City Natural Capital Accounting

- London: **Peter Massini,** and **Ashley Gorst**, Vivid Economics
- Stirling: **Jim Rouquette**, Natural Capital Solutions
- Singapore: **Peter Edwards**, Future Cities Laboratory

Building a natural capital account for London

Ashley Gorst

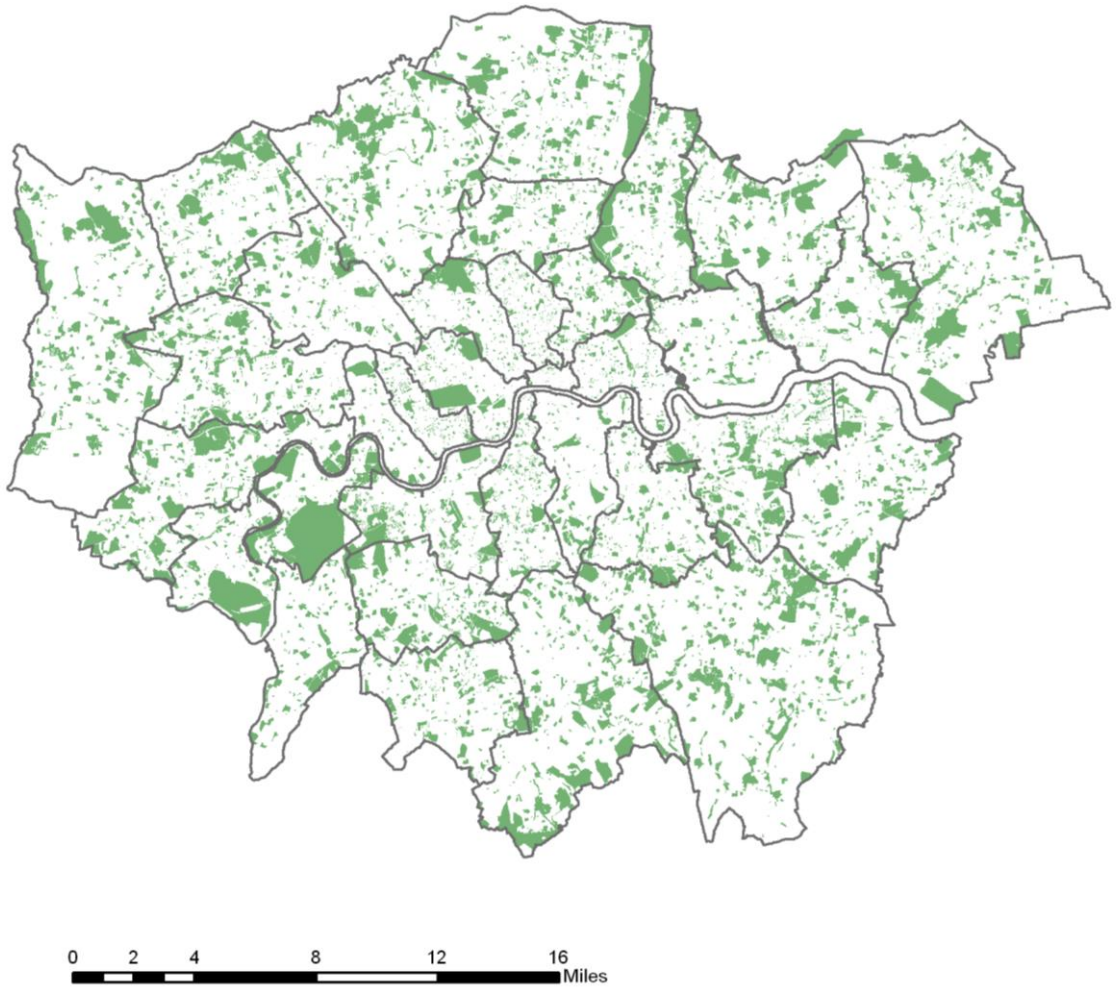
vivideconomics
putting economics to good use

Building London's natural capital account

Account components	Assessment	Information and tools required
Extent and condition of natural assets	How much of the asset is there? What is the condition of the asset?	Location and spatial extent of greenspaces, types of greenspaces, tree cover, vegetation types
+		
Services provided	What services does the asset provide?	Census data on population characteristics, health, greenspace usage
+		
Value of ecosystem services	How much do people value those services?	Healthcare costs, property values

Source: Vivid Economics and ONS/Defra (2017)

Step 1: Mapping London's 32,000 hectares of natural assets illustrates that the city contains a variety of types of greenspaces



Type of green space	Area (ha)	Proportion
Parks and gardens	9,207	29%
Natural and semi-natural urban greenspace	8,467	27%
Amenity	6,578	21%
Outdoor sports facilities	6,225	20%
Allotments, community gardens and city farms	979	3%
Play areas	71	<1%
Total	31,527	100%

Source: Vivid Economics and Greenspace Information for Greater London

Step 2: Register of ecosystem services provided by greenspaces and data required

Asset	Ecosystem Service	Type of service	Data needs
Green space	Physical activity and health	Cultural	Amount of greenspaces Survey/observed data on park visit frequency and activities, Census data on population characteristics and health outcomes Disease costs
	Mental wellbeing	Cultural	
	Amenity (revealed in property price)	Cultural	Amount of greenspaces Hedonic pricing model relevant to city context Property values
	Recreation	Cultural	Annual visits to greenspaces Cost paid to travel to each space
	Carbon sequestration	Regulating	Amount of greenspaces Vegetation types Tree cover Carbon price
	Local temperature regulation	Regulating	Cooling due to greenspaces on hot days Avoided health costs

Source: Vivid Economics

Step 3: London's natural capital account illustrates the value of multiple ecosystem services provided by urban greenspaces

Services provided by natural assets	Public services (£ billions)	Residents (£ billions)	Business (£ billions)	Total (£ billions)	Share (%)
Recreation		17		17	19
Mental health	1	3	2	7	7
Physical health	2	5	3	11	12
Amenity		56		56	61
Carbon (soil)				<1	1
Carbon (trees)				<1	<1
Temperature		1		1	1
Gross asset value	3	82	5	91	100
	4%	90%	6%	100%	

Source: London Parks Report

Step 3: Modelling economic benefits – mental health example

White et al. (2013) study whether individuals in areas with different amounts of urban green space (defined as percentage of land covered in green space) have better mental health outcomes (controlling for individual fixed effects and other covariates). Data is taken from a national survey between 1991-2008.

Step 1: Use dose-response relationship from White et al. (2013) between density of green space within a local area and mental health outcome.

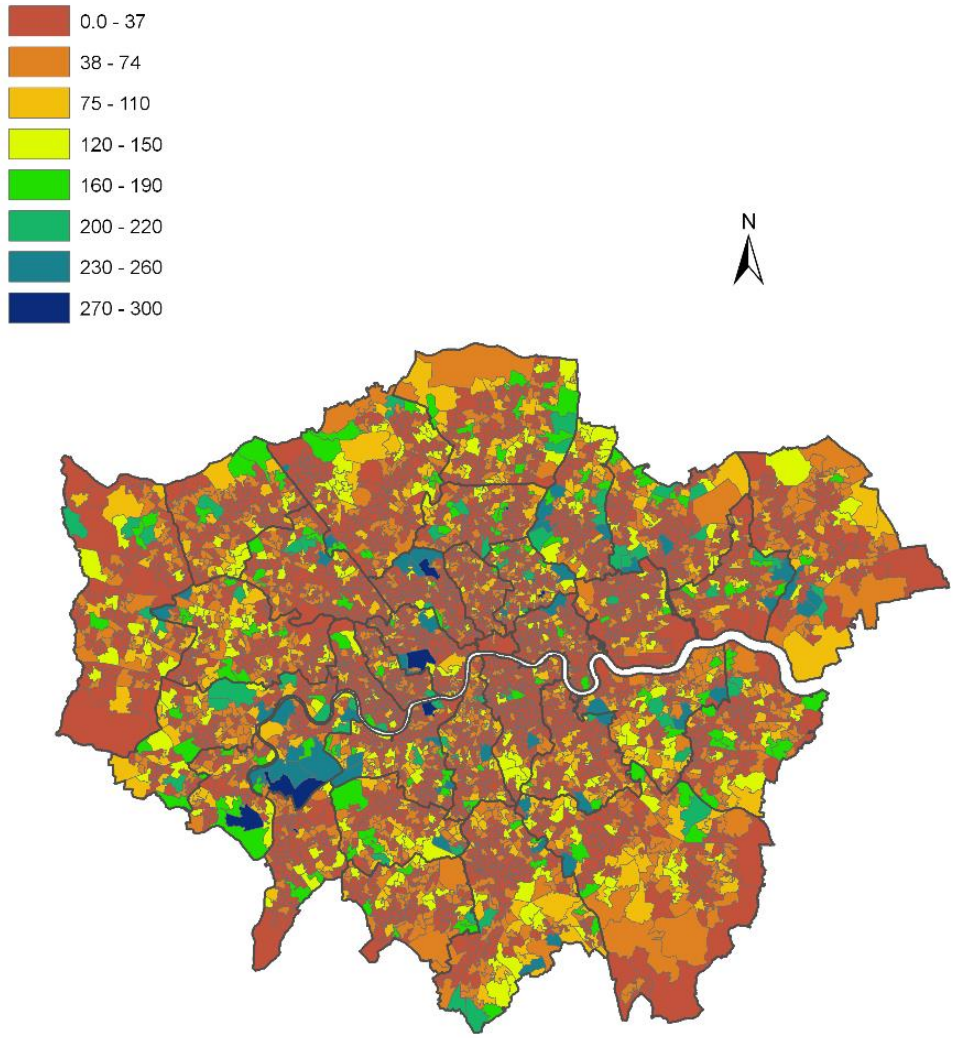
Step 2: Repeat the above calculation for each administrative area in London. The percentage of green space within each local area is assumed to be the relevant measure of access to green space.

Step 3: Attach an economic value to reductions in mental health burden based on the benefits of avoided incidence of mental health due to green space in each administrative area.

Source: ORVal, HEAT,

Avoided mental health costs can be disaggregated by area and per person

Category	Value
Annual reduction in mental health costs	£368 million per year
Proportion of total mental health costs	2%
Population	8.7 million
Average per person benefit	£42 per year



MAYOR OF LONDON

A Natural Capital?

Accounting for nature in city planning

Peter Massini
Greater London Authority

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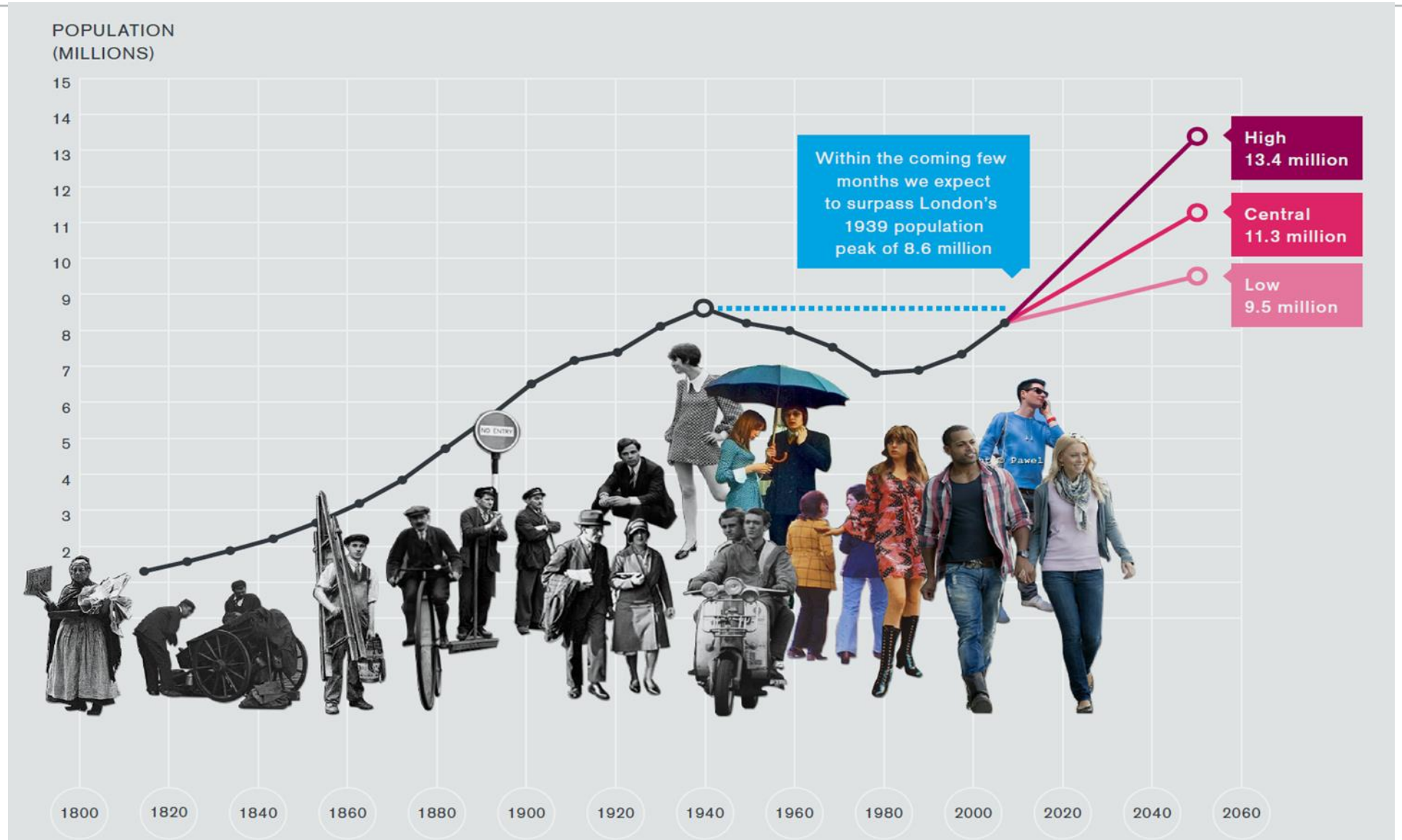

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CLOSED DUE 4pm
TO HEATWAVE
SORRY OPEN @ 10AM
TMRW.

