GREEN SURGE

NATURE-BASED SOLUTIONS PER LA RESILIENZA DELLE AREE METROPOLITANE

Raffaele LAFORTEZZA & Giovanni SANESI
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CGCEO, Michigan State University, USA

SEVENTH FRAMEWORK PROGRAMME

Raffaele LAFORTEZZA, PhD

- Docente Universitario Università di Bari, Italy
- Adjunct Professor at the Center for Global Change and Earth Observations (CGECO) Michigan State University, USA (since 10/2014)
- ESSP VISTAS - Visiting Scholars to Advance Science Grants (12/2015)

PERSONAL INFOGRAPHIC

UNIVERSITY OF COPENHAGEN

UNIVERSITY of GUELPH

UNIVERSITY OF CAMBRIDGE

THE UNIVERSITY OF TOLEDO 1872

THE UNIVERSITY OF TOKYO

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

POLITECNICO DI BARI

AEROSIGMA

筑波大学
University of Tsukuba

Luke
NATURAL RESOURCES INSTITUTE FINLAND

planetek italia

MICHIGAN STATE UNIVERSITY

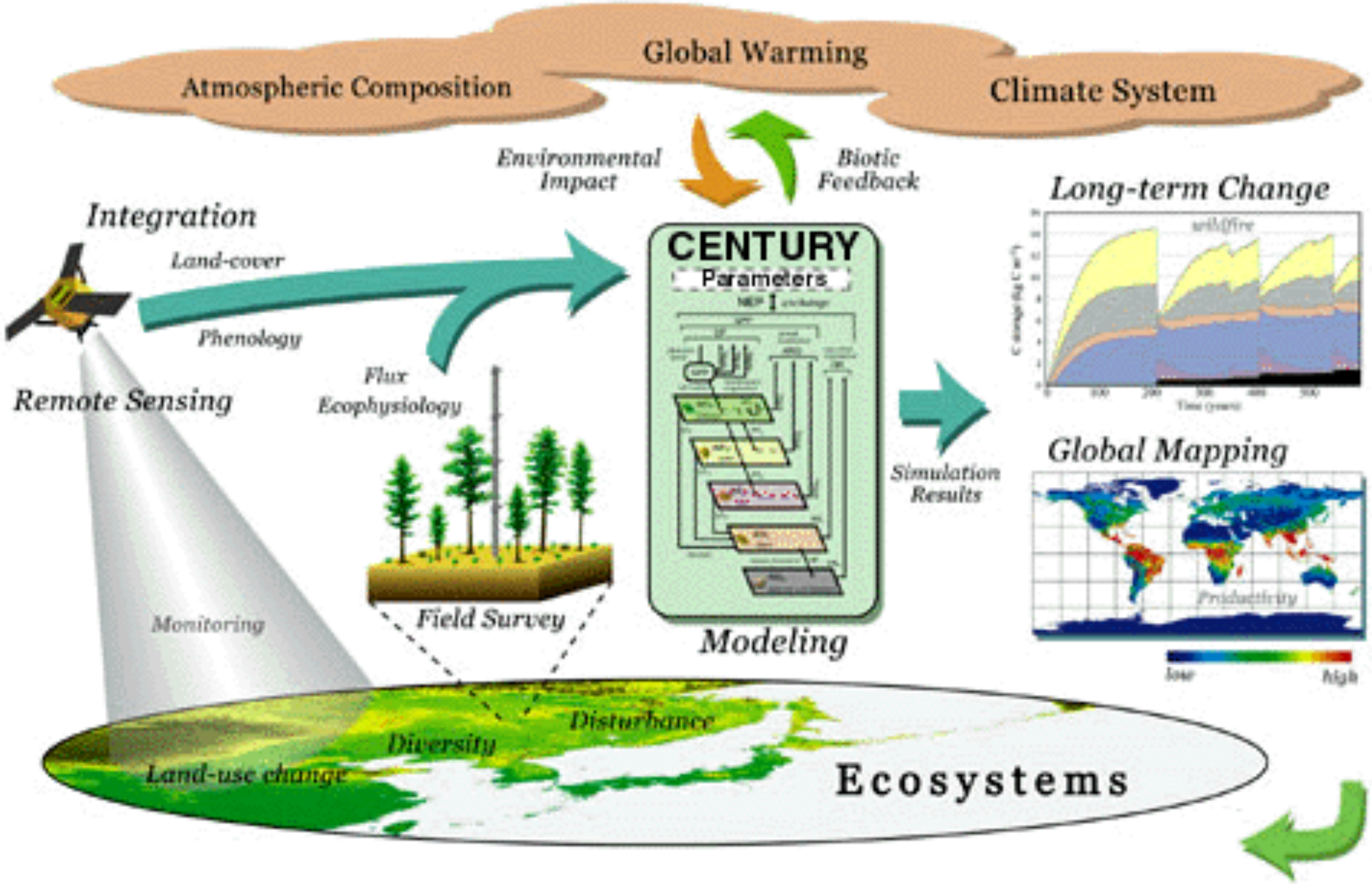
NASA

ZHEJIANG UNIVERSITY 1897

esa

OVERARCHING GOAL

- To provide natural resource managers and decision makers with **geospatial knowledge**, tools and indicators that would enable them to become better stewards of healthy and sustainable ecosystems



Center For Global Change & Earth Observations (CGCEO)

Faculty

Our diverse staff brings a range of expertise and passion to the Center's Work.

Jiaguo Qi

Director, CGCEO & Professor, Department of Geography

Telephone: (517) 353-8736

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ASIA WEF Nexus, Lingshui, China (Dec. 2016)

Landscape Ecology & Ecosystem Science Lab

Center for Global Change and Earth Observations | Department of Geography

http://lees.geo.msu.edu/people.html

MICHIGAN STATE UNIVERSITY

Raffaele Lafortezza, PhD

Adjunct Professor, Center for Global Change and Earth Observations | University of Bari, Italy
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Dr. Raffaele Lafortezza is Adjunct Professor at the Center for Global Change and Earth Observations (CGCEO), Michigan State University. He holds a PhD in Landscape Ecology and Planning from the University of Bari (2002) and has accumulated considerable experience in landscape ecology issues by participating in numerous research projects and scientific collaborations conducted worldwide. His main research interest lies in the fields of landscape modeling at multiple spatial and temporal scales, sustainable land management in the context of global change, ecosystem services associated with green infrastructures and nature-based solutions, quantitative assessment of biodiversity, and analysis of ecological disturbances, including forest fires and fragmentation in wildland urban interfaces. In addition, he seeks to understand the impact of human activity on ecosystems (i.e., coupled human and natural systems) and to discover methods for preserving ecological patterns and related processes/services.

Dr. Lafortezza has developed his research interests in the United States (University of Toledo, Michigan State University), Canada (University of Guelph), Japan (University of Tsukuba, University of Tokyo), and the United Kingdom (University of Cambridge) and has been involved, as principal- and co-investigator, in many research projects. He is Associate Editor of the journal "Urban Forestry & Urban Greening" (Elsevier) and a member of the Editorial Board of the Springer journals "Landscape Ecology" and "Ecological Processes".

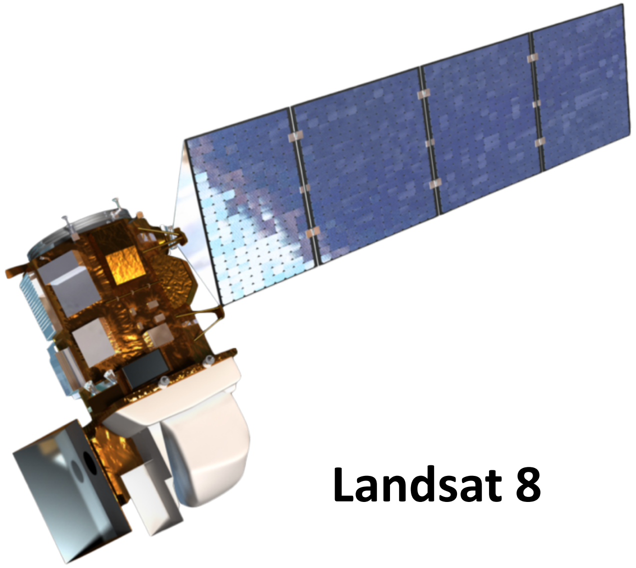
UNIBA students


Nature-Based Solutions for Landscape Resilience
Chisholm, p.441
Frank
MICHIGAN STATE UNIVERSITY
ESPP and CGCEO present a VISTAS lecture
Nature-based solutions (NBS) for Landscape Resilience
Dr. Raffaele Lafortezza
Department of Agricultural and Environmental Sciences
University of Bari, Italy
Wednesday, Dec. 9
3p.m., Giltner Hall 273
ABSTRACT: During the past couple of years, the environment unit within the Directorate-General (DG) Research and Innovation of the European Commission launched the concept of nature-based solutions (NBS) as a way of making ecosystems and nature an integral part of sustainable development. Nature-based solutions are understood as living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits. In the various reports and publications issued by the European Commission, as well as in presentations by EC officers, a range of examples of NBS have been presented. These include, for example, the use of soil conservation measures (such as cover crops, wind breaks, deep-rooted plants and minimum or conservation tillage) to enhance storage of soil carbon; retain and restore forest cover on steep slopes; use permeable surfaces and vegetation in urban settings. Nature-based solutions provide opportunities for adaptation to climate change, thus increasing urban resilience to risks, such as droughts, floods and heatwaves, as well as opportunities for small-scale climate mitigation through increased carbon storage.
RSVP to espp@msu.edu by Dec. 5

NASA ROSES-2017 proposal

Call A2- Multi-Source Land Imaging (MuSLI)

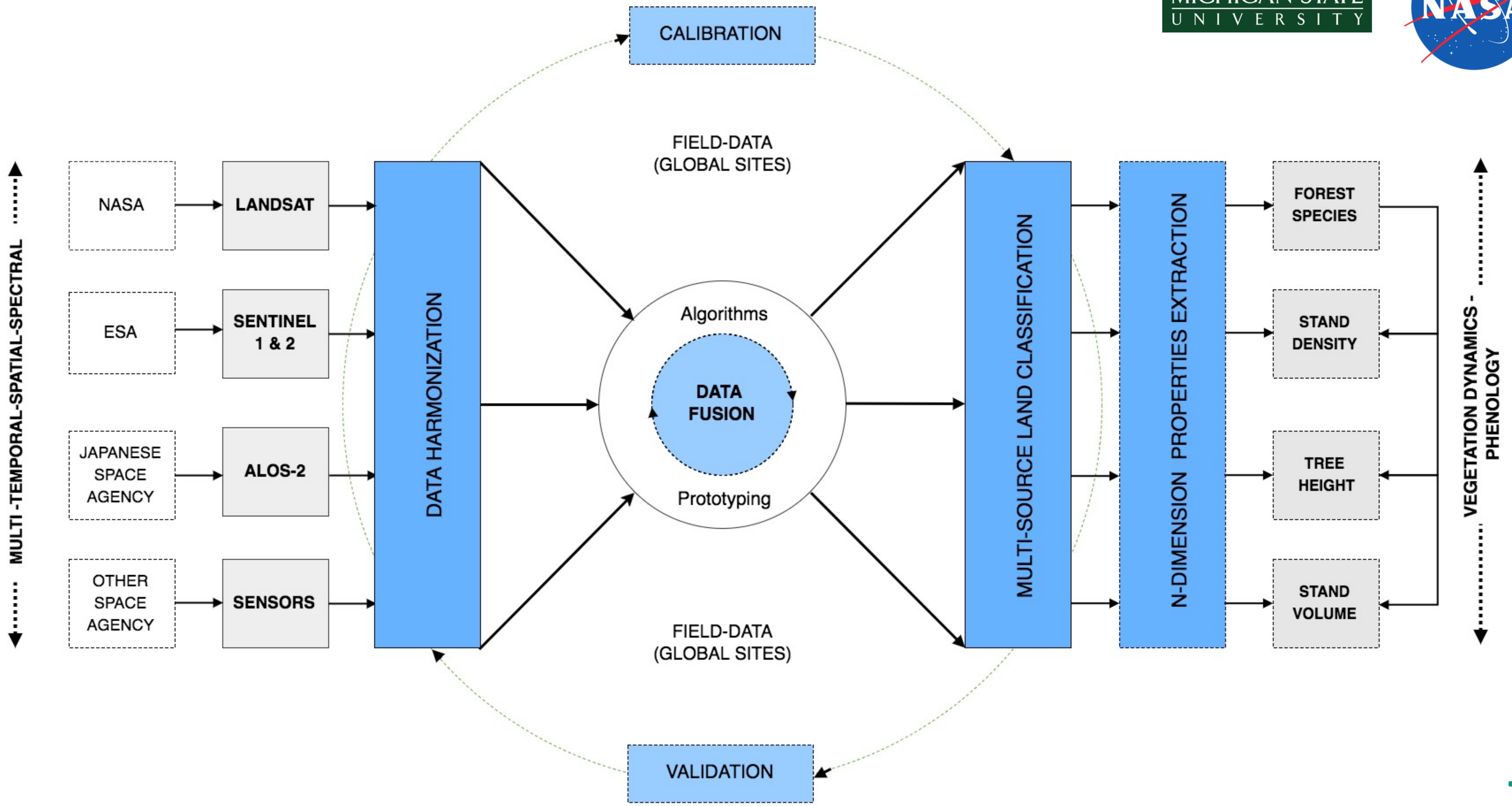
New algorithms and approaches to EXTract LAND cover attributes through the integration of multi-source and multi-temporal images (NEXTLAND)



Landsat 8

Sentinel 1

Sentinel 2


CALIBRATION
FIELD-DATA
(GLOBAL SITES)
MULTI -TEMPORAL-SPATIAL-SPECTRAL
NASA
LANDSAT
ESA
SENTINEL
1 & 2
JAPANESE
SPACE
AGENCY
ALOS-2
OTHER
SPACE
AGENCY
SENSORS
DATA HARMONIZATION
Algorithms
DATA
FUSION
Prototyping
MULTI-SOURCE LAND CLASSIFICATION
N-DIMENSION PROPERTIES EXTRACTION
FOREST
SPECIES
STAND
DENSITY
TREE
HEIGHT
STAND
VOLUME
VEGETATION DYNAMICS -
PHENOLOGY
FIELD-DATA
(GLOBAL SITES)
VALIDATION

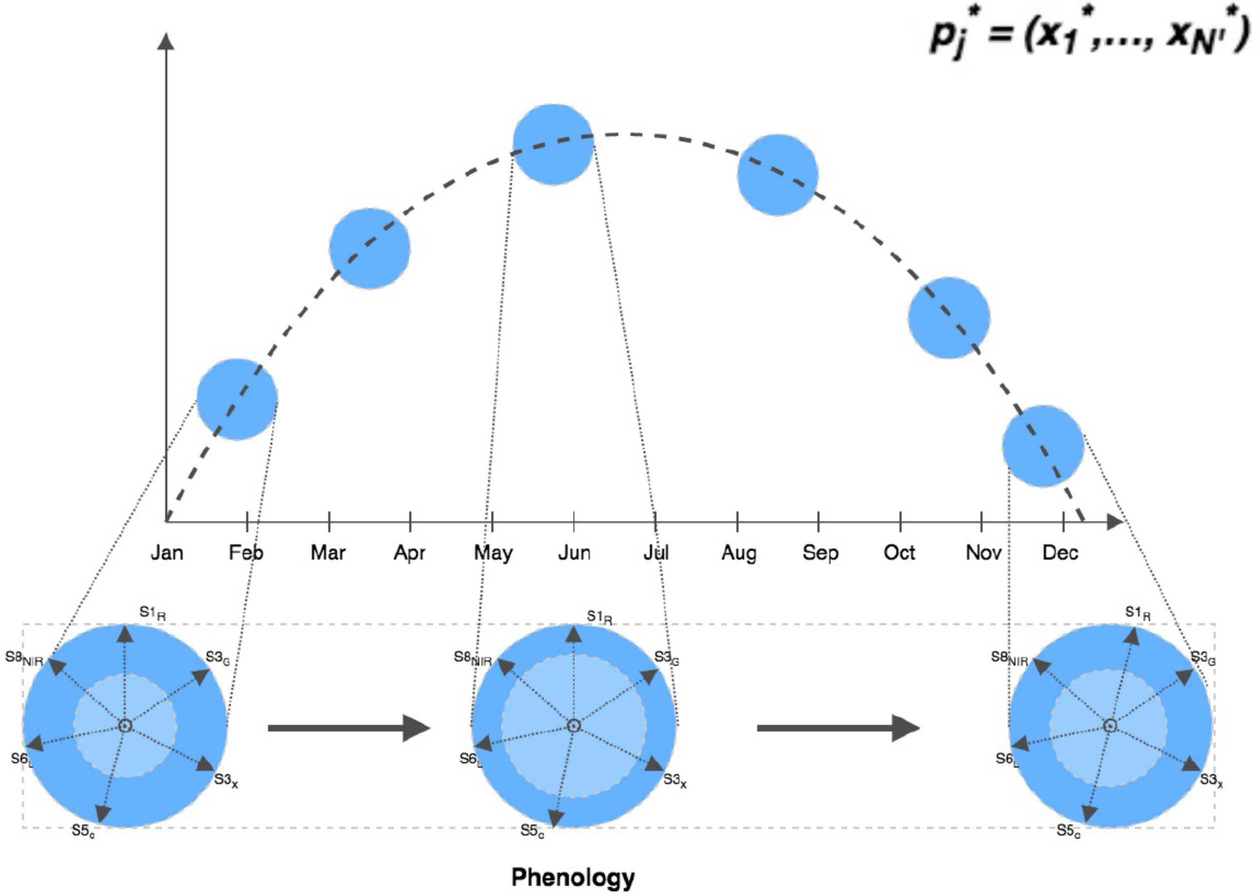
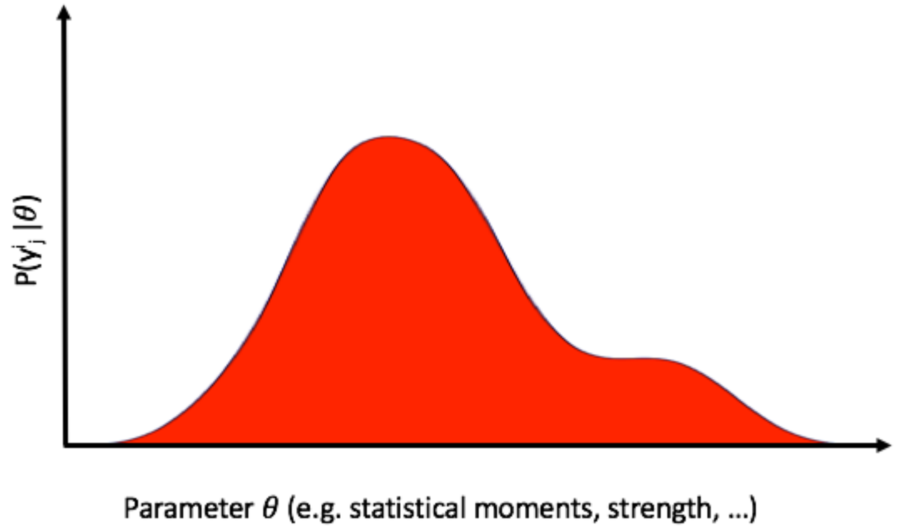


Figure 2 – Model-diagram illustrating the concept behind our approach to data fusion and attribute extraction. Considering a generic bell-shaped curve representing the variation of forest stand attributes during the year, spectral bands/channels are used to generate an $\mathbb{R}^N$, where we identify the main vectors (different sensors, e.g., S1, S2, S3, providing different bands e.g., $S1_R$; $S3_X$; $S6_L$) characterizing forest pixels over time (t).



$$V_{N'}(R) = \int \dots \int_{x_1^2+\dots+x_N^2 \le R^2} dx_1 dx_2 \dots dx_{N'} = C_{N'} R^{N'} V_{N'}(R)$$

$$V_{N'}(R) = \frac{\pi^{N'/2} R^{N'}}{\Gamma(N'/2+1)} \quad \text{and} \quad S_{N'-1}(R) = \frac{2\pi^{N'/2} R^{N'-1}}{\Gamma(N'/2)}$$

THEORETICAL BACKGROUND

PERSPECTIVE

Living in cities, naturally

Terry Hartig[1] and Peter H. Kahn Jr.[2]

Natural features, settings, and processes in urban areas can help to reduce stress associated with urban life. In this and other ways, public health benefits from, street trees, green roofs, community gardens, parks and open spaces, and extensive connective pathways for walking and biking. Such urban design provisions can also yield ecological benefits, not only directly but also through the role they play in shaping attitudes toward the environment and environmental protection. Knowledge of the psychological benefits of nature experience supports efforts to better integrate nature into the architecture, infrastructure, and public spaces of urban areas.

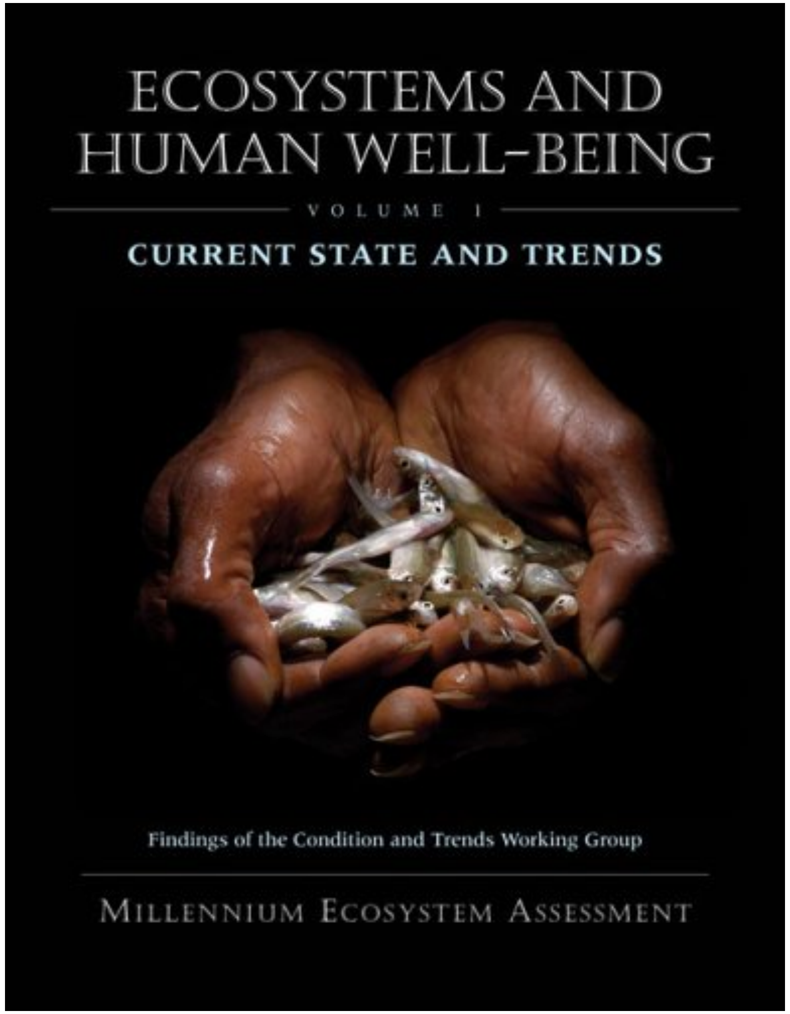
The ecological future of cities

Mark J. McDonnell[1*] and Ian MacGregor-Fors[2*]

The discipline of urban ecology arose in the 1990s, primarily motivated by a widespread interest in documenting the distribution and abundance of animals and plants in cities. Today, urban ecologists have greatly expanded their scope of study to include ecological and socioeconomic processes, urban management, planning, and design, with the goal of addressing issues of sustainability, environmental quality, and human well-being within cities and towns. As the global pace of urbanization continues to intensify, urban ecology provides the ecological and social data, as well as the principles, concepts and tools, to create livable cities.

