photo credit: Living Juicy

Biodiverse Design in the Intelligent City

Mike Wells

BIODIVERSITY BY DESIGN

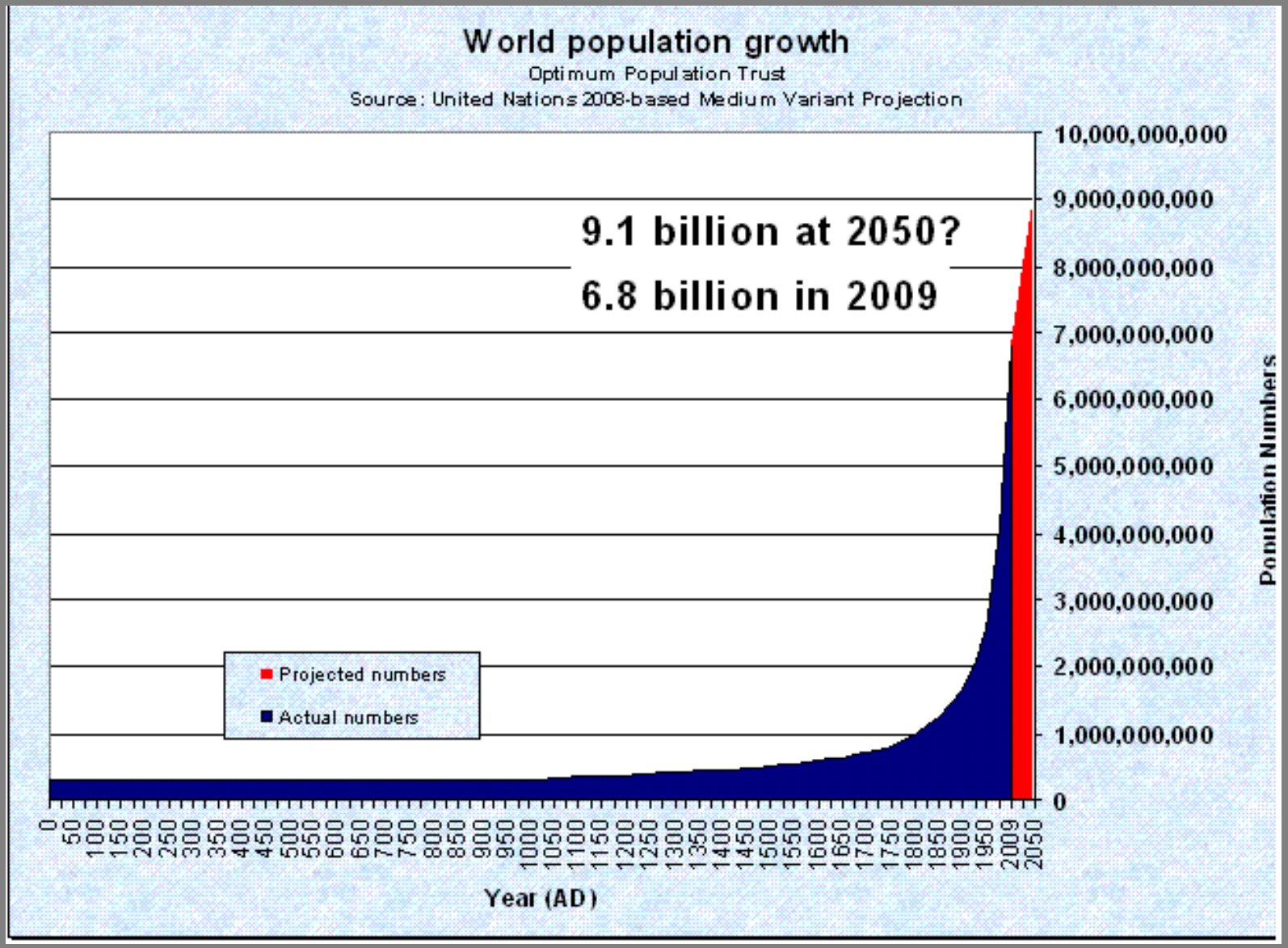
...we had already created enough problems before climate change...

Living Beyond Our Means

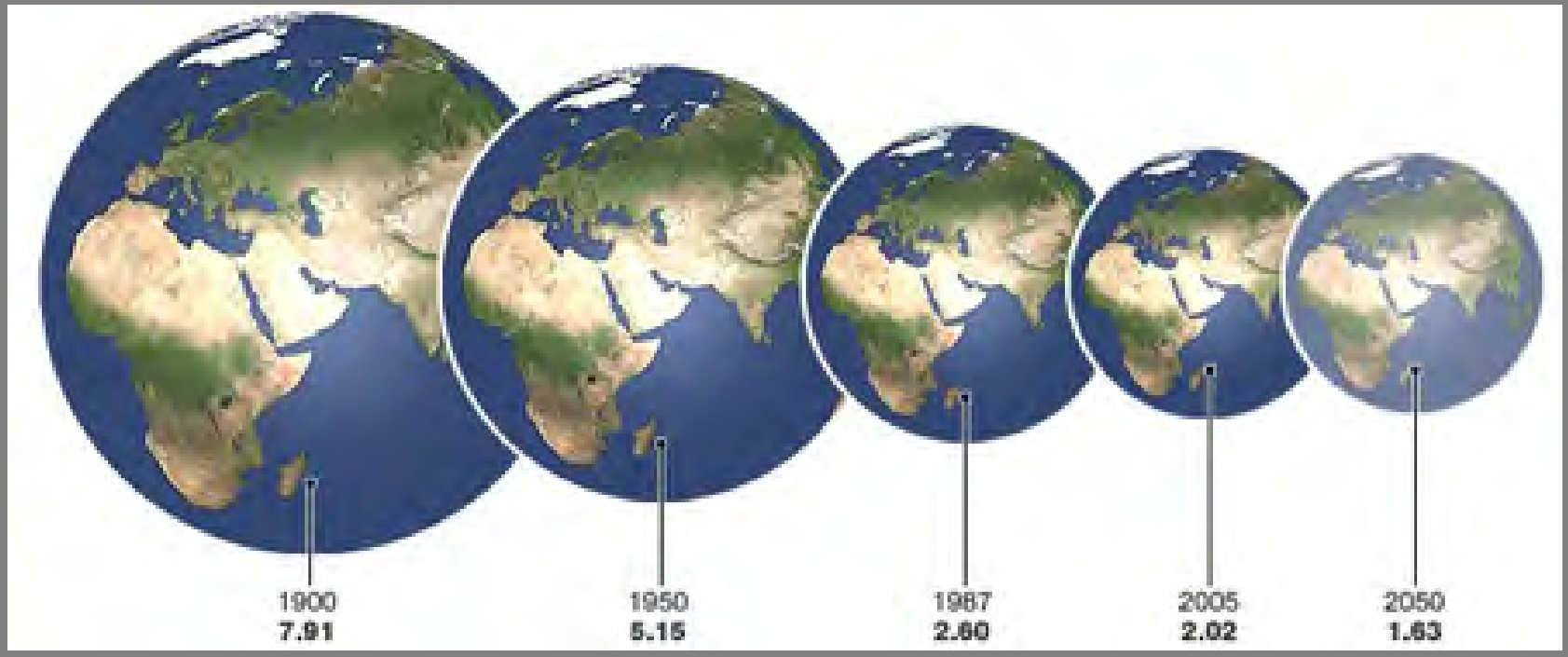
Natural Assets and Human Well-Being

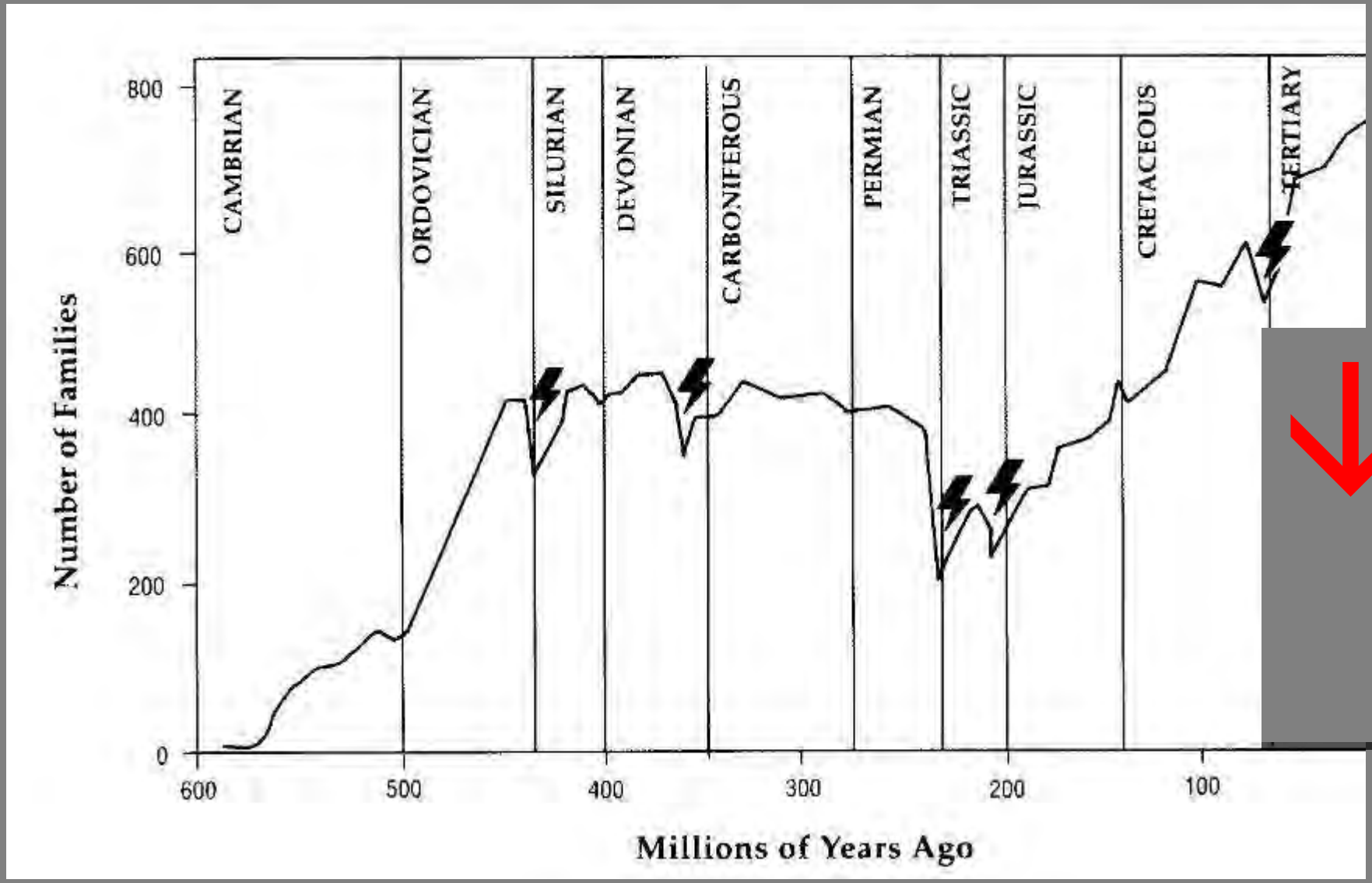
Statement from the Board

Millennium Ecosystem Assessment


World population growth
Optimum Population Trust
Source: United Nations 2008-based Medium Variant Projection
9.1 billion at 2050?
6.8 billion in 2009
Projected numbers
Actual numbers
10,000,000,000
9,000,000,000
8,000,000,000
7,000,000,000
6,000,000,000
5,000,000,000
4,000,000,000
3,000,000,000
2,000,000,000
1,000,000,000
0
Population Numbers
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2009 2050
Year (AD)