Green infrastructure is the network of green spaces, rivers and woodlands (as well as features such as street trees and green roofs) that is planned, designed and managed to:

- promote healthier living;
- lessening the impacts of climate change;
- improving air quality and water quality;
- encouraging walking and cycling; and
- enhancing biodiversity and ecological resilience.

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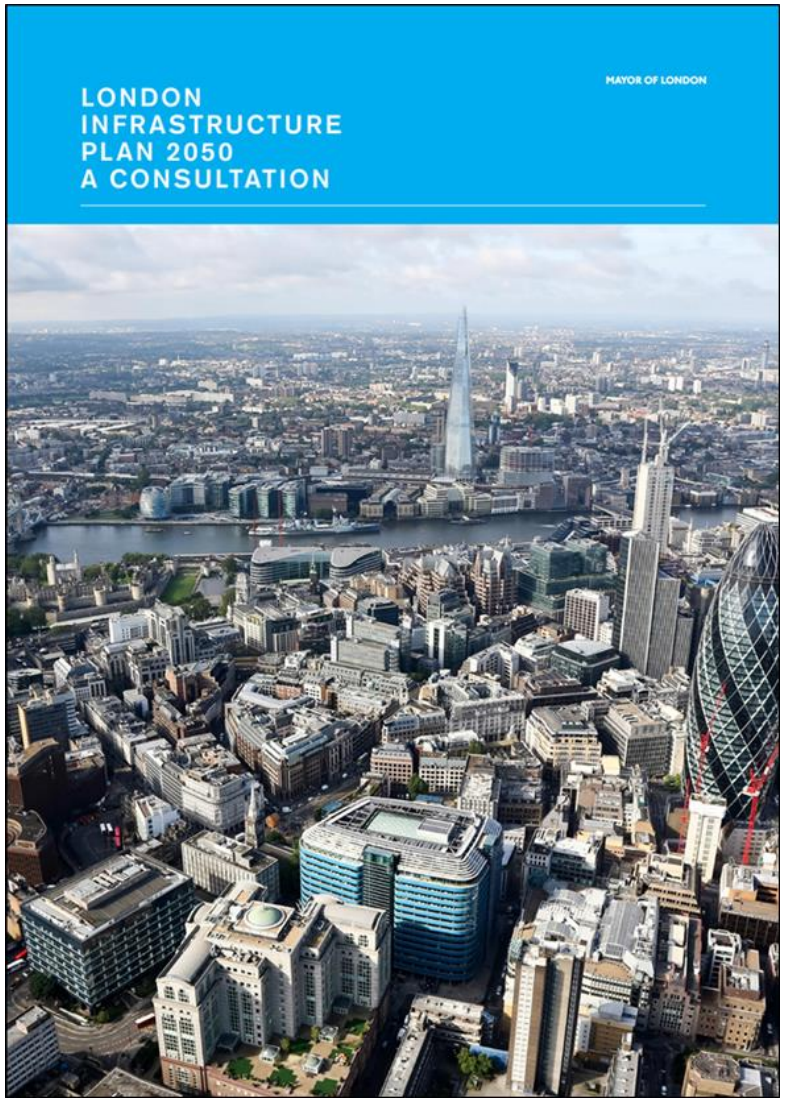

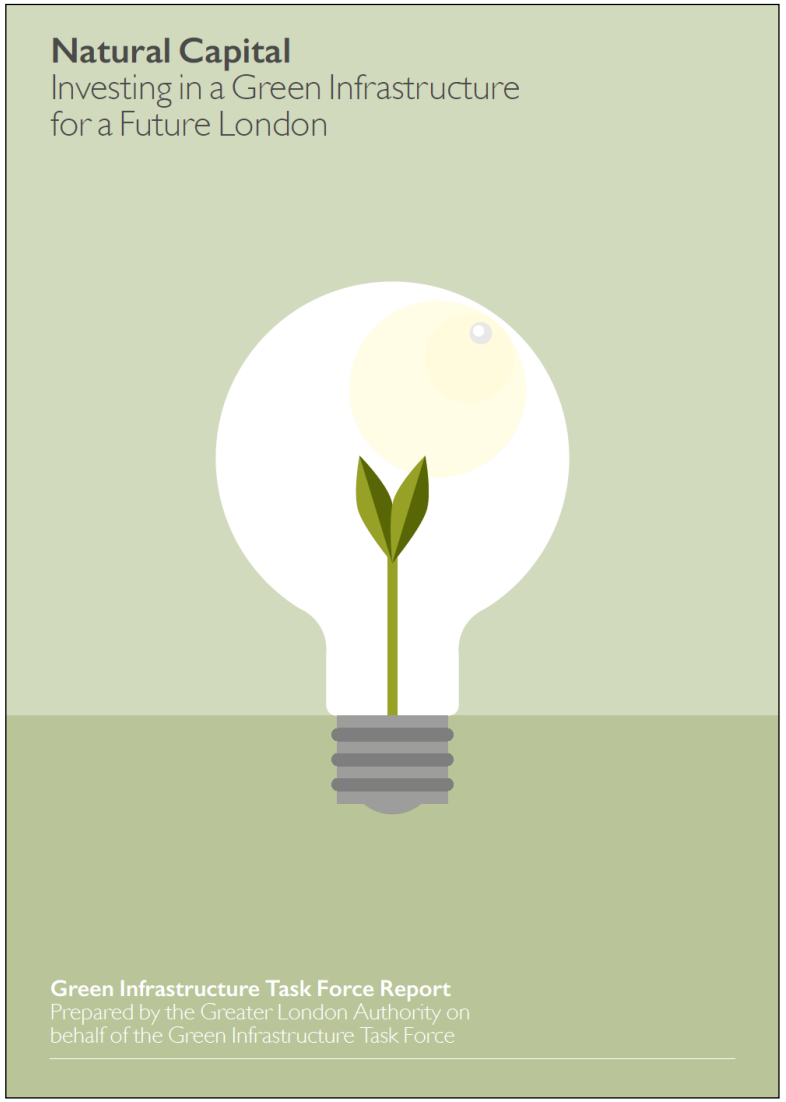

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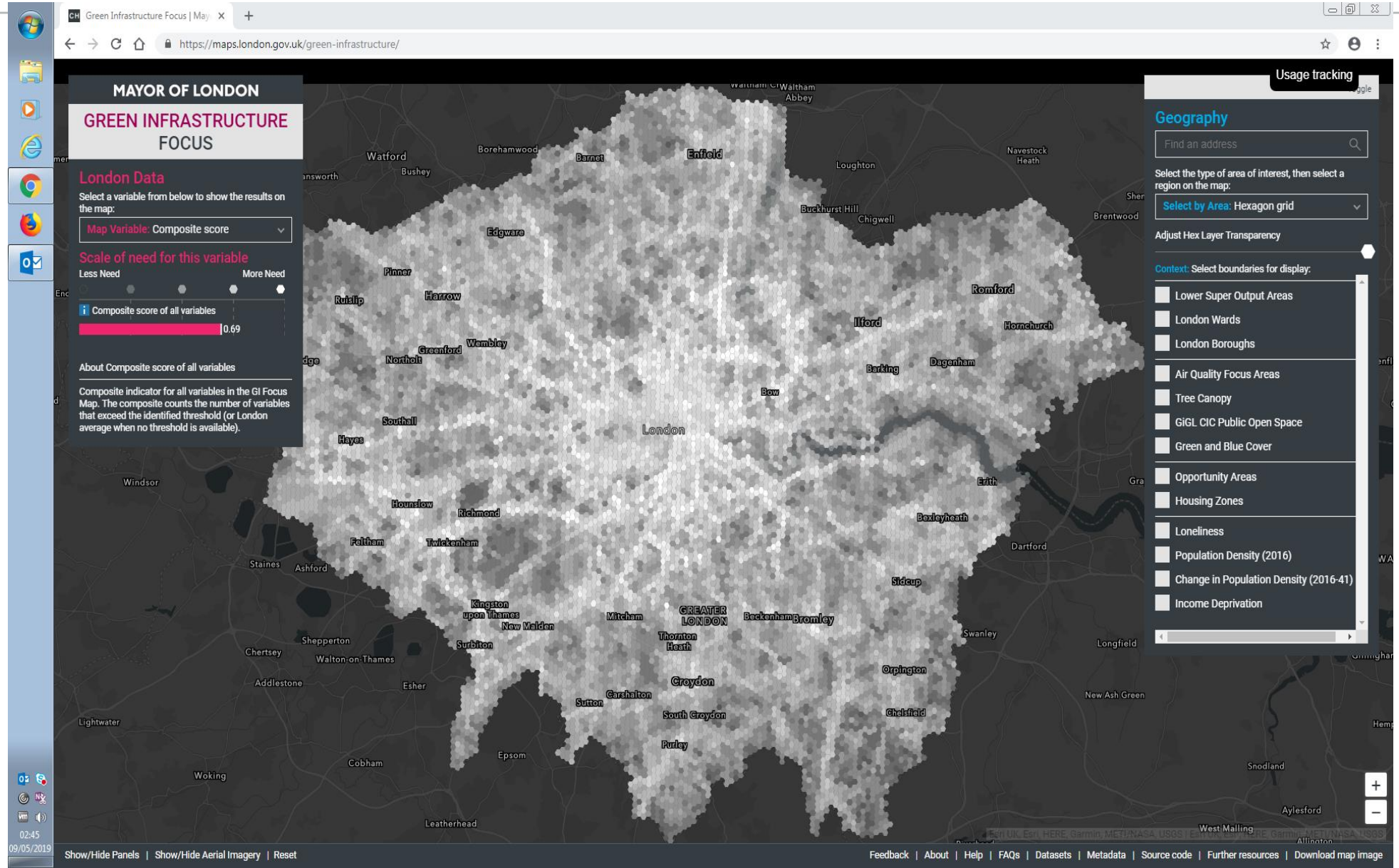


07/06/2017

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Ambition includes:

- By 2040, 80% of trips will be on foot or cycle or by public transport
- Londoners will do at least 20 minutes of active travel each day to improve their health

<u>Healthy Streets</u>

- improving local environments by providing more space for walking and cycling, and better public spaces for people
- prioritising better, safer and more appealing routes for walking and cycling
- planning new developments so people can walk or cycle to local shops, schools and workplaces

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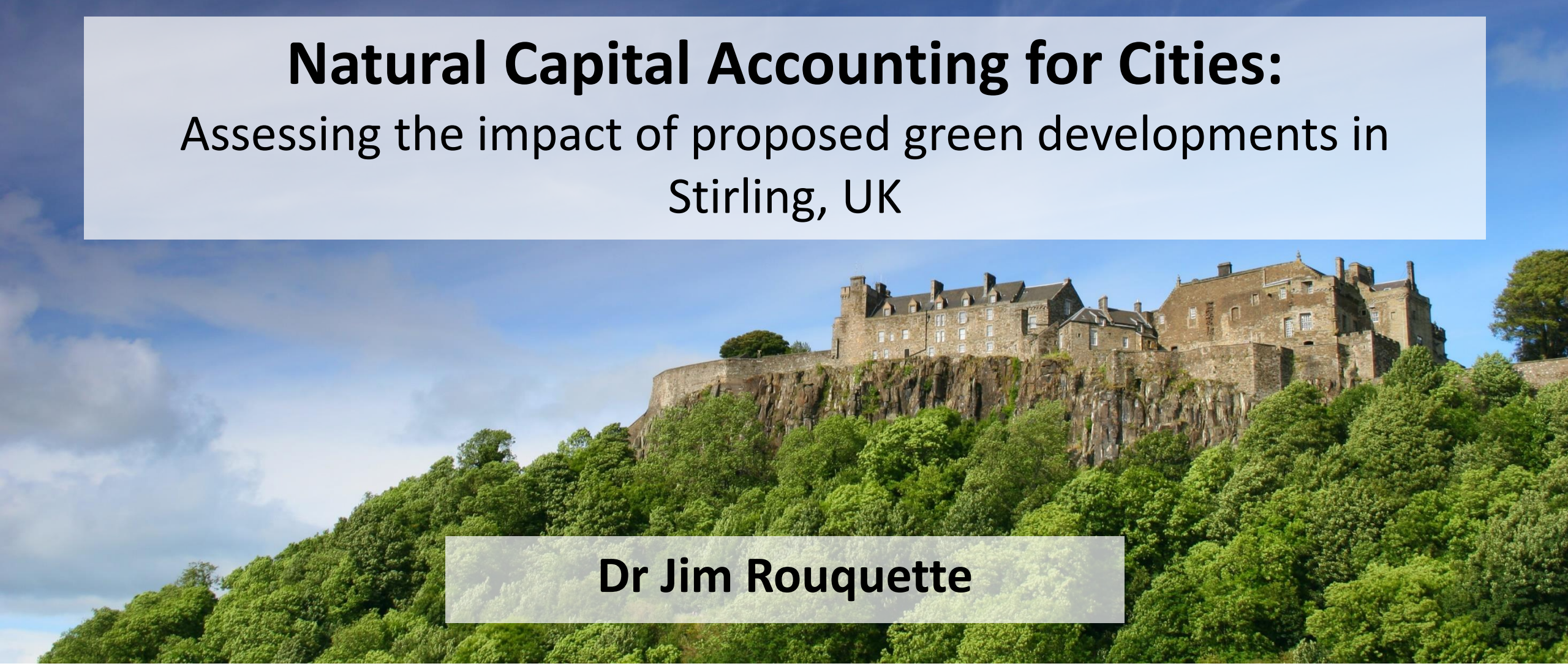
THANK YOU

peter.massini@london.gov.uk

@PeterMassini

Natural Capital Accounting for Cities:

Assessing the impact of proposed green developments in Stirling, UK



Dr Jim Rouquette

Global Platform for Sustainable Cities: Working Group Meeting

Natural Capital Solutions

8 – 10 May 2019

Natural Capital Solutions

Creating a sustainable Stirling

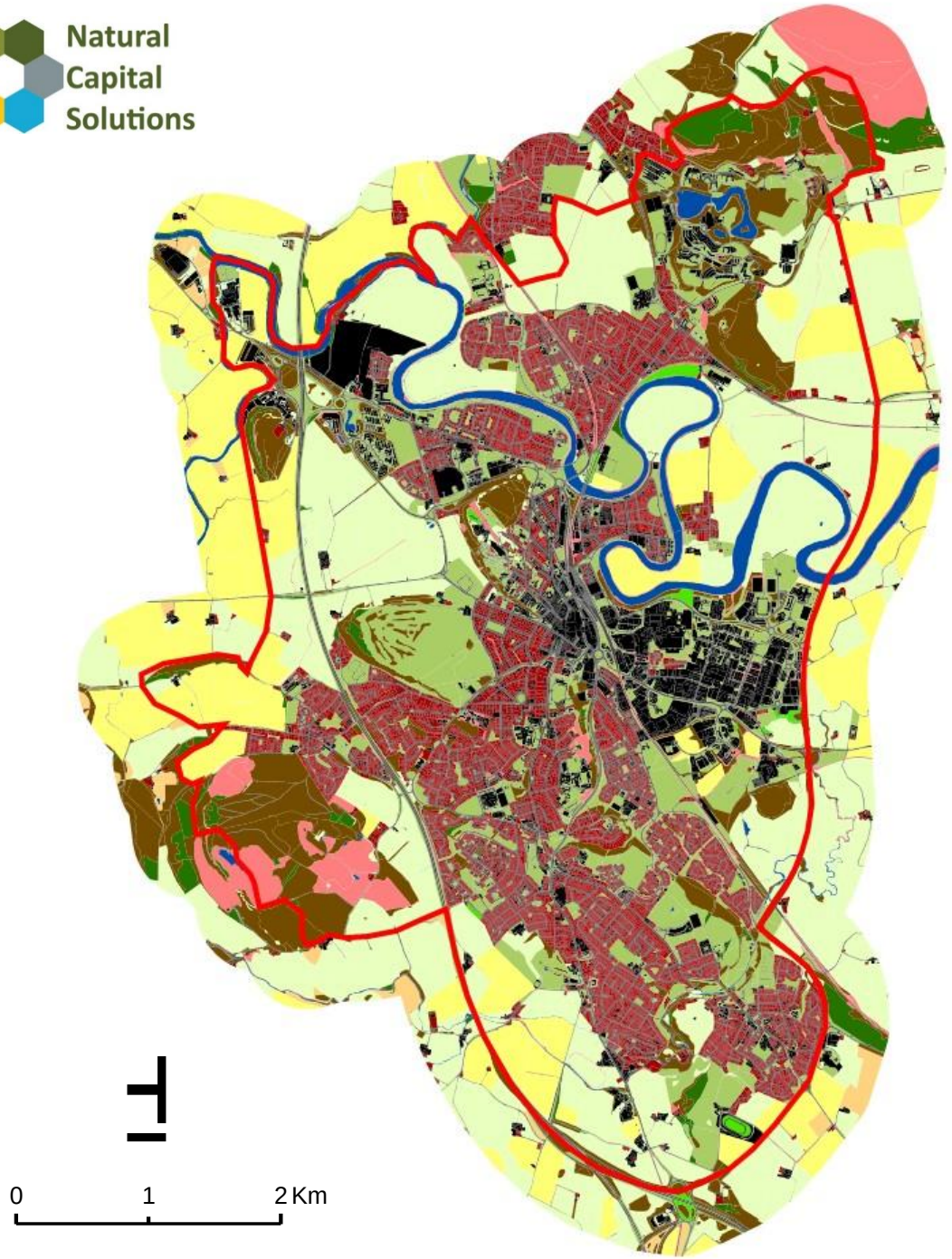
- Stirling is a small city (population c. 40,000) in central Scotland.
- The city was competing for funding for major investments in both the natural and built environments.
- What will be the impact of the new green investments on natural capital and the benefits that it provides?
- Will this derive a positive Return on Investment?
- What lessons can be learnt to support better decision making and to put natural capital at the heart of the economy?

A spatial assessment framework

Asset Register	Map natural capital assets before & after investment
Physical flow account	Map physical flow of benefits before & after investment
Monetary flow account	Map value of benefits before & after investment
Maintenance cost account	Calculate costs of creating and maintaining the assets
Economic appraisal	Examine costs and benefits over project lifetime to determine GVA and Return on Investment

Natural Capital Solutions

Natural capital assets - baseline



Legend

Stirling City boundary

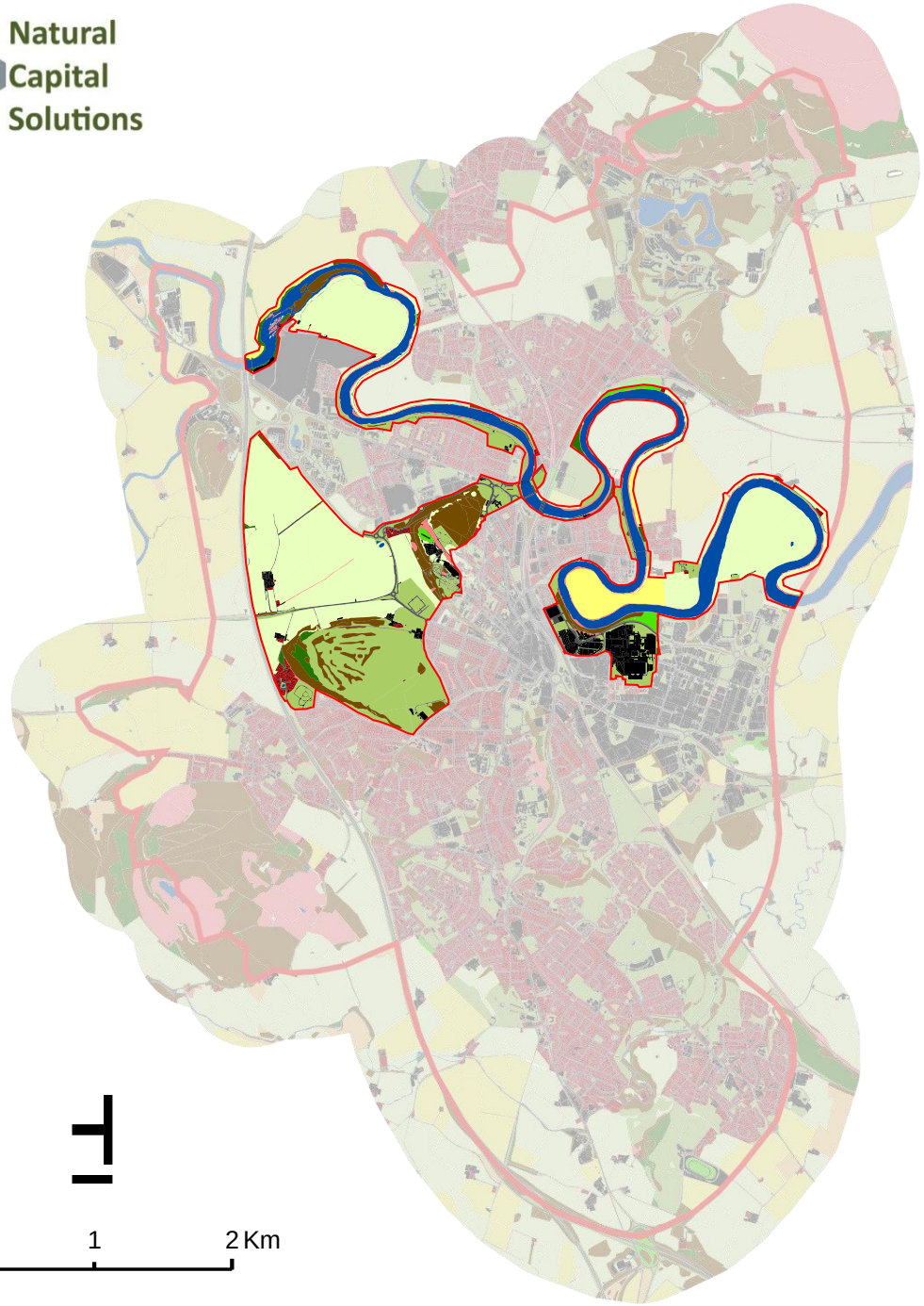
Broad habitat

- Cultivated land
- Uncertain agriculture
- Improved grassland
- Amenity grassland / road verges
- Semi-natural grassland
- Unknown grassland
- Woodland and scrub
- Water
- Built up areas
- Infrastructure
- Gardens
- Other habitats

Broad habitat	% cover
Cultivated land	7.1
Improved grassland	22.1
Amenity grassland / road verges	15.3
Semi-natural grassland	1.3
Unknown grassland	0.4
Scrub	1.1
Trees / Parkland	2.0
Broadleaved woodland	4.8
Coniferous woodland	2.7
Mixed woodland	1.3
Water	3.2
Built up areas	13.0
Infrastructure	10.0
Gardens	12.7
Other habitats	2.9

Natural Capital Solutions

Natural capital assets - baseline



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The planned investments

City Park

- New park in unique landscape setting
- Would act as gateway to Stirling and location for major events
- Grassland, lakes, woodland, wetlands, city farm
- Extensive path network, visitor centre and new road infrastructure

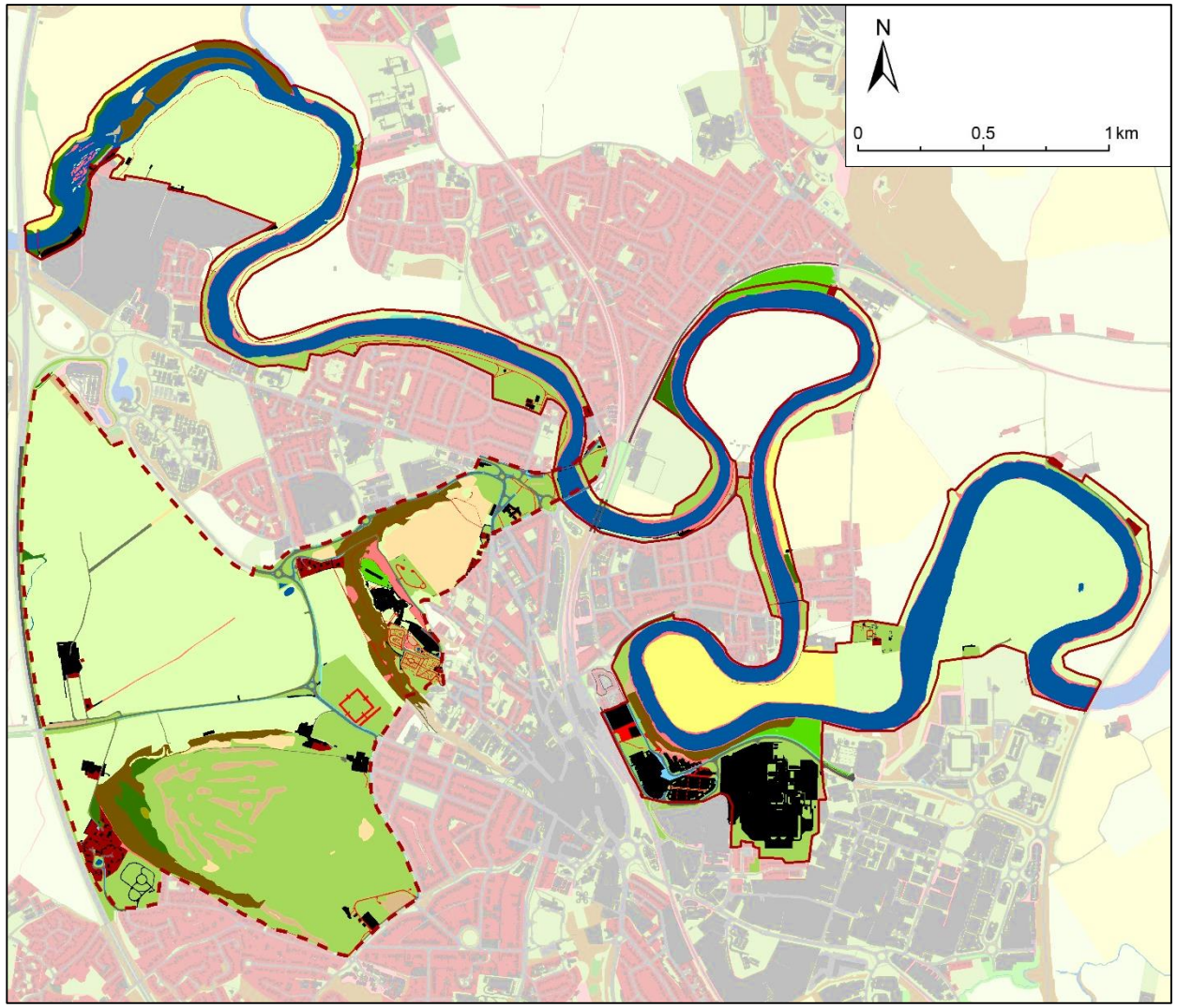
River project

- Reconnecting the city with its river and heritage
- Linking communities – new footpath and cycleway throughout length of river, plus new bridges
- Wildlife sanctuary within 5 mins walk of city centre
- Extensive plantings of wildflowers, trees, orchards