Science Vol 352, Issue 6288, 20 May 2016

THEORETICAL BACKGROUND



ECOSYSTEMS

Ecologists embrace their urban side

Climate change and the rise of cities have broadened what it means to study ecosystems.

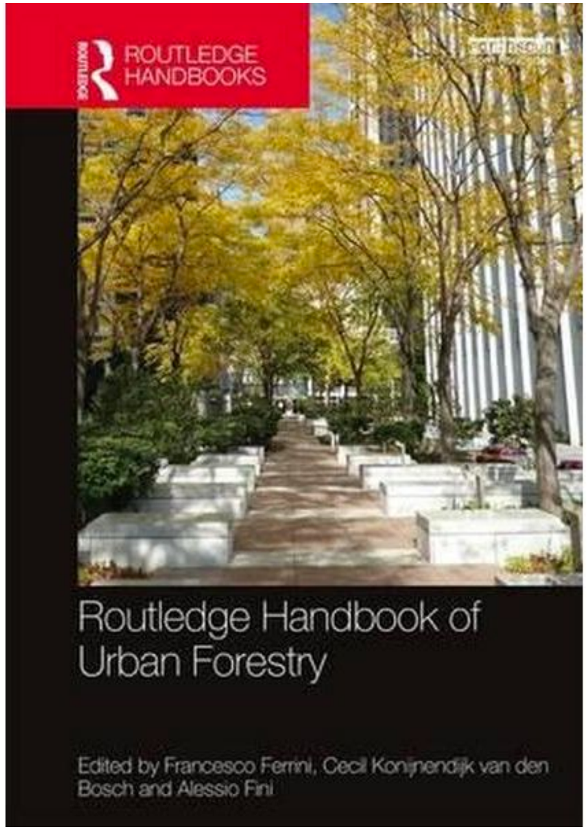
BY DANIEL CRESSEY, BALTIMORE, MARYLAND

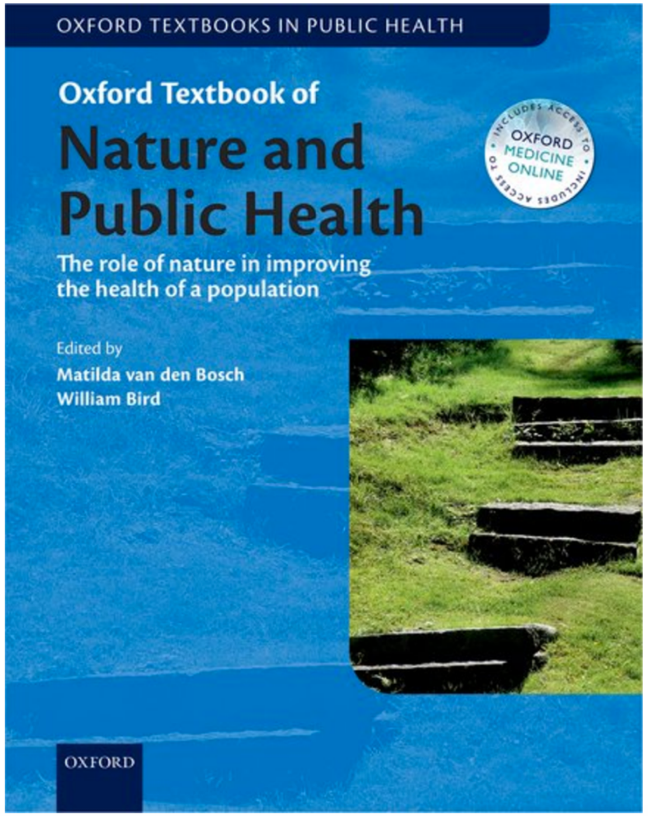
A concrete megalith overshadowed by skyscrapers and surrounded by roads that roar with traffic, the convention centre in downtown Baltimore may seem an inappropriate setting for an ecology conference. But the resolutely urban backdrop for the annual meeting of the Ecological Society of America (ESA) is a fitting symbol of the growing acceptance of, and interest in, 'urban ecology' — the study of cities and the organisms that dwell in them as ecosystems.

"In the past 10 years, it's really become more mainstream. People's reactions have shifted from 'What's that?' or 'Why do you do that?' to 'Oh, cool'," says Laura Martin, a historian and urban ecologist at the Harvard University Center for the Environment in Cambridge, Massachusetts. She presented work at this year's centennial meeting (which ran on 9–14 August) showing that orange jewelweeds (*Impatiens capensis*) in Manhattan and other urban settings are evolving defences to incursions of certain deer that eat them (L. J. Martin *et al. J. Ecol.* **103,** 243–249; 2015).

Martin is part of a team that called at ▶

THEORETICAL BACKGROUND





CHAPTER 8.4

Green infrastructure—approach and public health benefits

Raffaele Lafortezza and Cecil
Konijnendijk van den Bosch

13

STRATEGIC GREEN INFRASTRUCTURE PLANNING AND URBAN FORESTRY

Raffaele Lafortezza, Stephan Pauleit,
Rieke Hansen, Giovanni Sanesi and Clive Davies

THEORETICAL BACKGROUND

Environmental Research 159 (2017) xxx–xxx

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

ELSEVIER

The health benefits of nature-based solutions to urbanization challenges for children and the elderly – A systematic review

CrossMark

Nadja Kabisch[a,b,*], Matilda van den Bosch[c,d], Raffaele Lafortezza[e,f]

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[e] Department of Agricultural and Environmental Sciences, University of Bari A. Moro, Via Amendola 165/A, 70126 Bari, Italy
[f] Center for Global Change and Earth Observations (CGCEO), Michigan State University, East Lansing, MI 48823, USA

Environmental Research 159 (2017) 249–256

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

ELSEVIER

Nature-based solutions to promote human resilience and wellbeing in cities during increasingly hot summers

CrossMark

Angelo Panno[a,*], Giuseppe Carrus[a], Raffaele Lafortezza[b,c], Luigi Mariani[d], Giovanni Sanesi[b]

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[b] Department of Agricultural and Environmental Science (Di.S.A.A.T.), University of Bari A. Moro, Bari, Italy
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[d] Department of Agricultural and Environmental Sciences, University of Milan, Milano, Italy

Urban Forestry & Urban Greening 26 (2017) 78–84

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

ELSEVIER

The long-term prospects of citizens managing urban green space: From place making to place-keeping?

CrossMark

T.J.M. Mattijssen[a,*], A.P.N. van der Jagt[b], A.E. Buijs[a], B.H.M. Elands[a], S. Erlwein[c], R. Lafortezza[d,e]

[a] Wageningen University and Research Centre, Droevendaalsesteeg 3, 6708 PB Wageningen, The Netherlands
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[e] Center for Global Change and Earth Observations (CGCEO), Michigan State University, East Lansing, MI, 48823, USA

Land Use Policy 69 (2017) 93–101

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

ELSEVIER

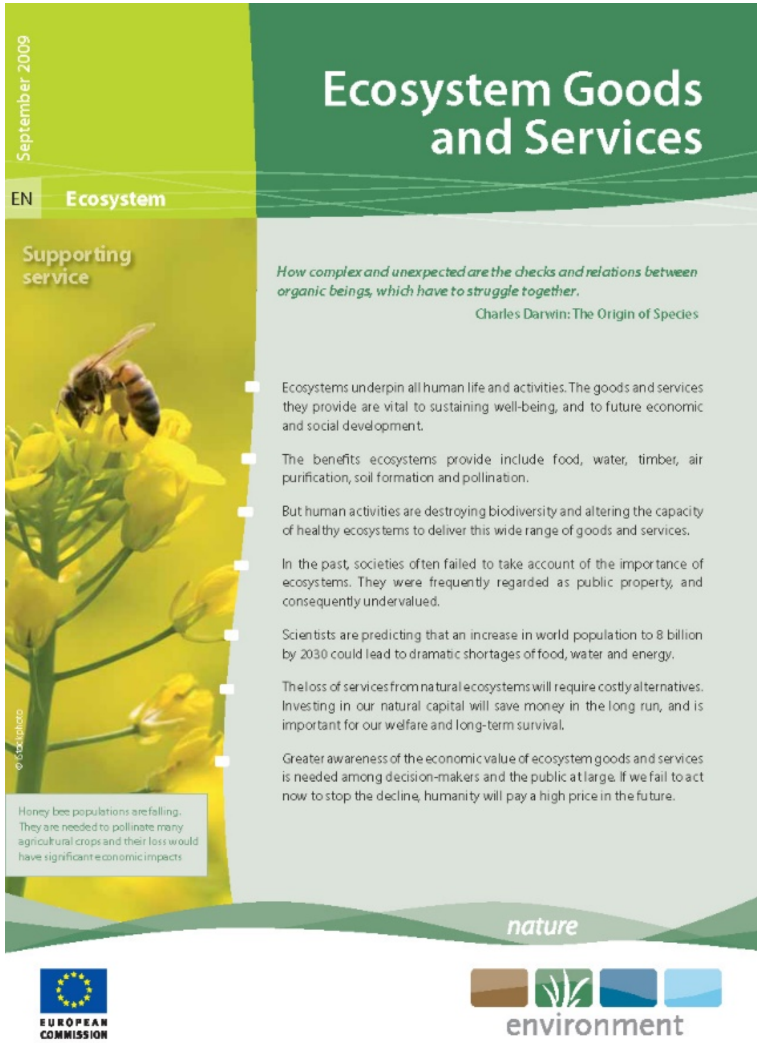
Urban green infrastructure in Europe: Is greenspace planning and policy compliant?

CrossMark

Clive Davies[a,c,*], Raffaele Lafortezza[a,b]

[a] Department of Agricultural and Environmental Sciences, University of Bari "A. Moro", Via Amendola 165/A, 70126 Bari, Italy
[b] Center for Global Change and Earth Observations (CGCEO), Michigan State University, East Lansing, MI, 48823, USA
[c] Department of Architecture, Planning & Landscape, Claremont Tower, Newcastle University, Newcastle upon Tyne, NE1 7RU, UK

ECOSYSTEM SERVICES



September 2009

EN Ecosystem

Supporting service

Ecosystem Goods and Services

How complex and unexpected are the checks and relations between organic beings, which have to struggle together.

Charles Darwin: The Origin of Species

Ecosystems underpin all human life and activities. The goods and services they provide are vital to sustaining well-being, and to future economic and social development.

The benefits ecosystems provide include food, water, timber, air purification, soil formation and pollination.

But human activities are destroying biodiversity and altering the capacity of healthy ecosystems to deliver this wide range of goods and services.

In the past, societies often failed to take account of the importance of ecosystems. They were frequently regarded as public property, and consequently undervalued.

Scientists are predicting that an increase in world population to 8 billion by 2030 could lead to dramatic shortages of food, water and energy.

The loss of services from natural ecosystems will require costly alternatives. Investing in our natural capital will save money in the long run, and is important for our welfare and long-term survival.

Greater awareness of the economic value of ecosystem goods and services is needed among decision-makers and the public at large. If we fail to act now to stop the decline, humanity will pay a high price in the future.

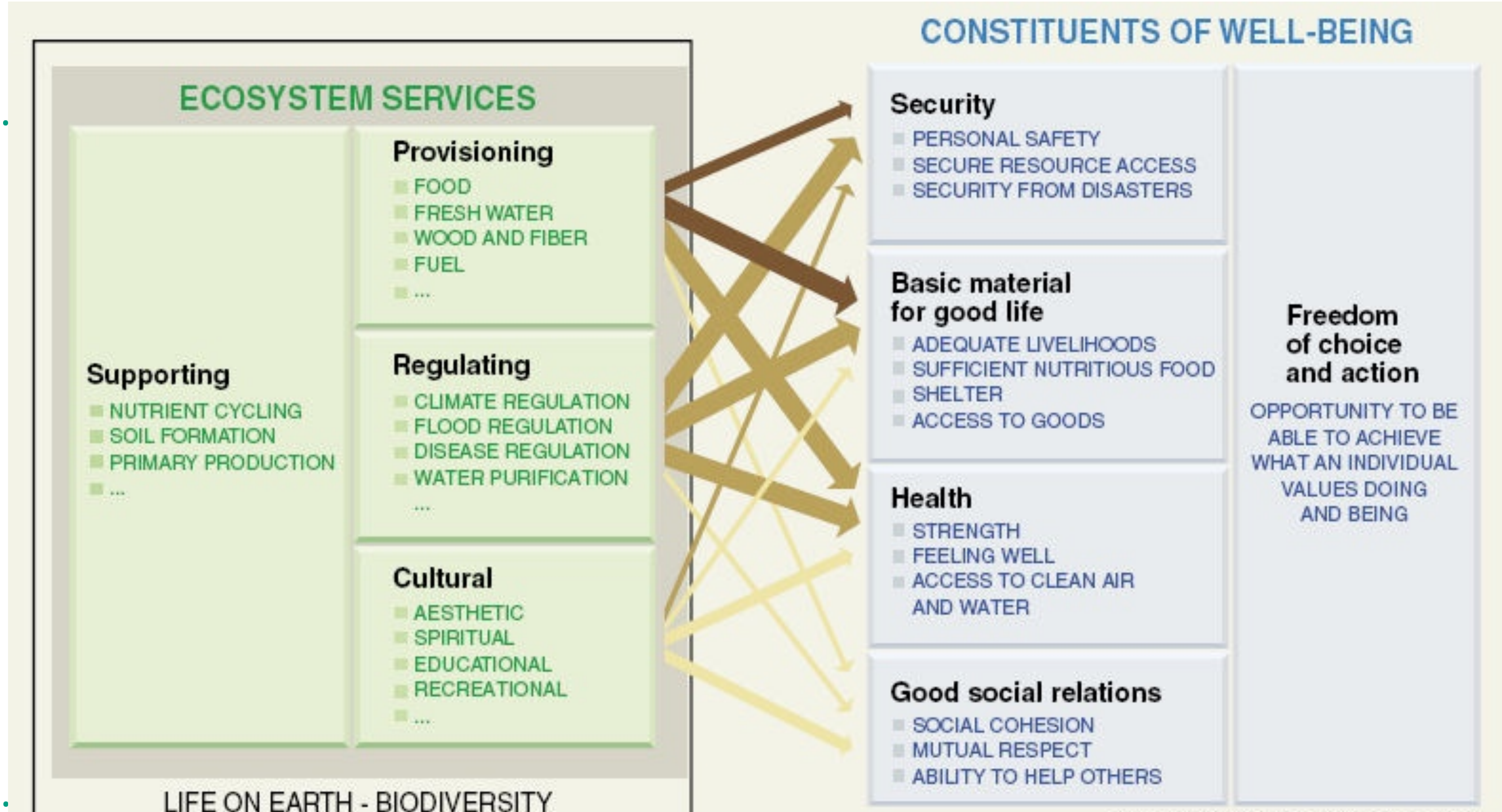
Honey bee populations are falling. They are needed to pollinate many agricultural crops and their loss would have significant economic impacts

nature

EUROPEAN COMMISSION

environment

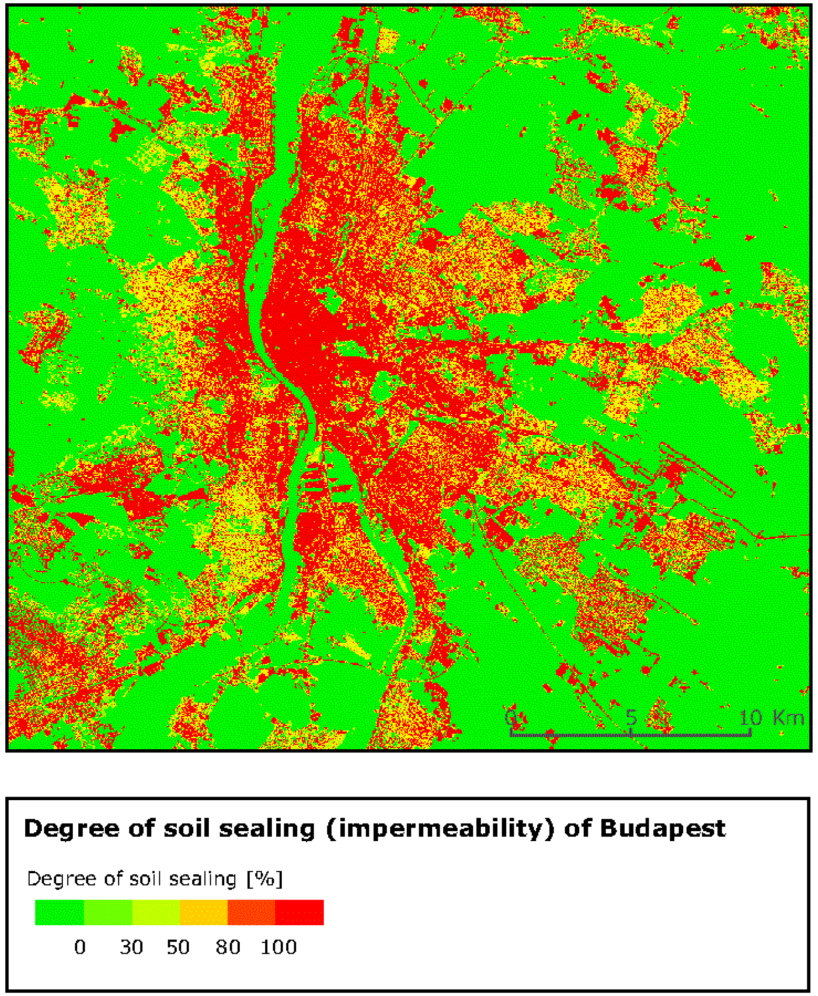
- Benefici multipli forniti dagli ecosistemi all'uomo (Millennium Ecosystem Assessment, 2005)
  - **Fornitura (approvvigionamento)**: forniscono i beni veri e propri, quali cibo, acqua, legname, fibre, combustibile e altre materie prime.
  - **Regolazione**: regolano il clima, la qualità dell'aria e le acque, la formazione del suolo, l'impollinazione, l'assimilazione dei rifiuti, e mitigano i rischi naturali quali erosione, infestanti ecc.
  - **Culturali**: includono benefici non materiali quali l'identità culturale, l'arricchimento spirituale e intellettuale e i valori estetici e ricreativi.
  - **Supporto**: comprendono la creazione di habitat e la conservazione della biodiversità genetica.

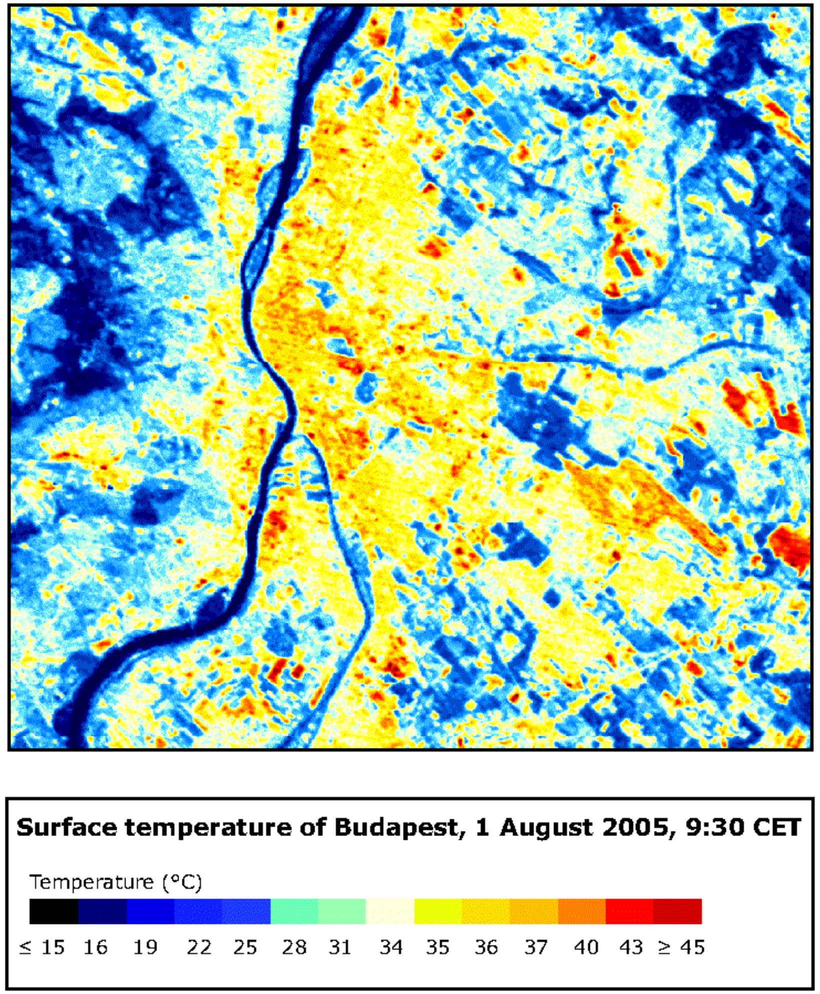


Source: Millennium Ecosystem Assessment

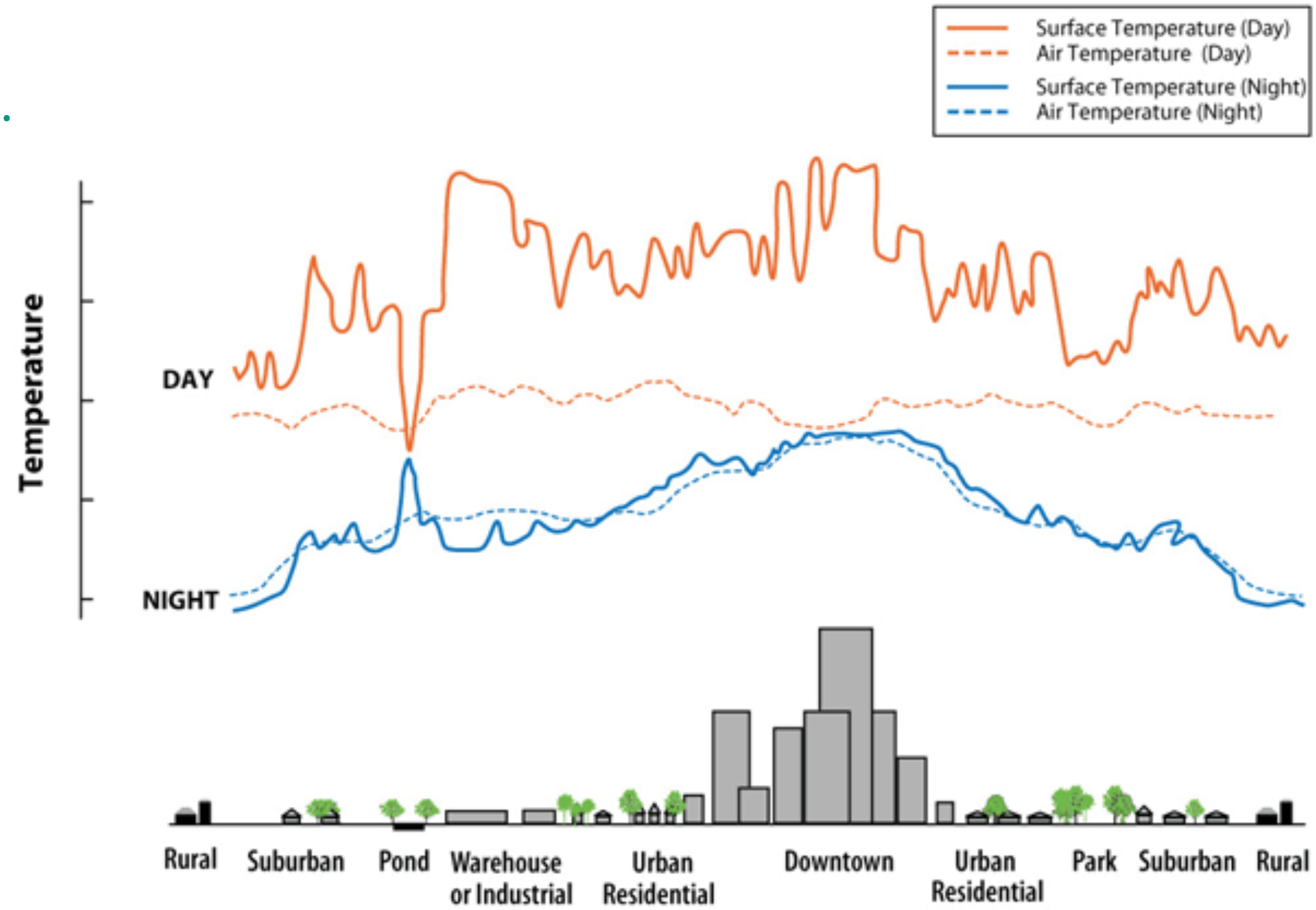
ECOSYSTEM SERVICES

Relazione tra grado di impermeabilizzazione del suolo e temperature medie al suolo nella città di Budapest, Ungheria (08/2005)





Source: Land use — SOER 2010 thematic assessment



Surface Temperature (Day)
Air Temperature (Day)
Surface Temperature (Night)
Air Temperature (Night)
Temperature
DAY
NIGHT
Rural
Suburban
Pond
Warehouse or Industrial
Urban Residential
Downtown
Urban Residential
Park
Suburban
Rural

GREEN INFRASTRUCTURE

June 2010

Green infrastructure

EN Nature

Europe's landscape has faced more habitat loss and fragmentation than any other continent. This is a major problem for biodiversity.