Change in hectares of available land per person from 1900





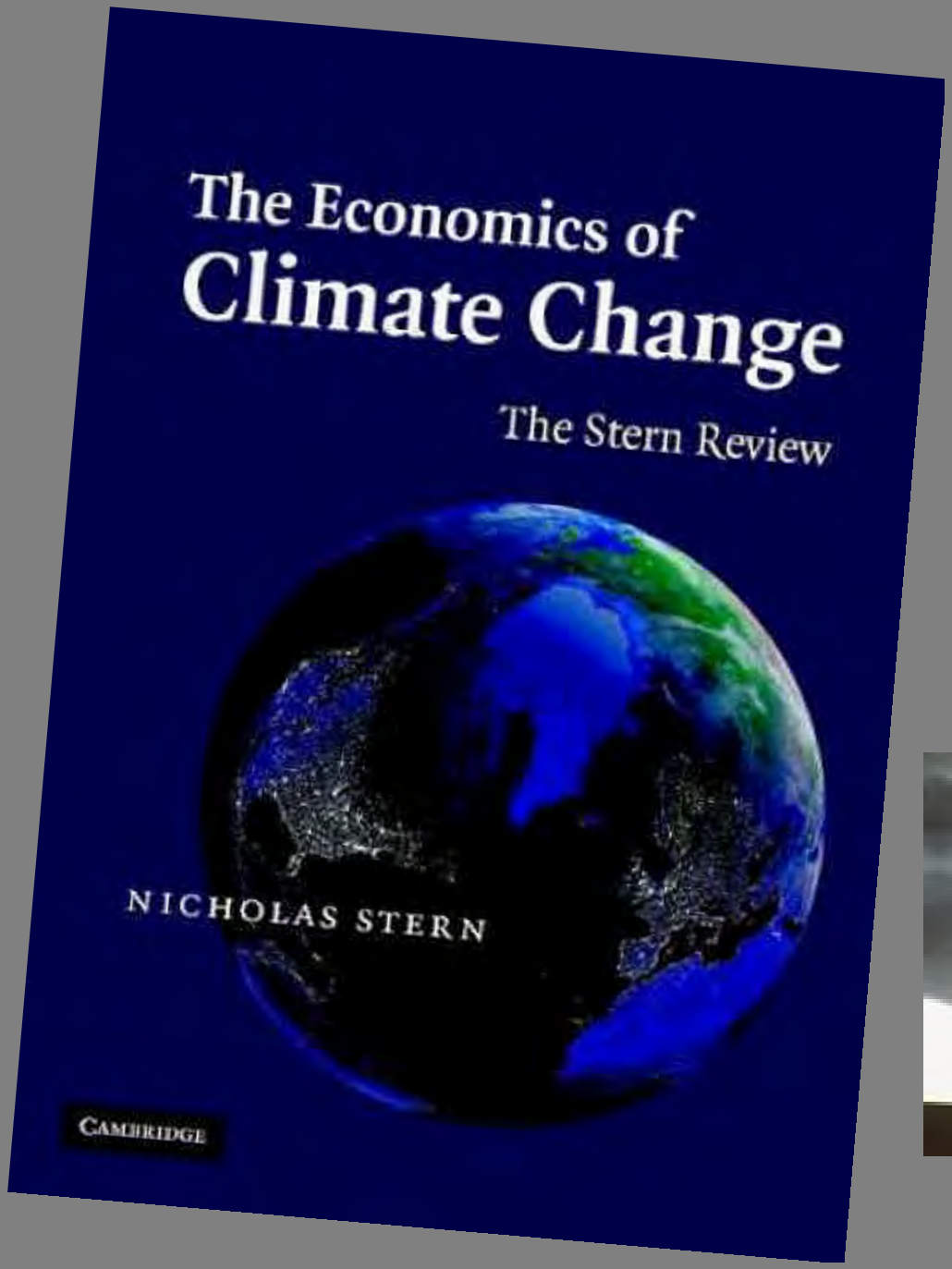
Previous mass extinctions from E.O. Wilson ‘The Diversity of Life (1992)


N3648S


LOW CLEARANCE
2.8m
ROAD SUBJECT TO
FLOODING
INDICATORS SHOW DEPTH

Man-induced climate change is increasing increases the risks and the harm we have already caused to our isolated support system

1968


The Economics of
Climate Change
The Stern Review
NICHOLAS STERN
CAMBRIDGE

‘We cannot solve our problems with the same thinking we used when we created them.’

Albert Einstein

If we were cats we would have all but used up our nine lives!

What positive changes can we make as a predominantly urban species?

By designing for and with biodiversity as the basis of ecosystem goods and services, simultaneously at the macro, meso, and micro scales, we increase our chances of achieving one-planet living, as well as limiting the damage of climate change and improving the quality of our lives

Nine principles for securing multiple benefits from and for biodiversity in urban design

Principle 1: Mandatory assessment of ecosystem services, ecological footprinting & sustainable sourcing of materials for all new development & refurbishment

Mechanisms: integrate ecosystem services values into national, regional and local accounting, establish traceability networks, implement Nagoya Protocol

Metrics: increase in true traceable sustainable materials, preservation of biodiversity source and carbon sink areas e.g wetlands, forests and reefs

Globally ecosystem goods and services are worth c. £22 trillion/year (£22,000,000,000/yr) (range £10-£36 trillion)

or 2 x GLOBAL GDP

Robert Costanza

Food including fisheries, agriculture pollination

Fuel and Carbon Sequestration

Microclimatic amelioration

Tourism

Adaptability and resilience to changing environment

Structural Protection

Aesthetic pleasure for quality of life

The air we breathe

Bio-indication and early warning systems

Building Materials and Clothing

Sea defences and flood risk managment

Medicines and Healing Environments

Soil creation & preservation

Pollution abatement, including air and water cleansing

Improved business profile, consents and and sales

Vital Place Making

All wood products

The Economics of Ecosystems & Biodiversity

TEEB FOR BUSINESS

EXECUTIVE SUMMARY

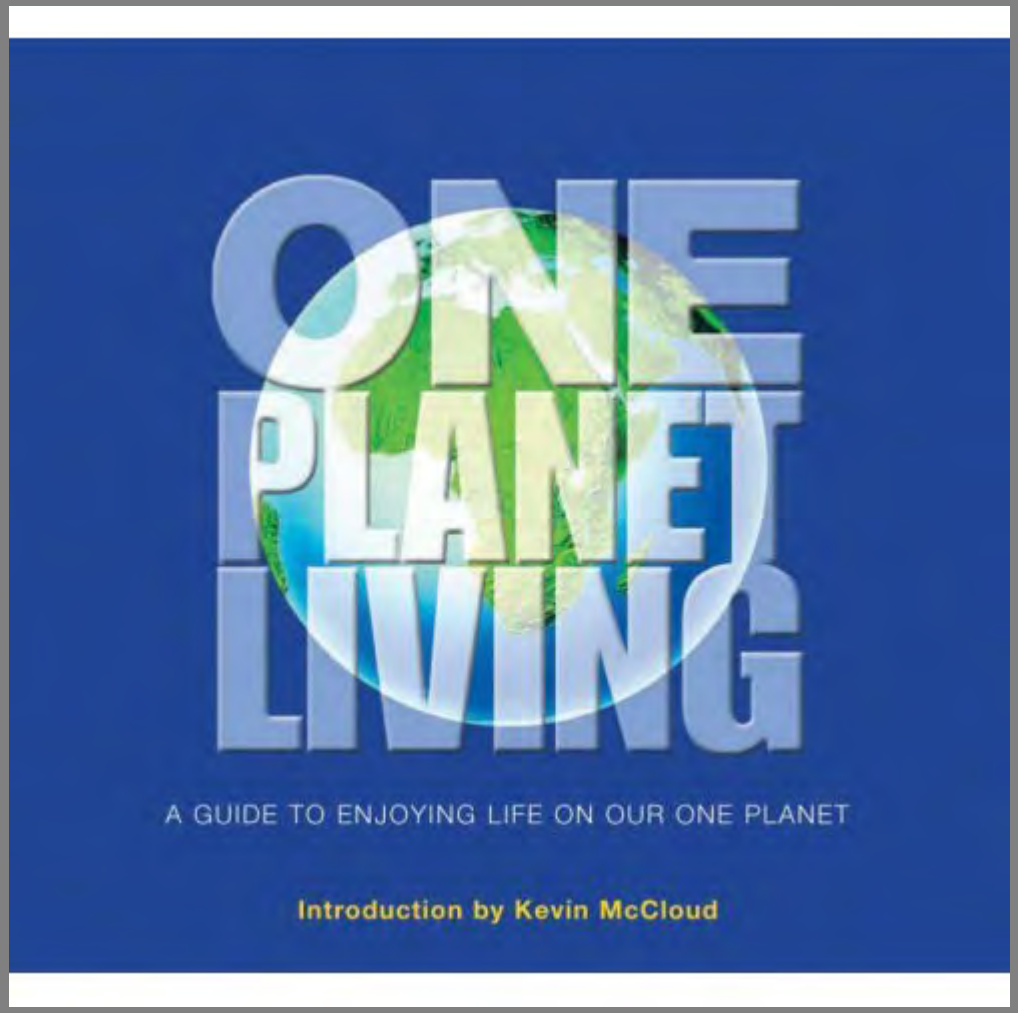
Nagoya Protocol Implementation Fund
June 2011

'We see this as a groundbreaking opportunity to add economic and social value to biodiversity and genetic resources, in particular to local and indigenous communities who have in the past not benefited as they should'

