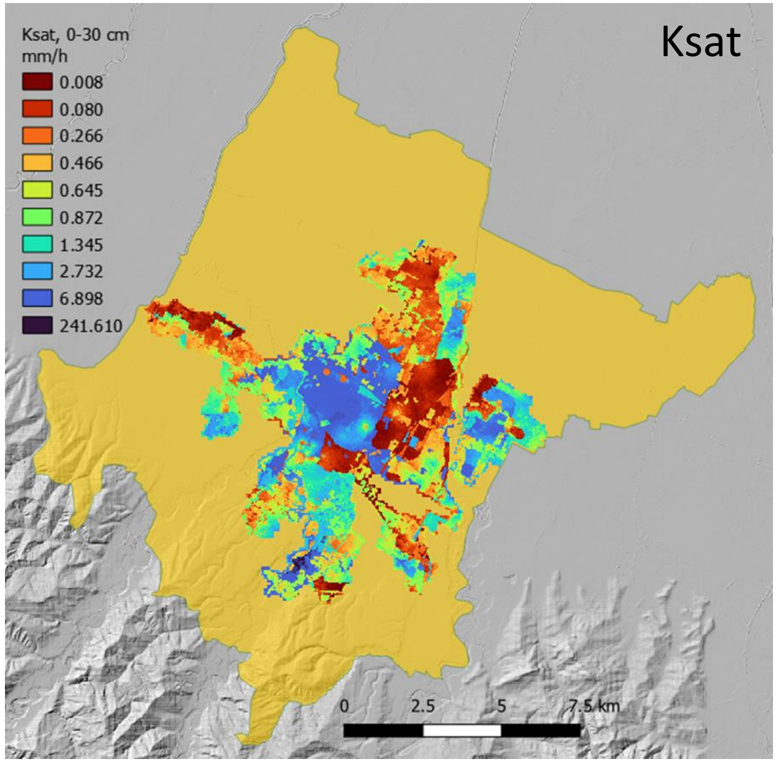




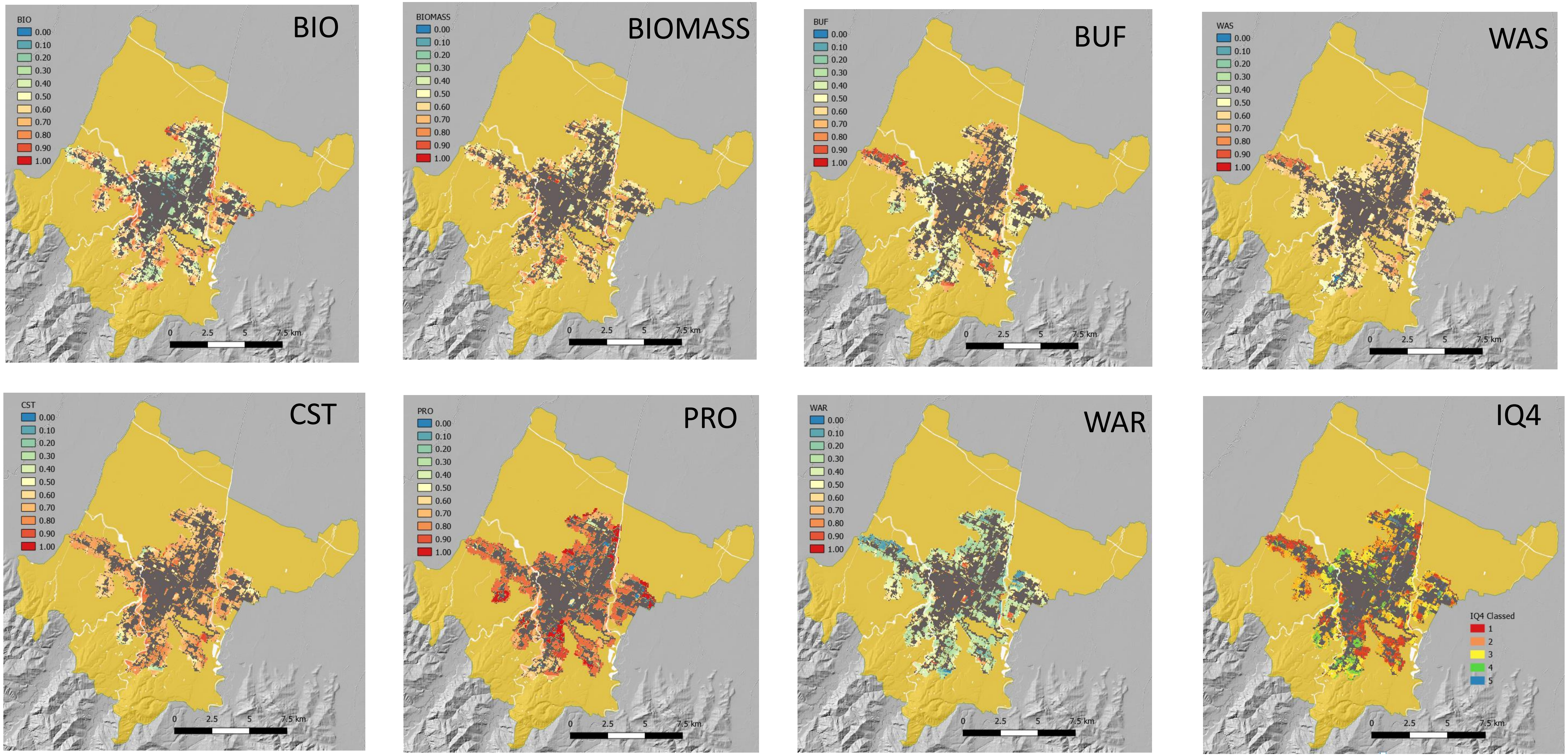






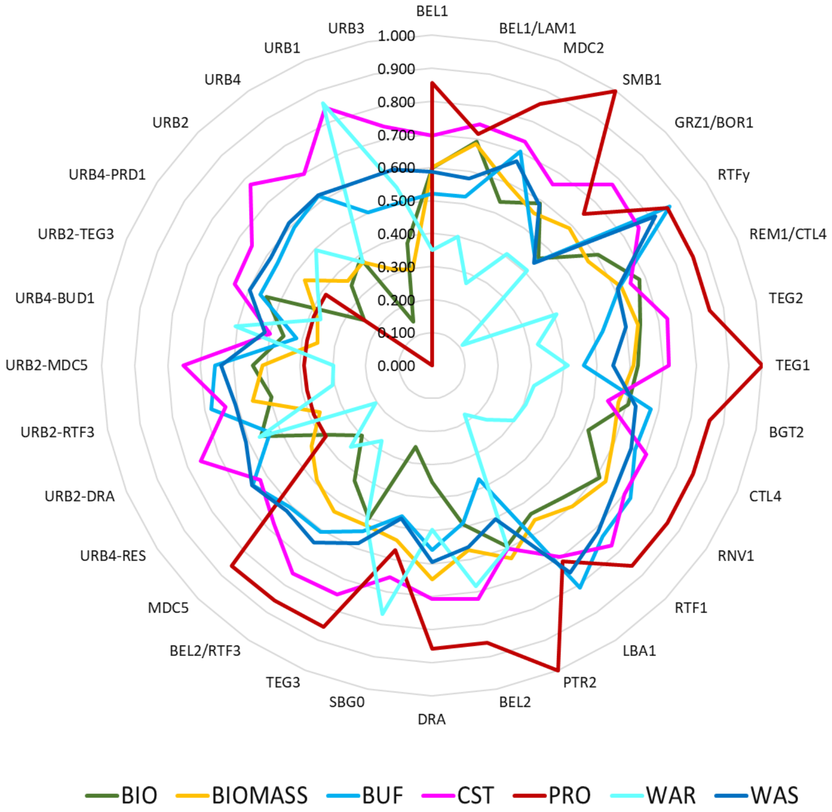


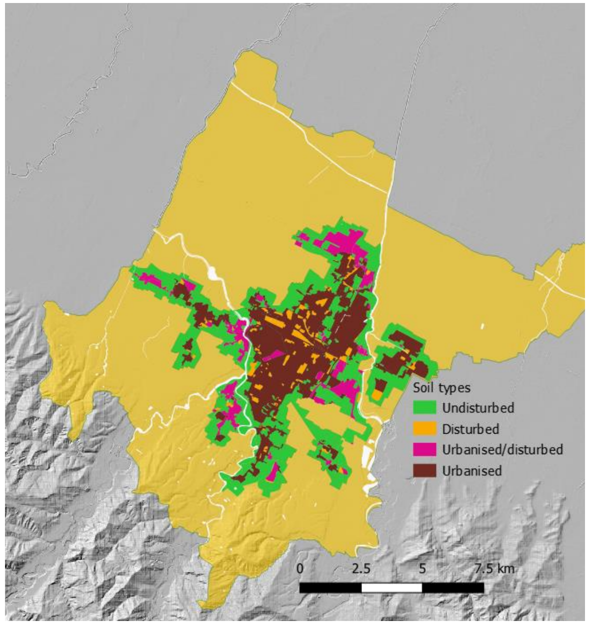
Ecosystem services of urban soils

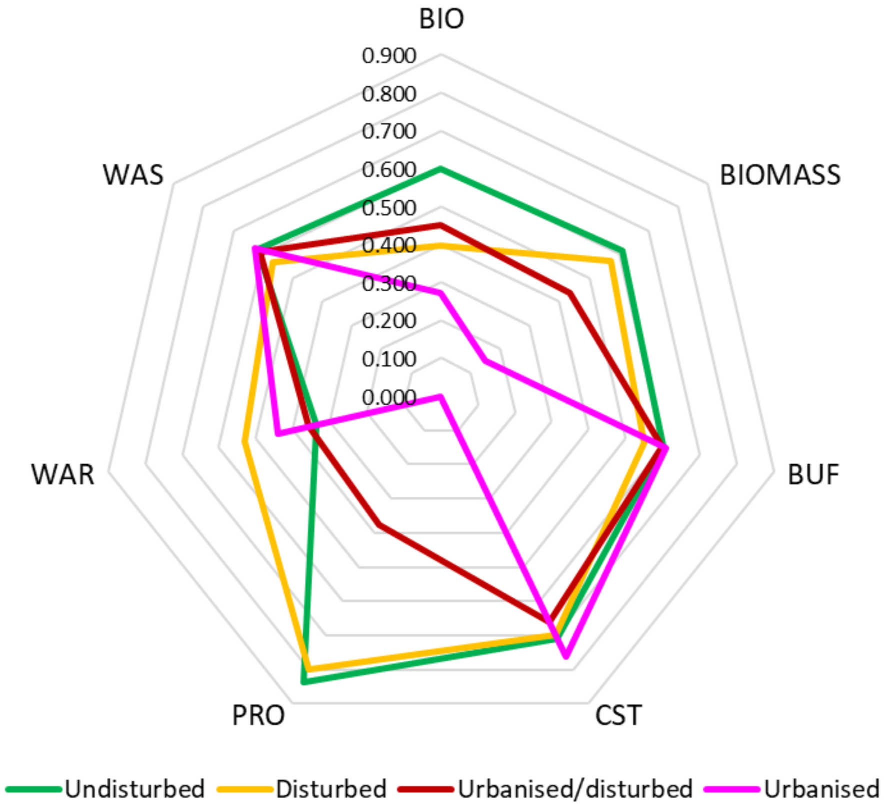


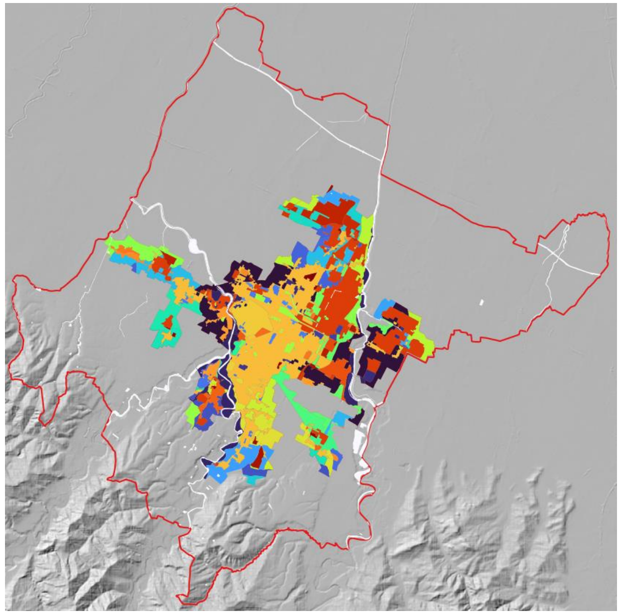