Although core nature areas are now largely protected under the Natura 2000 Network, species still need to be able to move between these areas if they are to survive in the long term.

A green infrastructure will help reconnect existing nature areas and improve the overall ecological quality of the broader countryside.

A green infrastructure will also help maintain healthy ecosystems so that they can continue to deliver valuable services to society such as clean air and fresh water.

Investing in a green infrastructure makes economic sense: maintaining nature's capacity, for instance in mitigating against the negative affects of climate change, is far more cost-effective than having to replace these lost services with much more costly man-made technological solutions.

A green infrastructure is best achieved through an integrated approach to land management and careful strategic spatial planning.

All land users and policy sectors should be engaged early on in the process of developing a green infrastructure and apportioned a share of the responsibility in its delivery.

The European Commission is developing a strategy for an EU-wide Green Infrastructure as part of its post-2010 biodiversity policy.

© iStockphoto

Rivers are an important element of green infrastructure

nature

- Una **rete di aree** naturali e semi-naturali pianificata a livello strategico con altri elementi ambientali, progettata e gestita in maniera da fornire un ampio spettro di **servizi ecosistemici** (Commissione Europea, 2010).

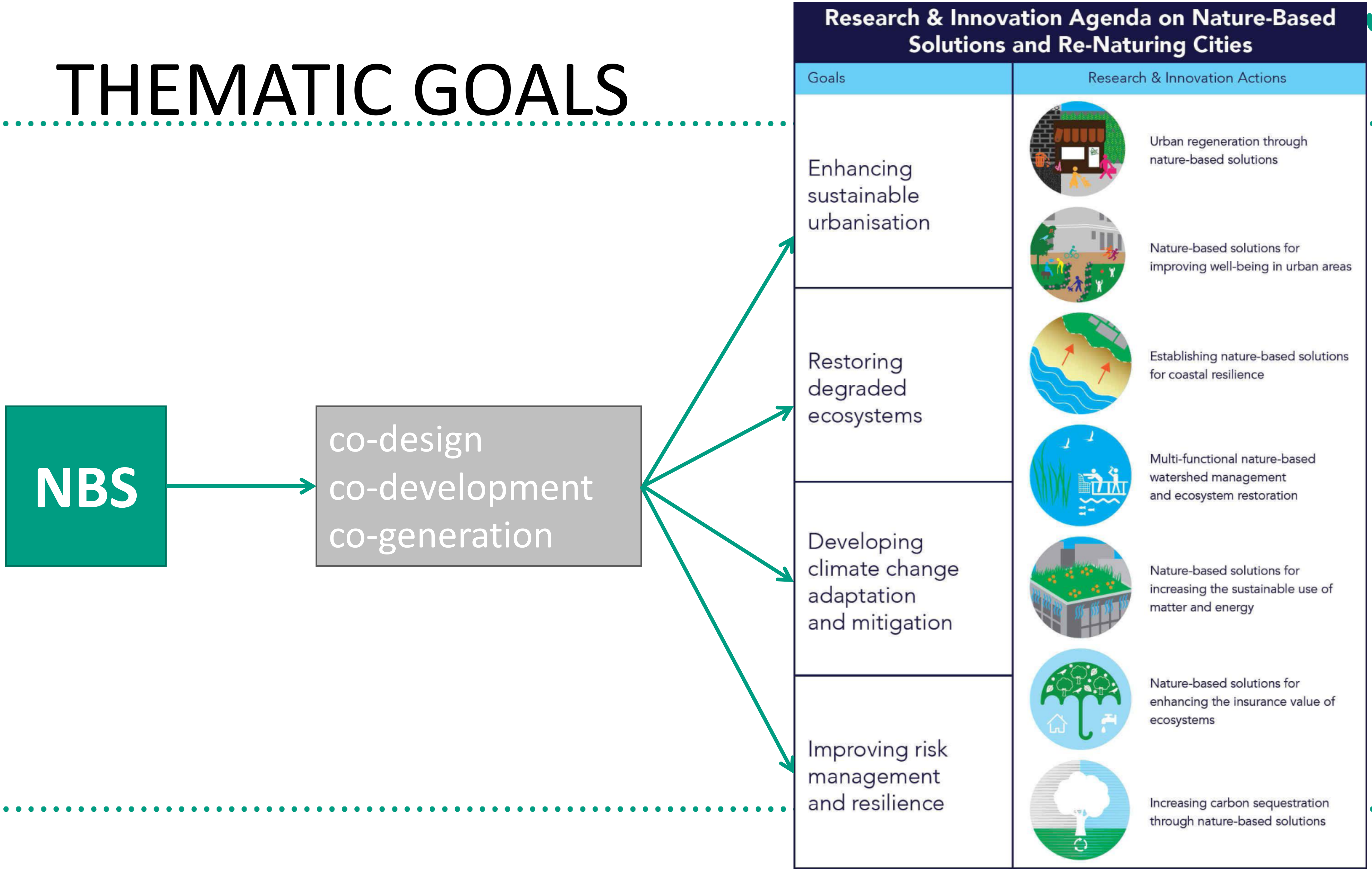
- Spazi aperti multi-funzionali, tra cui i parchi, giardini, boschi, corridoi verdi, corsi d'acqua, alberature stradali e spazi rurali, ecc.

NATURE-BASED SOLUTIONS (NBS)

- *Nature-based solutions are understood as living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits*

Source: EU-DG Research and Innovation, 2015

THEMATIC GOALS




BOSTON, USA


BOSTON, USA


CHICAGO, USA


中国人寿
NANJING, CHINA


BRUSSELS, BELGIUM


BRUSSELS, BELGIUM


EDINBURGH, SCOTLAND


MALMÖ, SWEDEN


LJUBLJANA, SLOVENIA


Guangzhou, China


Hangzhou, China

Hangzhou, China

Research & Innovation Agenda on Nature-Based Solutions and Re-Naturing Cities

Goals	Research & Innovation Actions
Enhancing sustainable urbanisation	Urban regeneration through nature-based solutions
	Nature-based solutions for improving well-being in urban areas
Restoring degraded ecosystems	Establishing nature-based solutions for coastal resilience
	Multi-functional nature-based watershed management and ecosystem restoration
Developing climate change adaptation and mitigation	Nature-based solutions for increasing the sustainable use of matter and energy
	Nature-based solutions for enhancing the insurance value of ecosystems
Improving risk management and resilience	Increasing carbon sequestration through nature-based solutions

Urban regeneration through nature-based solutions

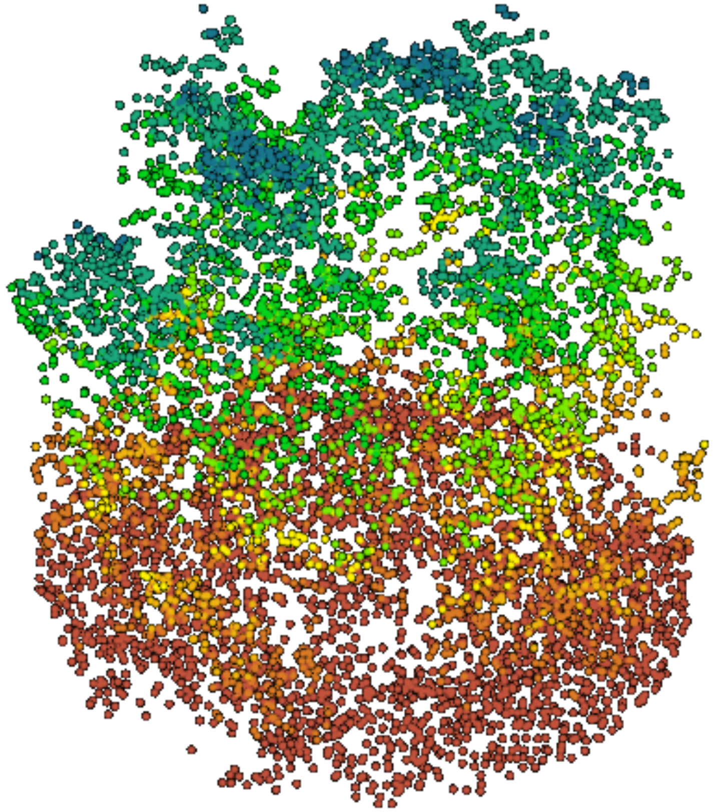
Changes in land use, neglected land and abandoned areas are challenges for many cities. Urban regeneration through nature-based solutions offers a context for innovative interventions for green growth.

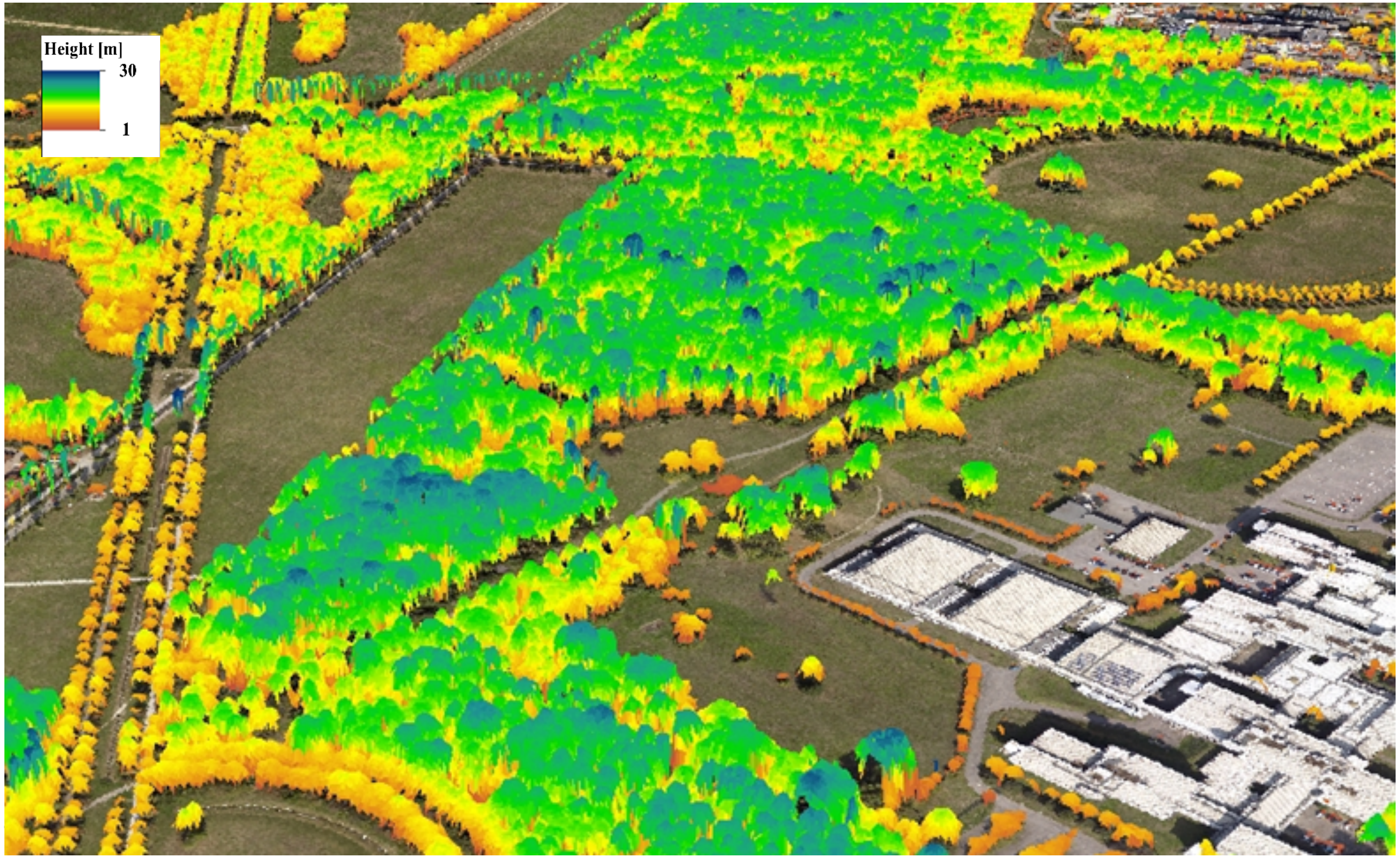
Nature-based solutions have an important role to play, for instance, through supporting the implementation and optimisation of green, blue and grey infrastructure. Green infrastructure can contribute to cutting energy and resource demands and costs, as trees provide cooling and insulation and reduce the urban heat island effect, and green roofs and green walls can decrease the need for heating and air conditioning. Co-benefits include reduced air pollution, flood control, and recreation. Planners are now seeking to exploit space more effectively through finding new uses for underused and unused land and grey infrastructure, often using nature-based solutions. The Promenade Plantée in Paris, where an elevated freight rail line was transformed into a park and plans for the use of underground space for underground parks in New York (Low Line)[19] are good examples. Possibilities for sustainable urban growth also can be found in the conversion of abandoned land into urban farms and community gardens and the regeneration of former factory sites through the bioremediation of toxic soils and subsequent transformation into green space. Parco Nord in Milan is just one of many examples.


MILANO, ITALY

PARCO NORD MILANO

PARCO NORD MILANO





Stand volume and biomass

remote sensing

MDPI

Article

Estimating Stand Volume and Above-Ground Biomass of Urban Forests Using LiDAR

Vincenzo Giannico [1,*], Raffaele Lafortezza [1,2], Ranjeet John [2], Giovanni Sanesi [1], Lucia Pesola [1] and Jiquan Chen [2]

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Academic Editors: Nicolas Baghdadi and Prasad S. Thenkabail

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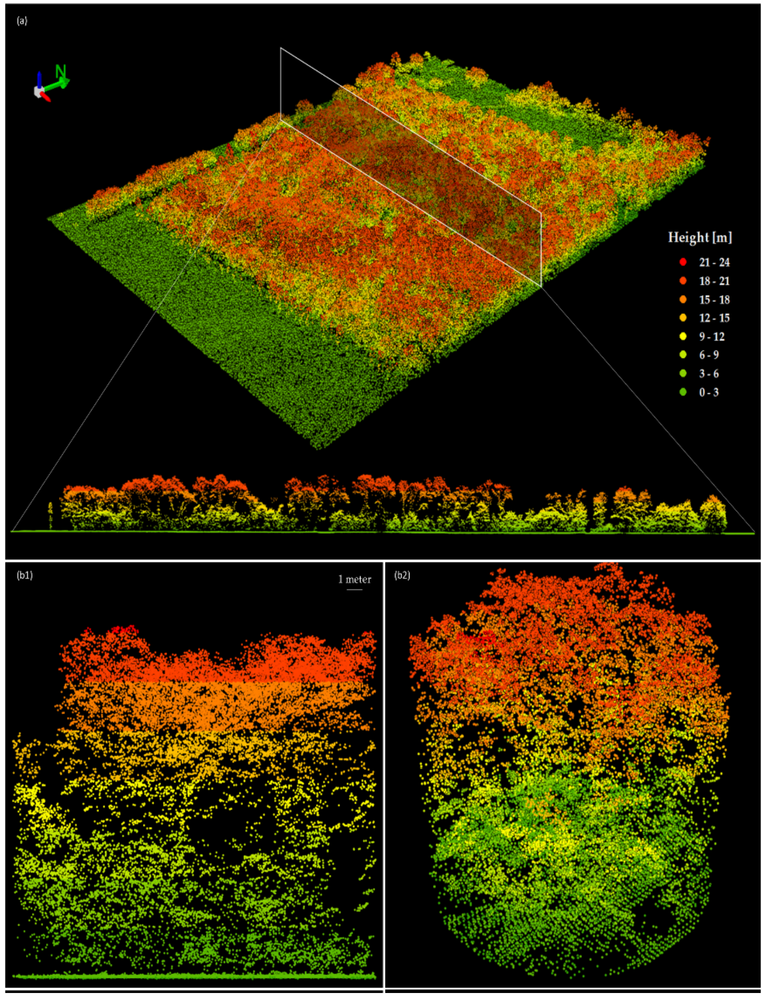
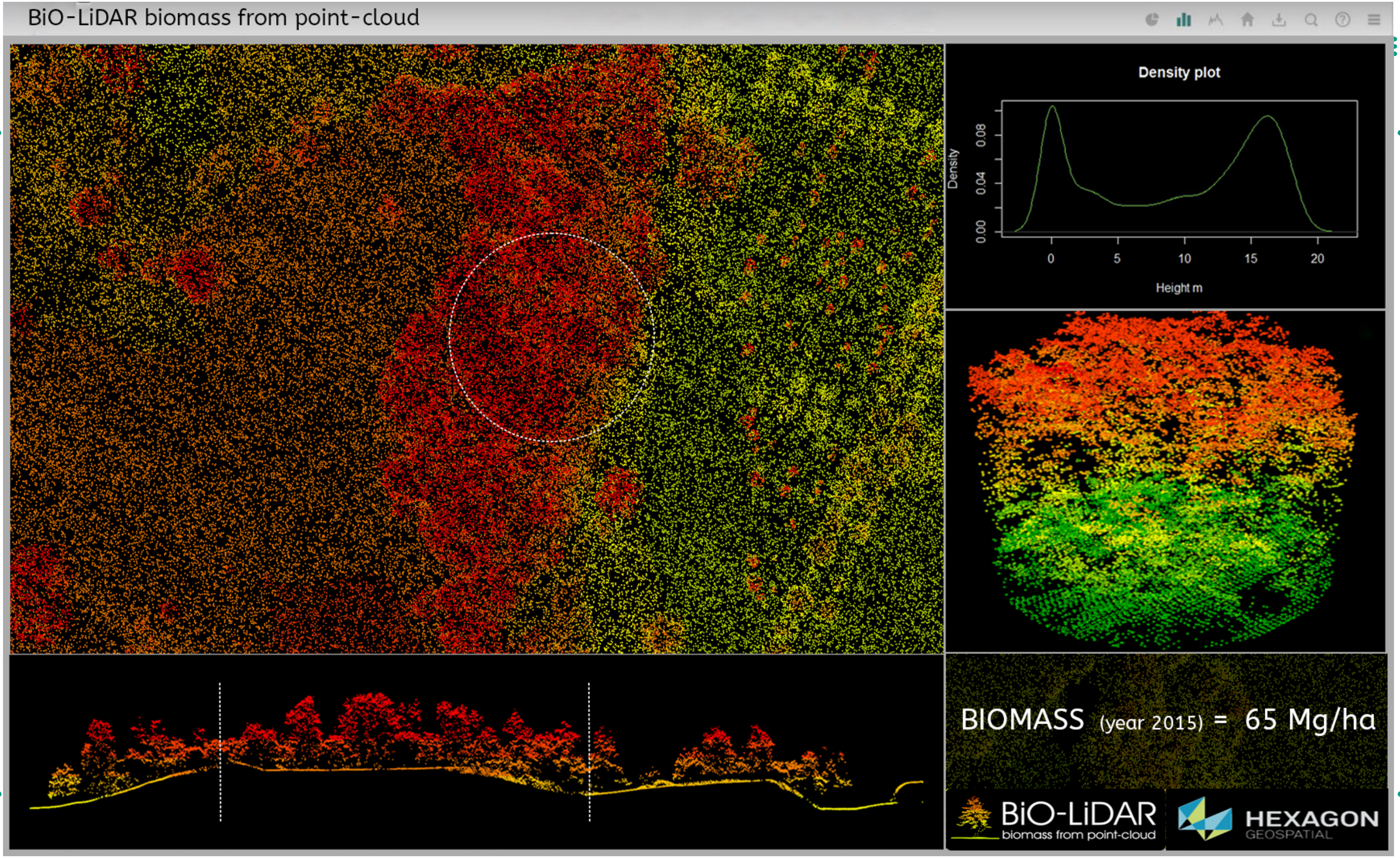
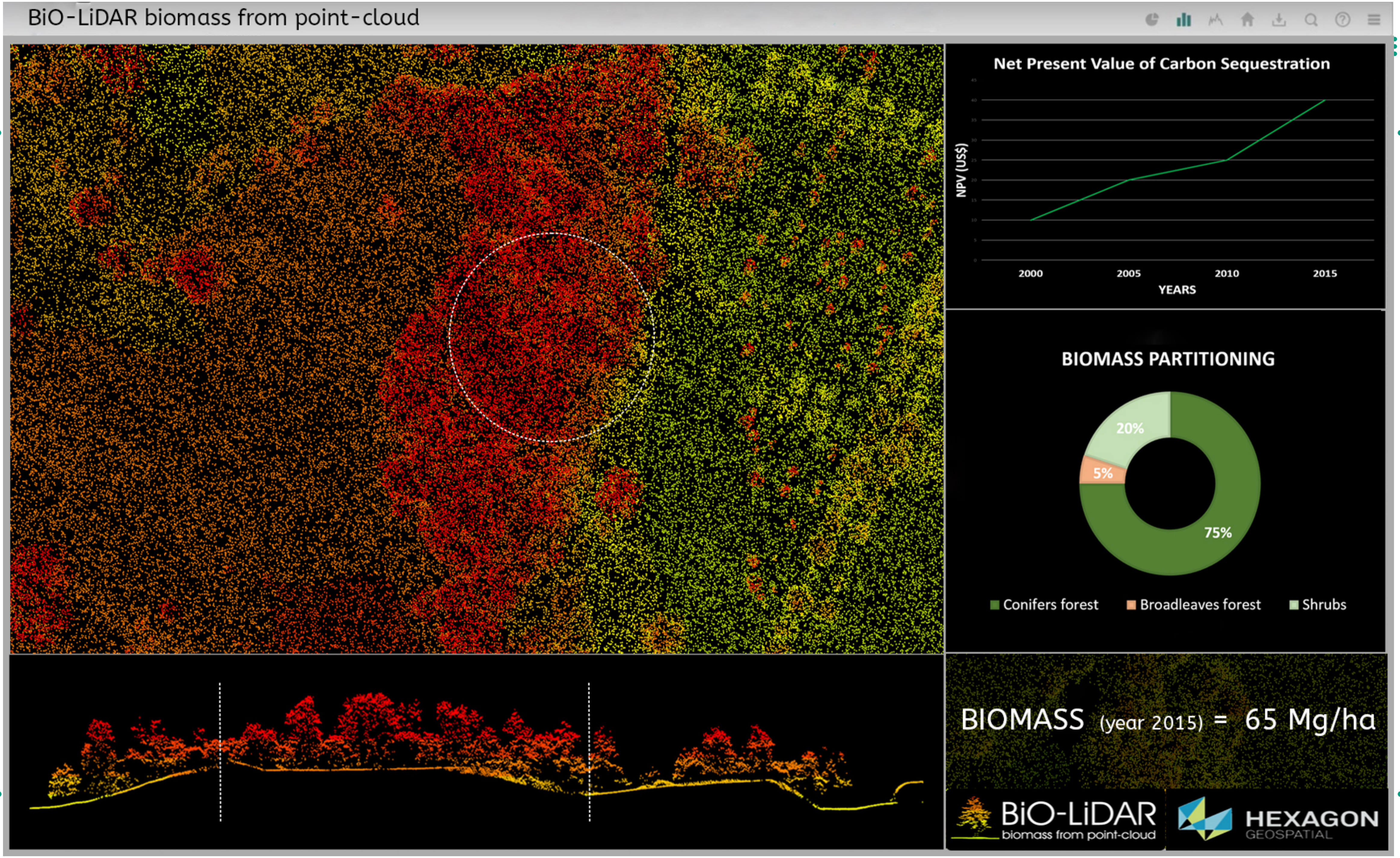