Monique Barbut, CEO and Chairperson of the Global Environment Facility

HM Government

The Natural Choice: securing the value of nature

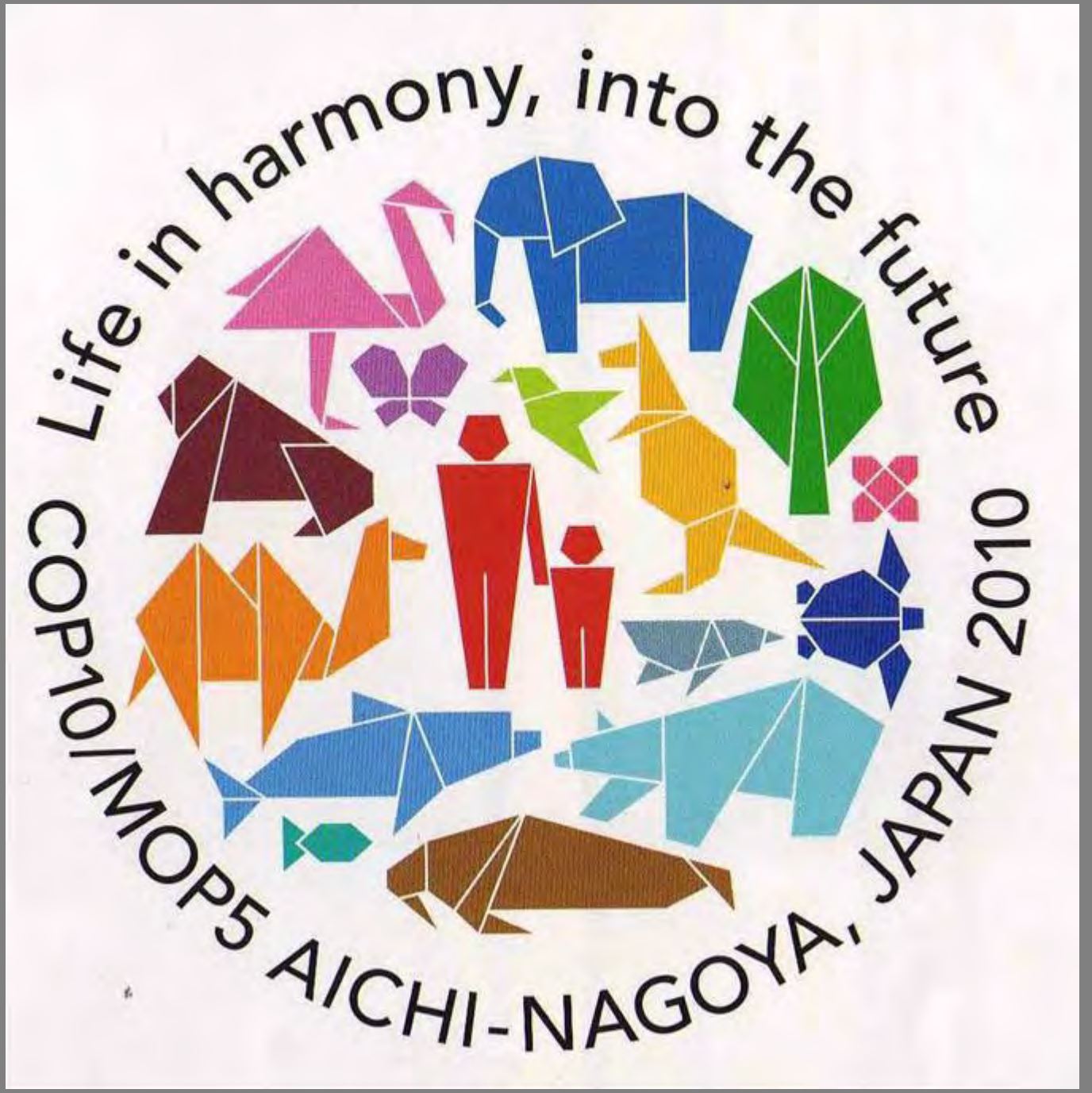


1. Zero carbon
2. Zero waste
3. Sustainable transport
4. Sustainable materials
5. Local and sustainable food
6. Sustainable water
7. Land use and wildlife
8. Culture and heritage
9. Equity and local economy
10. Health and happiness

N.B. ‘THRIVING’ - NOT JUST ‘LIVING’!

Ecological Footprint

- ..is the total of the different land use types (built up areas, grazing and crop land, managed forest land, energy land and fishing grounds) required for production and consumption of human goods and services (food, housing, transport, other consumables) and disposal of the waste.
- Ecological footprints are usually expressed in hectares, or hectares per capita (per person), for a given year


Life in harmony, into the future
COP10/MOP5 AICHI-NAGOYA, JAPAN 2010

FSC

100%

From well-managed forests

Cert no. TT-COC-1110

www.fsc.org

Principle 2 : Promote sustainable and naturally produced urban and peri-urban food production

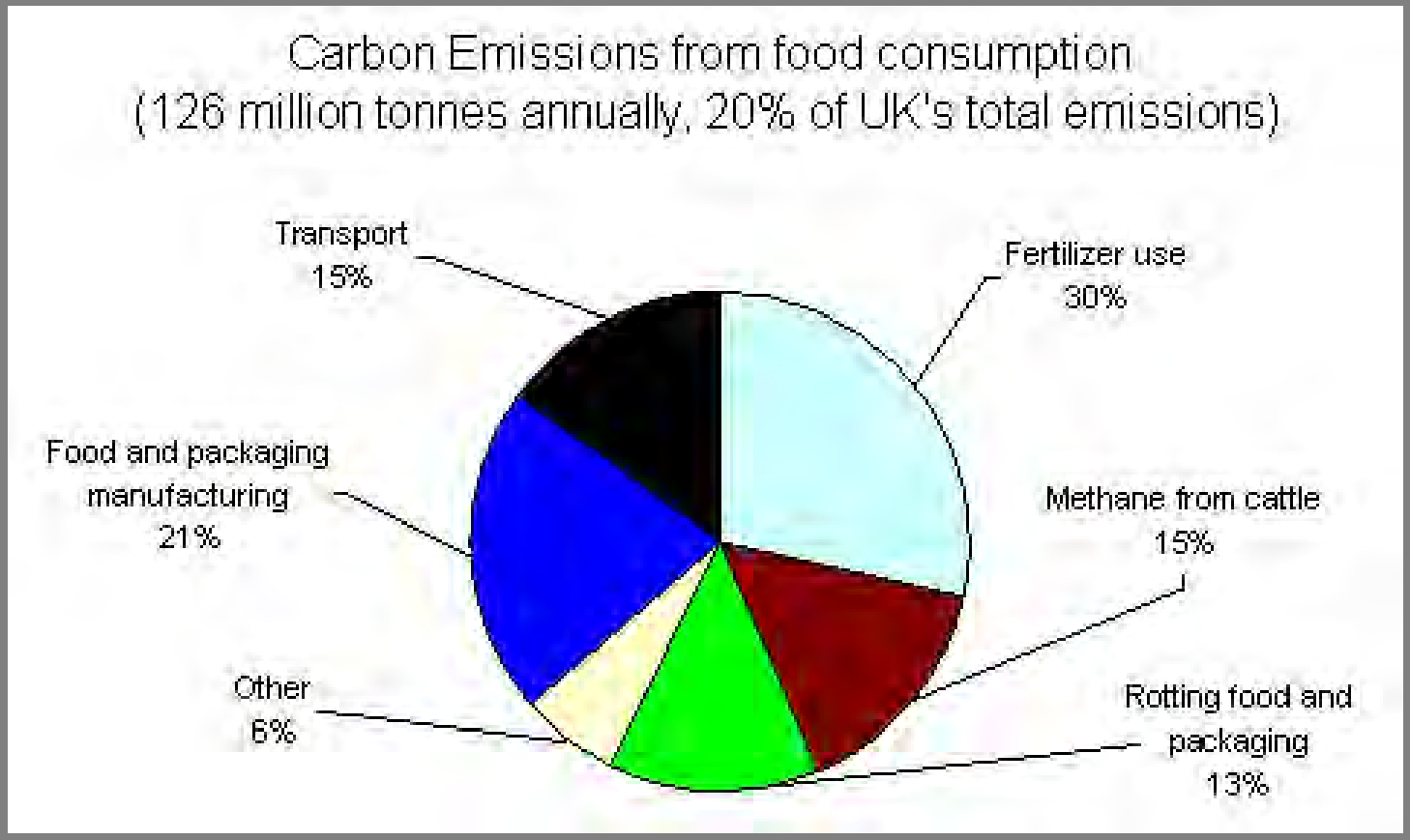
↓

Mechanisms: urban agriculture and permaculture, community food projects, foodroofs and facades etc

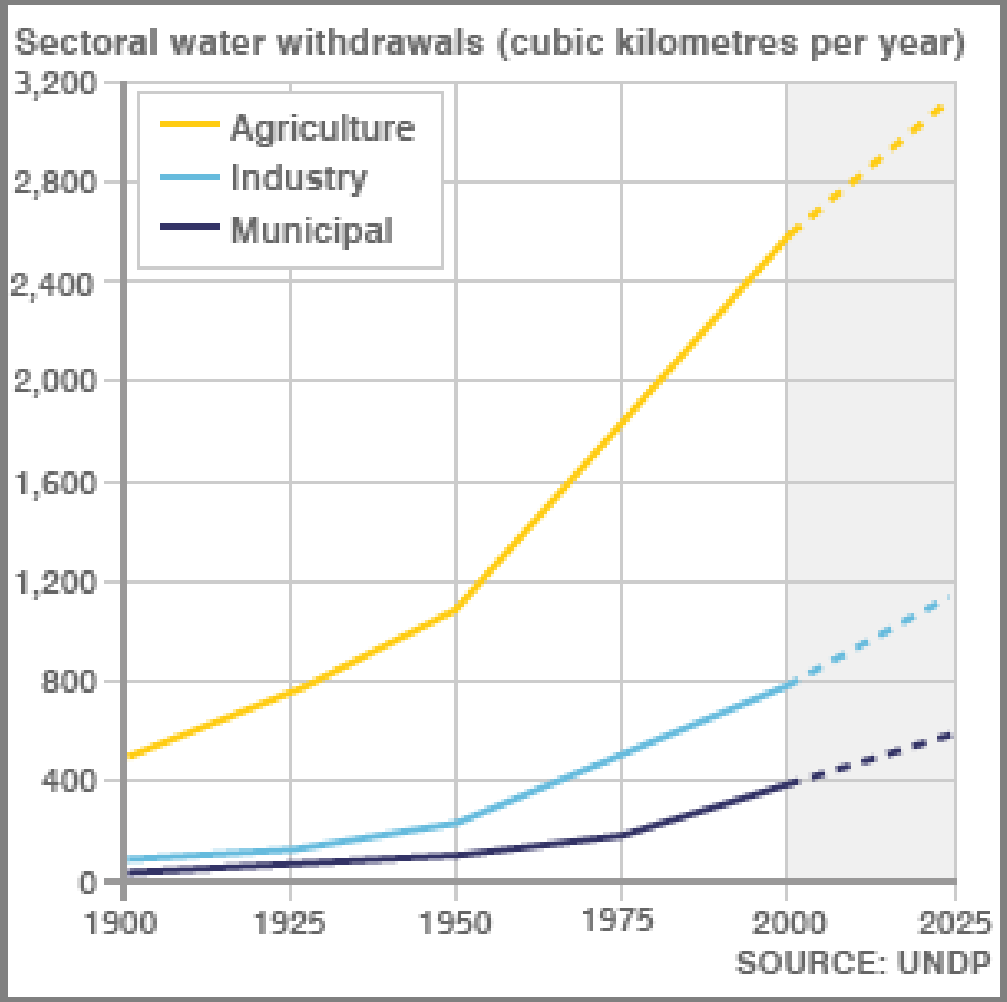
↓

Metrics: reduced ecological, water and carbon footprint, improved human wellbeing and social cohesion, wildlife benefits

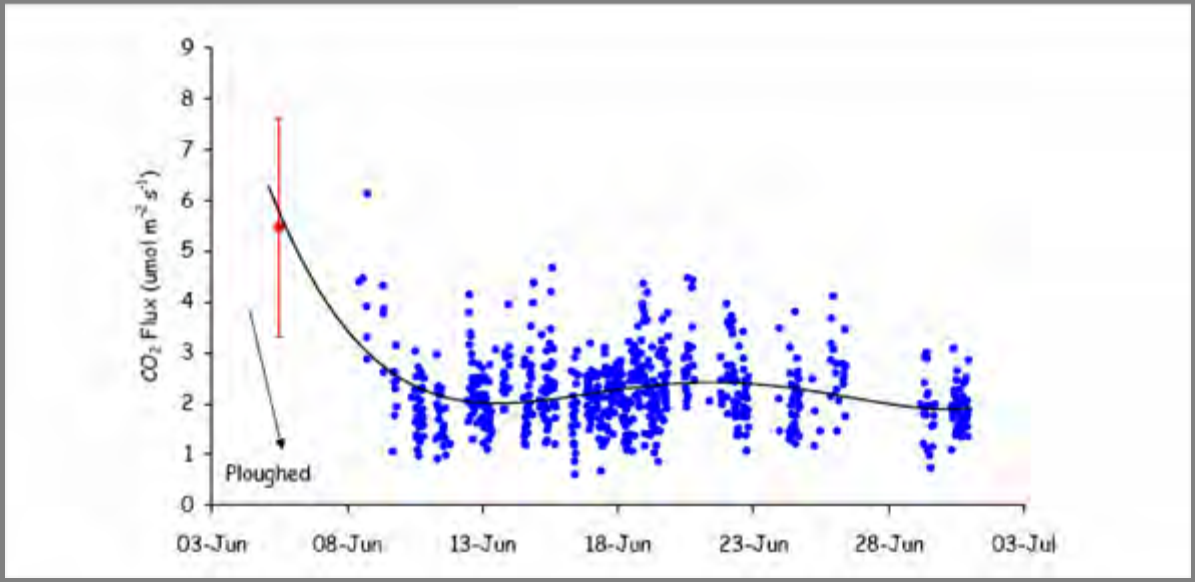
Reduce carbon of transport, packaging and food waste