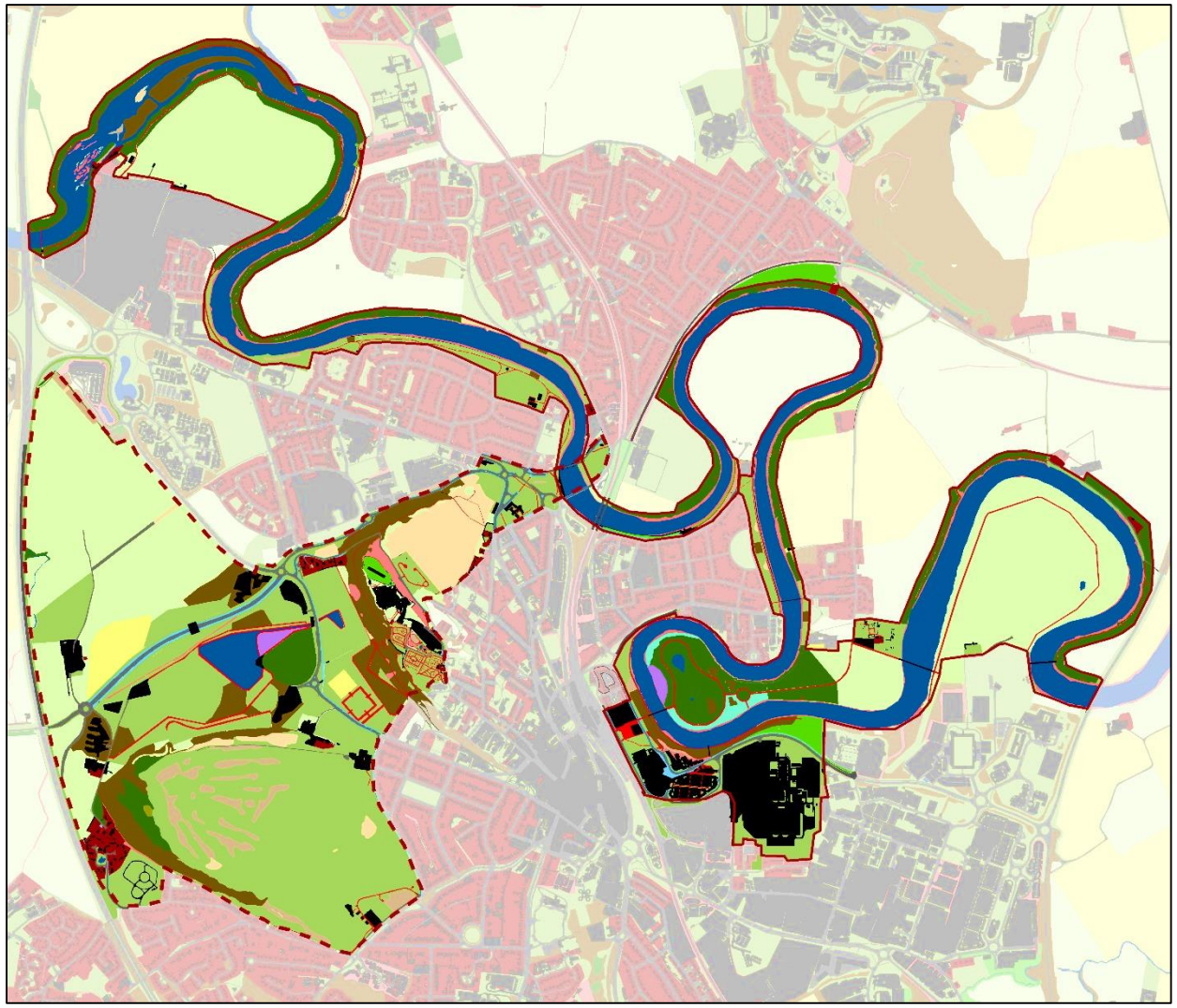
Natural Capital Solutions

Natural capital assets: City Park and River projects

Baseline



Investment



Mapping ecosystem services and their values

Type of service	Benefits	Physical & monetary flows
Provisioning	Agricultural production	✓
	Timber/woodfuel production	✓
Regulating	Atmospheric carbon	✓
	Air quality regulation	✓
Cultural	Recreation	✓
	Physical health	✓
Other benefits	Property values	✓
	Tourism	✓

Type of service	Benefits	Indicative maps
Regulating	Noise regulation	✓
	Local climate (urban heat) regulation	✓
	Water flow regulation	✓
	Water quality	✓
Cultural	Accessible nature	✓

Atmospheric carbon

New plantings will sequester (take up) an additional:

- 14.1 tonnes of **CO_2** along the river and 62.9 tCO_2 in the City Park

Changing land-use will reduce agricultural emissions by:

- 67.5 tCO_2 along the river and 106.6 tCO_2 in the City Park

Providing an annual benefit of **£5,230** (river) and **£10,840** (City Park).

Air quality regulation

New plantings will absorb an additional:

- 74 kg of PM_{10} along the river and 139 kg in the City Park
- 0.83 kg of SO_2 along the river and 0.62 kg of SO_2 in the City Park,

With an annual value of **£5,700** (river) and **£10,700** (City Park)

Recreational visits

New accessible greenspace estimated to attract an additional:

- 580,00 recreational visits to the river area and 560,000 to the City Park each year
- providing additional annual welfare benefits worth **£2.40M** and **£2.31M** respectively

Health and wellbeing

- River project will provide a large increase in accessible greenspace close to people's homes. City Park will provide large destination greenspace.
- Provides a setting for active visits that increase Quality Adjusted Life Years (QALYs).
- Minimum annual welfare gain or costs avoided through physical activity:

  River: **£278,300** City Park: **£16,100**

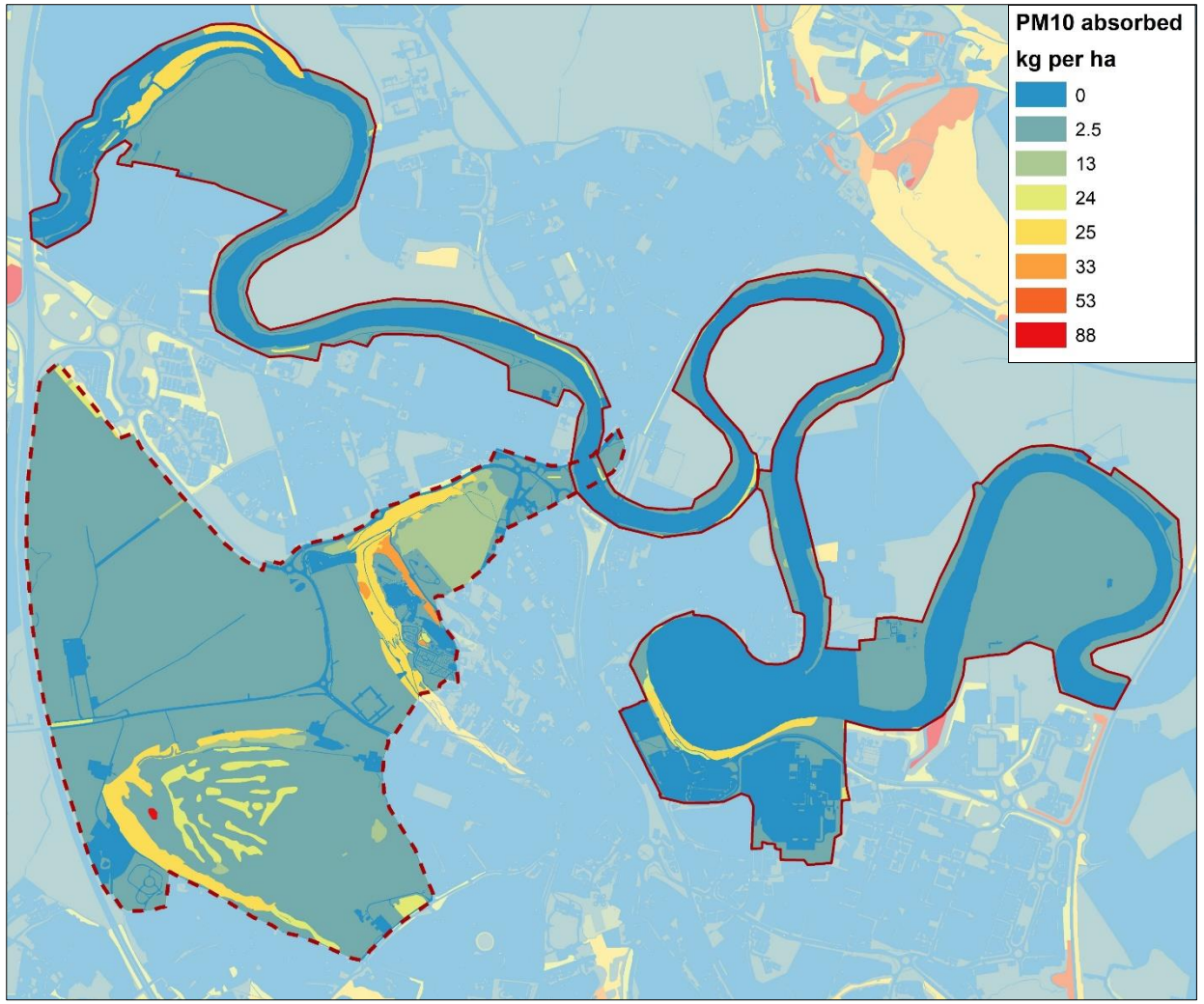
Annual monetary flow account – City Park

Natural Capital benefit	City Park (£ 2017)		
	Baseline	Investment	Change
Carbon sequestration	10,800	14,800	4,020
Agricultural emissions	- 14,300	- 7,460	6,820
Air quality regulation - PM10 - SO2	80,800 24.5	91,500 25.8	10,700 1.3
Agricultural production	- 8,560	- 4,600	3,970
Timber / wood fuel	1,510	2,270	754
Recreation	1,630,000	3,950,000	2,310,000
Physical health	NA	NA	16,100