BiO-LiDAR biomass from point-cloud
Density plot
Density
0.00
0.04
0.08
0
5
10
15
20
Height m
BIOMASS (year 2015) = 65 Mg/ha
BiO-LiDAR
biomass from point-cloud
HEXAGON
GEOSPATIAL


BiO-LiDAR biomass from point-cloud
Net Present Value of Carbon Sequestration
NPV (US$)
2000
2005
2010
2015
YEARS
BIOMASS PARTITIONING
20%
5%
75%
Conifers forest
Broadleaves forest
Shrubs
BIOMASS (year 2015) = 65 Mg/ha
BiO-LiDAR
biomass from point-cloud
HEXAGON
GEOSPATIAL

Modeling LiDAR point-cloud

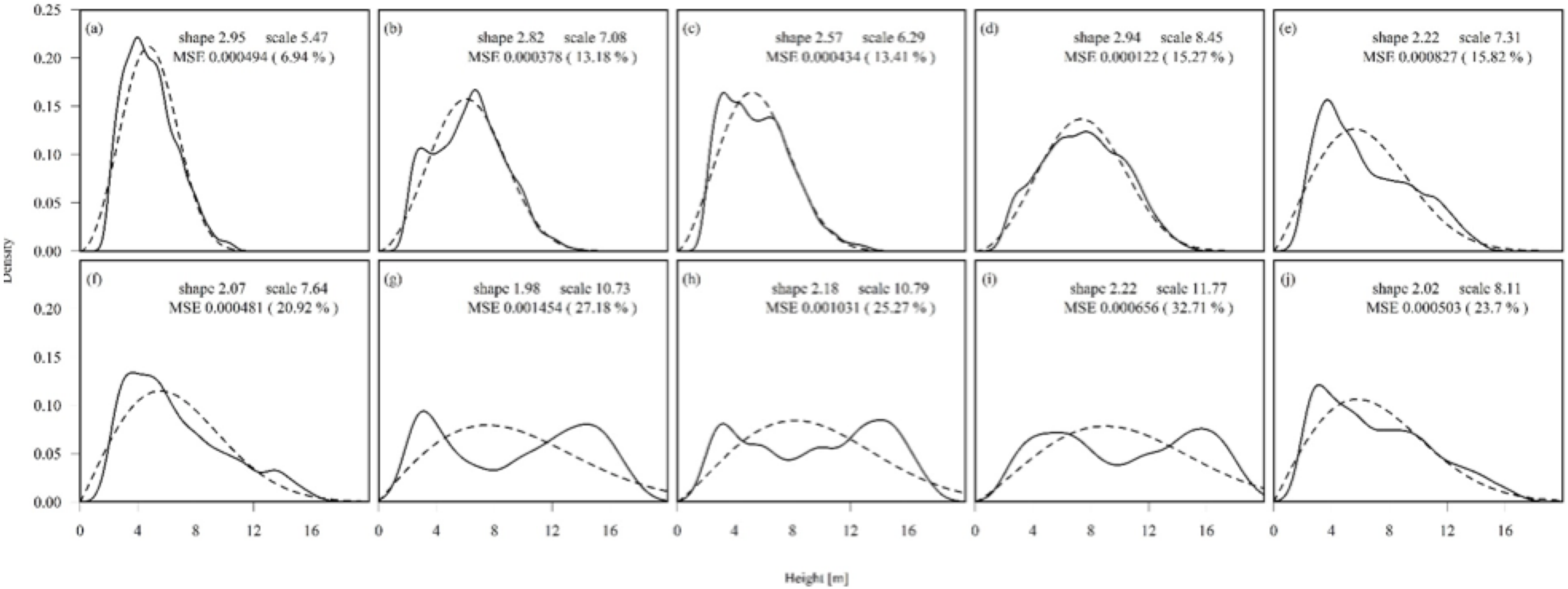


Figure 4. Fitted Weibull distribution for each plot: (a) plot 28C (12 years), (b): 25A (16), (c): 23b (17), (d): 18C (20); (e): 14A (21); (f): 9A (25); (g): 2A (28); (h): 2AND (28); (i): 1A (29); (j): 1D (29). Solid line represent the height distribution of LiDAR points belonging to all return except the first. Dashed line represent the fitted Weibull distribution. Parameters and Mean Squared Error are shown for each fit.

Modeling LiDAR point-cloud

Table 3. R^2, AIC, RMSE and RMSEcv of the best models for selected models. RMSE is expressed in m^3ha^{-1} for VOL and in [Mg ha^{-1}] for AGB. (i) Indicates the presence of an interaction term.

Response variable	Model	R^2	AIC	RMSE	RMSEcv
ln VOL [m^3ha^{-1}]	**ln $wb_{nofirst}$ + ln $Perc_{first}95$**	**0.81**	**4.59**	**23.66 (23.3%)**	**32.86 (32.3%)**
	ln $A_{nofirst}0\_10$ + ln $Perc_{first}90$	0.76	6.81	26.19 (25.7%)	35.64 (35%)
	ln $wb_{nofirst}$ + ln $Perc_{first}95$ (i)	0.81	6.58	23.67 (23.3%)	34.1 (33.5%)
	ln $A_{nofirst}0\_20$ + ln $Perc_{first}95$ (i)	0.84	4.71	20.18 (19.8%)	33.9 (33.3%)
ln AGB[$Mgha^{-1}$]	**ln $wb_{nofirst}$ + ln $Perc_{first}95$**	**0.77**	**4.8**	**19.59 (23.9%)**	**26.89 (32.9%)**
	ln $A_{nofirst}0\_10$ + ln $Perc_{first}90$	0.72	6.81	21.52 (26.3%)	28.76 (35.1%)
	ln $wb_{nofirst}$ + ln $Perc_{first}95$ (i)	0.77	6.79	19.63 (24%)	27.81 (34%)
	ln $A_{nofirst}0\_20$ + ln $Perc_{first}95$ (i)	0.80	5.31	17.97 (22%)	31.11 (38%)

Awarded by Hexagon Geospatial (2017)

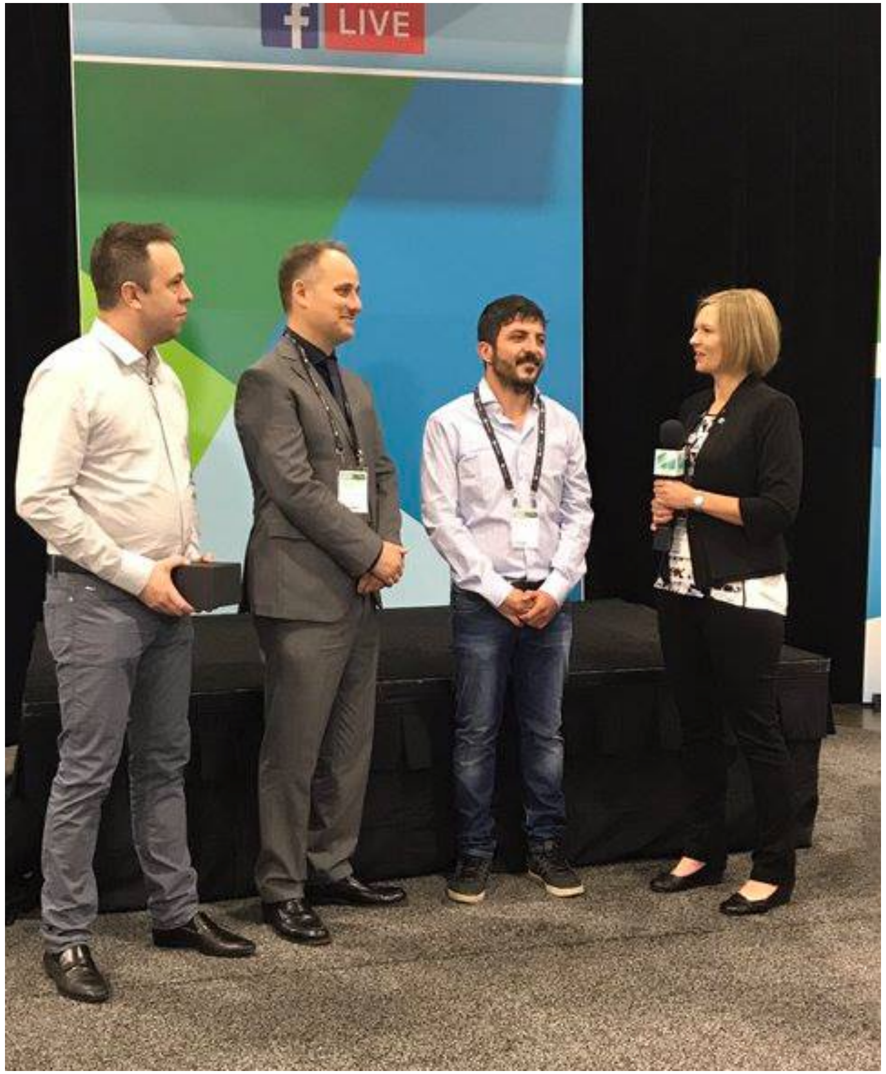
The Winning Project is...

Vincenzo Giannico (PhD Student) and his Advisor Prof. **Raffaele Lafortezza** from the University of Bari, Italy, in cooperation with Michigan State University, for their research in biomass estimation in urban areas from LiDAR. This group of researchers developed an innovative methodology for the biomass estimation in urban areas from LiDAR (laser scanner) data and the results were published in the Remote Sensing (April 2016) magazine. The study was made over an urban forest plantation located in the metropolitan area of Milan, Northern Italy: Parco Nord Milano. The analysis processes were conducted using Hexagon Geospatial software. The methodology developed includes two main steps: data production and modeling. LiDAR classification, orthorectification of multispectral imagery, DTM extraction, and quality control were some of the functionalities used in ERDAS IMAGINE. Statistics from the results of ERDAS IMAGINE were used in conjunction with statistical analysis open source software to derive the results. Through the development of ad hoc mathematical models, it was possible to estimate the amount of biomass present in the study area. This study has great potential for future applications in the estimation of carbon sinks in urban areas.

Winners of the 2017 HxGN LIVE EDU Contest 0

http://blog.hexagongeospatial.com/2017-hxgn-live-edu-contest/

Awarded by Hexagon Geospatial (14/06/2017)



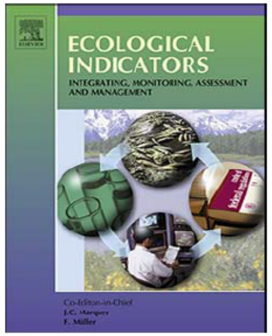
http://blog.hexagongeospatial.com/2017-hxgn-live-edu-contest/

CATEGORIA ES		Pineta di San Francesco alla Rena	Giardini di Pane e Pomodoro	Parco Perotti	Parco Due Giugno	Lama Balice	Orto urbano via Pappacena	Parco Don Tonino Bello	Giardino Riccardo Cucciolla	Giardini di Piazza Umberto I	Giardino Piazza I. d'Aragona
Approvvigionament	Agricoltura urbana										
	Regimazione delle acque meteoriche										
	Stoccaggio e assorbimento del carbonio										
Regolazione	Protezione contro l'erosione e mantenimento della fertilità del suolo										
	Mitigazione degli effetti delle isole di calore										
	Riduzione del rumore										
	Purificazione dell'aria										
Culturali	Benessere psico-fisico										
	Apprezzamento estetico, identità storica, opportunità ricreative										
Supporto	Ripristino e mantenimento degli habitat e della biodiversità										
	Impollinazione e dispersione dei semi a beneficio di aree verdi circostanti										

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind



Combining high-resolution images and LiDAR data to model ecosystem services perception in compact urban systems

Raffaele Lafortezza[a,b,*], Vincenzo Giannico[a]

[a] *Department of Scienze Agro-Ambientali e Territoriali, Università degli Studi di Bari "A. Moro", Via Amendola 165/A 70126 Bari, Italy*
[b] *Center for Global Change and Earth Observations (CGCEO), Michigan State University, East Lansing, MI, 48823 USA*


BARI, ITALY
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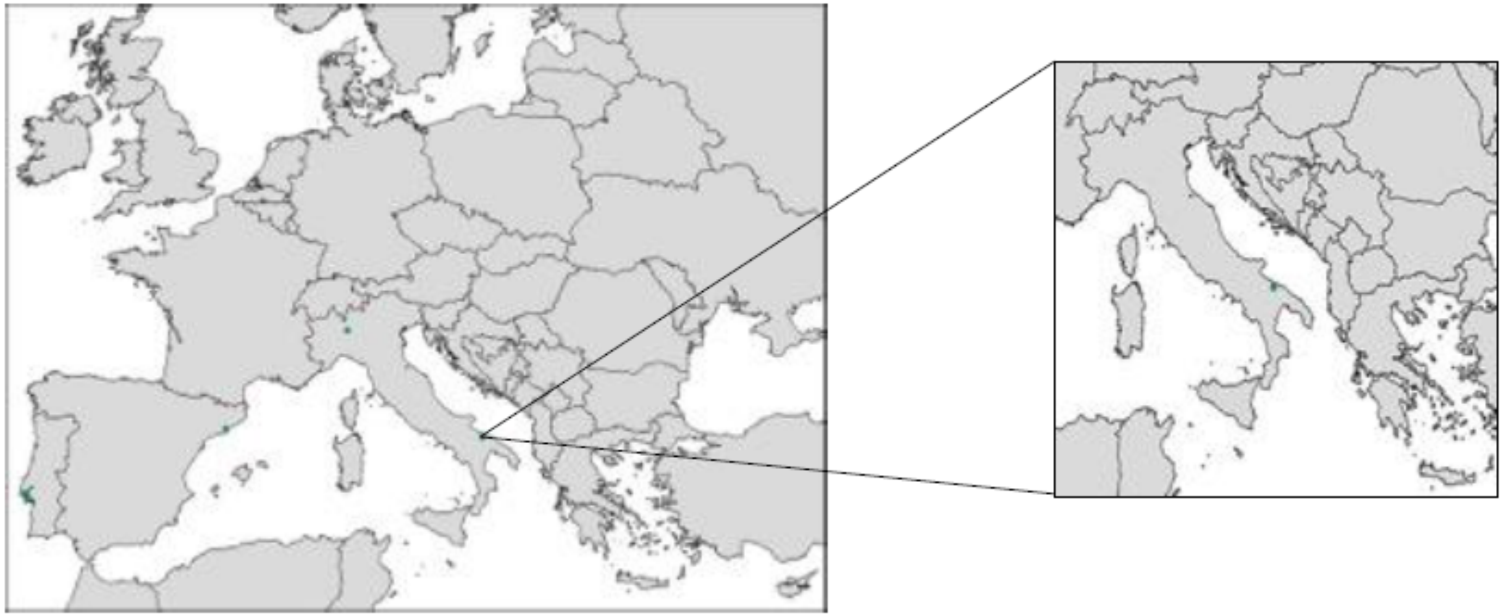
1) INTRODUCTION: Facts and Figures

Core city	Bari	**Biogeographic region**	Mediterranean
Region	Apulia	**Planning family**	Mediterranean/ Urbanism
Area ▪ Core city ▪ Larger urban zone	 11 471 ha 89 763 ha	**Population** (2012) ▪ Core city ▪ Larger urban zone	 313 213 577 283
Average annual population change rate (1991-2012; Core city)	-0.4	**Public recreational green space per capita** (2006, Core city; m² per inhabitants)	5.57

Location Map




BARI, ITALY

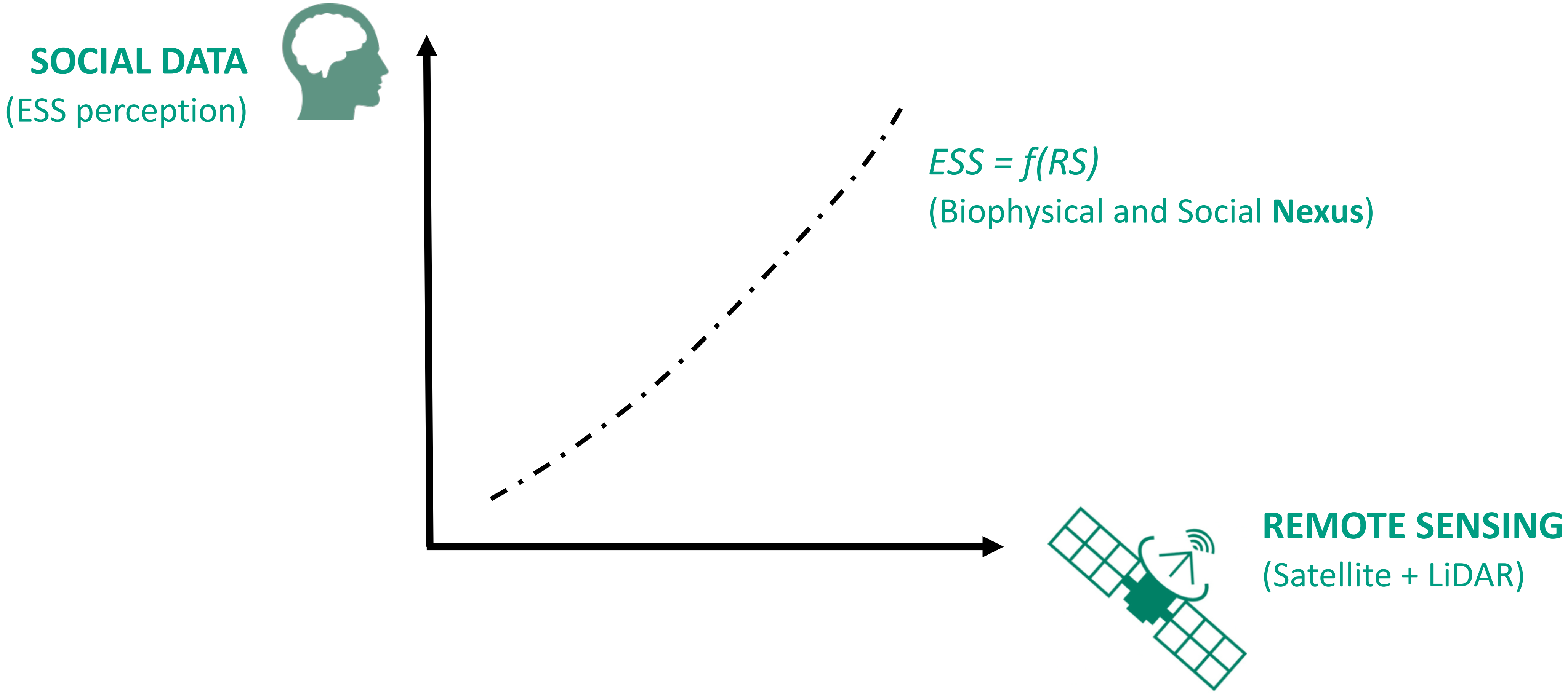
Case Study City Portrait; part of a GREEN SURGE study on urban green infrastructure planning and governance in 20 European cities

In cooperation with: Anna Maria Curcuruto, Laura Casanova, and Cesare Trematore; Municipality of Bari

Main Authors: Yole DeBellis, Marinella Spanò, Giovanni Sanesi, Raffaele Lafortezza
Università degli Studi di Bari 'Aldo Moro' (UNIBA), Italy

1.0 • February 5th 2015

MAIN HYPOTHESIS



SATELLITE

- Sensor: **WorldView-2**
- Date: 09/06/2014
- Bundle (panchromatic + multispectral 8 bands)
- Spectral resolution: 0.5 m panchromatic, 2 m multispectral
- Study area: Bari (274 kmq)

planetek italia

Preciso® italia

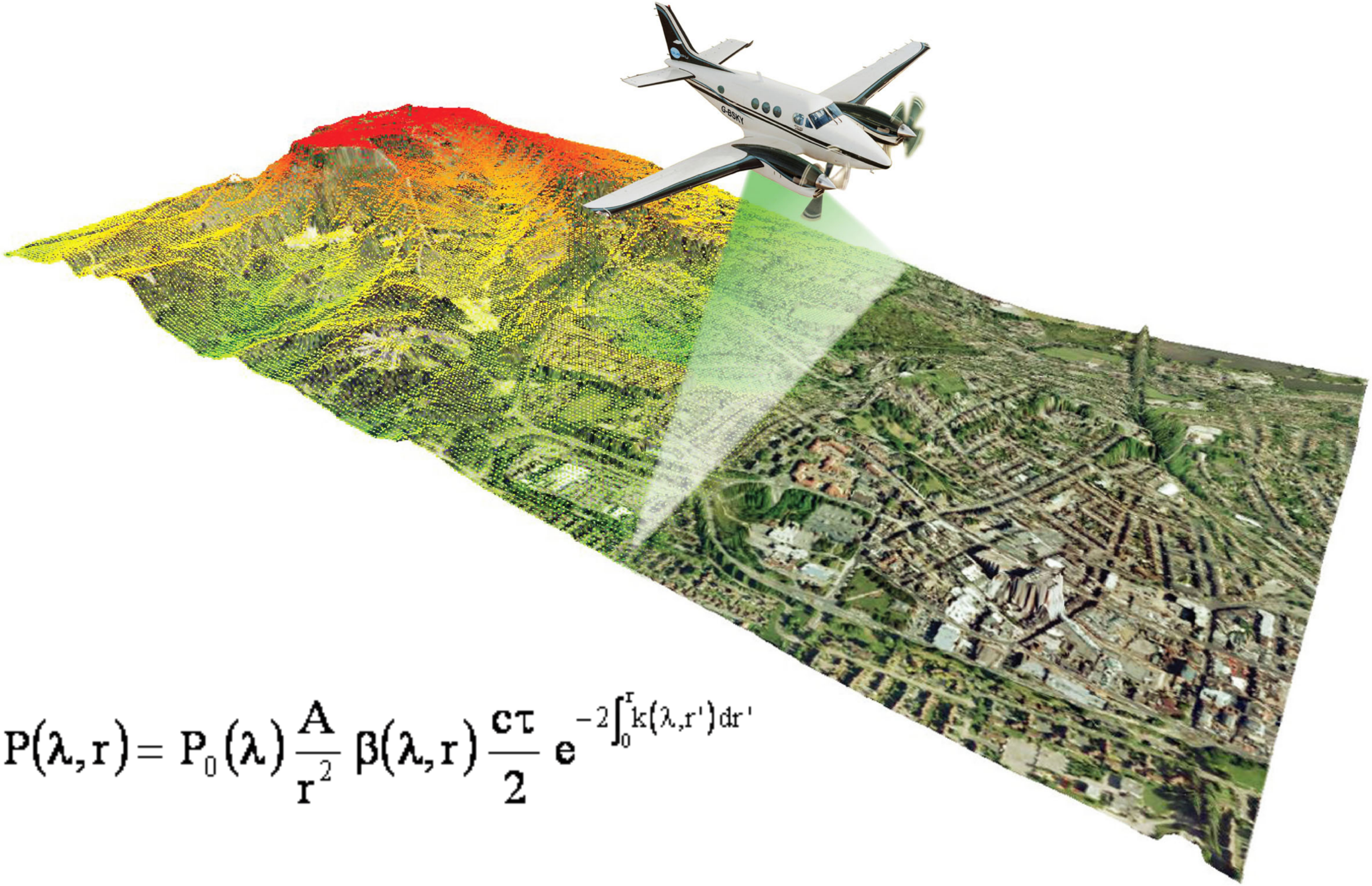
LiDAR (point-cloud)