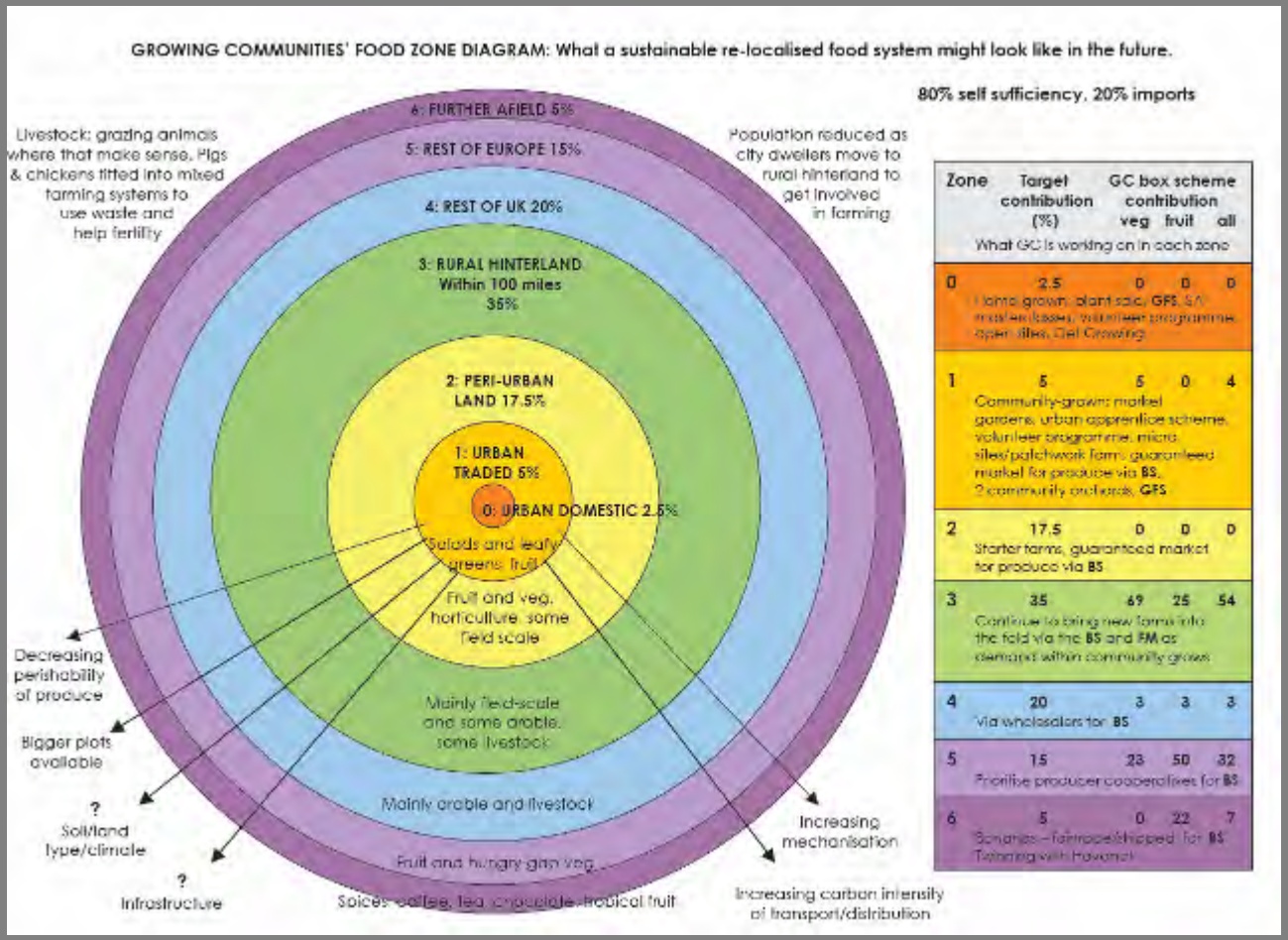
Growing agricultural water use



Carbon loss from soils at ploughing



London, UK, Borough of Hackney, seeking greater food sustainability



Multi-functional food allotment, Northern Ireland, UK

Community food and nature rooftop garden, Reading, UK

St Petersburg Rooftop Gardening Society

Traditional biodiverse orchards - for urban communities

Waste heat to vegetables, USA supermarket

Brooklyn Grange Rooftop Farm, New York

Competitive hydroponics: Omega Systems Canada

The Continuous Productive Urban Landscape – Havanna Cuba

Decline in pollinators e.g. bees

Tastier, higher value cheese from cows raised in more biodiverse meadows

Principle 3: Promote water harvesting, attenuation, cleansing and storage combined where possible with natural systems

↓

Mechanisms: Sustainable integrated, biodiverse urban drainage, smart storage technologies

↓

Metrics: reduced heat island effect, increased amenity in heat wave, reduced flood hazard, reduced maintenance costs, can be reduced infrastructure cost

SWITCH

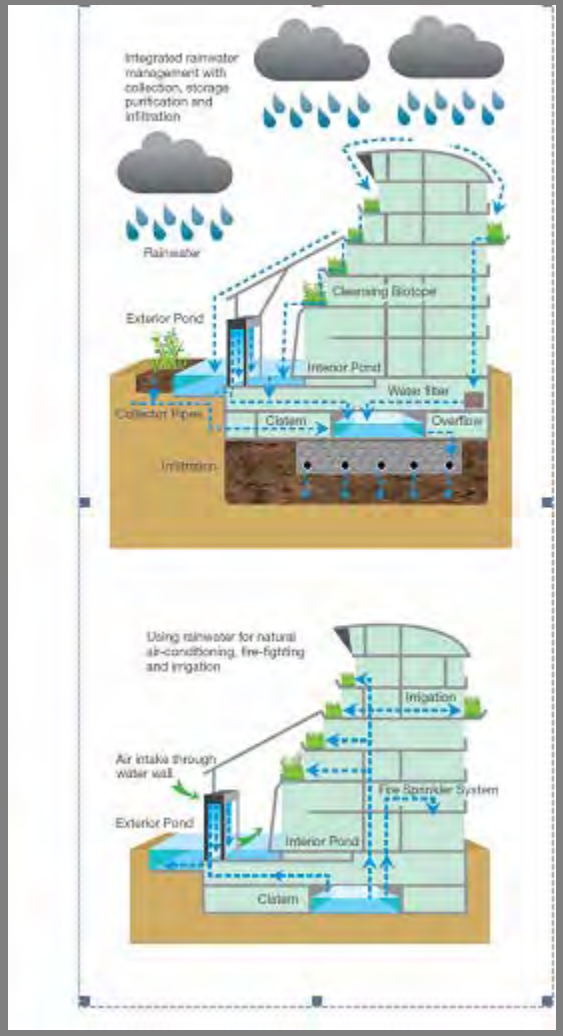
Sixth Framework Programme (2002-2006)

018530 - SWITCH WP2.1

Sustainable Water Management in the City of the Future

Integrated Project
Global Change and Ecosystems

Singapore's *'Active Beautiful Clean'* Manual for Surface Water Management



Sky-marshes and urban roadside biodiverse flowering wet meadows

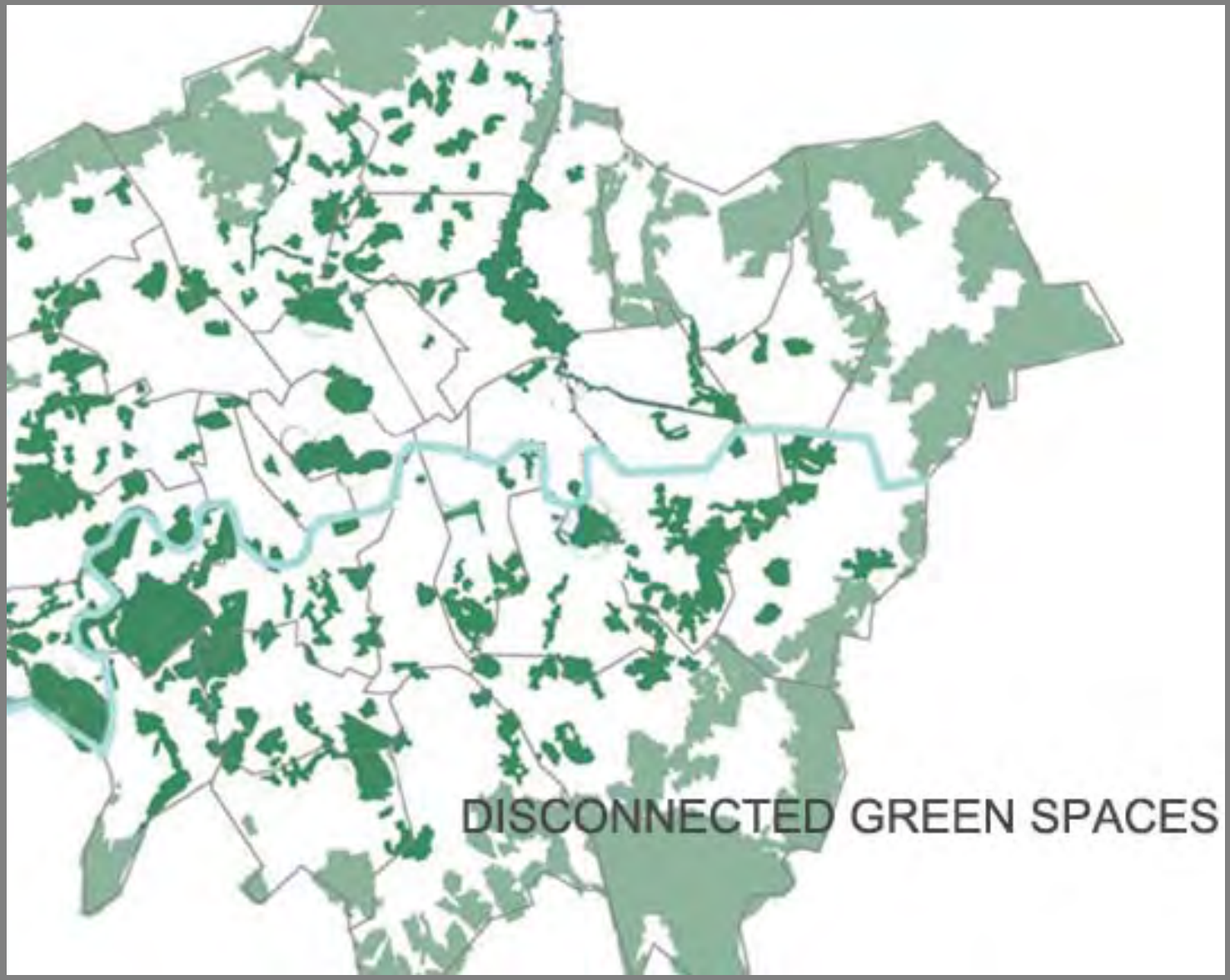
Principle 4: promote green infrastructure to increase connectivity and resilience of urban and peri-urban ecosystems

↓

Mechanisms: restore major coastal ecosystems and river corridors, map and link habitat remnants, form green webs and multifunctional networks at all scales

↓

Metrics: favourable conservation status of quality indicator species, reduced flooding and heat island, cleaner air and water, urban biofuel, urban food etc.