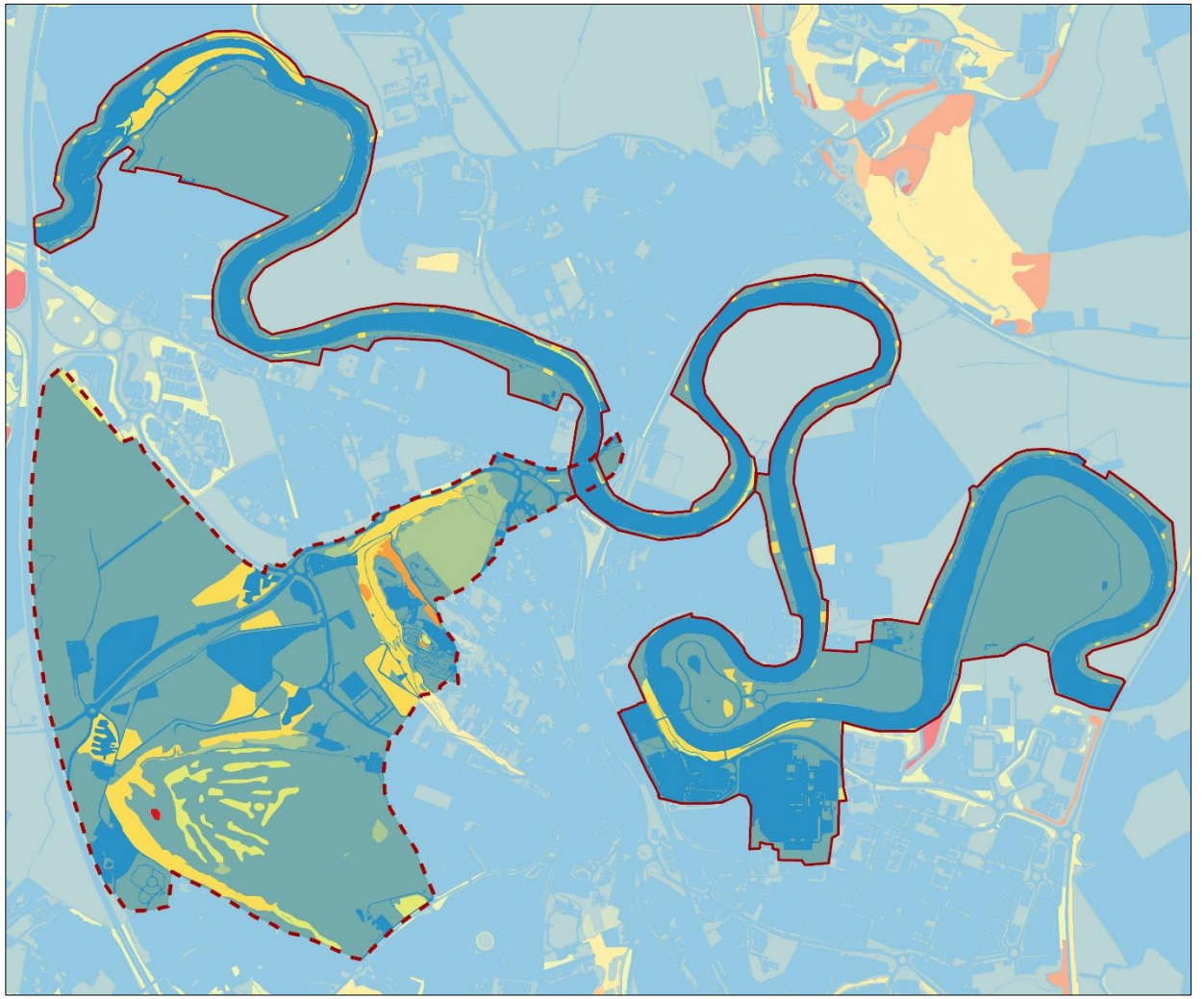
Natural Capital Solutions

Air quality regulation

Baseline



Investment



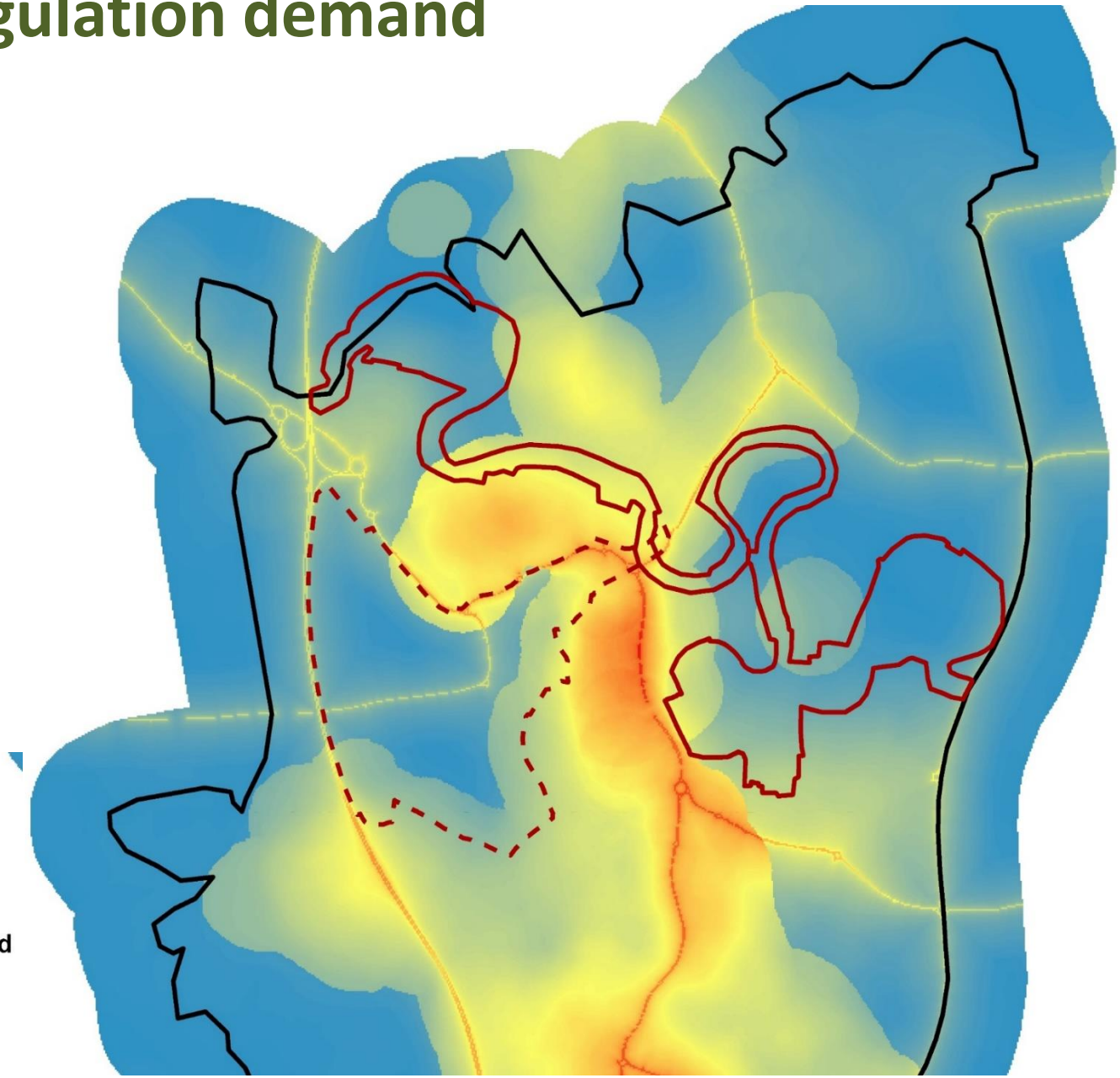
Natural Capital Solutions

Air quality regulation demand

The **demand** for some services can also be mapped

Indicates most appropriate areas to create new habitat to meet this demand

For air quality, demand based on 2 indicators of air pollution sources and 2 indicators of societal need for air purification.



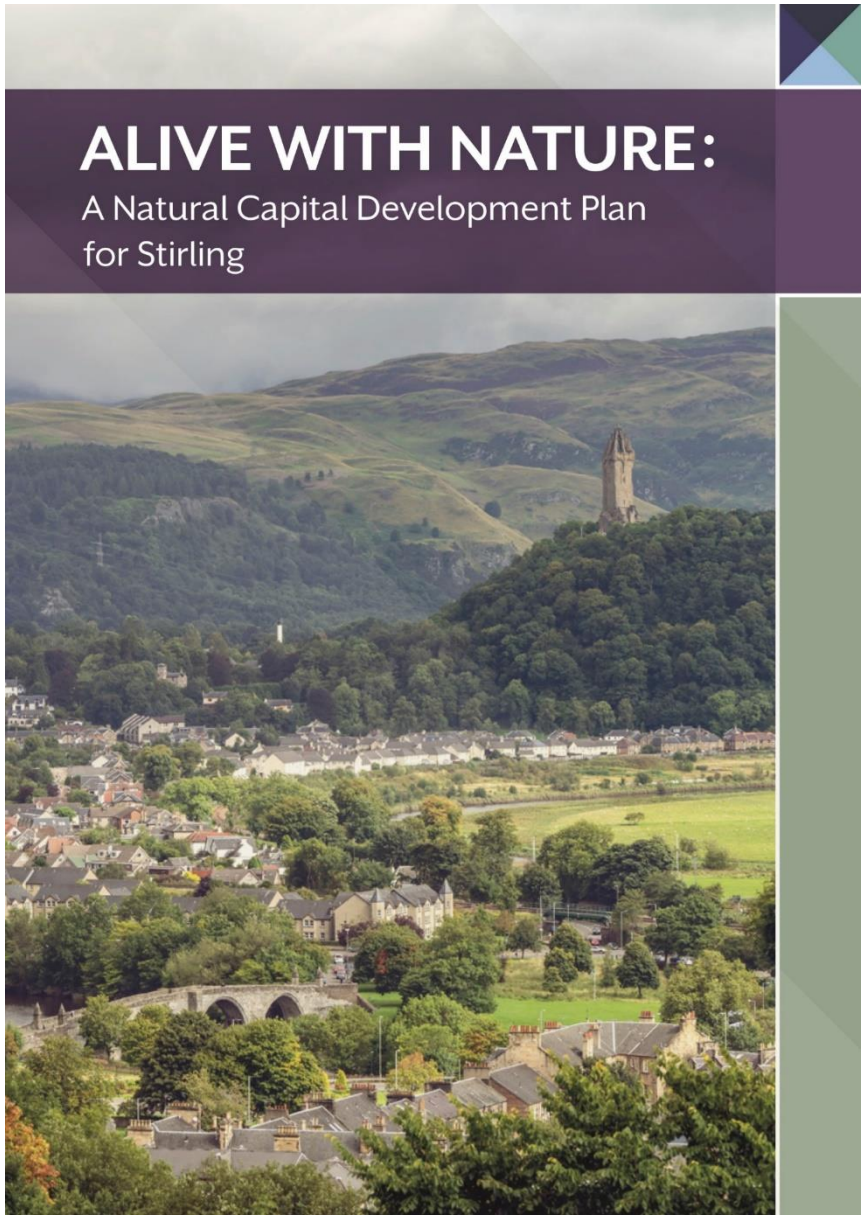
Economic appraisal of investments

		City Park	River
		Present value at 3.5%, £M (2017 prices)	
Benefits (assets)	Ecosystem services	41.0	46.8
	Property enhancement	12.0	12.8
	Tourism	95.7	143.6
	GVA benefit gain from investment	32.9	38.6
	TOTAL	**181.7**	**241.7**
Costs (liabilities)	Capital	44.1	53.2
	Operational & maintenance	49.5	59.1
	TOTAL	**93.3**	**112.3**
Net Present Value	50 years at 3.5%	**88.1**	**129.5**
Internal Rate of Return		**12.5%**	**13.7%**
Sensitivity analysis	NPV range (low-high benefits)	43-173	46-210

Natural Capital Solutions

Key points

- Natural capital accounting can be applied successfully to assess proposed developments in cities and integrated with standard economic appraisals.
- The benefits of investing in natural capital are considerable and should be taken into account in decision making.
- Recreation and health and wellbeing provide the greatest benefits.
- The value of ecosystem service benefits ensure a positive Return on Investment for the proposals in Stirling.
- Mapping the spatial location and distribution of benefits (especially in relation to demand) provides valuable additional information.



Further information

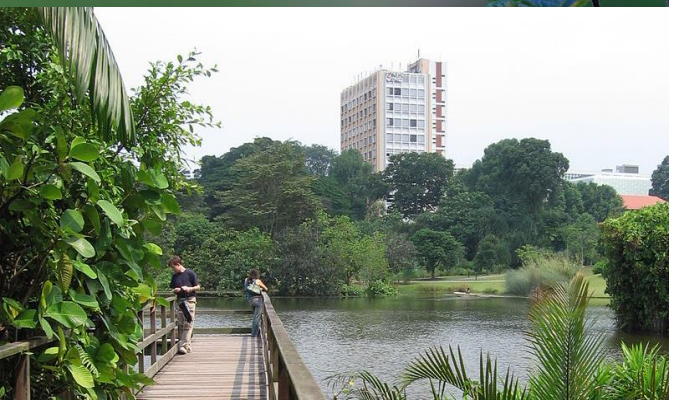
- Full technical report containing all maps, methods and results available from (go to case studies page): www.naturalcapitalsolutions.co.uk
- Summary document also available
- Please get in touch for further info: jim.rouquette@naturalcapitalsolutions.co.uk

Natural Capital Solutions

Stirling Council

Scottish Wildlife Trust

Scottish Forum on Natural Capital



Natural Capital Singapore

Assessing natural capital in a tropical city

Prof. Peter Edwards

9th May 2019
The World Bank Headquarters, WDC

Photos: Tan Puay Yok, Fung Tze Kwan, Dan Friess

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NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE
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ETH zürich