- Sensor: **RIEGL LMS-Q680i**
- Date: 10-14/05/2014
- Point density: **5 points/m2**
- N°: 23 strips
- Flight: 3000 ft
- Scan mode: line
- Study area: Bari (274 kmq)

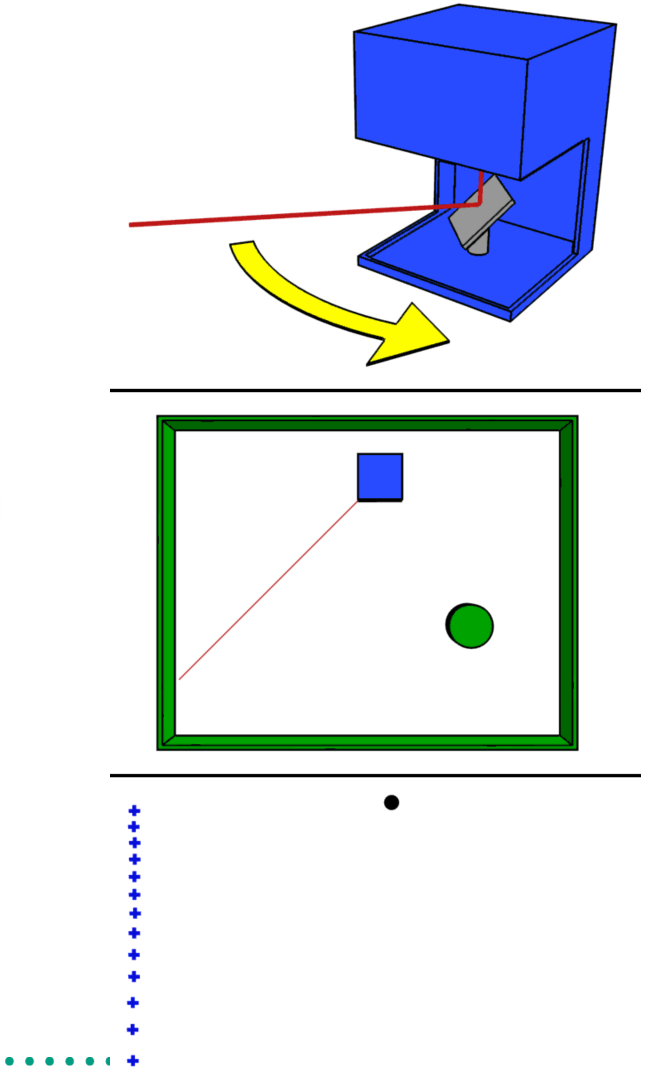
SIT SERVIZI DI INFORMAZIONE TERRITORIALE

AEROSIGMA

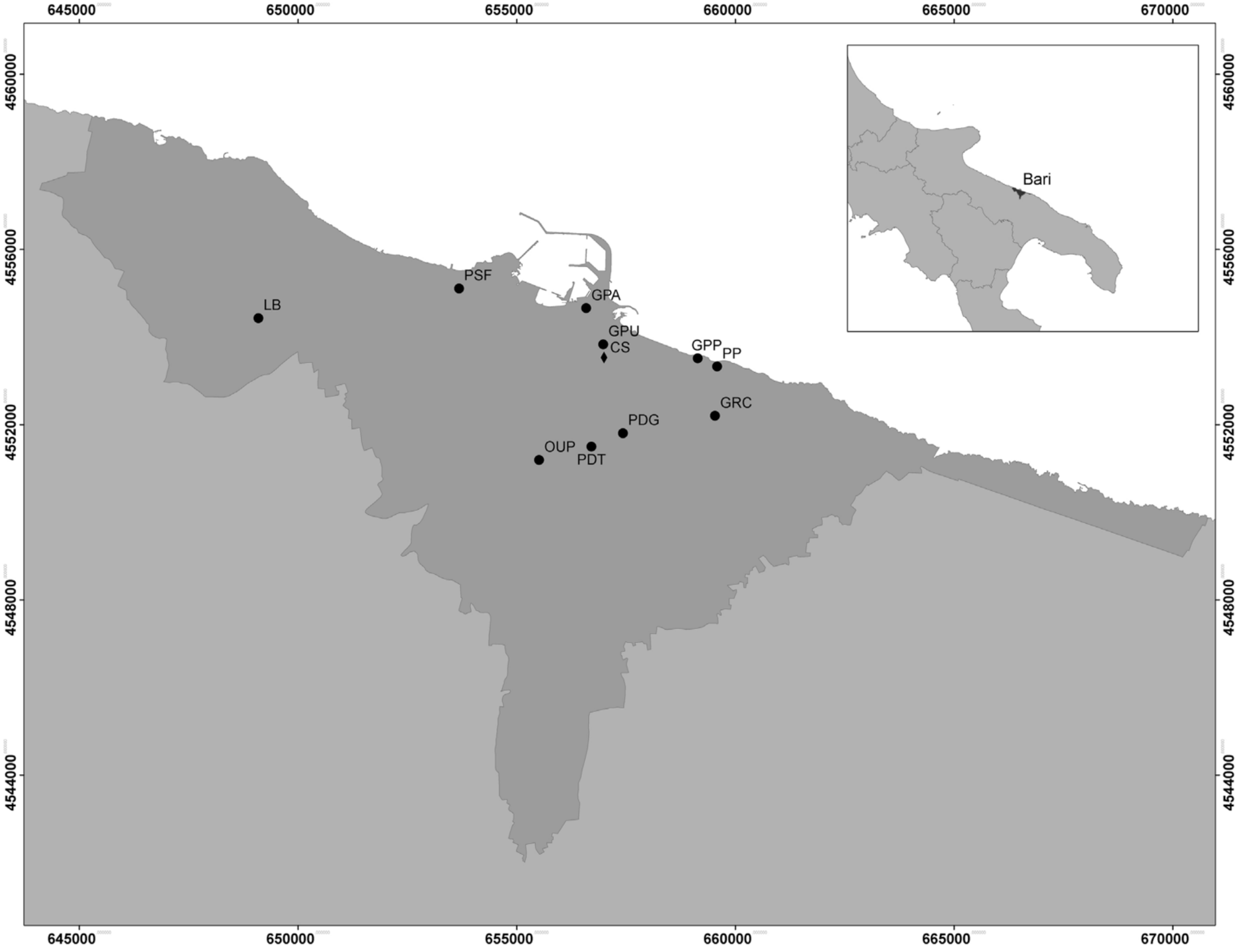
Laser Imaging Detection and Ranging (LiDAR)



$$P(\lambda,r) = P_0(\lambda)\,\frac{A}{r^2}\,\beta(\lambda,r)\,\frac{c\tau}{2}\,e^{-2\int_0^r k(\lambda,r')\,dr'}$$



GREEN SPACES IN BARI

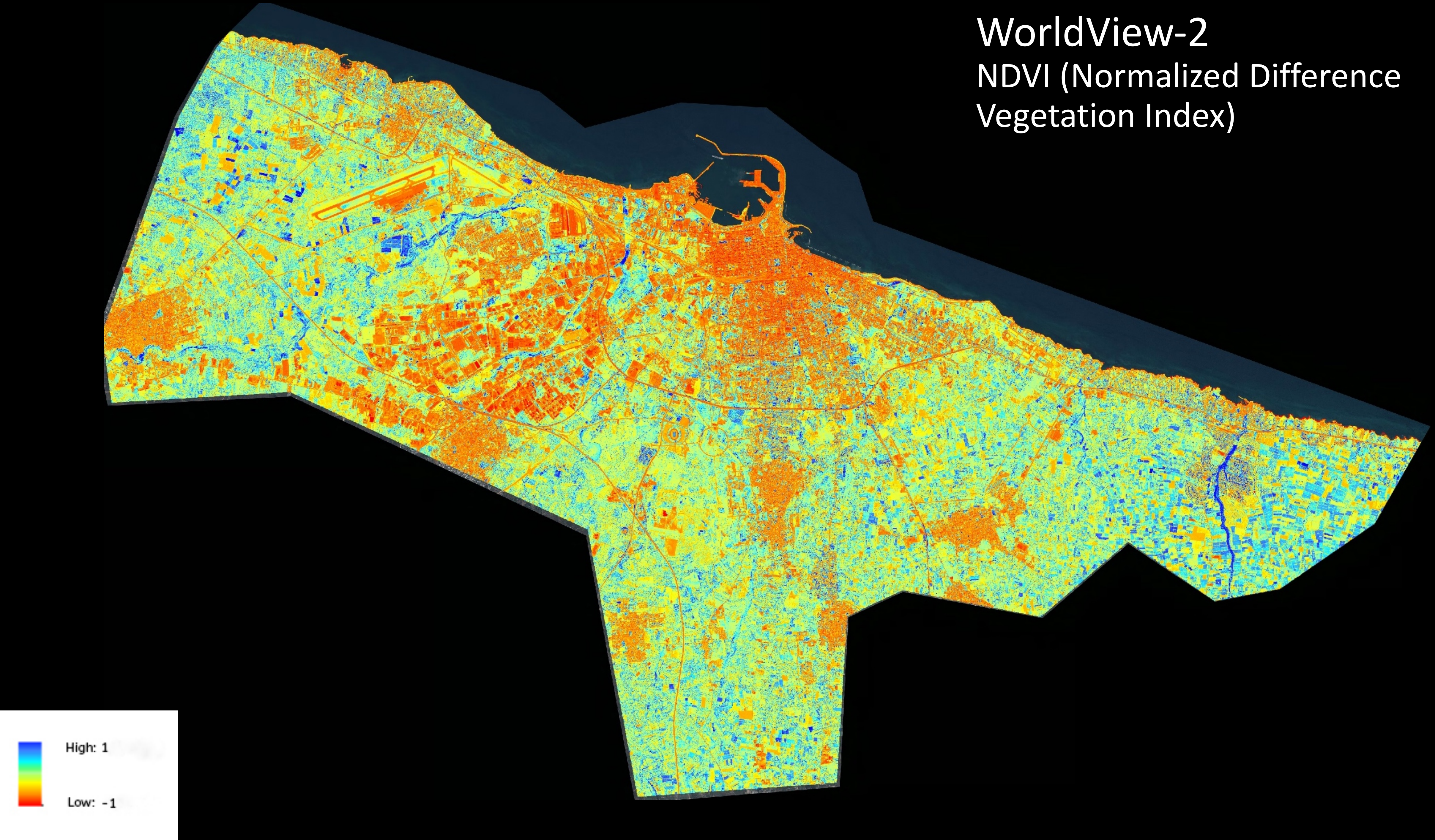


Code	Green space name	Typology	Size (ha)
OUP	Orto Urbano Pappacena	District/community garden	3.74
GRC	Giardino Riccardo Cucciolla	District/community garden	0.62
GPA	Giardino Piazza d'Aragona	Historical garden	0.50
PDT	Parco Don Tonino Bello	District/community garden	1.25
GPU	Giardini Piazza Umberto I	Historical garden	1.88
PDG	Parco Due Giugno	Urban park	5.72
PP	Parco Perotti	Coastal park	5.99
GPP	Giardini di Pane e Pomodoro	Coastal park	7.19
PSF	Pineta di San Francesco	Urban park	8.12
LB	Lama Balice	Periurban park	75.99

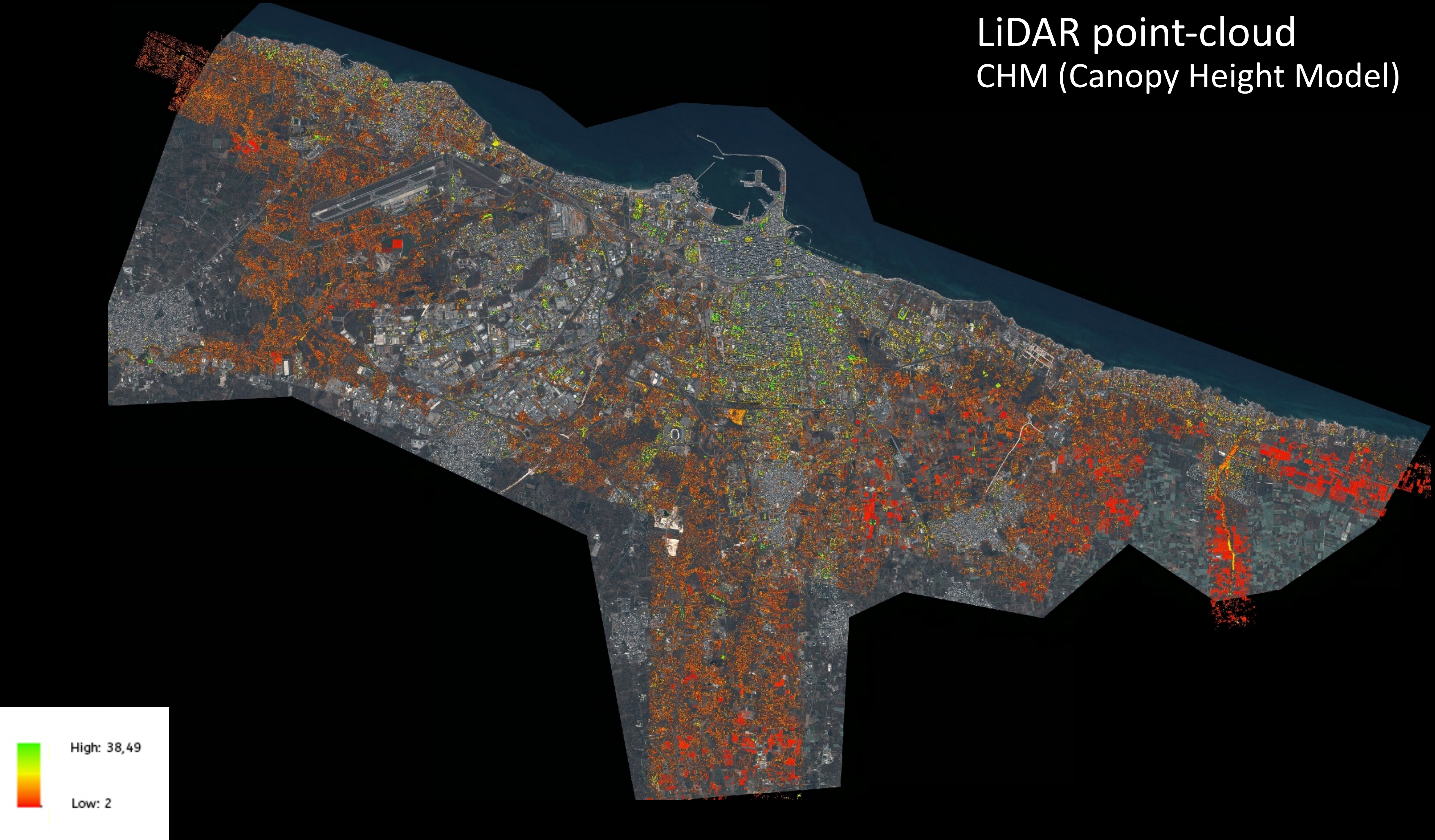
Fig. 1. Map of the study location – City of Bari within the context of Southern Italy (box). Each green space is indicated by a dot on the map; the rhombus refers to the central station (CS). The following acronyms are explained in Table 1: GPA, Giardino Piazza d'Aragona; GPP, Giardini di Pane e Pomodoro; GPU, Giardini Piazza Umberto I; GRC, Giardino Riccardo Cucciolla; LB, Lama Balice; OUP, Orto Urbano Pappacena; PDG, Parco Due Giugno; PDT, Parco Don Tonino Bello; PP, Parco Perotti; PSF, Pineta di San Francesco.

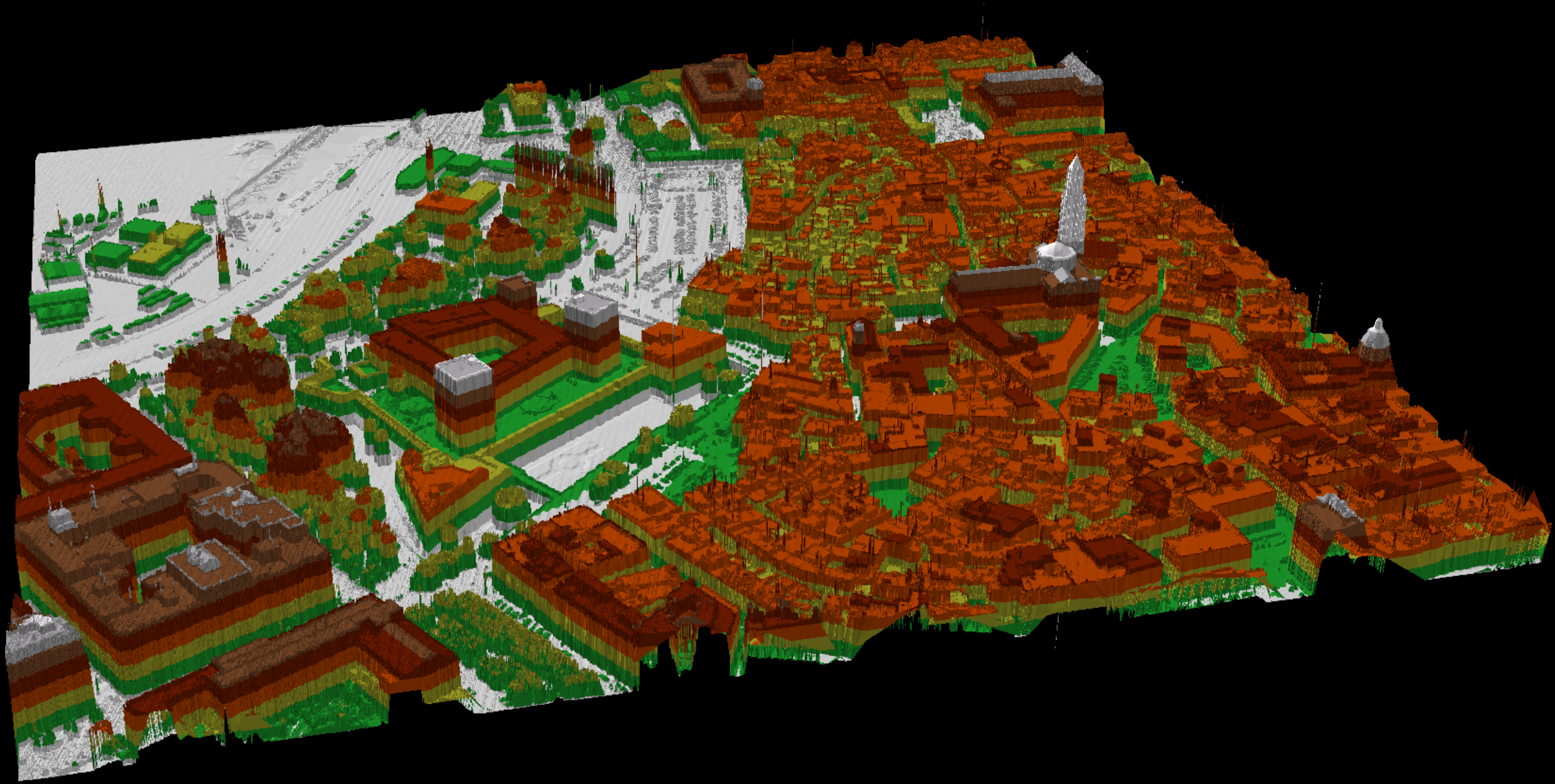
WorldView-2

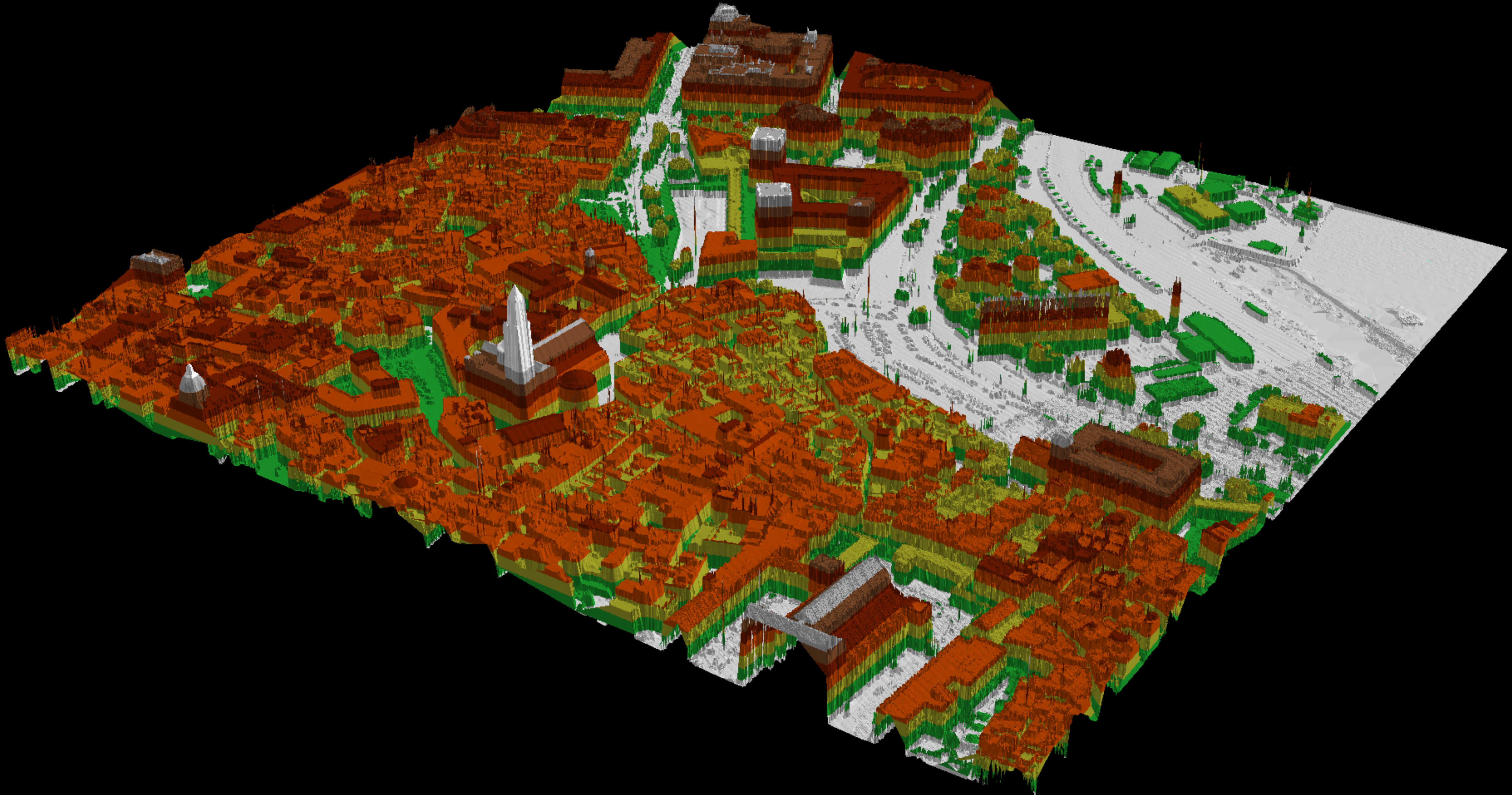
WorldView-2
NDVI (Normalized Difference Vegetation Index)