DISCONNECTED GREEN SPACES


RECONNECTED GREEN SPACES
CORE SITES/ REMNANTS
EXPANDED OR BUFFERED

Environment Agency

bringing your rivers back to life

A strategy for restoring rivers in North London

Charter Quay urban river restoration, Kingston, London

Safe links for wildlife over and under transport corridors

Shade-giving, wind-break, dust trapping, air-conditioners

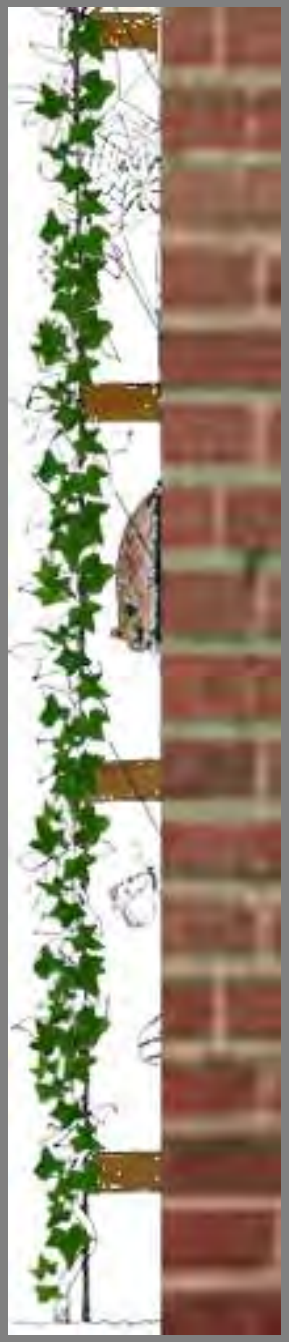
Indicators of success

The UK’s Longest Living Wall –

Westfield, London, UK

True retail therapy

Photo Credit: Gary Grant/AECOM



Protection of structures against weathering & pollution whilst providing niches for beneficial fauna

A place for true rarities

Symbiosis of nature and power generation

Cultural landscapes of ethnic minorities – can still support native biodiversity

Possible Guiding Principles for Green Infrastructure Strategy

GI should be:

•Mandatory social space for workers

•Should be the PRIMARY consideration, before built form design or other infrastructure

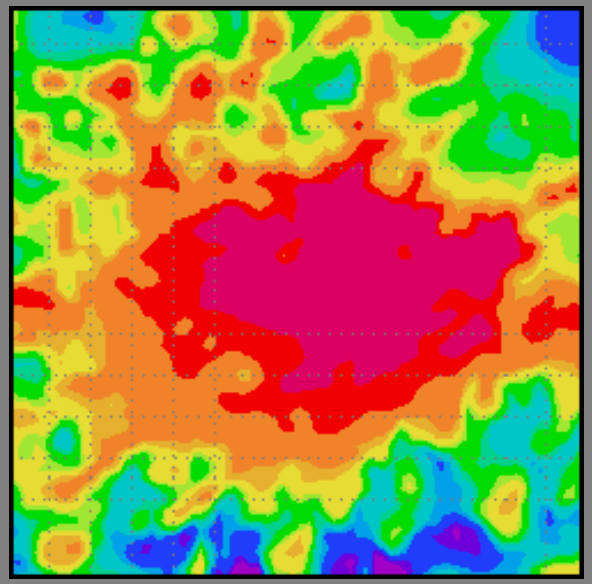
•Factored into land values

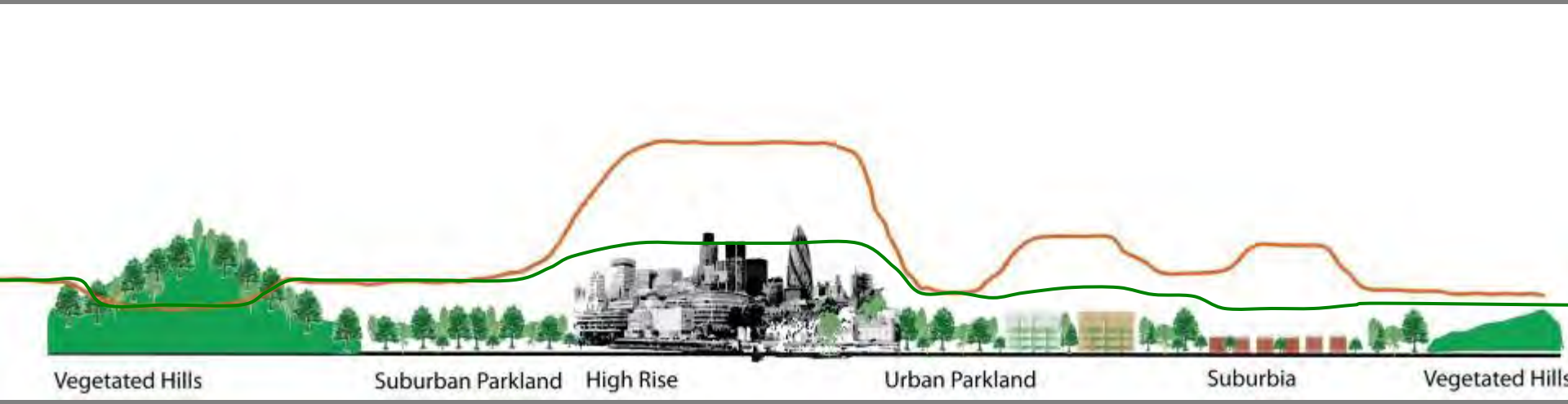
•Widely distributed and interconnected

•Functional at different geographical scales

- Multifunctional
- Locally distinctive
- Accessible
- Delivered by cross-departmental and organisational partnerships
- Well-funded to function in perpetuity

=





Current Heat Island effect

Potential effect with abundant, lush vegetation

Intertidal vegetation storm and tsunami buffers

Principle 5: Adopt ‘biophilic design’ approaches for health and well-being and multiple other benefits

↓

Mechanisms: focus on biodiversity, natural materials, green connectivity, ubiquity and abundance , celebration of water, mixture of wooded and open landscapes, internal greening, cooling, air and water cleaning…

↓

Metrics: public satisfaction indices, reduced absenteeism, increased productivity, accelerated convalescence, reduced societal and individual medical expenditure

Fighting urban pathologies

Life-Support

Incorporating Biodiversity into Community Strategies

biology letters

Community ecology

Biol.
doi:10.1098/rsbl.2007.0
Published online

Psychological benefits of greenspace increase with biodiversity

Richard A. Fuller[1,*], Katherine N. Irvine[2], Patrick Devine-Wright[2,†], Philip H. Warren[1] and Kevin J. Gaston[1]

Klinikum, Basel - biophilic healing

An ideal view for patients in Switzerland

Perceived

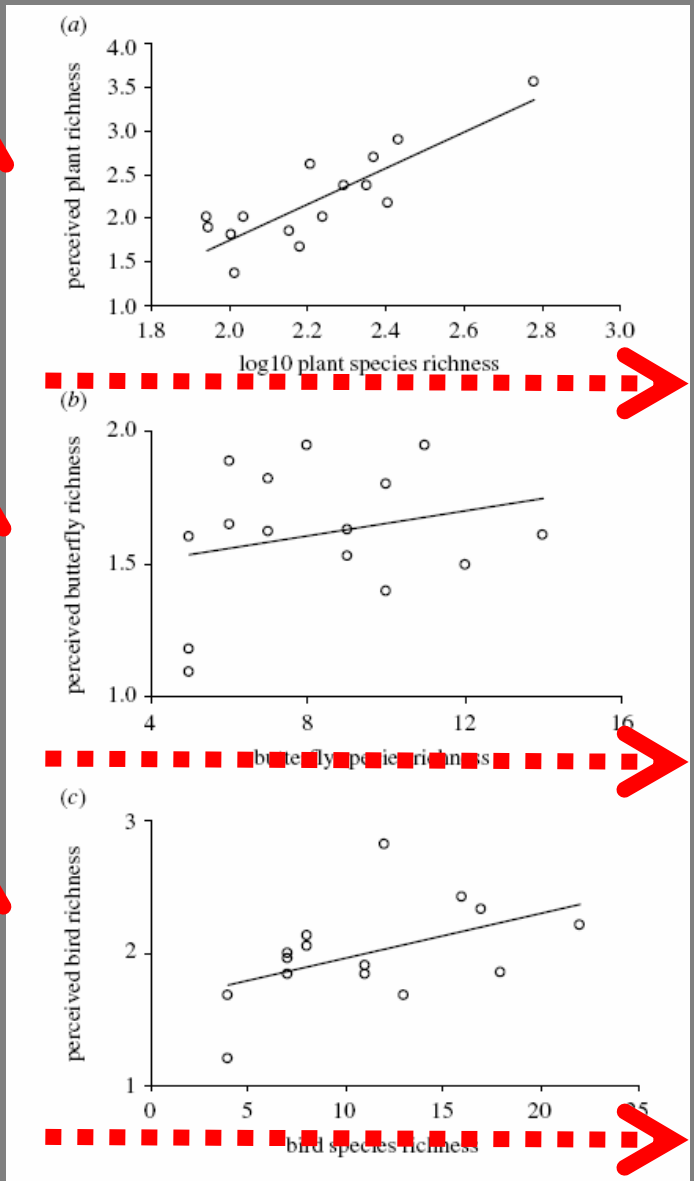


Figure 2. Relationship between perceived and sampled species richness of (*a*) plants, (*b*) butterflies and (*c*) birds. The relationship in the plant data remains highly significant on removal of right-hand data point. See text and table 1 for explanation of units.

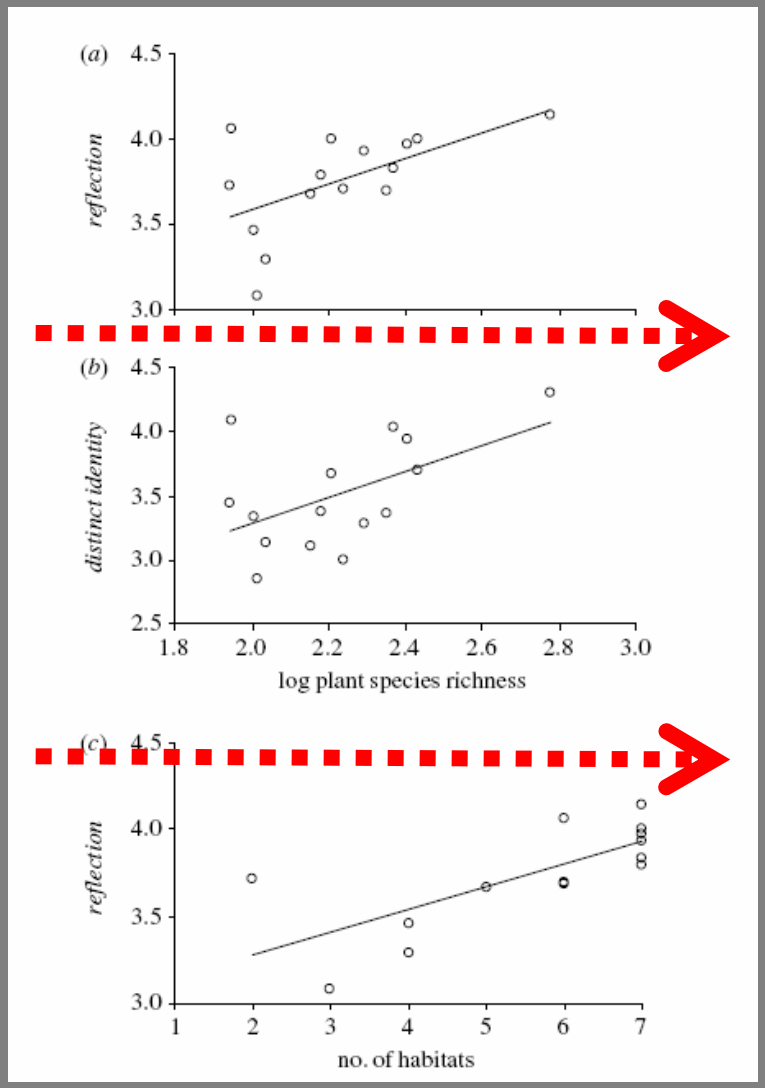
Actual

Plants

Butterflies

Birds

Perceived



Actual

‘reflection’ versus plant species-richness

‘distinct identity’ versus plant species-richness

‘reflection’ versus number of habitats present

Source of this and previous slide:
Psychological benefits of greenspace increase with biodiversity
By Fuller *et al.* Biol. Lett. 22 August 2007 **vol. 3 no. 4** 390-394