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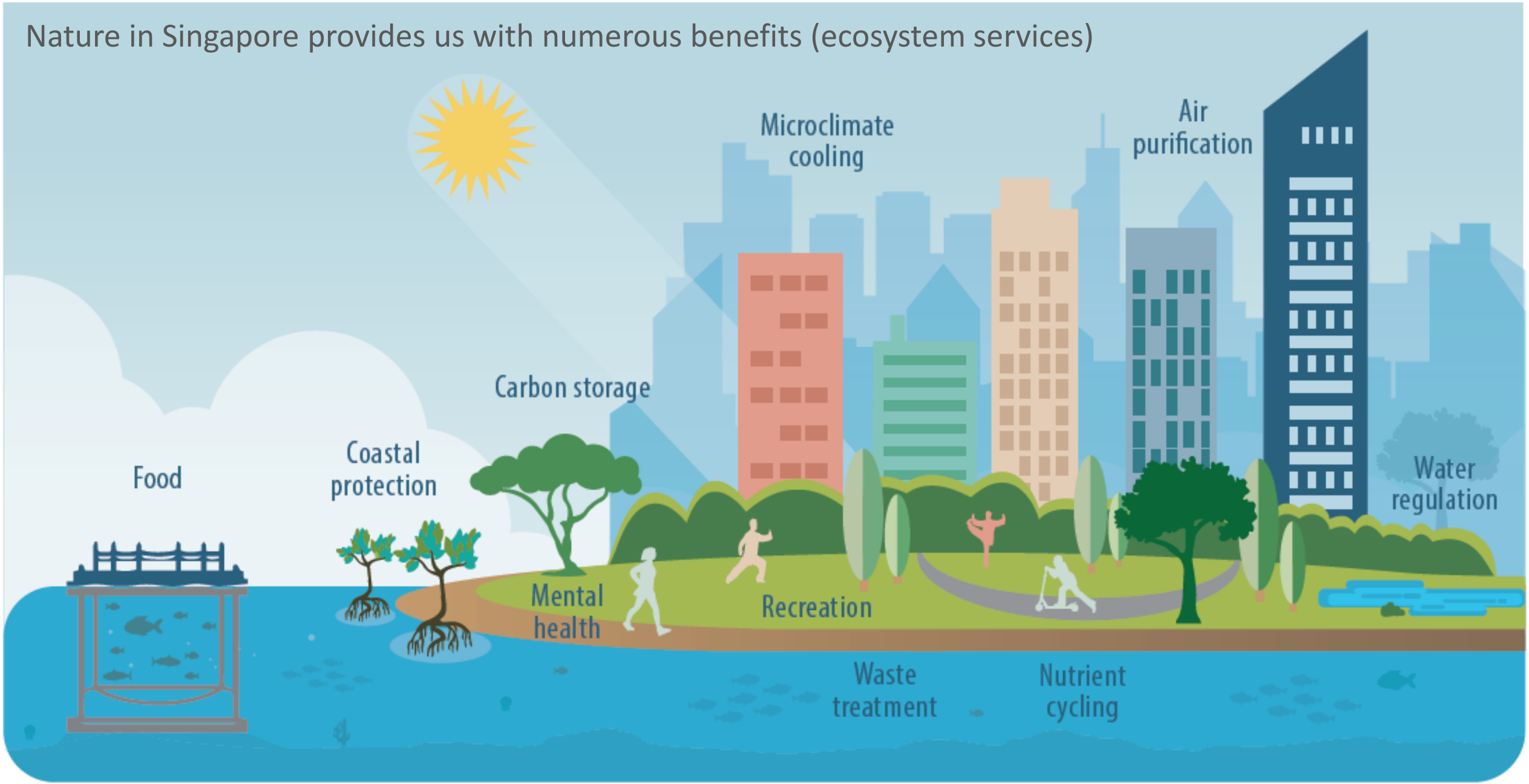
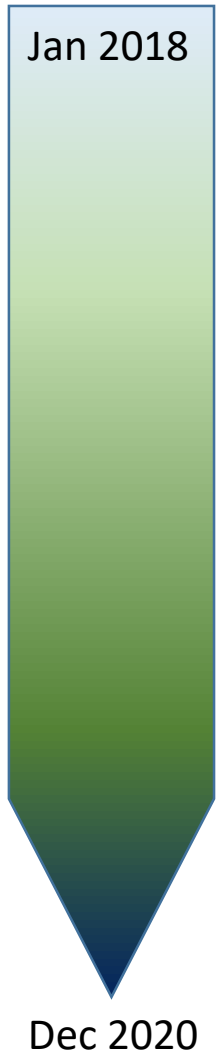
Nature in Singapore provides us with numerous benefits (ecosystem services)



Ecosystem services are produced for free by our *Natural Capital:* our stock of natural resources

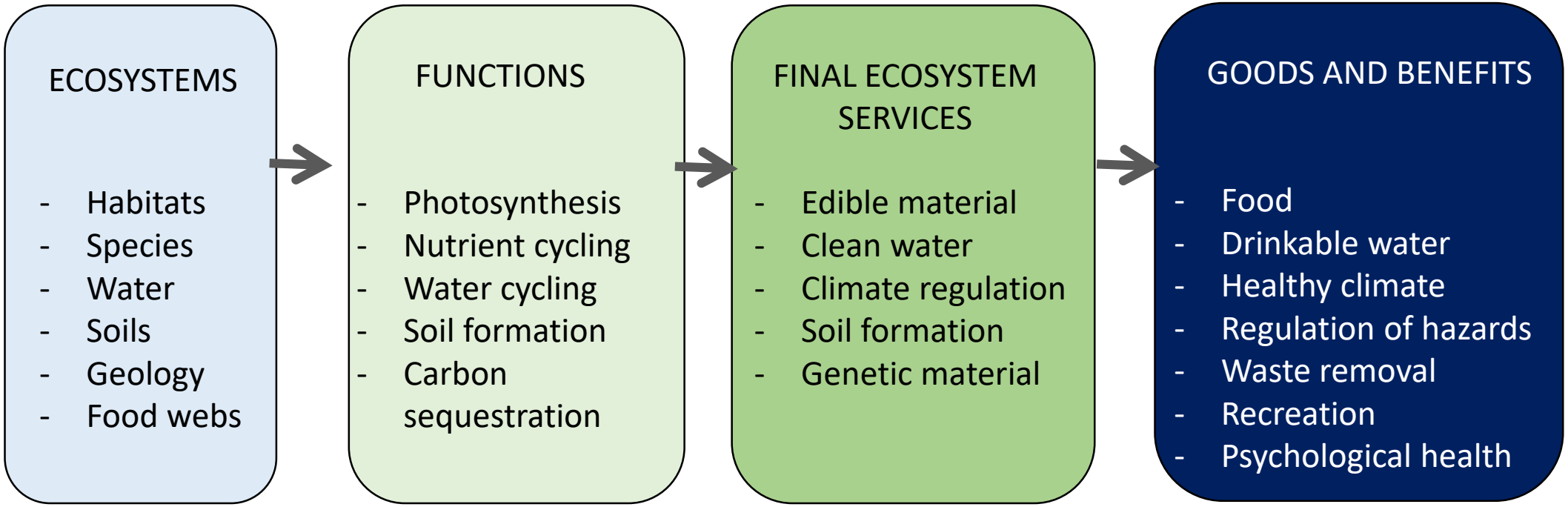
Assessing Singapore's Natural Capital



- **Objective 1:** quantify the *current status and health* of Singapore's terrestrial and coastal-marine ecosystems
- **Objective 2:** quantify the *value* of Singapore's ecosystem services to society – both economic and societal.
- **Objective 3:** assess *interactions* between urban development (urban assets) and natural capital (natural assets)
- **Objective 4:** assess *future policy and development opportunities* that integrate natural capital within a sustainable future city

Methodological considerations

- Similar stepwise process to national accounting best practice
- Adapt established ES frameworks – e.g. CICES
- Able to use standard valuation techniques



Specific considerations in a city

1. The typology of ecosystems differs in the urban setting
2. A city is heterogeneous in 3 dimensions meaning that we must consider ecosystems and processes at a fine spatial scale
3. Understanding human perception and behavior is important
4. The sources of value are diverse, e.g. conservation, optimising human wellbeing
5. The designed and cosntructed environment is important

1. Ecosystem typology

- What are the ecosystems in a city?
- How do you separate out the human inputs and built environment in supporting the ecosystem? For example:
  - A park built and maintained by humans
  - Vertical greenery on a building facade

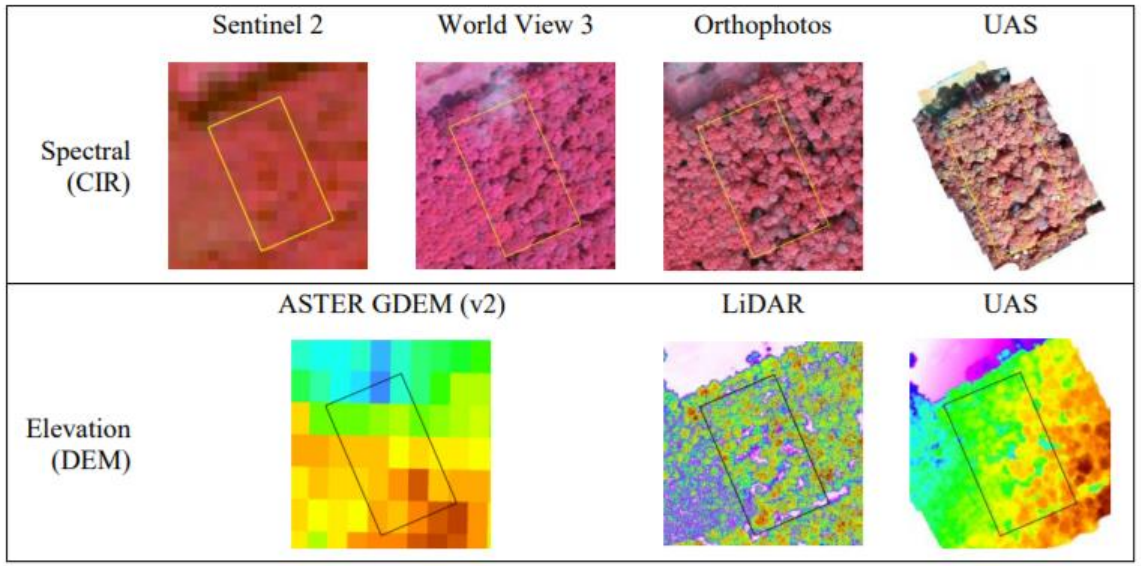
Rain garden and bioretention basin in residential estate for stormwater management (Tan Puay Yok)

A naturalized canal provides recreational and environmental education opportunities (Tan Puay Yok)

