Urban Ecosystem Services: The Good, the Bad, and the Ugly

Richard V. Pouyat

1. It ain't easy being green!

The Obvious

- Human disturbance
- Built structures and sealed surfaces
- Disturbed soils

Ecological

- Novel habitats and species assemblages
- Cultivated plants
- Domesticated pets

2. Biological activity/productivity

- High fluxes, large sinks per unit area
- High resource availability
- Human desires
- Potential for ES!

Photo by Henrik Sjöman

3. A “New Heterogeneity”

Our Biggest Challenge!

Heterogeneity: human behavior & decision making

- Irrational decisions
- Culture & value systems vary
- Intrinsic vs. monetary values

4. Trade-offs services/disservices


WUE

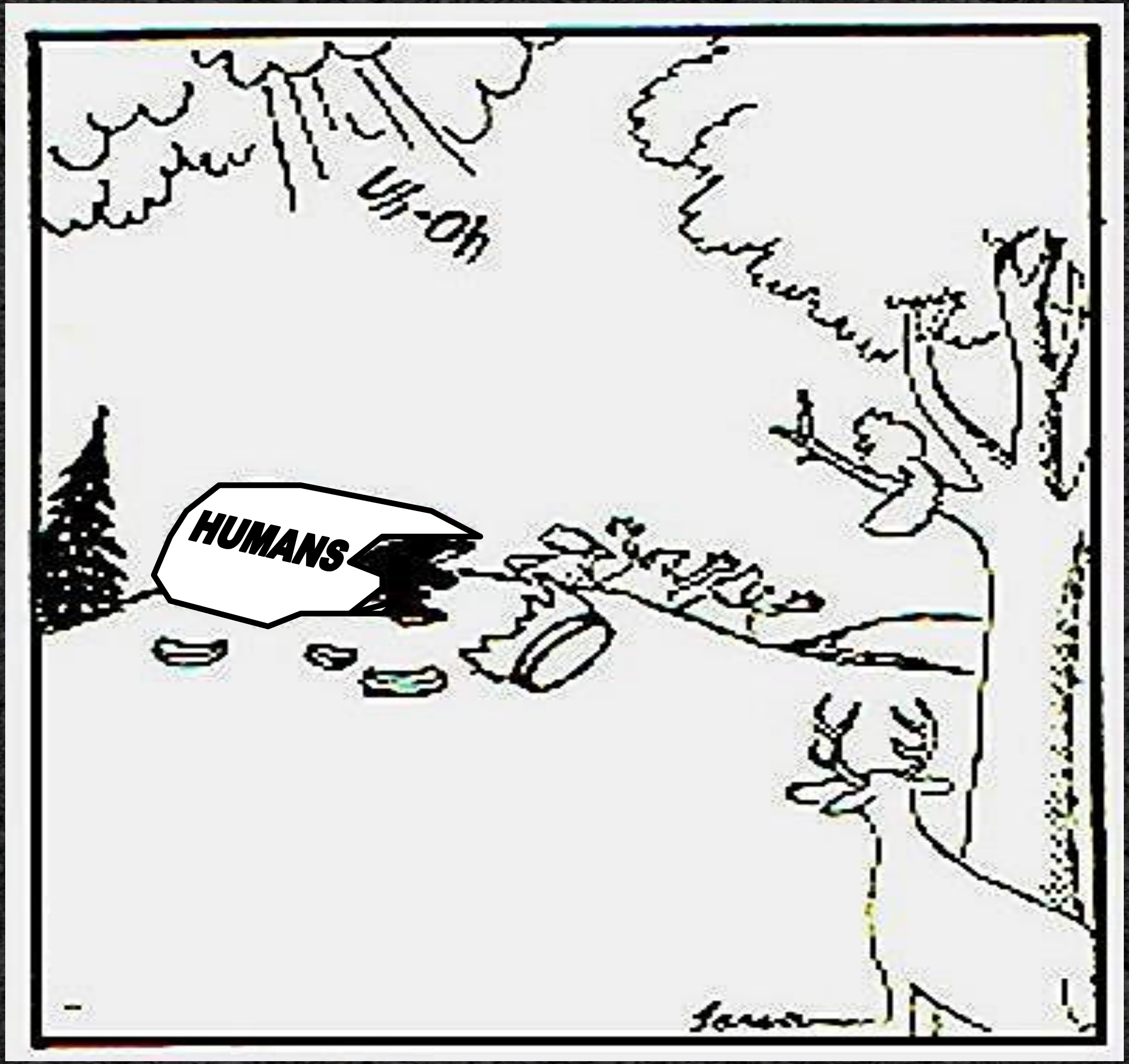
Ecosystem service?

Emissions

Risk

Performance?