Biophilic Design

Stephen R. Kellert · Judith H. Heerwagen · Martin L. Mador

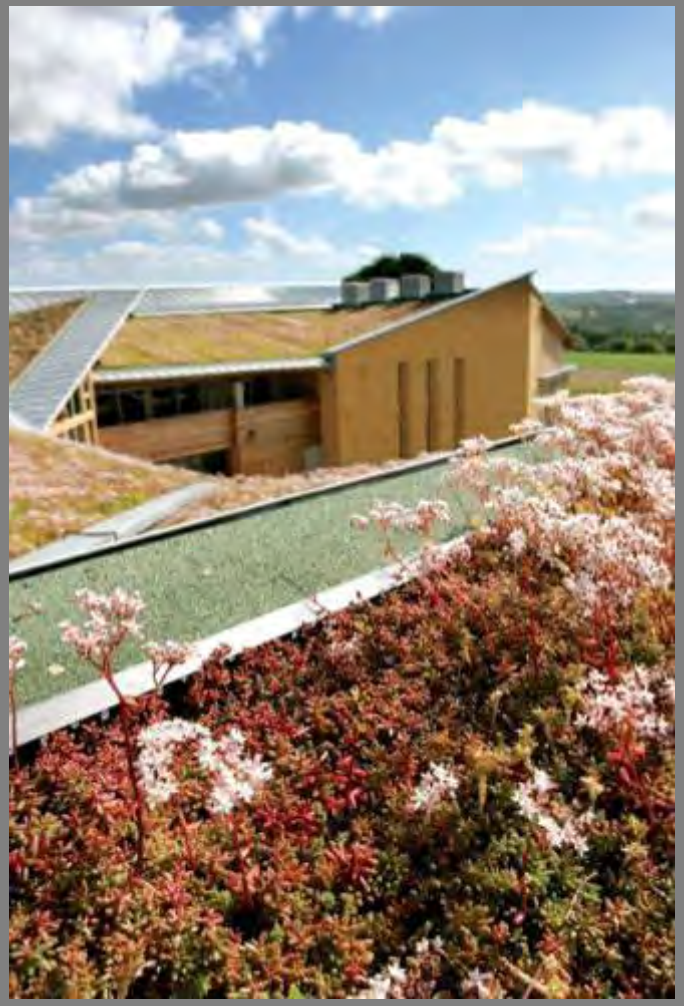
...encouraging a recall of instincts..

Promoting species and imagery of beneficial psychological ‘affect’

Reduced crime

Kuo, Illinois USA

Increasing productivity in the workplace: Rivergreen Offices, Newcastle, UK



Gateway House Basingstoke – Peter Foggo /Charles Funke

Increased business rental values

Arlington Business Parks, UK

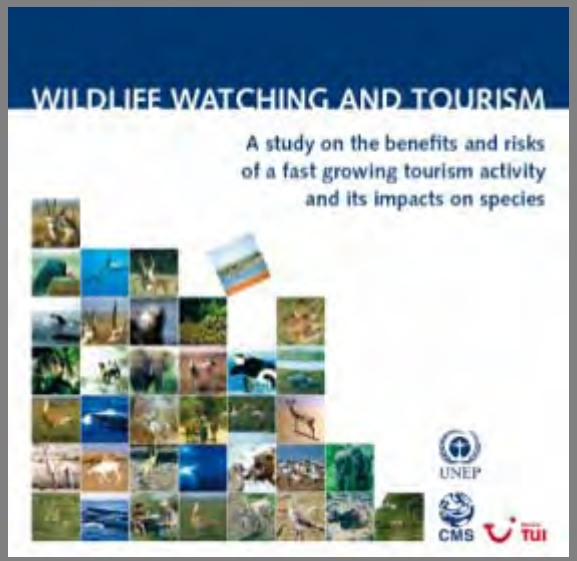
Enhanced real estate values

‘It is interesting that in most of the cases studied, properties that directly overlook a park cluster at around **5% to 7% above** an identical property in the same market area, but outside the influence of the park…….but up to **to 34%.**

Cabe Space, UK

Contribution to tourism strategy

20% to 40 % of all international tourists have an interest in some form of wildlife watching
(but such activity must be carefully controlled and wardened)



Contribution to commercial strategy of attracting top talent - Singapore City of Gardens *and Water*

Principle 6: Promote ecosystem complexity

↓

Mechanisms: Devise diverse appropriate species and habitat mixtures, bespoke to place and task

↓

Metrics: Reduced failure of plantings, reduced incidence & duration of invasive species outbreaks, improved ecosystem service performance

Integrated Pest Management Depends on Biodiversity

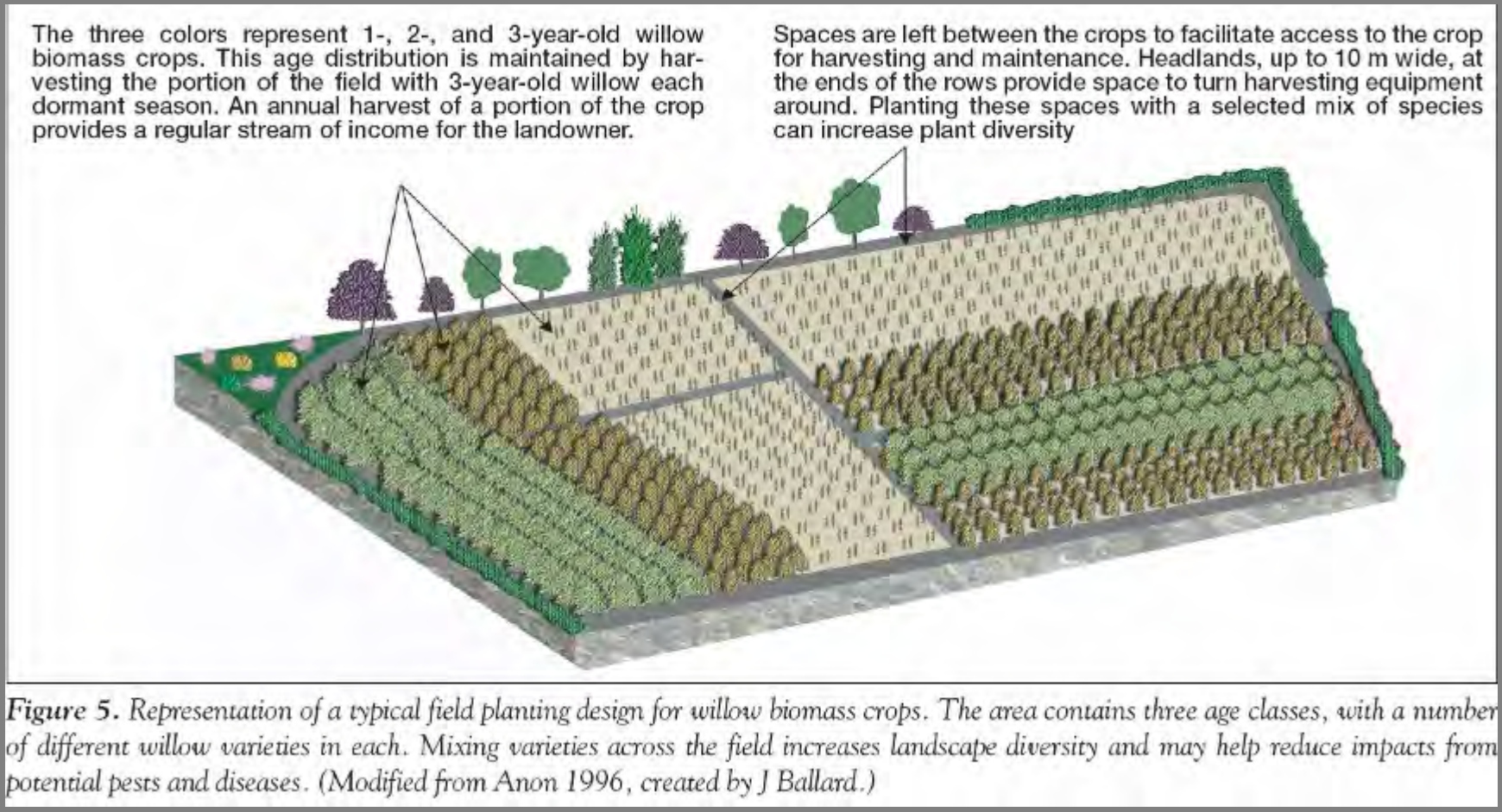
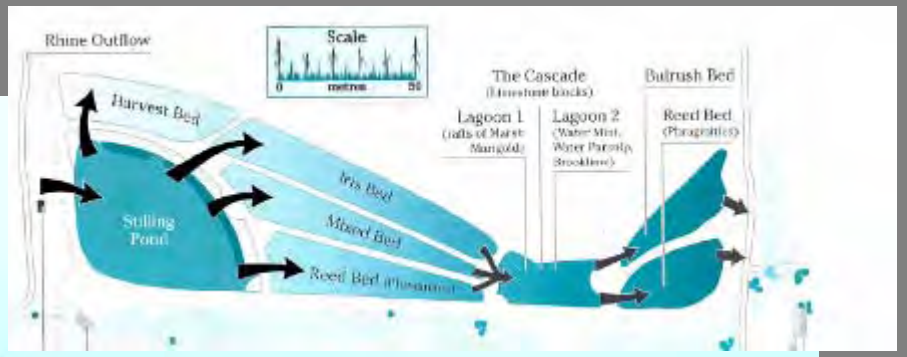


Figure 5. Representation of a typical field planting design for willow biomass crops. The area contains three age classes, with a number of different willow varieties in each. Mixing varieties across the field increases landscape diversity and may help reduce impacts from potential pests and diseases. (Modified from Anon 1996, created by J Ballard.)