Ecosystem services of urban soils

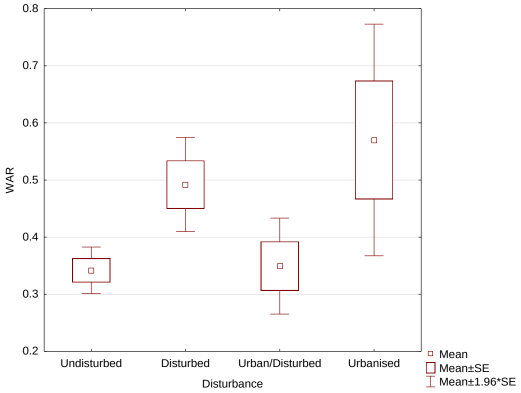
Variable	*Means*	*Std.Dev.*	BIO	BIOMASS	BUF	CST	PRO	WAR	WAS
BIO	0.484	0.180	1.000	0.506	0.427	0.373	0.437	-0.102	0.421
BIOMASS	0.519	0.156	0.506	1.000	0.328	0.351	0.762	0.218	0.330
BUF	0.580	0.152	0.427	0.328	1.000	0.711	0.277	-0.342	0.890
CST	0.680	0.156	0.373	0.351	0.711	1.000	0.258	0.089	0.838
PRO	0.649	0.281	0.437	0.762	0.277	0.258	1.000	-0.001	0.305
WAR	0.395	0.183	-0.102	0.218	-0.342	0.089	-0.001	1.000	-0.217
WAS	0.587	0.137	0.421	0.330	0.890	0.838	0.305	-0.217	1.000