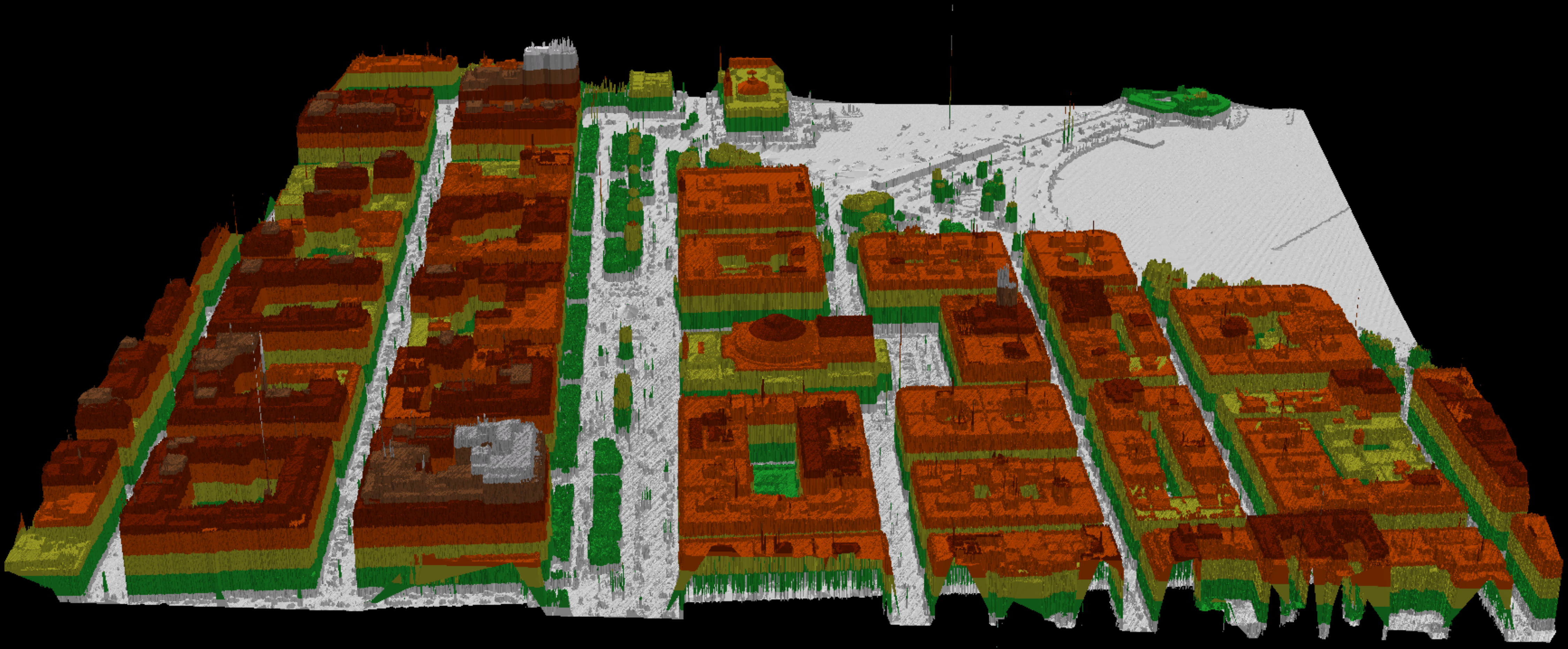


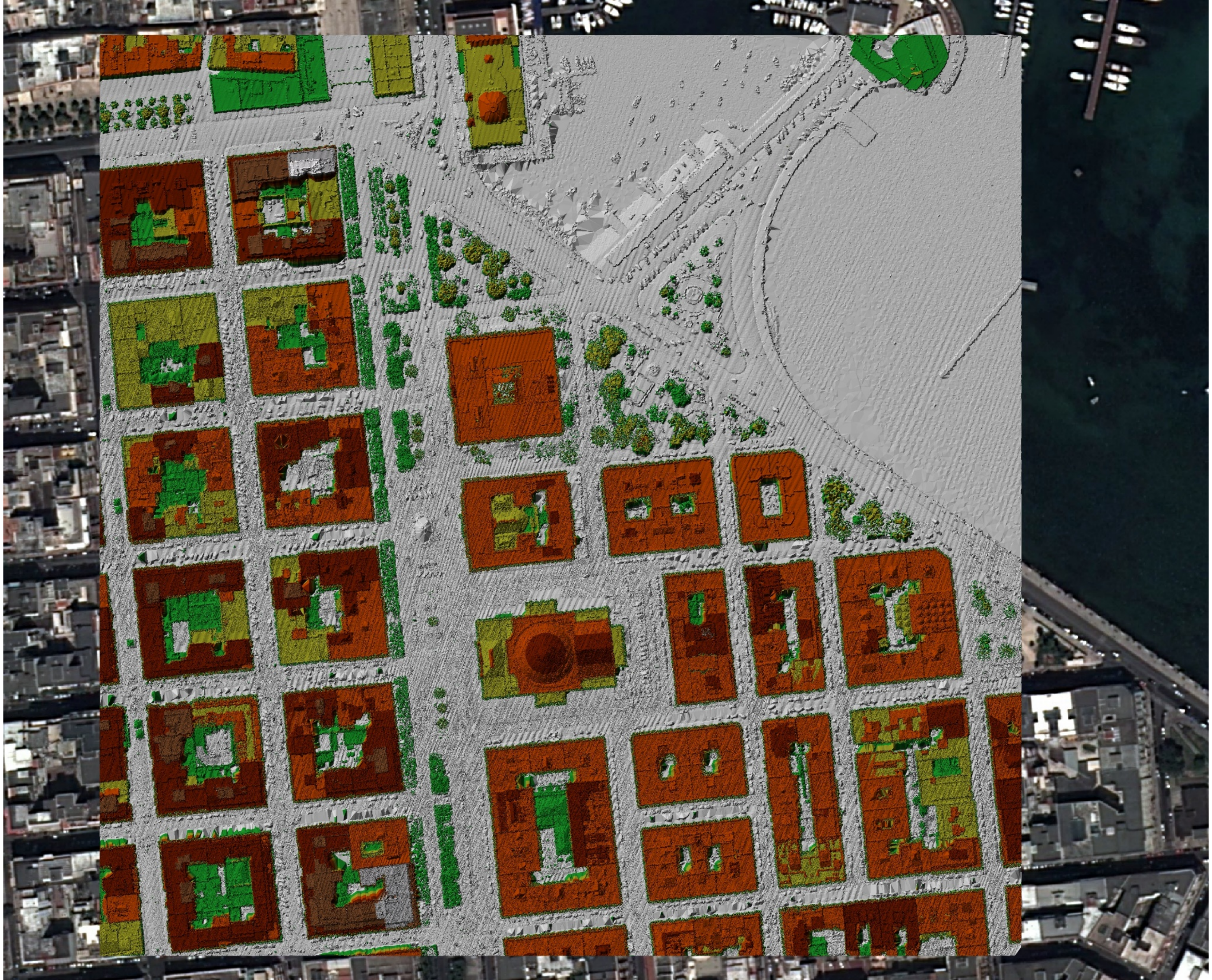
LiDAR point-cloud
CHM (Canopy Height Model)



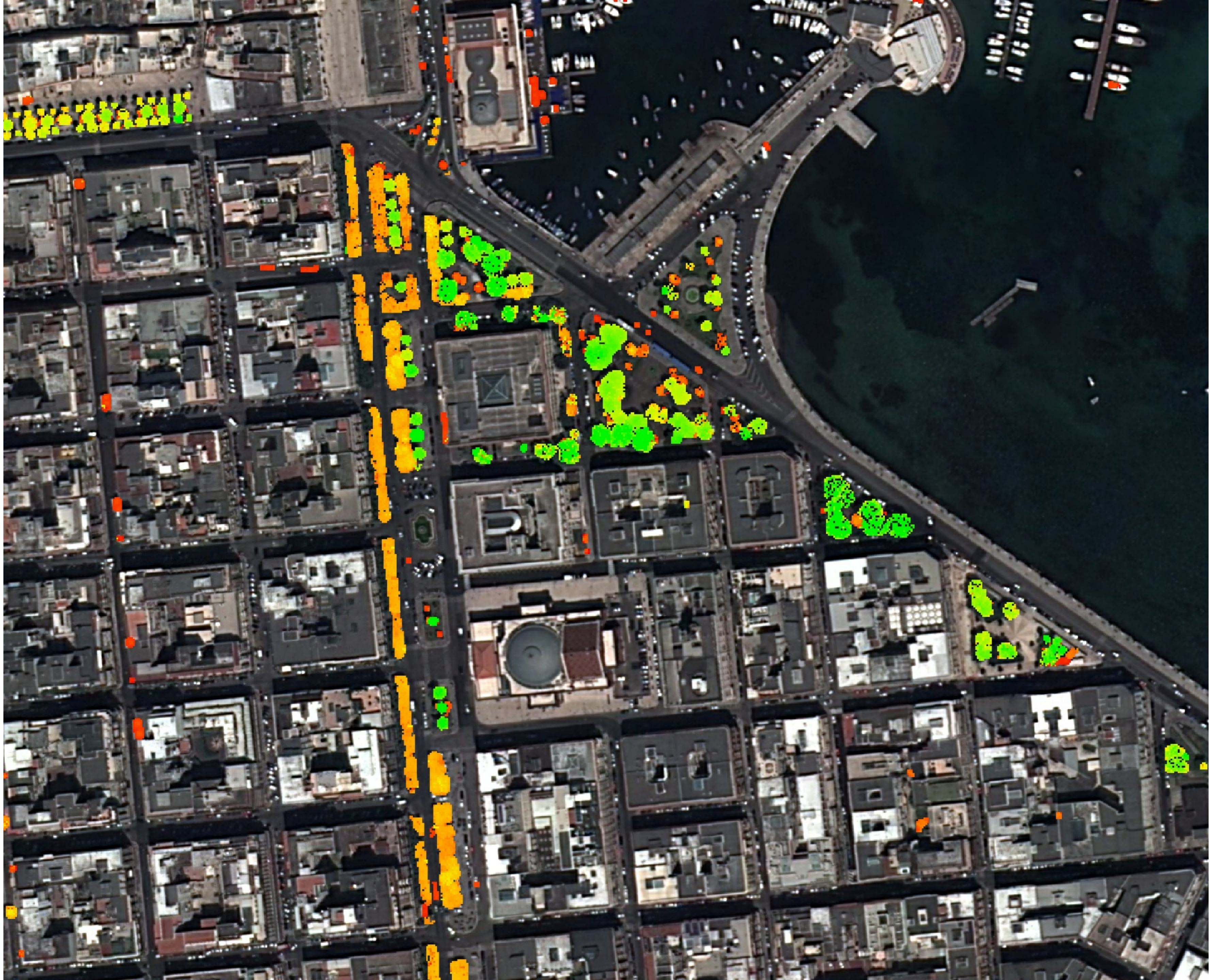






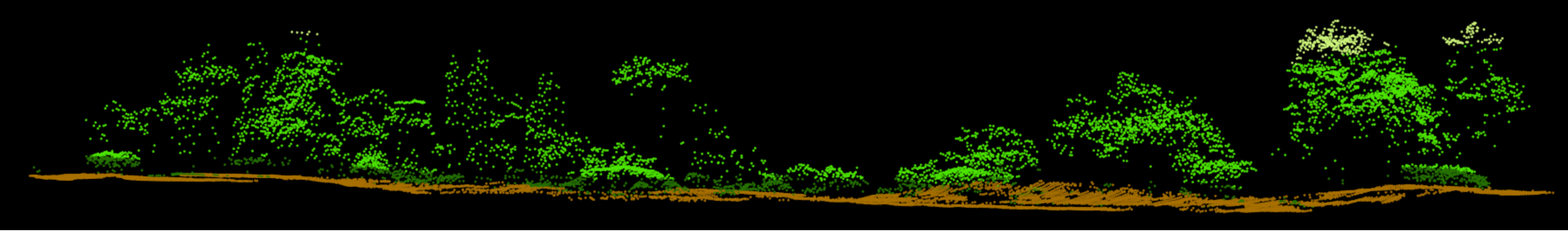


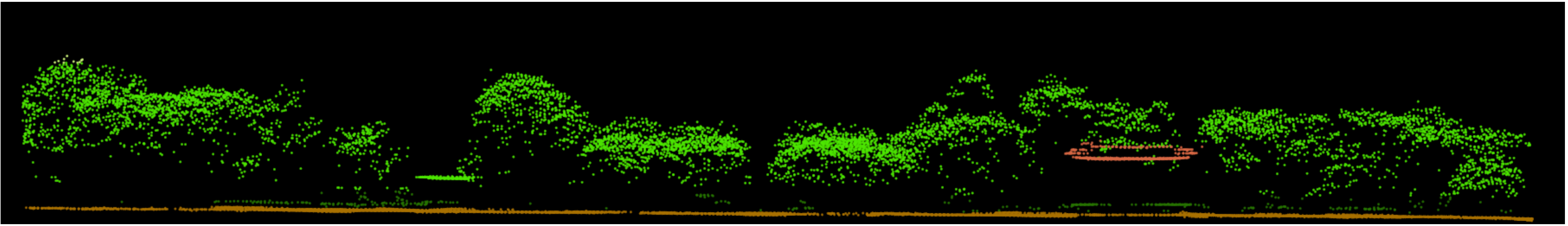
LiDAR
CHM

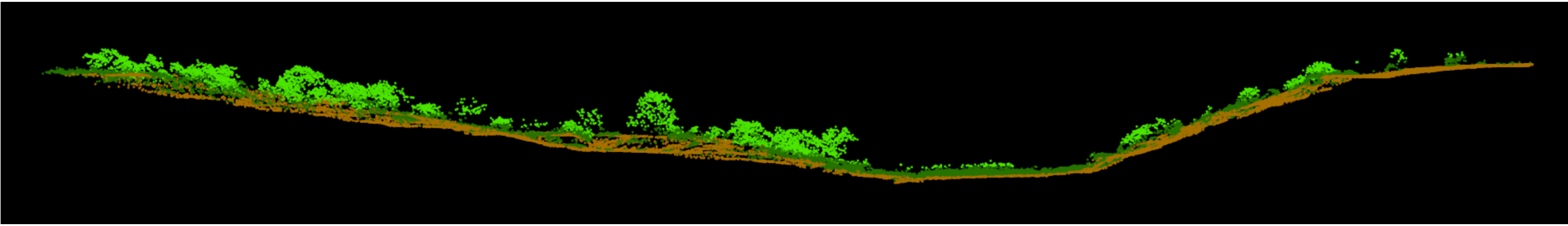


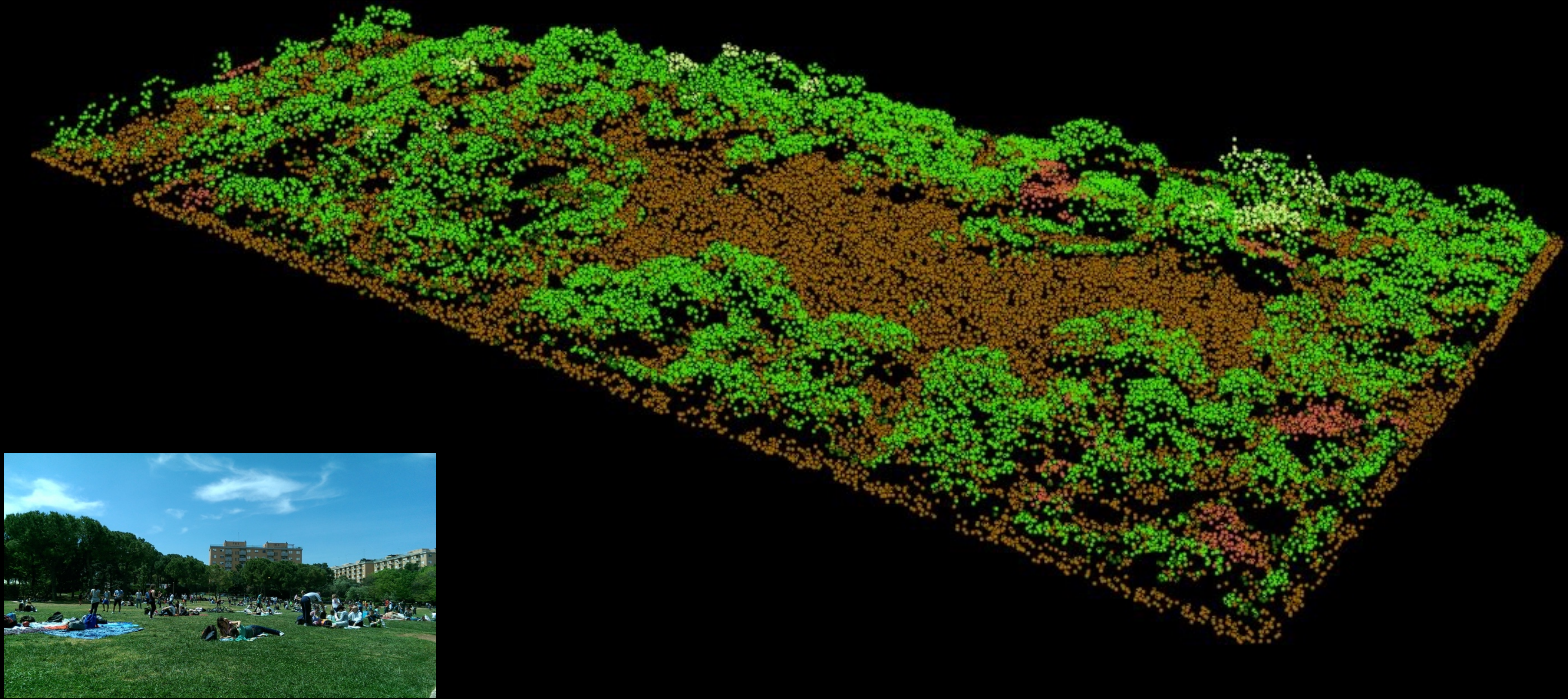
WorldView-2
NDVI

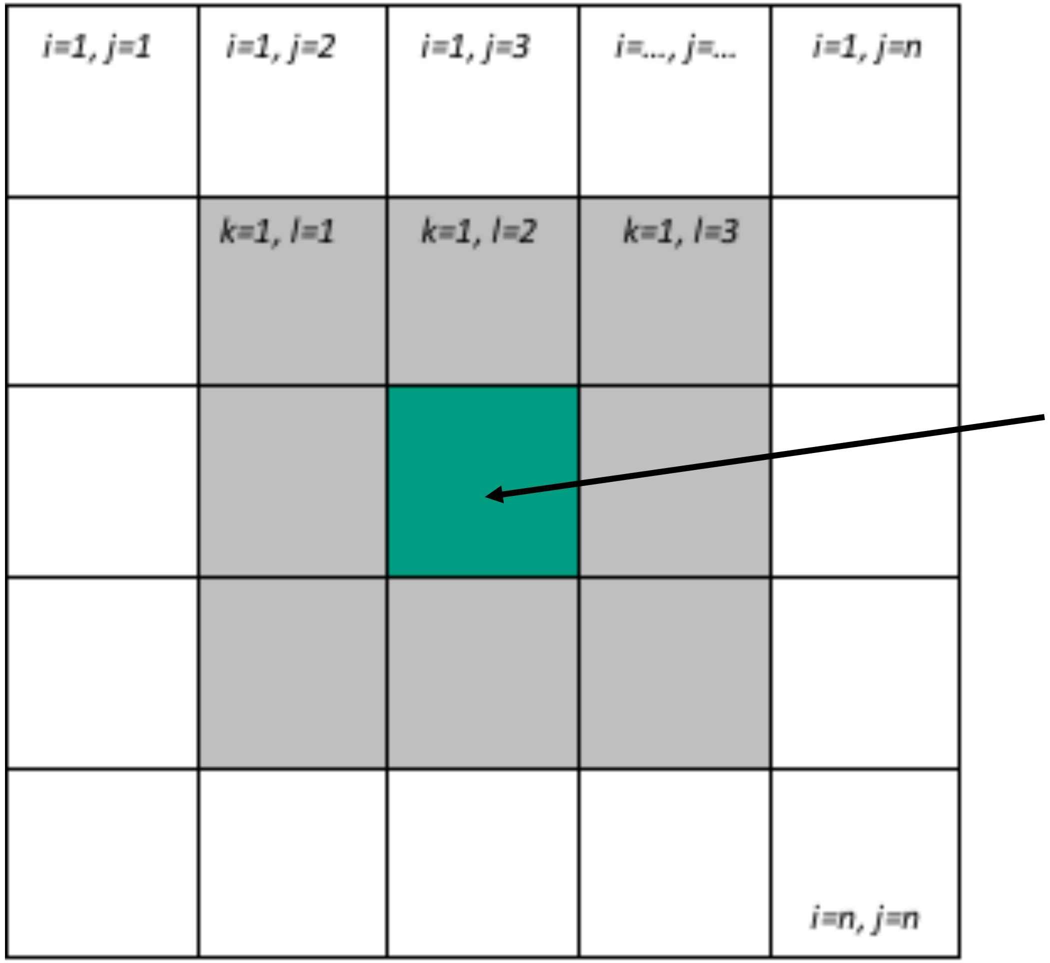
High: 1
Low: -1











$$CHM_{land}[i,j] = \frac{\frac{1}{M}\sum_{(k,l)\in N} CHM[k,l]}{max_{(k,l)\in N} CHM[k,l]}$$