Rhine Outflow
Scale
0
metres
50
Harvest Bed
Stilling Pond
Iris Bed
Mixed Bed
Reed Bed (Phragmites)
The Cascade
(Limestone blocks)
Lagoon 1
(tufts of Marsh Marigold)
Lagoon 2
(Water Mint, Water Parsnip, Brooklime)
Bulrush Bed
Reed Bed
(Phragmites)

Deadwood is important to healthy woodland ecosystems

Principle 7: Design built form to safeguard biodiversity

↓

Mechanisms: wildlife overpasses and underpasses, increased visual noise of facades, considerate lighting, careful drainage design

↓

Metrics: reduced quantity and species range of bird strike, reduced faunal fatalities, increased proximity of species to residents, reduced number of traffic accidents

BIRD-FRIENDLY URBAN DESIGN GUIDELINES

Integrating Natural Systems with Human Activities

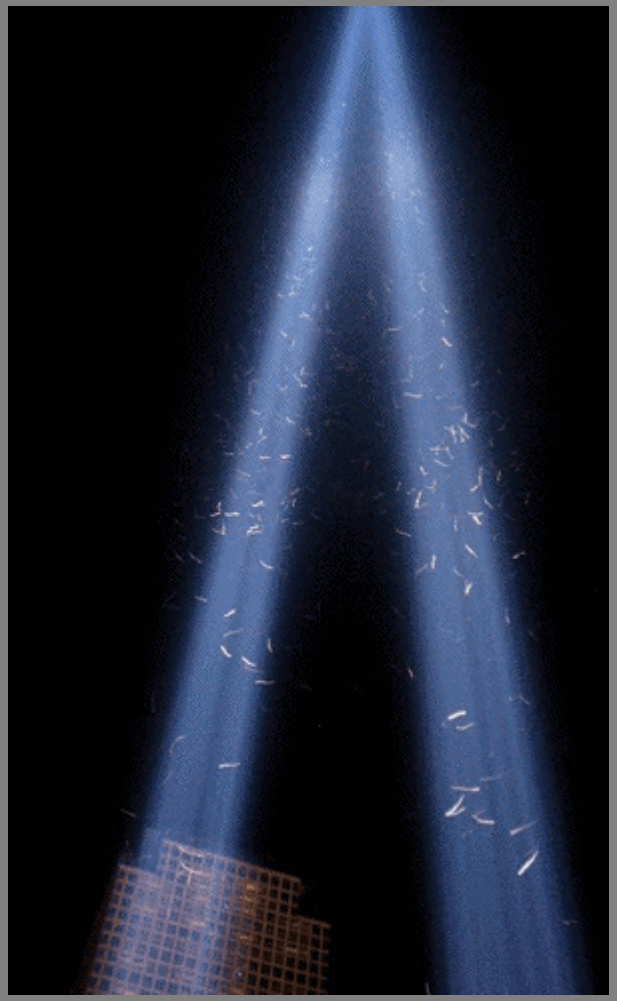
DRAFT REPORT SEPTEMBER 2010

calgary.ca/landuse | call 3-1-1

THE CITY OF CALGARY
LAND USE PLANNING & POLICY

Visual noise is best when natural and multifunctional

Risks to birds and bats – and solutions



Principle 8: Instigate ecological landscape management and aftercare

↓

Mechanisms: community wardens, work parties, community orchards and farms, public-private-charity partnerships, new models

↓

Metrics: reduced ‘locational autism’, progressive ecosystem maturation and stable development


WWW.MAJOR-GRASSCARE.COM

Principle 9: Set Ecological Targets for all urban developments and then measure success

↓

Mechanisms: detailed inventory of environmental baseline including trends, appropriate and practical monitoring protocols, involve additional agencies

↓

Metrics: species richness and diveristy, rarity, water quality, air quality, bird song etc.


baffled reedbed
cascade
pools
waterfalls
wet woodland
pools
water theatre
flowering marsh
cascade
open water
nature pool
still lake
KEY
(1) IT Street Greenery
(2) plaza entrance and water theatre
(3) performance area
(4) basement orchard
(5) mall spaces
(6) waterfall
(7) swales
(8) still lake
(9) concourse
settling pond
(10) wet woodland
(11) reeds
(12) marsh
(13) polishing pond
cascades
dense urban Planting
water directed form roofs to ground

PLAN

TARGET SPECIES

1 Priority species for nature conservation
2 Flagship: species that could symbolise scheme success

Indicator species/umbrella species that indicate healthy populations of supporting species and/or good semi-natural environmental conditions

3 Indicator of good populations of small mammals
4 Indicator of good populations of small birds
5 Indicator of good populations of fish/ amphibians
6 Indicator of good populations of invertebrates
7 Indicator of good water quality
8 Species with special aesthetic qualities or interest to man e.g. conspicuous beauty, song or tendency to use artificial refuges

KEY

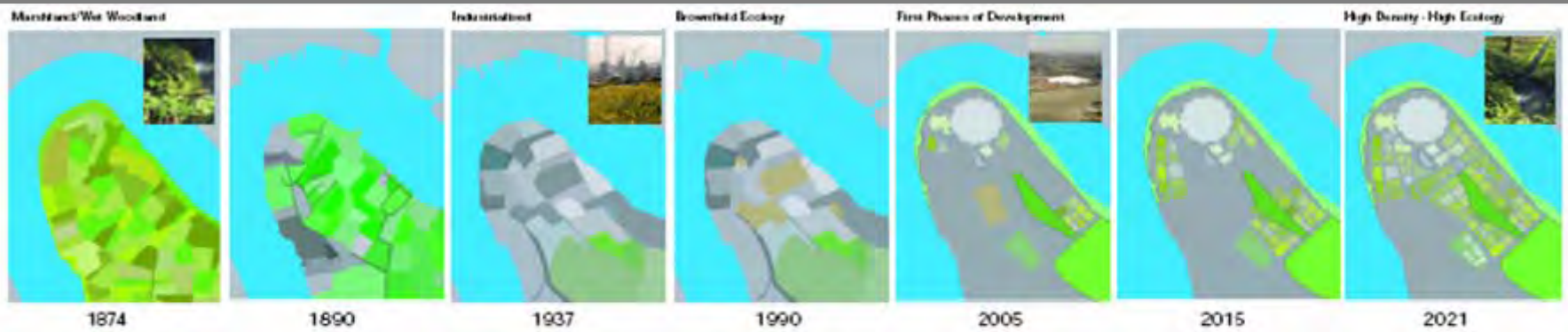
DPS Dominant plant species
WQ Water quality
AA Approximate area

Pair Breeding
F Feeding

J F M A M J J A S O N D

Biodiversity Target	Shrub Roofs	Grassland Roofs	Planted facades	Densely wooded area	Reeds and Settlement pond	Wet Woodland	Marsh	Polishing Pond with Rafts	Flowing Water and Still Ponds-Urban	Streetscape Planting
	DPS WQ Moderate AA	DPS WQ Moderate AA	DPS WQ AA	DPS WQ AA	DPS WQ Moderate AA	DPS WQ High AA	DPS WQ High AA	DPS WQ Very High AA	DPS WQ Moderate-High AA	DPS WQ AA
Target Species										
Siberian Weasel *Mustela sibirica* 3,4				F	F	F	F			
Shrews *Crocidura fuscata* *Crocidura suaveolens* 6				F		F	F			
Rodents *Several species*				F	F	F	F			
Northern Bat *Eptesicus nilssonii* 6,8	F	F	F	F		F				F
Daubenton's Bat *Myotis daubentonii* 7,8					F			F	F	
Big-footed Myotis *Myotis macrodactylus* 6,8					F			F	F	F
Moorhen *Gallinula chloropus* 5					F		F	F	F	
Eastern Spot-billed Duck *Anas zonorhyncha* 4								F	F	
Little Egret *Egretta garzetta* 2,3					F	F	F	F		
Eurasian Sparrowhawk *Accipiter Nisus*	F		F	F		F				

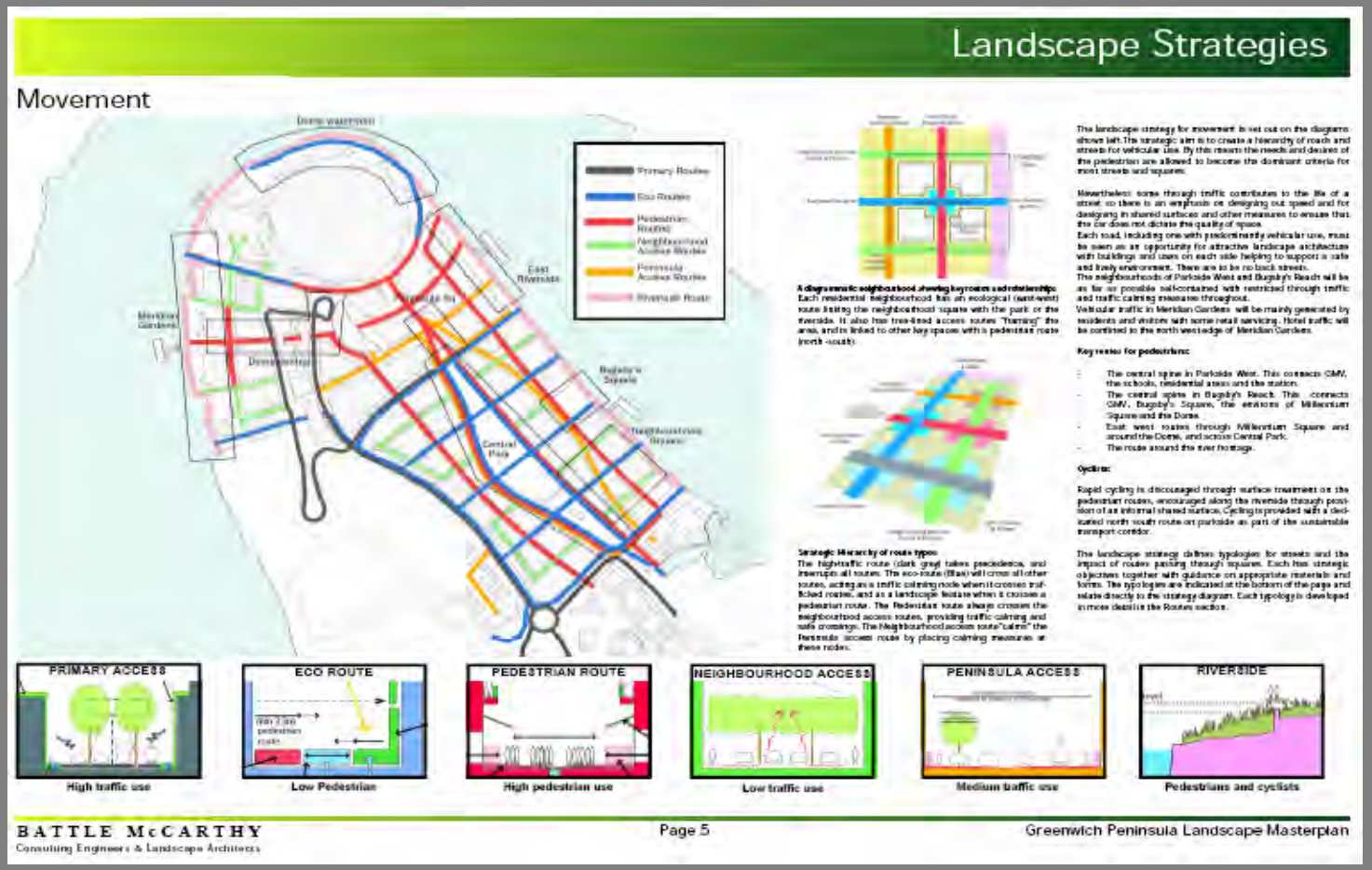
Bringing it all together: two examples from London, UK


Marshland/Wet Woodland
Industrialised
Brownfield Ecology
First Phases of Development
High Density - High Ecology
1874
1890
1937
1990
2005
2015
2021