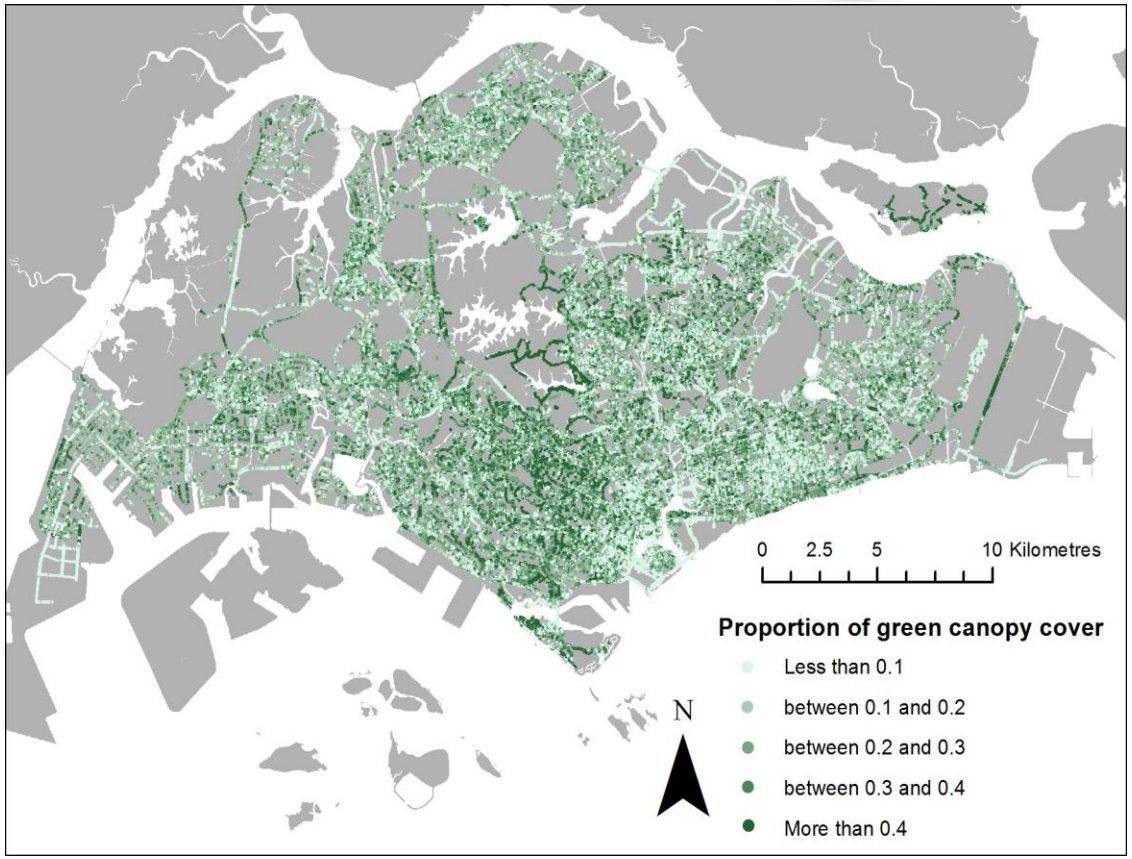
2. Fine-scale 3D data

Google Streetview

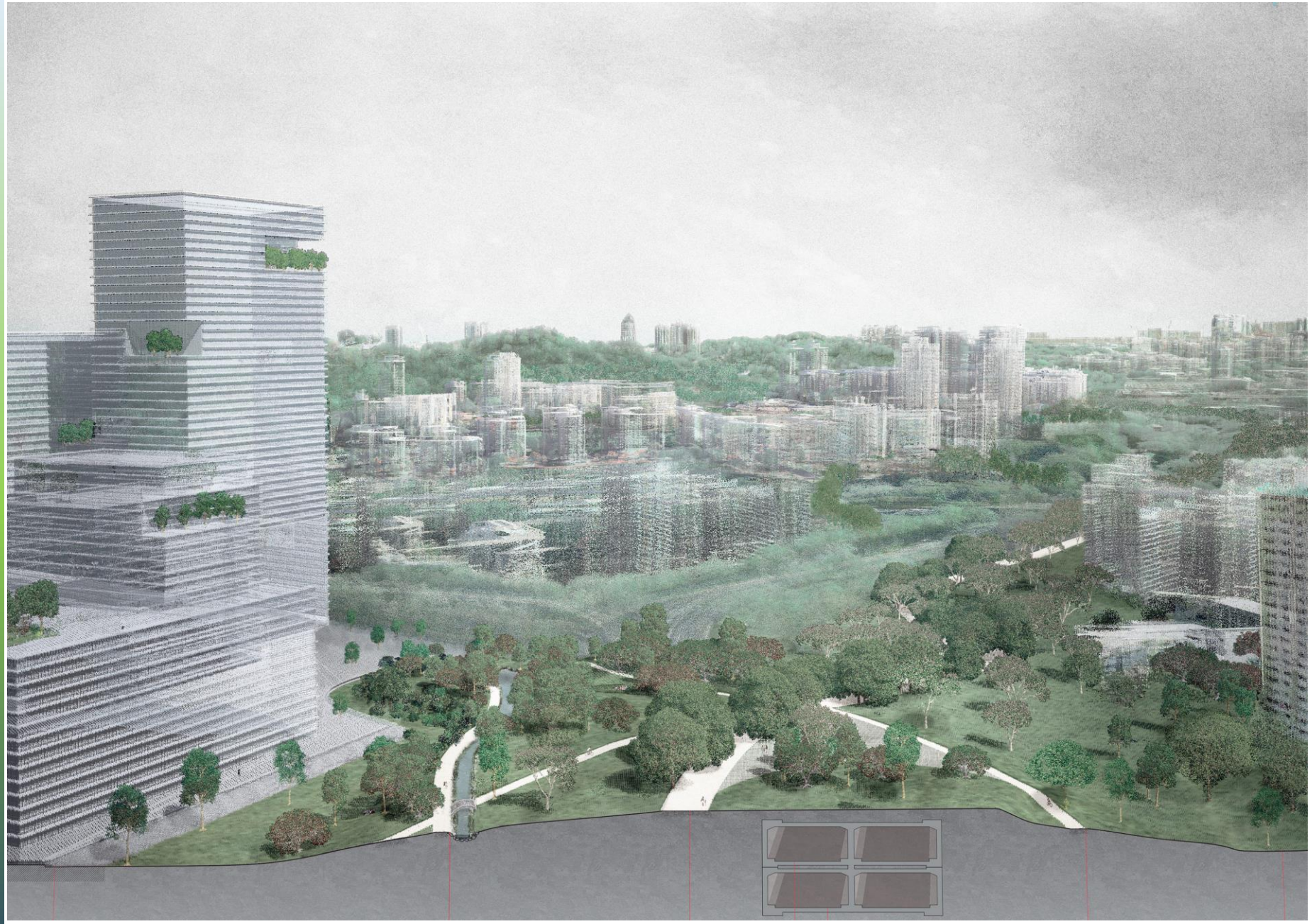
New technologies for fine-scale quantification:
LiDAR, HiRes multispectral imagery, ortho-photography,
Google street views and Cloud Platforms



Source: Leon Gaw (2018) Thesis



Richards and Edwards 2017. Ecological Indicators



Christophe Girot,
Philipp Urech
Chair of Landscape Architecture, ETH

Laser-scanned point clouds as a design and visualization tool

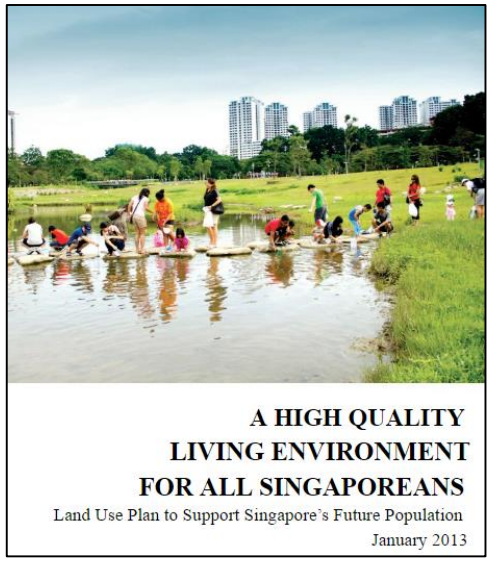
3. Human perception and behaviour

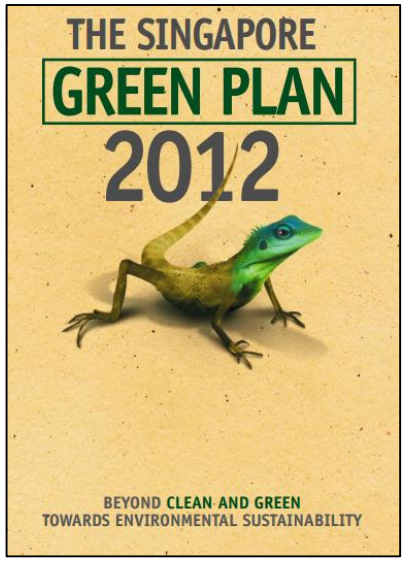
Heat stress outdoors influences use of parks in the daytime

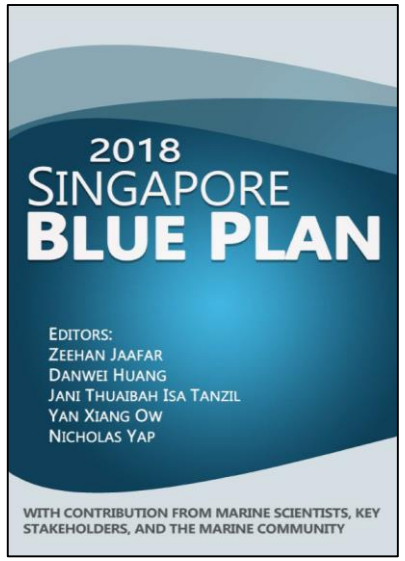
Disservices can be important,
Aedes aegypti and dengue fever

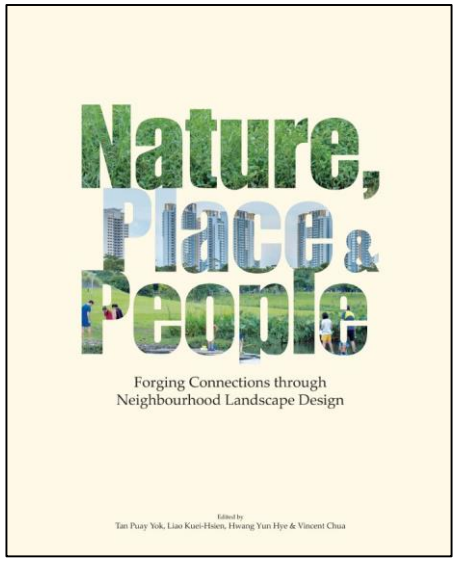
4. Designing a City for ES: h ow can natural capital accounting be utilised for urban planning processes?