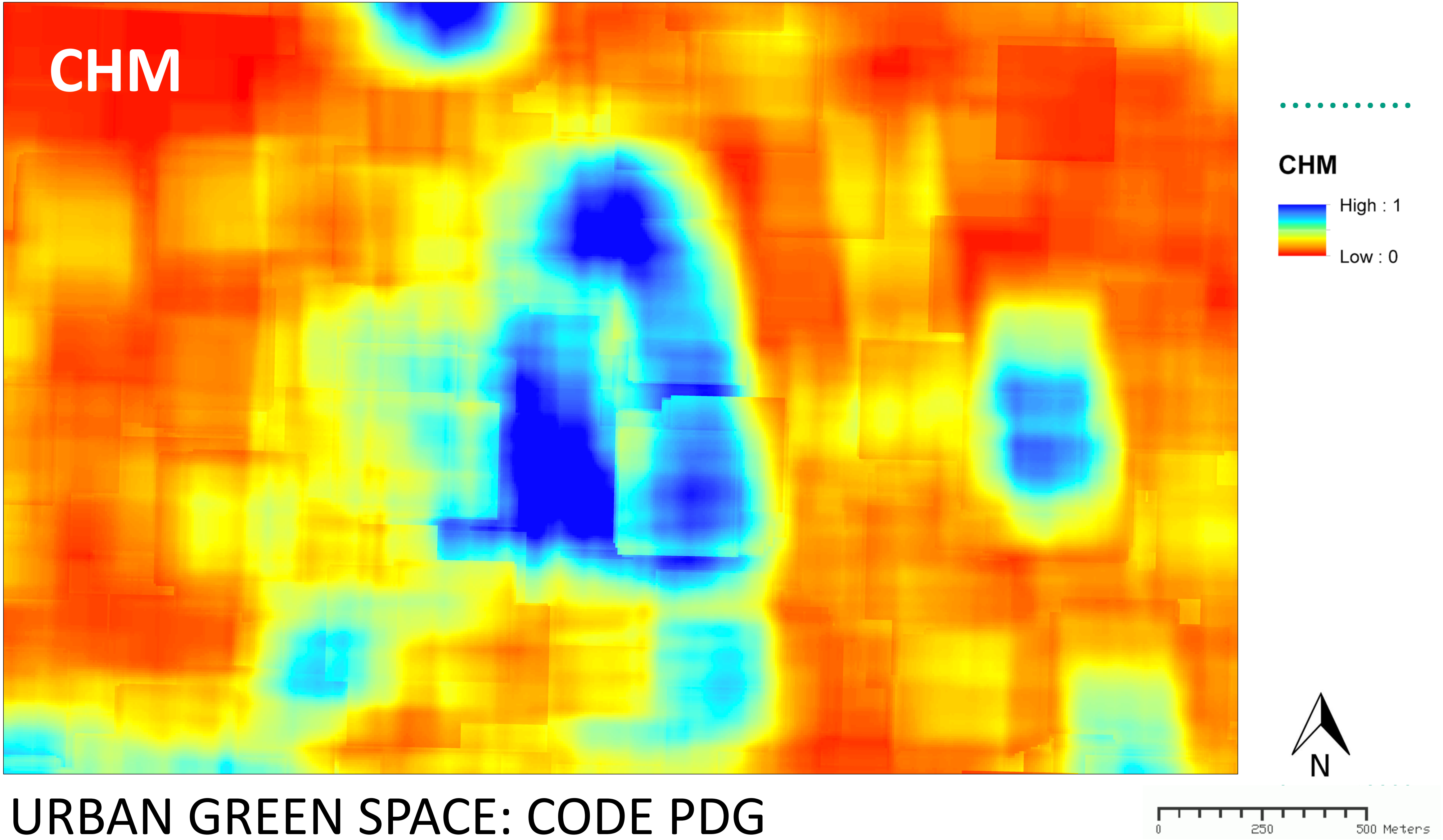
$$BHM_{land}[i,j] = \frac{\frac{1}{M}\sum_{(k,l)\in N} BHM[k,l]}{max_{(k,l)\in N} BHM[k,l]}$$

$$NDVI_{land}[i,j] = \frac{1}{M}\sum_{(k,l)\in N} NDVI[k,l]$$

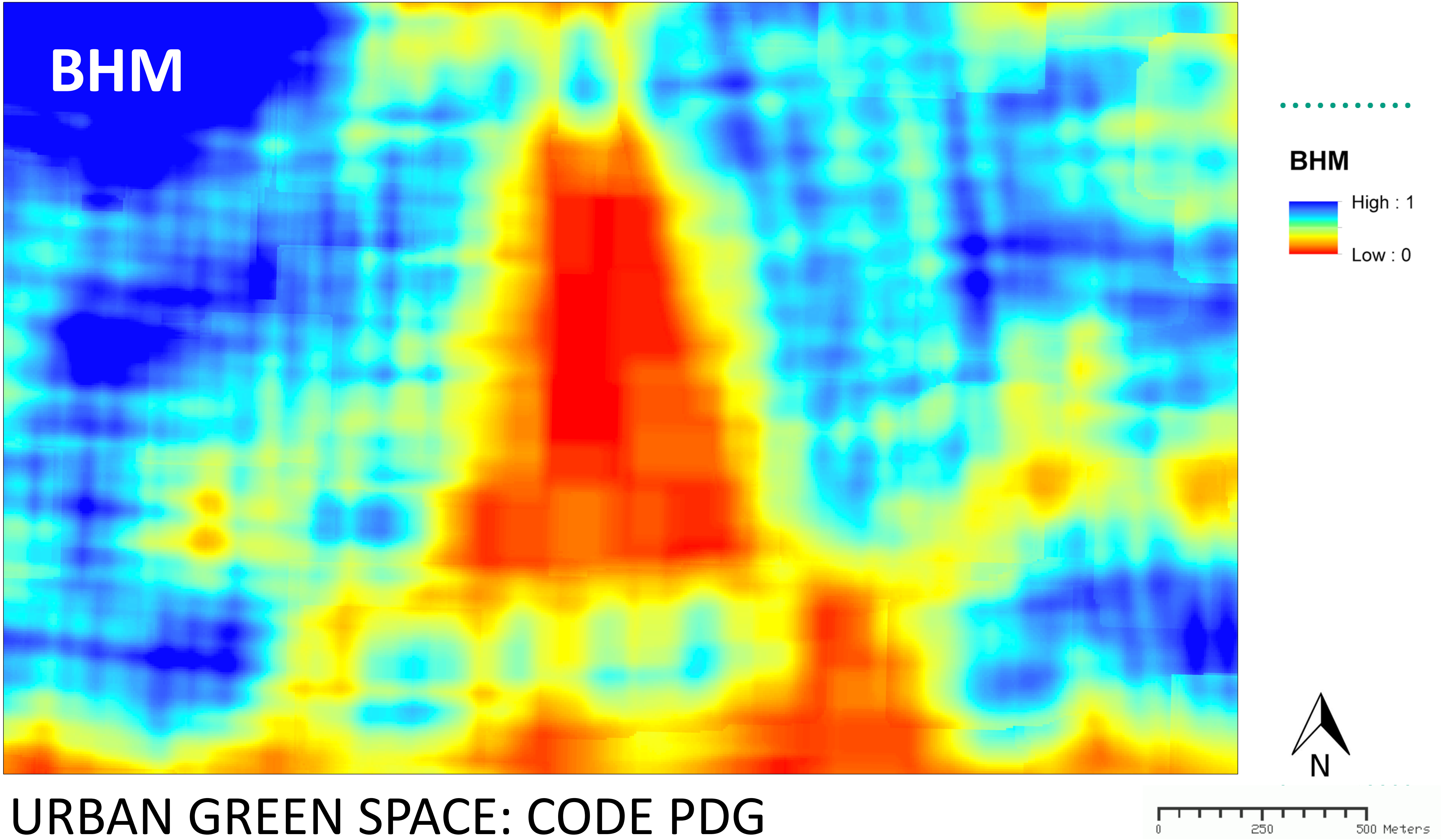
M = 3 x 3

N = LOCAL NEIGHBORHOOD

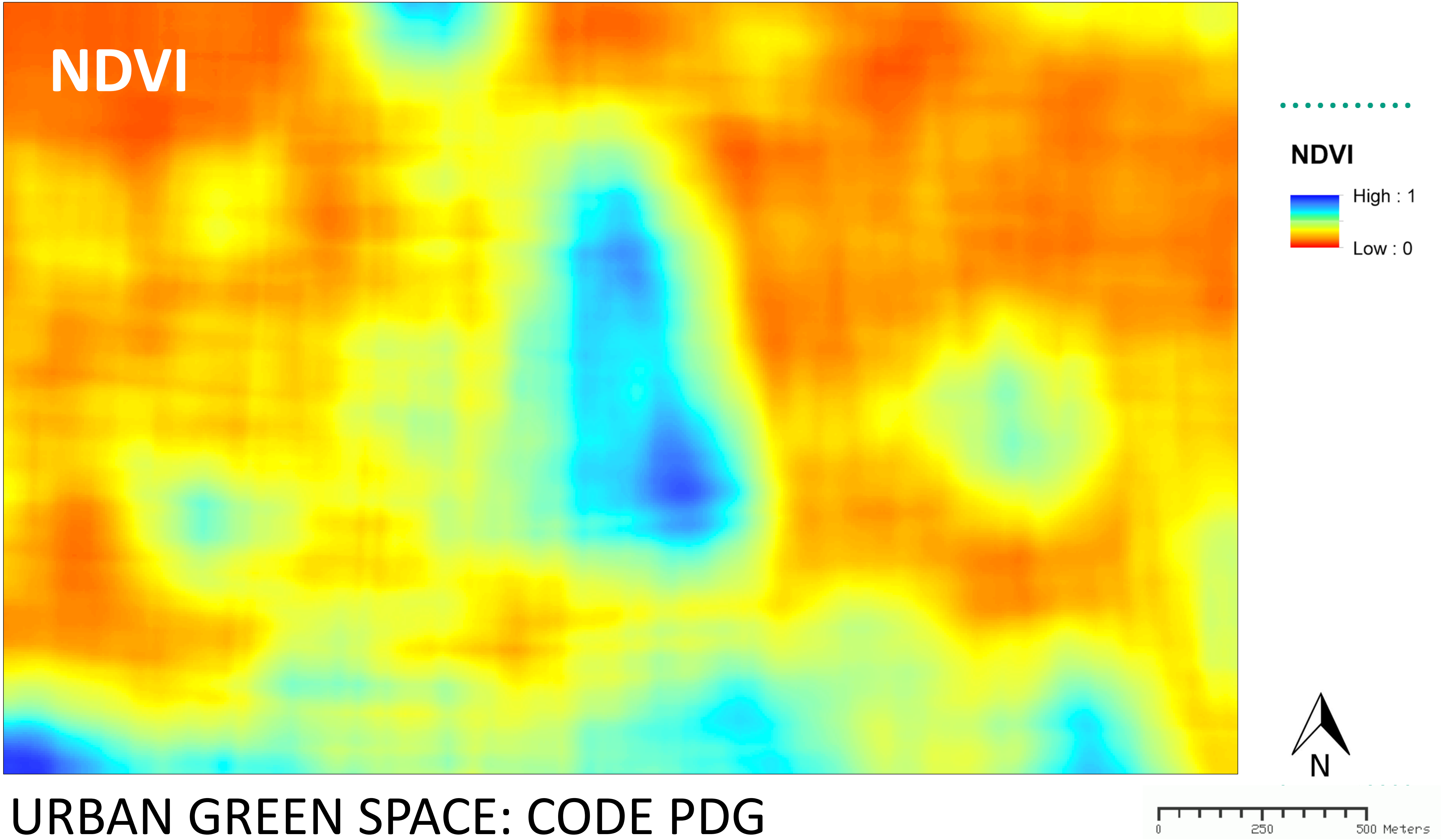
URBAN GREEN SPACE: CODE PDG



URBAN GREEN SPACE: CODE PDG



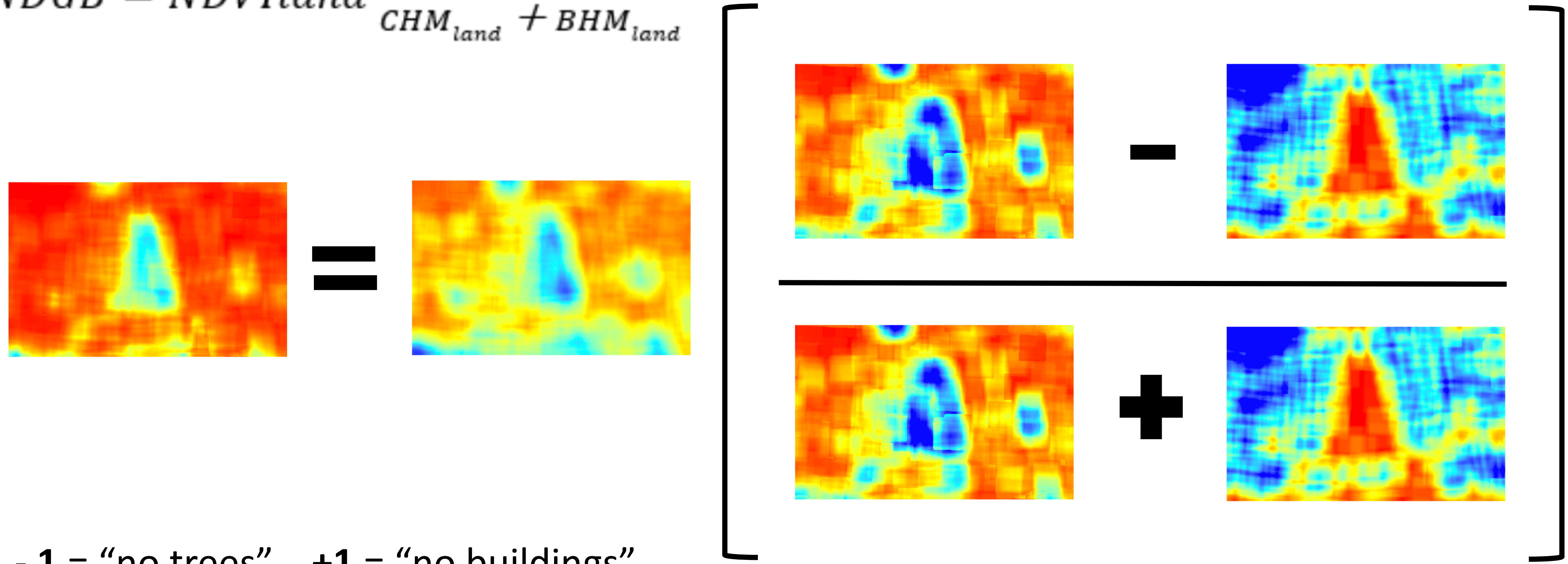
URBAN GREEN SPACE: CODE PDG



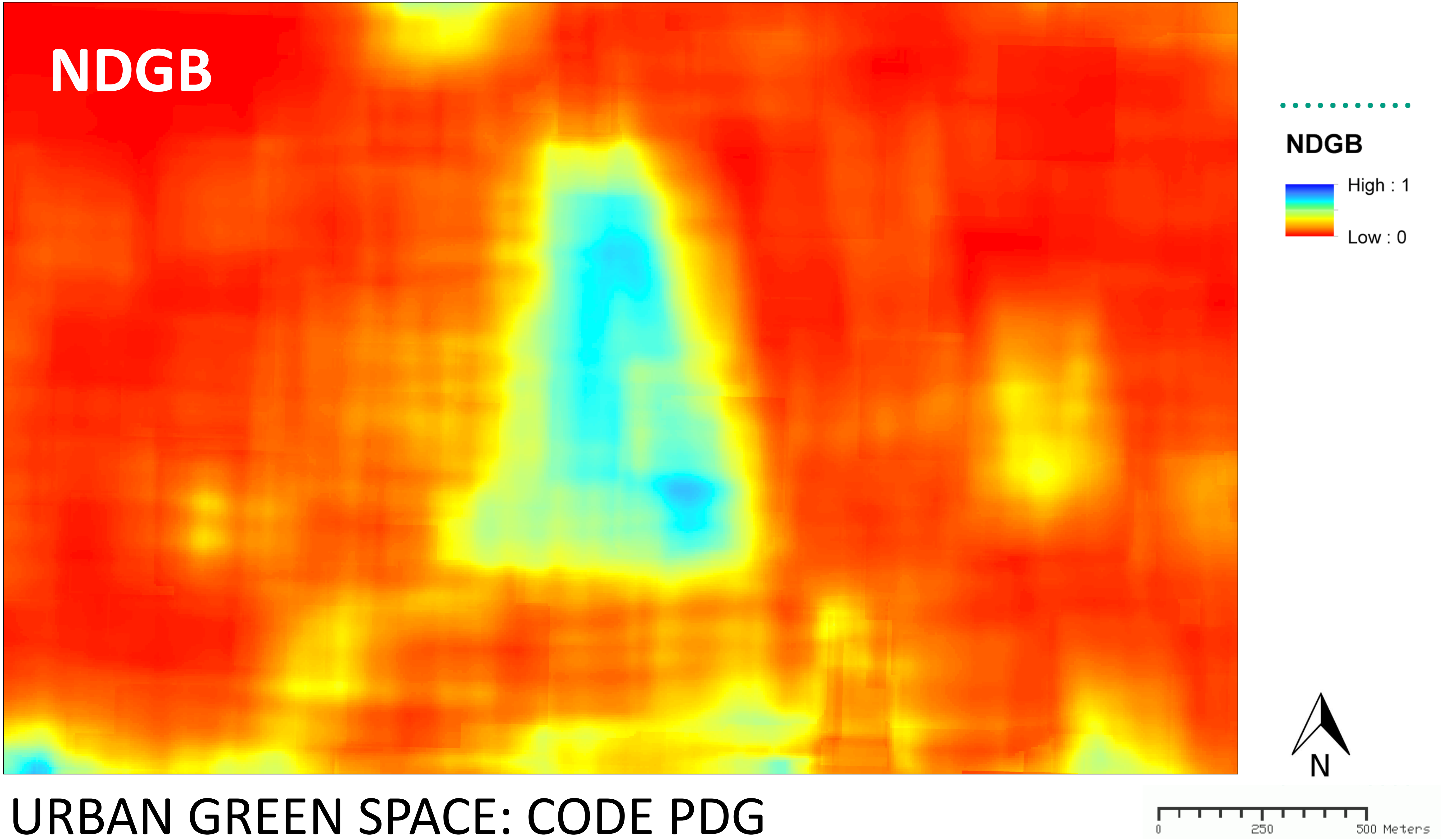
URBAN GREEN SPACE: CODE PDG

Normalized Difference Green and Building volumes (**NDGB**)

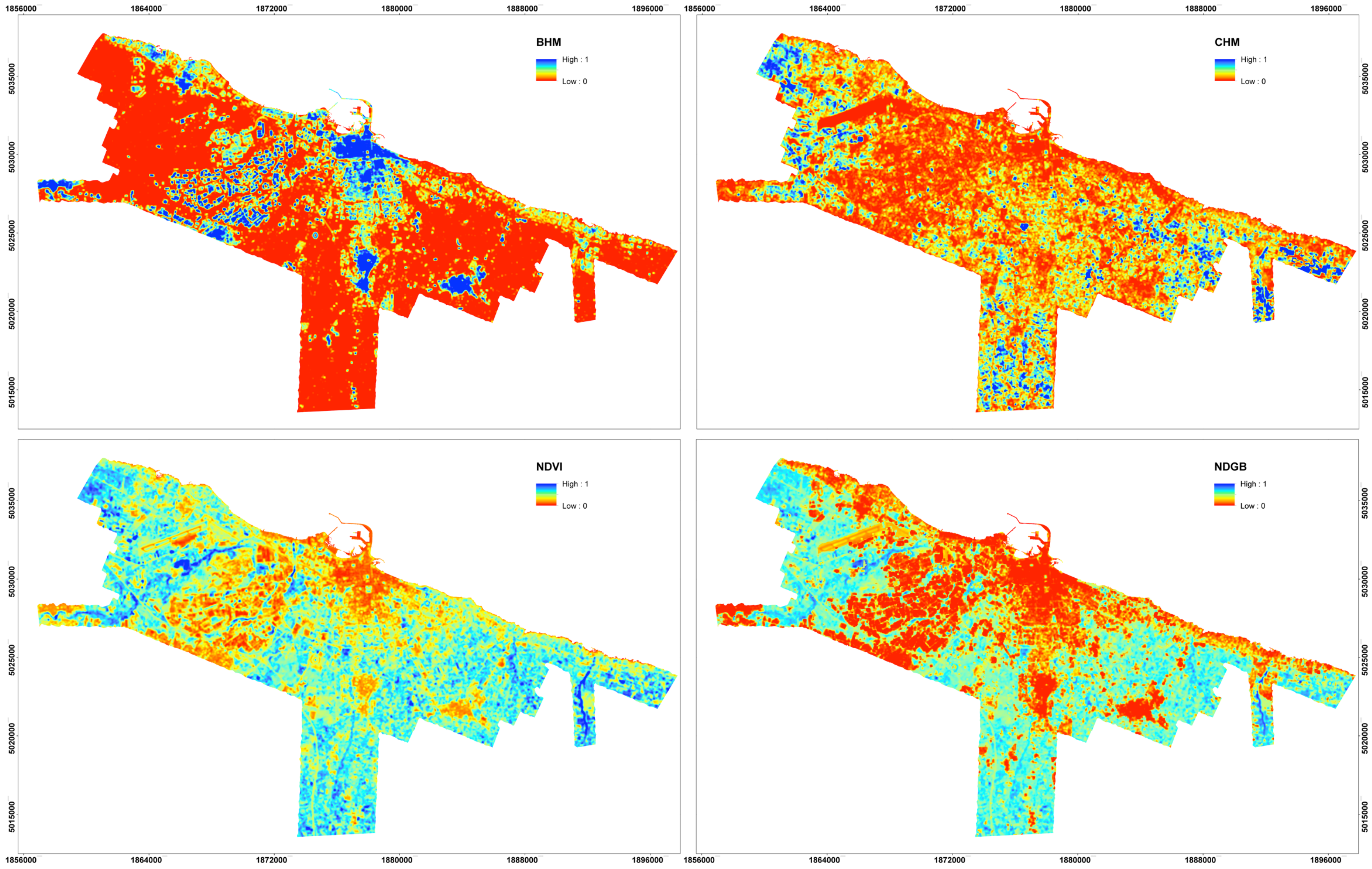
$$NDGB = NDVIland \frac{CHM_{land} - BHM_{land}}{CHM_{land} + BHM_{land}}$$



- 1 = “no trees” **+1** = “no buildings”



URBAN GREEN SPACE: CODE PDG


BHM
High : 1
Low : 0
CHM
High : 1
Low : 0
NDVI
High : 1
Low : 0
NDGB
High : 1
Low : 0
1856000
1864000
1872000
1880000
1888000
1896000
5035000
5030000
5025000
5020000
5015000


GREEN SURGE
GREEN INFRASTRUCTURE AND URBAN BIODIVERSITY FOR SUSTAINABLE URBAN DEVELOPMENT AND THE GREEN ECONOMY


SURGE


GREEN SURGE
Workshop
IL VALORE DELLE INFRASTRUTTURE VERDI
Martedì 19 Gen 2016 - ore 15.00
Dip. di Scienze Agro-Ambientali e Territoriali (DISAAT)
Aula 10 - piano terra - Edificio Presidenza (Ex Facoltà di Agraria)
15.00 Registrazione e welcome coffee
15.30 Presentazione del Progetto "GREEN SURGE"
Raffaele LAFORTEZZA
Giovanni SANESI
16.00 Laboratorio Urbano infrastrutture verdi: idee a confronto fra stakeholder
18.00 Conclusione


GREEN SURGE
GREEN INFRASTRUCTURE AND URBAN BIODIVERSITY FOR SUSTAINABLE URBAN DEVELOPMENT AND THE GREEN ECONOMY
SEVENTH FRAMEWORK PROGRAMME
Collaborative Project involving 24 Partners from 11 Countries