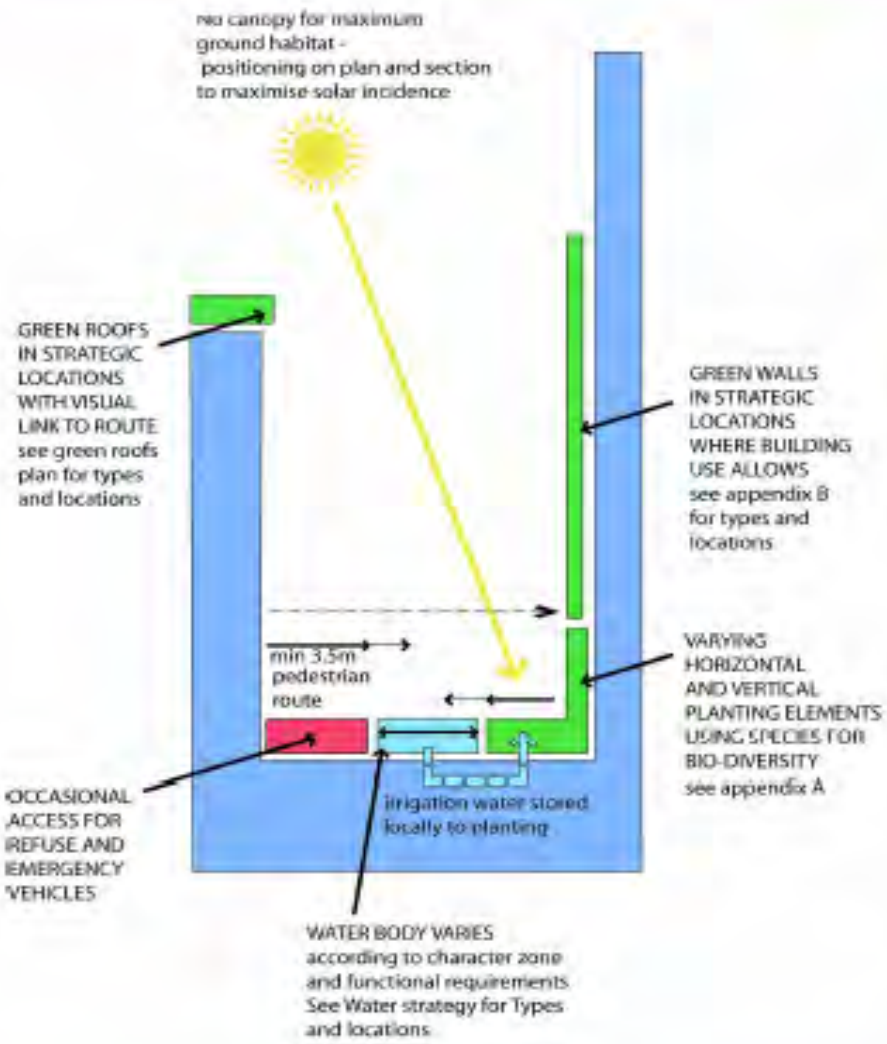

TIDAL TERRACES
reed bed
TIDAL TERRACES
saltmarsh
TIDAL TERRACES
foreshore

Ecology

....demonstrate how biodiversity can ‘fit’ into a logical hierarchy of design....



Routes



Key Features:
- Low-level planting of native species typical to shaded urban riverfront habitats
- No trees for maximum solar penetration
- Water channels and gravel beds for water storage
- Green facades
- Dumble surfaces to accommodate movement

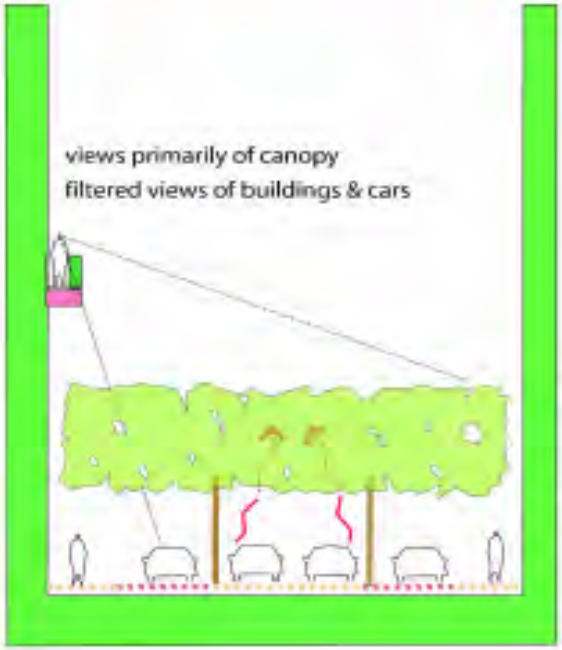
Typical Hard Materials:
- Timber decking
- Stone
- Concrete
- Loose gravel

Typical Soft Materials:
- Native mosses
- Native lichen
- Native ferns
- Native grasses
- Native of naturalised wildflowers
- Native ivy

Lighting:
- Soft low-level spot lighting
- Cowled lighting

Character Zone Change Along Peninsula Length:
- Informal to formal, decreased proportion of soft landscape

Routes



proportion varies with street width

Tree type / formality varies with character zone

Key Features:
- Shared surface with pedestrian and trafficked areas ideignated by varied surface/paving), allowing easy manoeuvrability
- Predominantly hard landscape with extensive tree canopy to screen views of cars from above
- Light-coloured surface treatment for maximum reflectivity
- Clutter free - signage and street furniture minimised

Typical Hard Materials:
- Textured surface e.g. reclaimed granite setts
- Self-binding gravel

Typical Soft Materials:
- Small deciduous trees e.g. Fraxinus oxycarpa 'Raywood' or Sorbus aria
- Consider roof trained trees as more formal option

Lighting:
- Uplighting to trees
- Lighting bollards for human scale
- Lights suspended from tree canopy
- Down lights attached to building facades

Character Zone Change Along Peninsula Length:
- Informal to formal, change in materials - different tree species and surface materials, becoming more formal closer to the Dome

Ecology:
- Limited artificial refuges for birds or bats on buildings (e.g. Housemartin/Swift)

Roof Masterplan

Illustration of maximum potential

WATER
Green roofs recreate the natural watercycle. Rainfall is absorbed by the soil and plants and returned to the atmosphere by evaporation and plant transpiration.

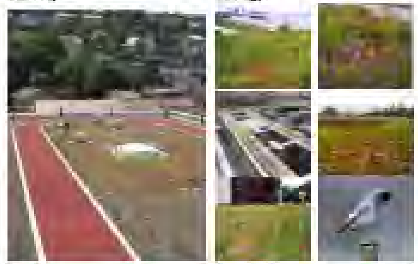
INTRODUCTION
Green roofs provide us with direct benefits in terms of enhanced lifestyles and property values. They also help to restore and support the virtuous cycles and balance of our environment - retaining rainfall, cleaning and cooling the air, reducing the heat island effect and providing important wildlife habitat, whilst also protecting building materials and reducing building operating costs.

EXTENSIVE ROOFS (<100kg/m²)

Extensive Roofs

Amenity

Ecology

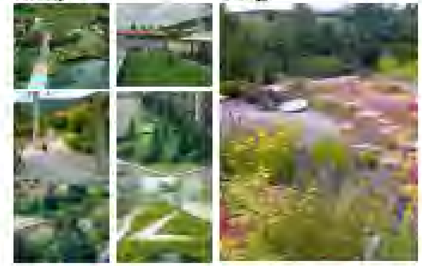


INTENSIVE ROOFS (>100kg/m²)

Intensive Roofs

Amenity

Ecology



Increasing property values
Developing recreational spaces on the roofs maximises the potential available building area of the site.

Reducing the heat island effect
Impervious building materials reflect heat, raising the local ambient temperature. Plants provide a relatively non-reflective surface and water retained by a green roof both humidifies and cools the air through the process of evaporation and evapotranspiration.

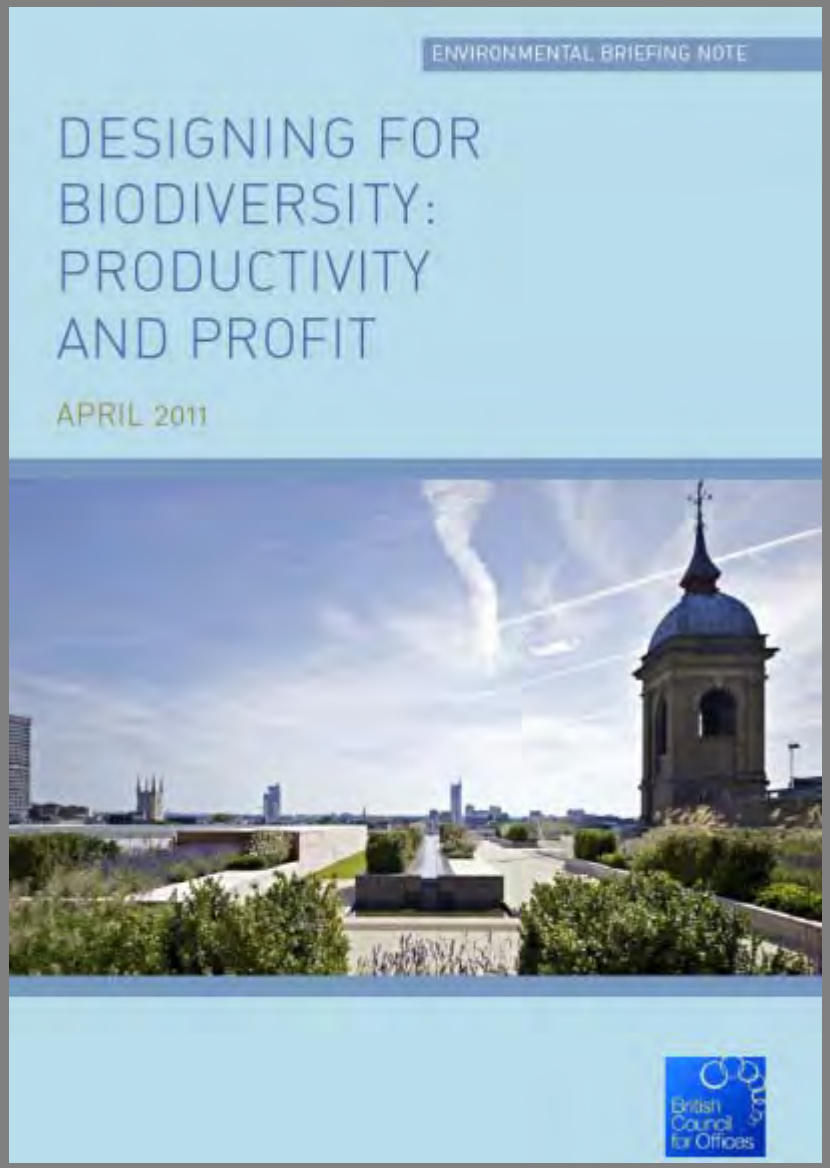
Noise reduction and filtration of dust and pollutants
Green roofs have excellent sound reduction qualities, both from external sound (up to 3dB) and internal noise (up to 9dB). The vegetation filters airborne pollution and dust particles, removing them from the surrounding environment, air and improving air quality.

Flood mitigation and storm water management
Soft landscape roofing helps to reduce the risk of flooding, by retaining to 90% of rainwater and reducing water run-off. If applied to 100% of the Greenwich peninsula roofscape (ca. 20 hectares) a minor increase of the green roof buildup (+40-50mm) could make a major contribution to required flood mitigation for the whole development and possibly remove the need for construction of a new pumping station.

Reduced building running costs
A green roof improves the thermal insulation of the building, providing a more balanced temperature within. This reduces heating cost in winter and air conditioning expenses in summer.

Protection of Roof Materials
Vegetation on roofs has been found to protect the roofing material from deterioration from weather exposure and sunlight. Decades after installation, outer 'weather layers' underneath vegetation of green roofs have been found to be in excellent condition, whereas the same materials on nearby ungreened roofs were noted to have been replaced several times in the same period.

Biodiversity
A key driver for installation of 'green' roofs at Greenwich is mitigation for loss of former naturally colonised habitat in the post-industrial landscape of the peninsula. The green roof masterplan as shown, illustrates a provision of self-seeded extensive roofs (based on building waste substrates) that should more than satisfy planning conditions for their provision. The location of these particular roof types is driven by the need to be dispersed throughout the masterplan area, making connections across the peninsula if possible and not immediately adjacent to intensive roof types or tree canopy that could attract Robins (which are considered to competitively exclude Black Redstarts). Modifications to location could be considered if these key constraints are met. These self-seeding roofs are intended to make the greatest contribution to habitat creation for Black Redstarts and many uncommon plants and invertebrates that are expected to colonise naturally. Key principles behind their design are set out in the Ecology Strategy sub-document.



Biodiversity by Design with Ken Yeang for the British Council of Offices April 2011

UNDERSTANDING DRIVERS AND SETTING TARGETS FOR BIODIVERSITY IN URBAN GREEN DESIGN

MIKE WELLS, FLEUR TIMMER, ALISTAIR CARR