4.1 Link to city strategies, targets and plans







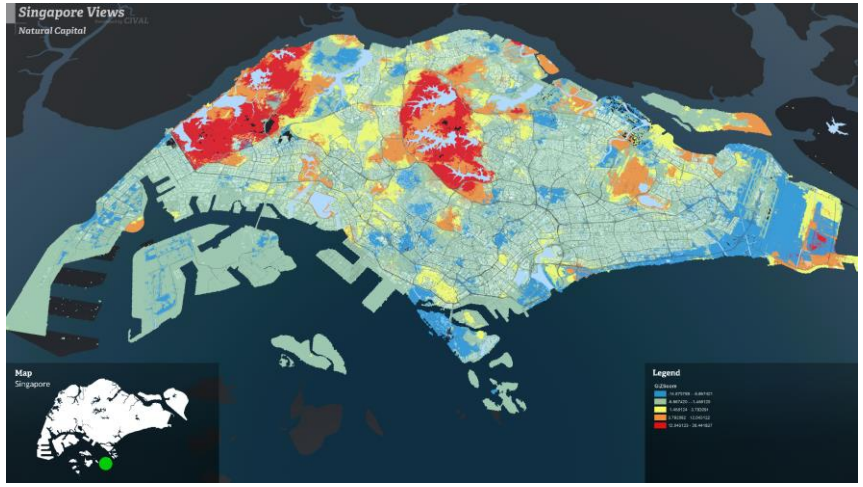


4.2: Map ecosystem services

Waterflow regulation

Climate regulation

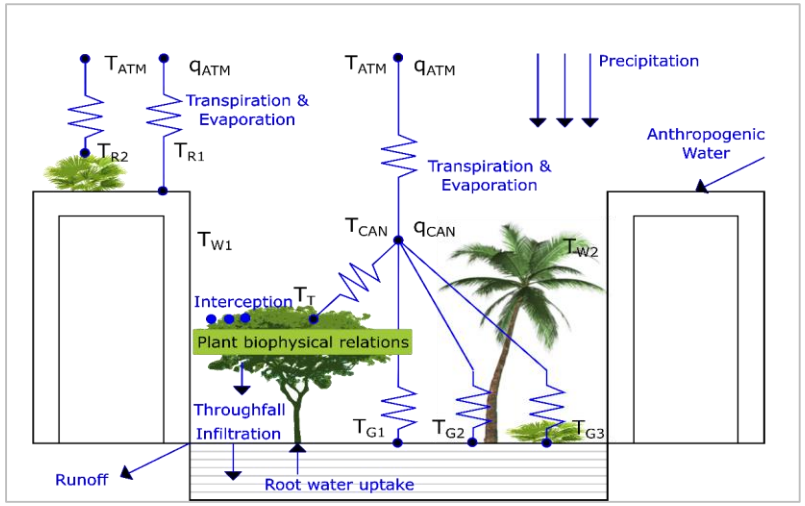
Carbon storage



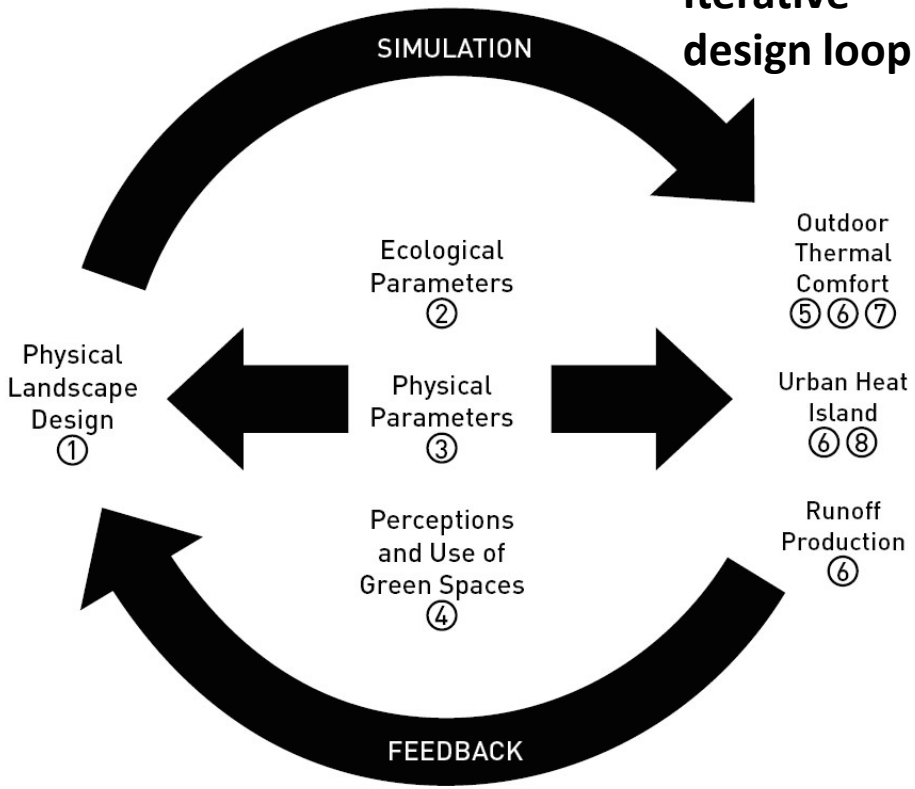
Ecosystem service hotspots

4.3: Simulation

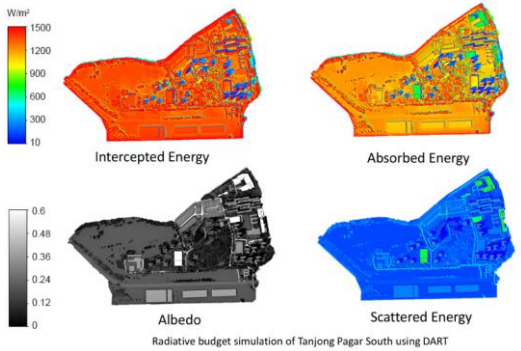
Urban Ecohydrological Model



Iterative design loop

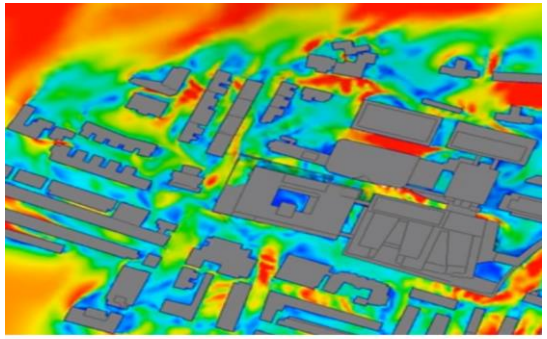


DART

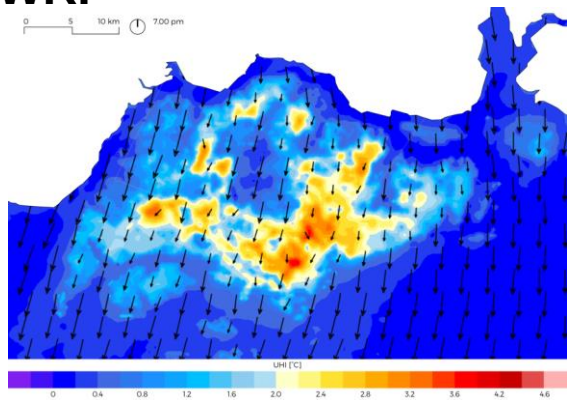


Radiative budget simulation of Tanjong Pagar South using DART

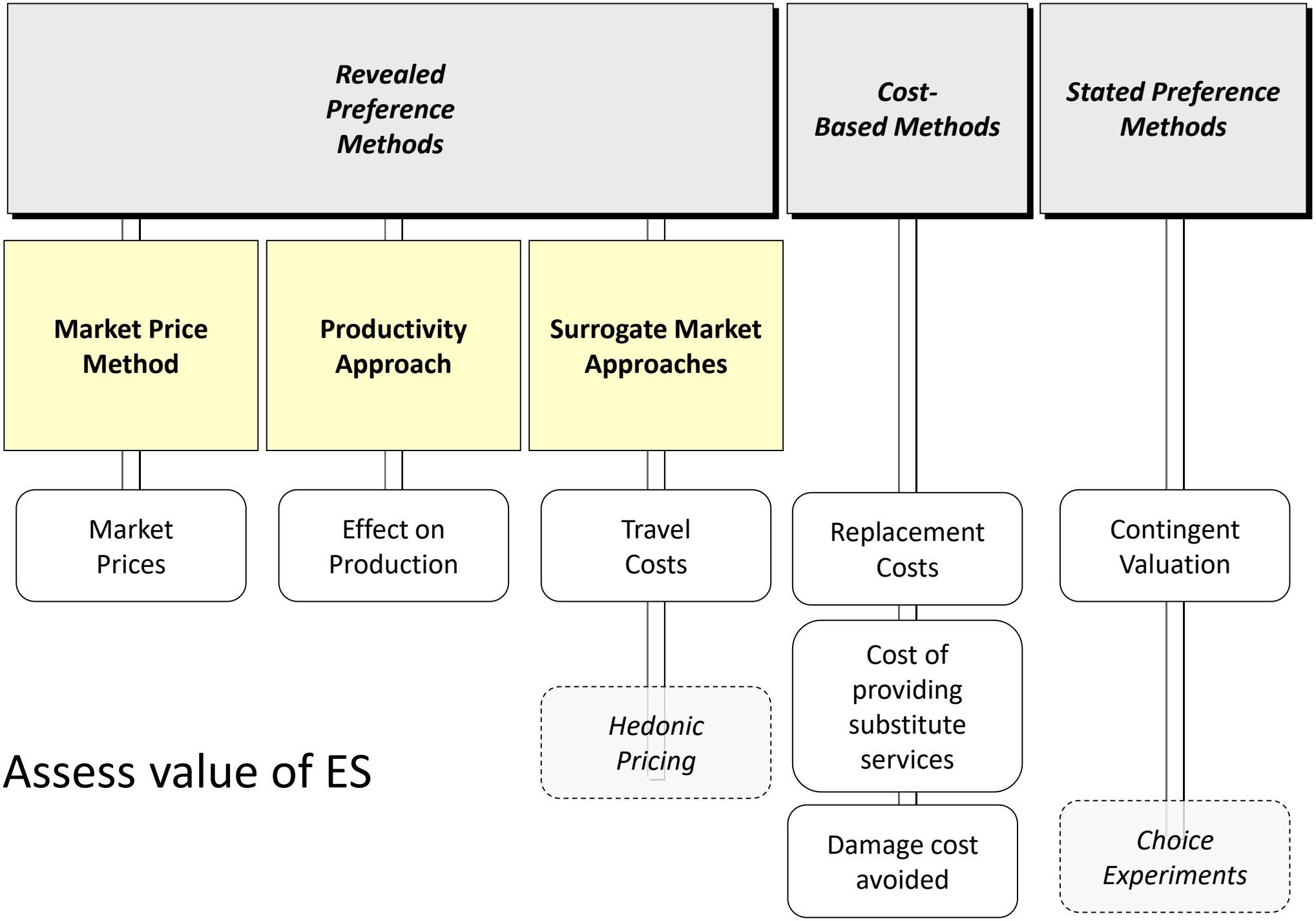
OpenFoam



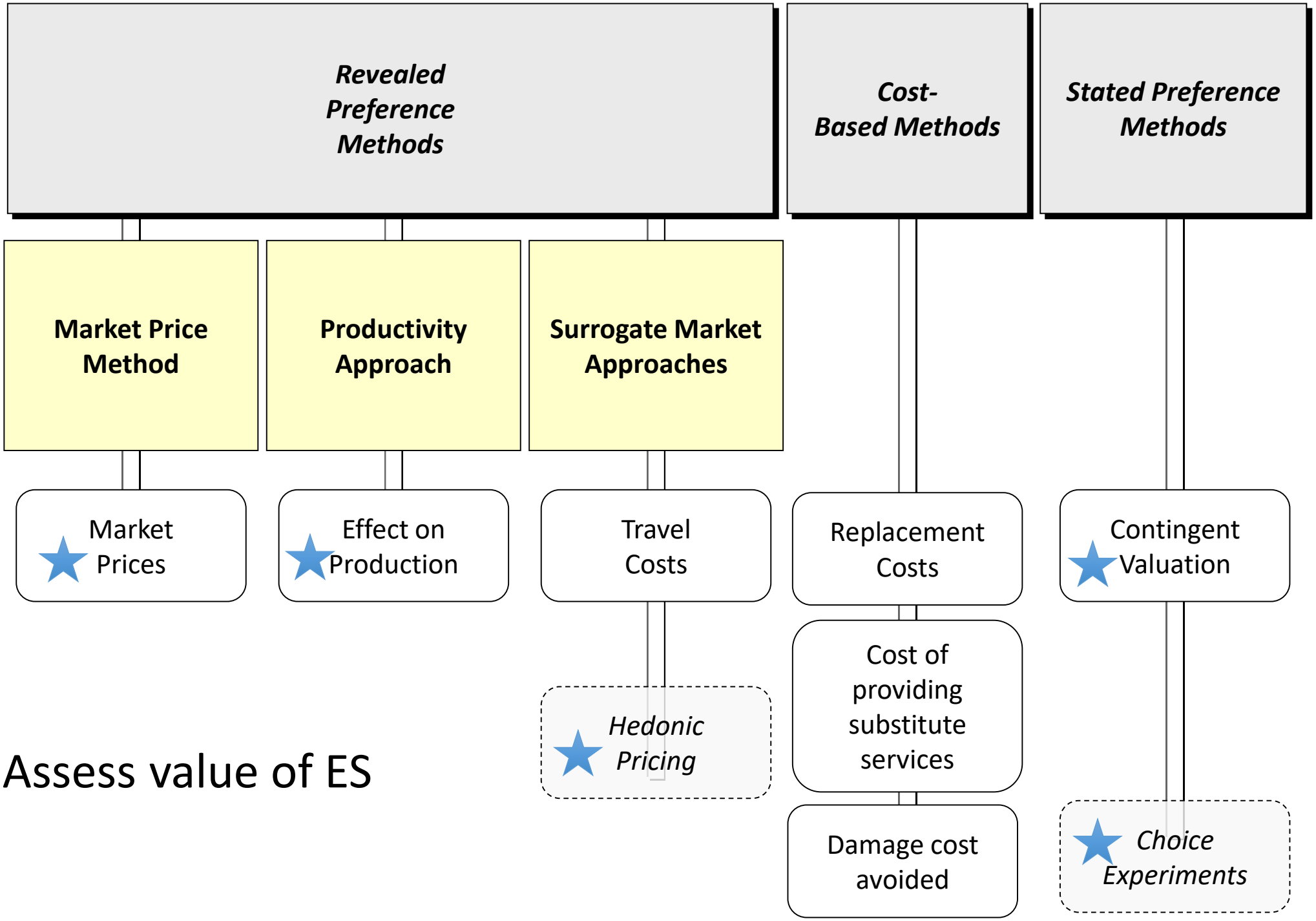
WRF



4.4: Assess value of ES

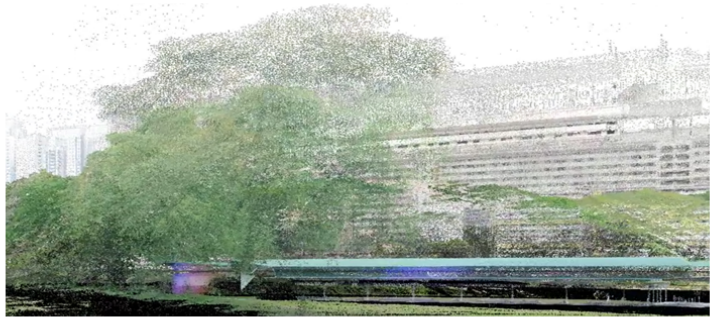


4.4: Assess value of ES



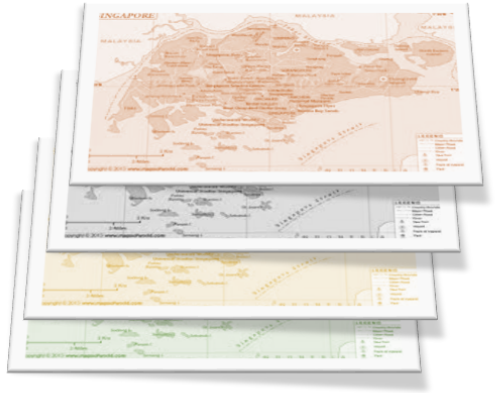
4.5: Interactive Decision Support Tools for planners and designers

Conversion:
Grass to built…
Tree to grass…



Landscape: Point Clouds

Modification:
Add or change trees in park
Trees along roads



Ecosystem Services Maps

Costs Purchase: $
Costs Management: $$
Effect on Service A: +
Effect on Service B: --

Webplatform (CIVAL)

Natural Capital Singapore

Thank you!

www.naturalcapital.sg

Twitter: @NatCapSG

Prof. Peter Edwards
peter.edwards@env.ethz.ch

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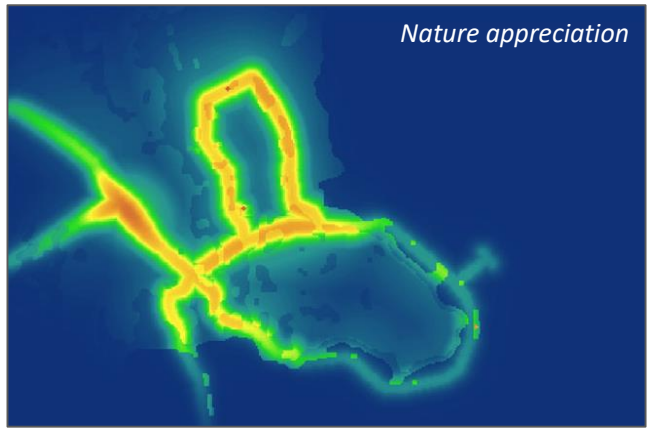
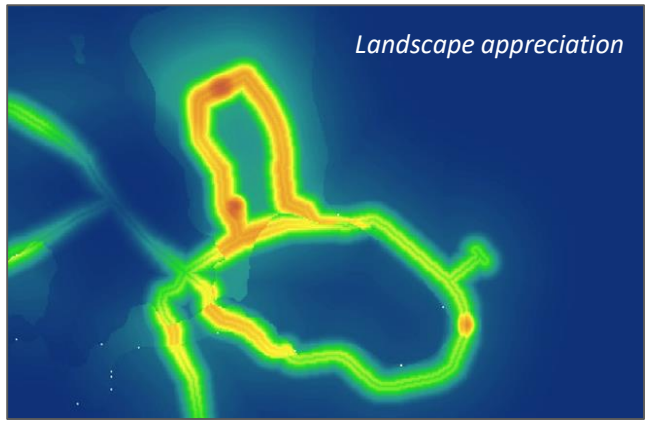
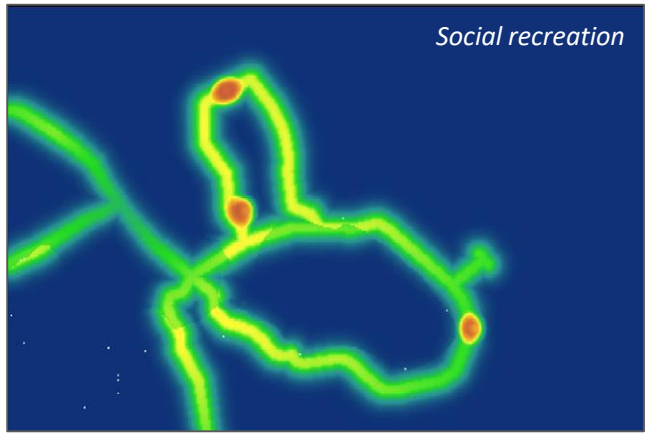
ETH zürich

Using social media photographs to model the spatial distribution of cultural ecosystem services at Chek Jawa







Richards & Friess. 2015. A rapid indicator of cultural ecosystem service usage at a fine spatial scale: content analysis of social media photographs. **Ecological Indicators** 53, 187-195.