Collaborative Project involving 24 Partners from 11 Countries

1. PINETA DI SAN FRANCESCO ALLA RENA

PINETA DI SAN FRANCESCO ALLA RENA

3. PARCO PEROTTI

PARCO PEROTTI


APPROVVIGIONAMENTO
P.1 Agricoltura urbana
P.2 Regimazione delle acque meteoriche
P.3 Stoccaggio e assorbimento del carbonio
P.4 Mitigazione degli effetti delle isole di calore
REGOLAZIONE
R.1 Protezione contro l'erosione e mantenimento della fertilità del suolo
R.2 Riduzione del rumore
R.3 Purificazione dell'area
CULTURALI
C.1 Benessere psico-fisico
C.2 Apprezzamento estetico, identità storica, opportunità ricreative
SUPPORTO
S.1 Ripristino e mantenimento degli habitat e della biodiversità
S.2 Impollinazione e dispersione dei semi a beneficio di aree verdi circostanti

APPROVVIGI
gimazione delle acque meteoriche
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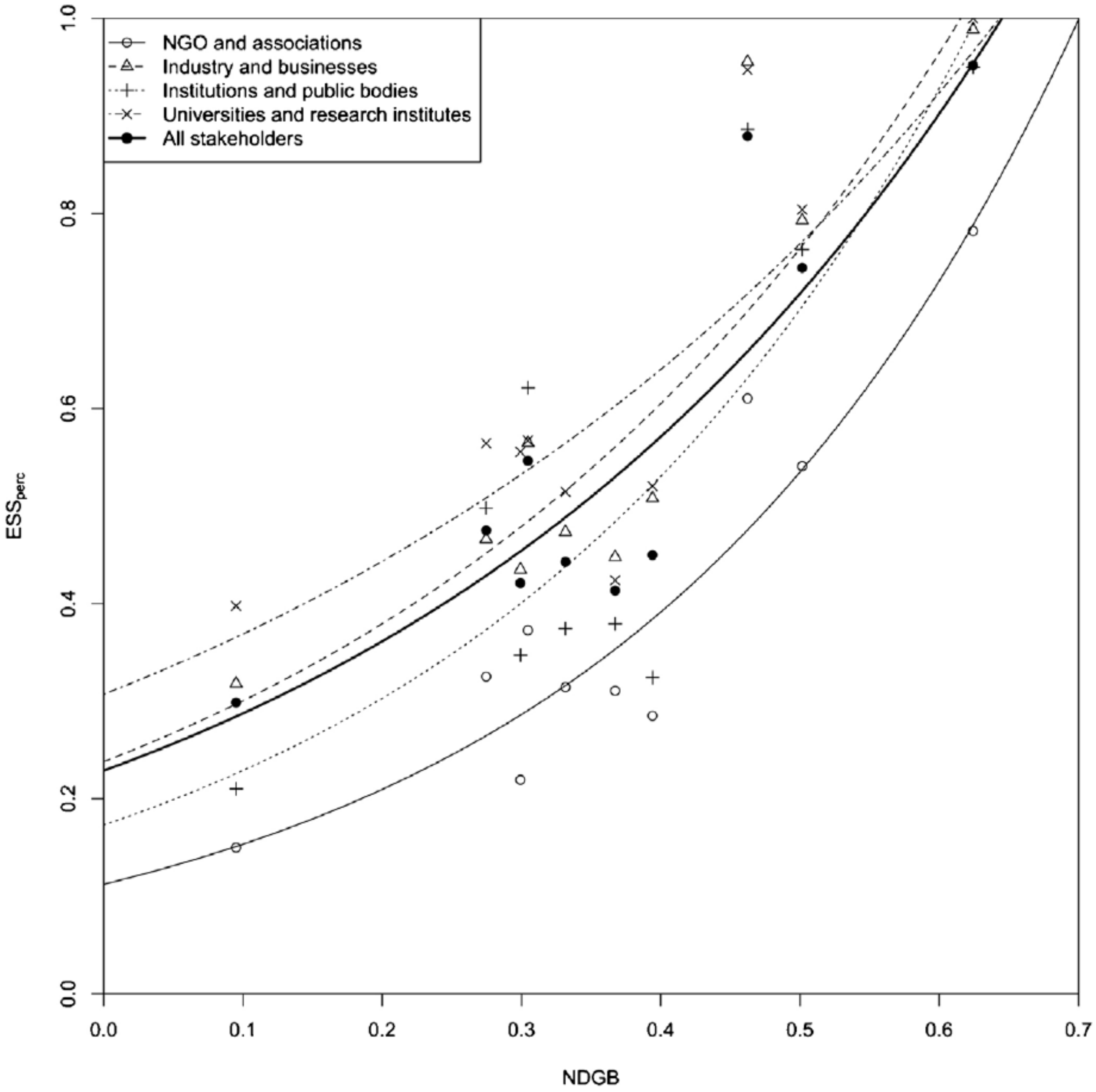
SUPPORTO
S.1 Ripristino e mantenimento degli habitat e della biodiversità
S.2 Impollinazione e dispersione dei semi a beneficio di aree verdi circostanti
scala 1:30.000
aggiornamento dicembre 2010

68

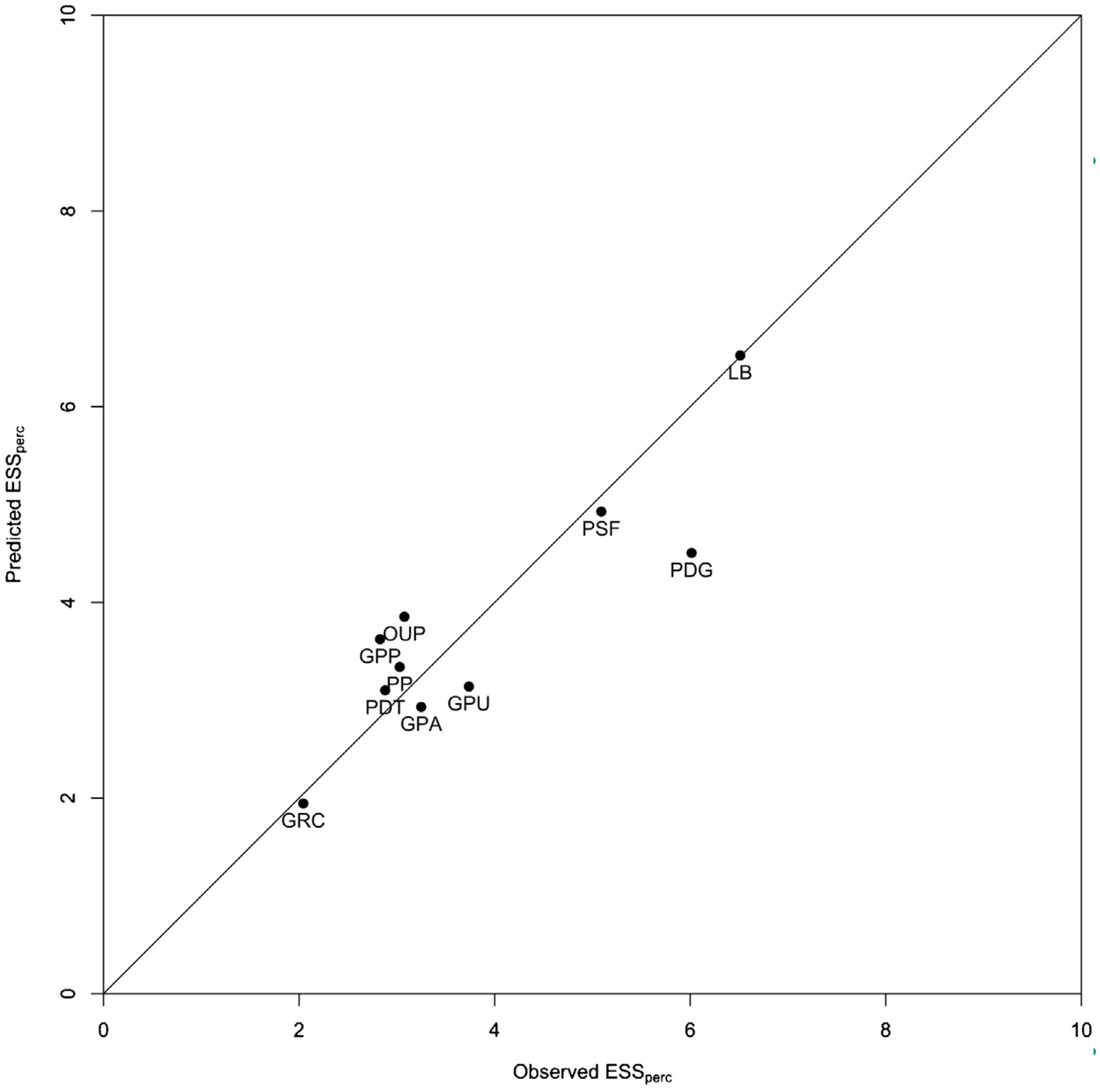
CATEGORIA: ASSOC.		Pineta di San Francesco alla Rena	Giardini di Pane e Pomodoro	Parco Perotti	Parco Due Giugno	Lama Balice	Orto urbano via Pappacena	Parco Don Tonino Bello	Giardino Riccardo Cucciolla	Giardini di Piazza Umberto I	Giardino Piazza I. d'Aragona
Approvvigionamento	Agricoltura urbana	X				X	X				
	Regimazione delle acque meteoriche					X					
	Stoccaggio e assorbimento del carbonio		X					X			
	Mitigazione degli effetti delle isole di calore	X		X	X			X	X	X	X
Regolazione	Protezione contro l'erosione e mantenimento della fertilità del suolo										
	Riduzione del rumore		X	X	X						
	Purificazione dell'aria			X	X				X	X	
Culturali	Benessere psico-fisico		X	X	X		X				
	Apprezzamento estetico, identità storica, opportunità ricreative	X		X	X					X	
Supporto	Ripristino e mantenimento degli habitat e della biodiversità					X					
	Impollinazione e dispersione dei semi a beneficio di aree verdi circostanti					X					



Models explaining ecosystem services perception as a function of *NDGB* for each stakeholder group and the entire range.

Stakeholder group	R^2	β_0	β_1	RMSE	RMSEcv
NGOs and associations	0.84	0.77	3.12	0.46 (0.11%)	0.52 (0.12%)
Industry and businesses	0.82	1.63	2.33	0.68 (0.15%)	0.79 (0.17%)
Institutions and public bodies	0.66	1.18	2.80	0.94 (0.19%)	1.08 (0.21%)
Universities and research institutes	0.70	2.1	1.84	0.71 (0.17%)	0.83 (0.2%)
All stakeholders	0.80	1.57	2.29	0.64 (0.14%)	0.74 (0.16%)

Note: The model developed to predict ESS perception as a function of *NDGB* is expressed by the following general equation $y = \beta_0 \ e^{x\beta 1}$. *NDGB*, Normalized Difference Green-Building Volume; NGO, non-governmental organization; RMSE, root mean square error; RMSEcv, root mean square error of cross-validation.



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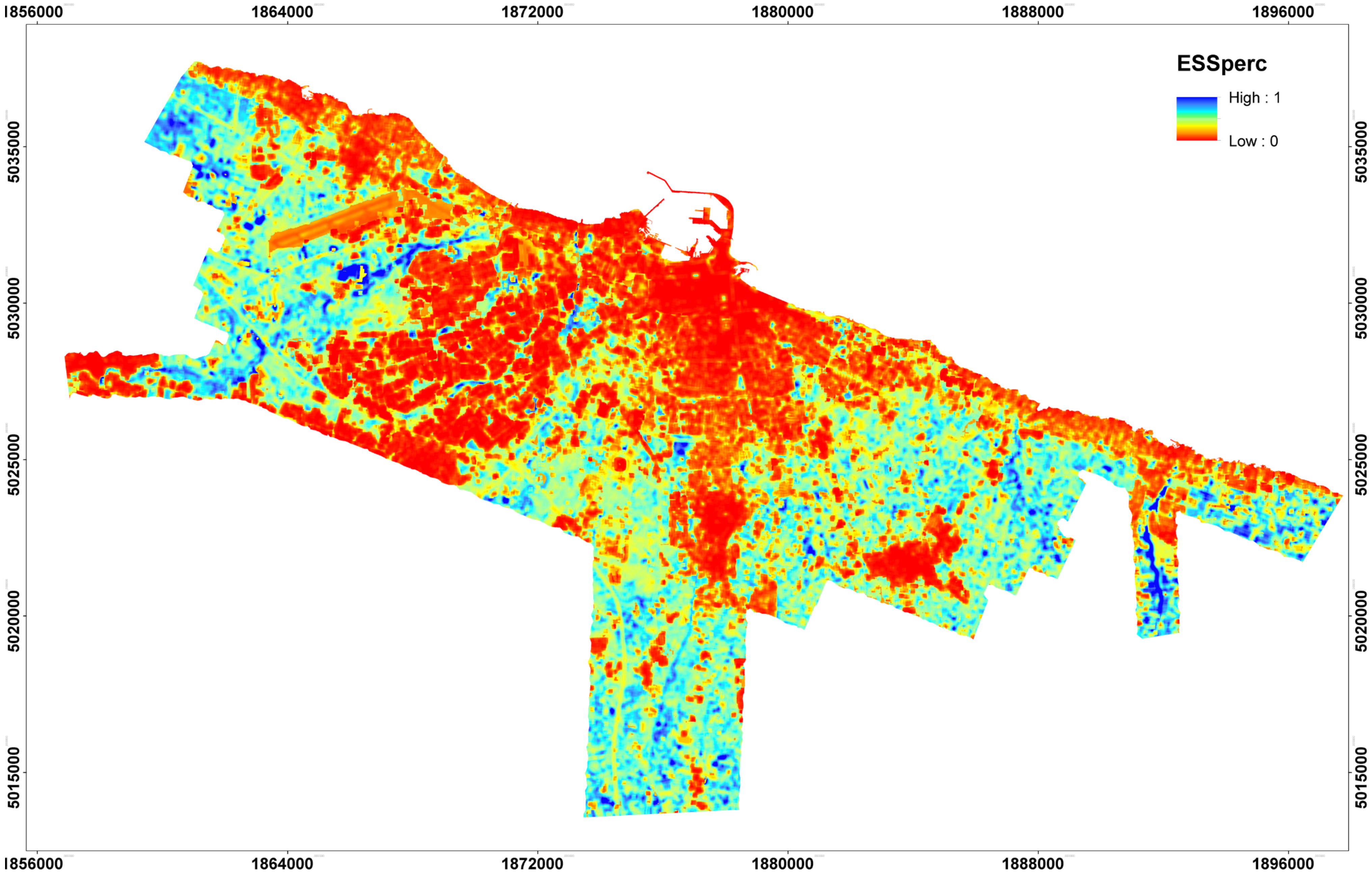
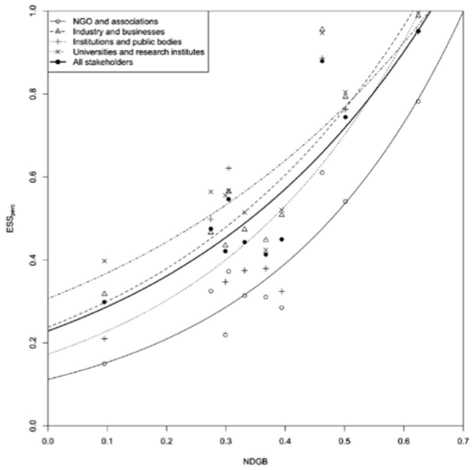


$$ESS_{perc} = 1.57e^{NDGB2.287}$$



GREEN SURGE (European project)


GREEN SURGE

GREEN INFRASTRUCTURE AND URBAN BIODIVERSITY FOR SUSTAINABLE URBAN DEVELOPMENT AND THE GREEN ECONOMY

Type of funding scheme:
Collaborative Project Part B

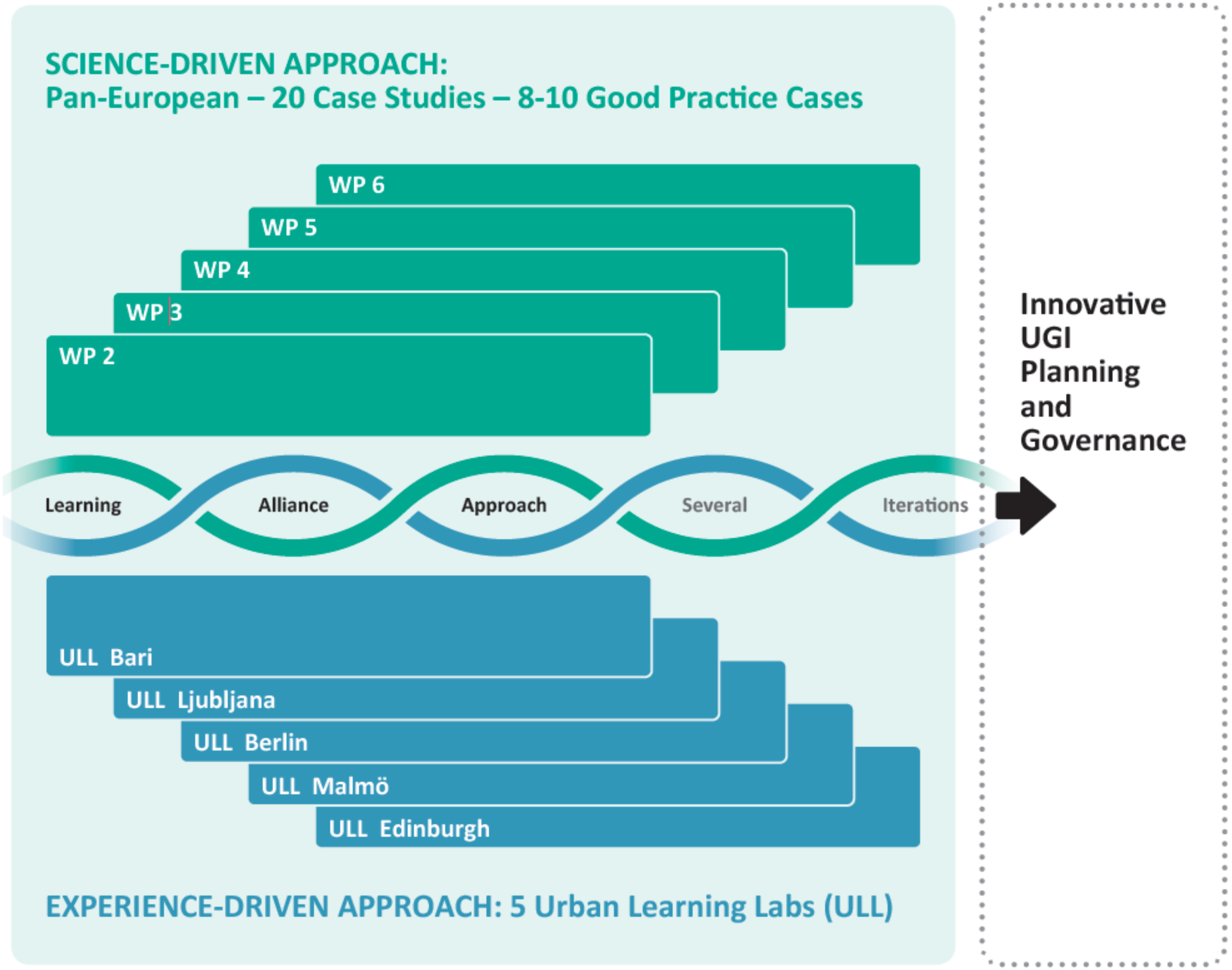
Work programme topics addressed:
ENV.2013.6.2-5 Urban biodiversity and green infrastructure – FP7-ENV-2013-two-stage

Name of coordinator:
Cecil C. Konijnendijk van den Bosch
University of Copenhagen, Denmark

- **GREEN** INFRASTRUCTURE AND **UR**BAN BIODIVERSITY FOR SUSTAINABLE URBAN DEVELOPMENT AND THE **G**REEN **E**CONOMY (FP7-ENV-2013-two-stage)
- 48 months (**10/2013** – **10/2017**) (budget ~ 7.2M€)
- 24 partners 11 nazioni: Denmark, Finland, Germany, Netherland, Sweden, UK, **Italy**, Hungary, Poland Portugal, Slovenia
- 5 Urban Learning Lab (ULL): **BARI**, BERLIN, EDINBURGH, MALMÖ, LUBIANA

Approccio interattivo a *doppia elica* -

Learning Alliance (LA)



BARI'S URBAN LEARNING LAB/FOCAL LEARNING ALLIANCE

GREEN SURGE
GREEN INFRASTRUCTURE AND URBAN BIODIVERSITY FOR SUSTAINABLE URBAN DEVELOPMENT AND THE GREEN ECONOMY

2014

Kick-off press conference to present GREEN SURGE + ULL/FLA

- ***Aim: engage local authorities and stakeholders in ULL/FLA***
- ***Stakeholders: Dept. of Urban Planning, Municipality of Bari; GI expert, NGOs, technicians***

2015

Meeting with local officials to decide the key issue: Effective land management and planning for climate change adaptation

- *Later, changing roles of local authority led to changing key issues*

2016 - 2017

Stakeholder Workshop 1 + local events

- *Aim: stakeholders assess ESS to develop UGI (2016) + residual urban spaces (2017)*
- ***Surveys query stakeholders' perception of ESS in UGI:***
  - ***UGI quality does not correspond to needs and expectations***
  - ***GI must increase/involve strategic planning of multiple sectors***

2017 - present

Stakeholder Workshop 2

- ***Aim: discuss urban regeneration/NBS for** developing Bari's derelict areas*
- ***GREEN SURGE presentation + survey***
- ***Speaker presentations (Brussels/EU)***


SURGE


GREEN SURGE
Verde Urbano e
Diversità Culturale
berlin
SEVENTH FRAMEWORK PROGRAMME

GREEN SURGE Publications (N. 16)

- **Lafortezza R.**, Konijnendijk C., 2018. *Green infrastructure – approach and public health benefits*. In: Bird W, van den Bosch M (eds.) Nature and Public Health: The Role of Nature in Improving the Health of a Population, pp. 252-256
- **Lafortezza R.**, Giannico V., 2017. *Combining high-resolution images and LiDAR data to model ecosystem services perception in compact urban systems*. Ecological Indicators. doi: 10.1016/j.ecolind.2017.05.014
- Mattijssen, T.J.M., Van Der Jagt, A.P., Erlwein, S., **Lafortezza, R.**, 2017. *From place making to place keeping? The long-term perspective for the management of urban green space* by citizens. Urban Forestry and Urban Greening, 26: 78-84
- Spanò M., Leronni L., **Lafortezza R.**, Gentile F., 2017. *Are ecosystem service hotspots located in protected areas? Results from a study in Southern Italy*. Environmental Science & Policy, 73: 52-60

GREEN SURGE Publications (N. 16)

- **Lafortezza R.**, Pauleit S., Hansen R., Davies C., Sanesi G., 2017. *Strategic green infrastructure planning and urban forestry*. In Ferrini F. et al: Handbook of Urban Forestry. Routledge Environment & Sustainability, USA, 179-193
- Spanò M., Gentile F., Davies C., **Lafortezza R.**, 2017. *The DPSIR framework to support the green infrastructure planning: a case study in Southern Italy*. Land Use Policy, 261: 242:250
- Pesola L., Cheng X., Sanesi G., Colangelo G., Elia M., **Lafortezza R.**, 2017. *Linking aboveground biomass and biodiversity to stand development in urban forest areas: a case study in northern Italy*. Landscape and Urban Planning, 157: 90-97
- Giannico V., **Lafortezza R.**, John R., Sanesi G, Pesola L., Chen J., 2016. *Estimating stand volume and above-ground biomass of urban forests using LiDAR*. Remote Sensing, 8(4), 339: 1-14