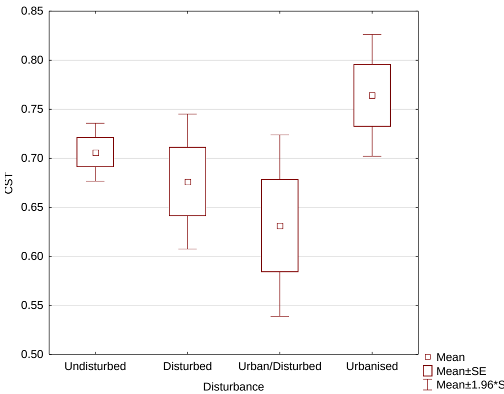












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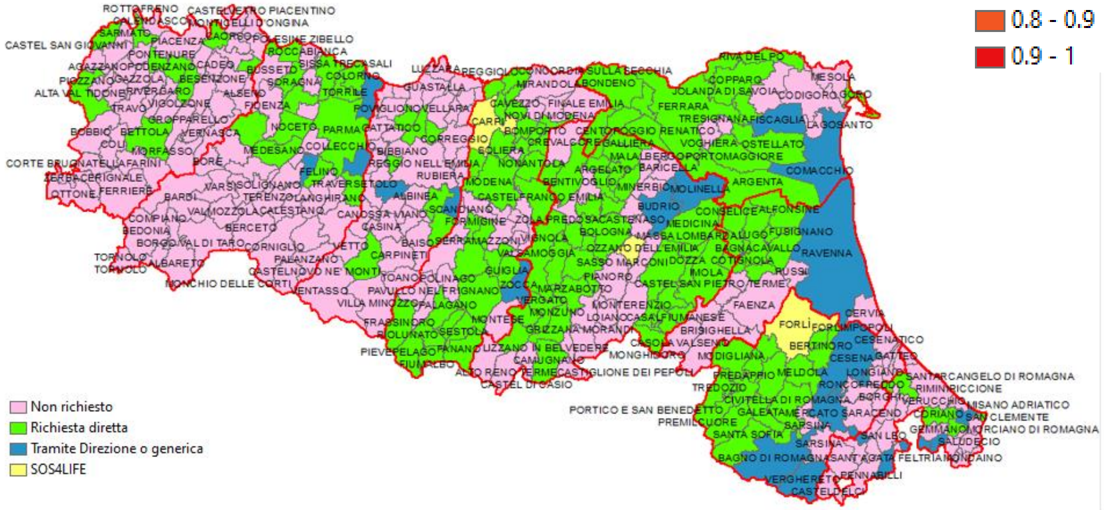
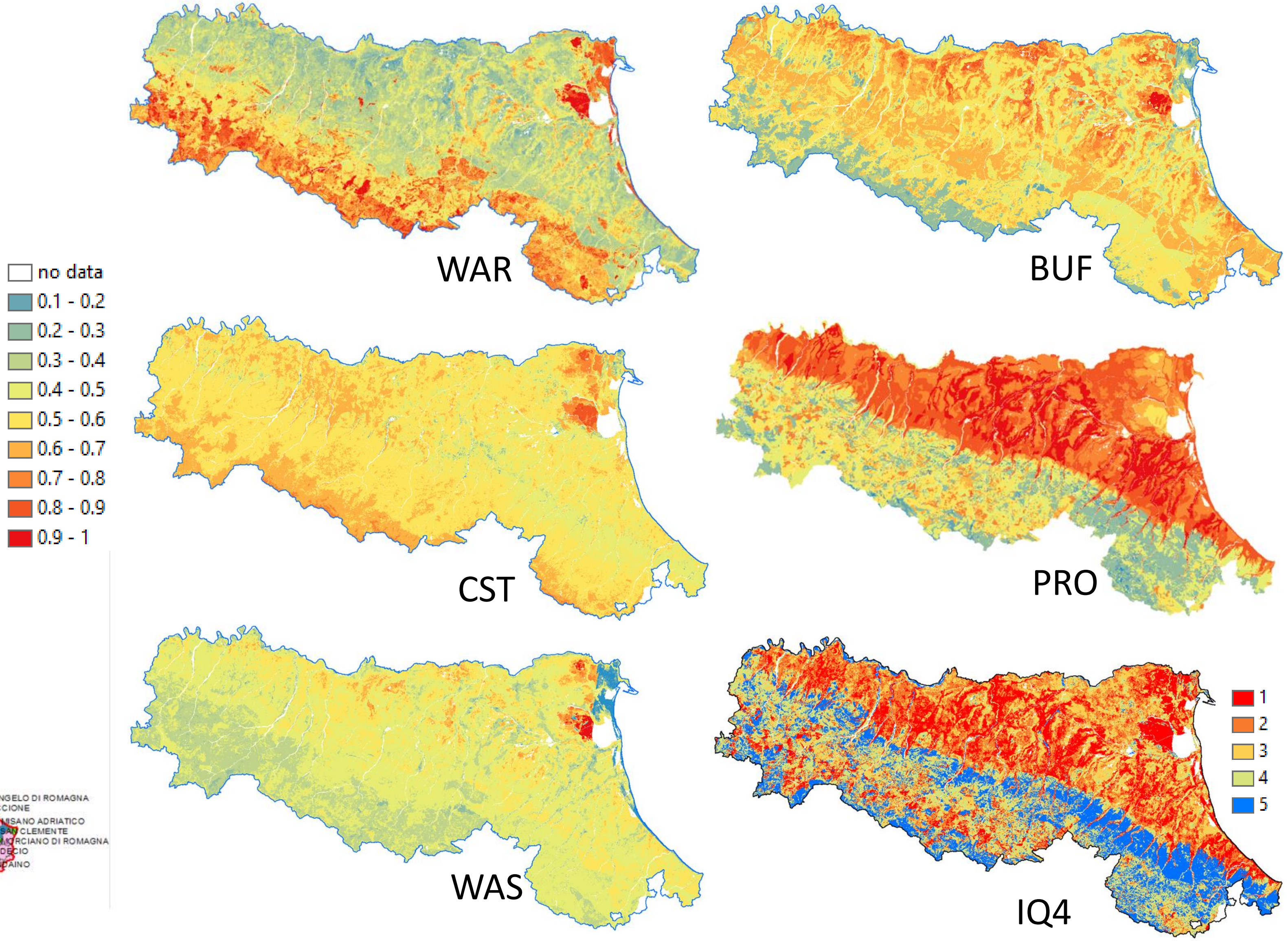
Ecosystem services of urban soils

Province	Number of Municipalities	SES request	% request
BO	55	36	65.5
MO	47	29	61.7
FC	30	20	66.7
PR	44	15	34.1
FE	21	15	71.4
RA	18	10	55.6
PC	46	9	19.6
RN	27	9	33.3
RE	42	9	21.4
	330	**152**	**46.1**





Ecosystem services of urban soils

The presented approach

- Allows to assess and compare the impact of soil sealing in term of reduction/loss of the ecosystem services provided by urban soils under different management options;
- Provides assessment tools to support land planning (i.e. maps) to the aim to reduce/compensate soil sealing taking explicitly into account local land resources and the functions of different soils
- Highlights the multifunctional role played by soils in the urban environment and the relevance of the services provided to the citizens
- Urban soils have characteristics and properties similar to those of agricultural soils in the peri-urban areas, and result from less or more intense disturbance of in situ soils with or without addition of soil materials from nearby areas
- The inherent complexity of the urban soil environment requires ad hoc survey to properly quantify the contribution of soil ecosistem services and to identify potential disservices due to mis-use/-management

https://ambiente.regione.emilia-romagna.it/it/geologia/suoli/suoli-pianificazione/servizi-ecosistemici-del-suolo

https://www.sos4life.it/wp-content/uploads/Valutazione-dei-servizi-Ecosistemici-del-suolo.pdf

https://mappegis.regione.emilia-romagna.it/gstatico/documenti/dati_pedol/servizi_ecosistemici_suoli.pdf

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Thanks for your kind attention!