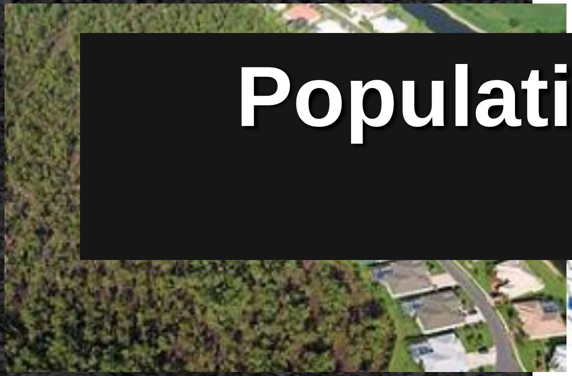
5. Steep learning curve!

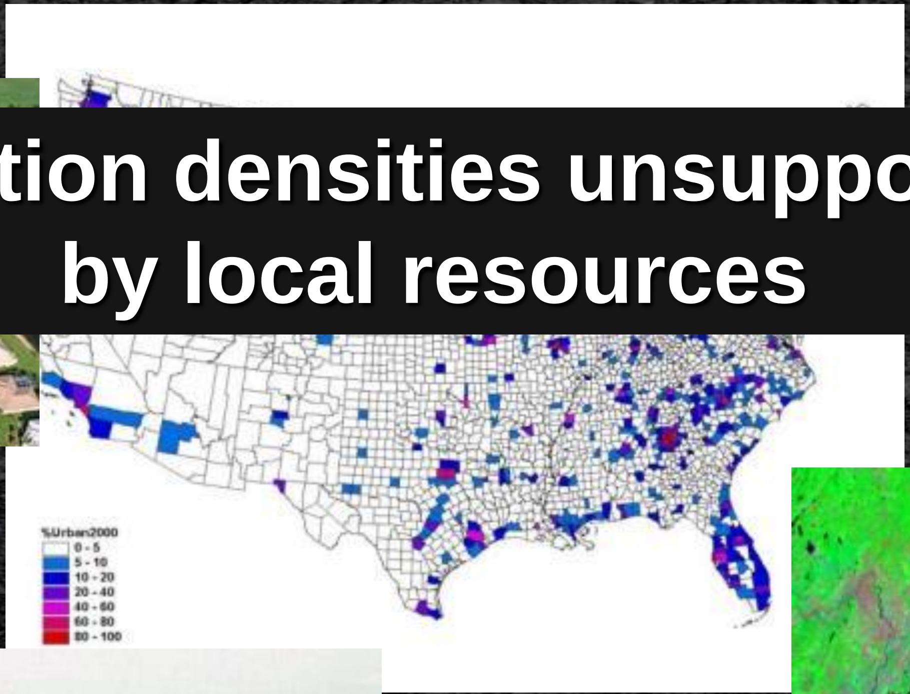


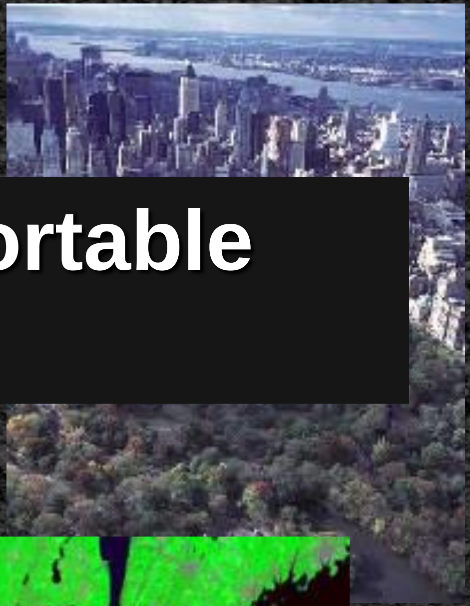
Understanding/data?

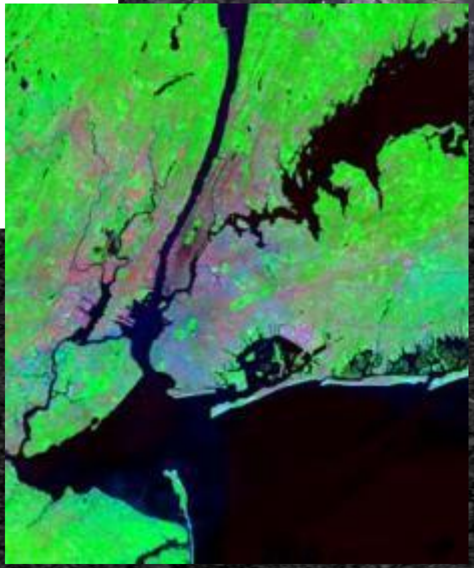
Ecological definition of urban?

Population densities unsupportable by local resources

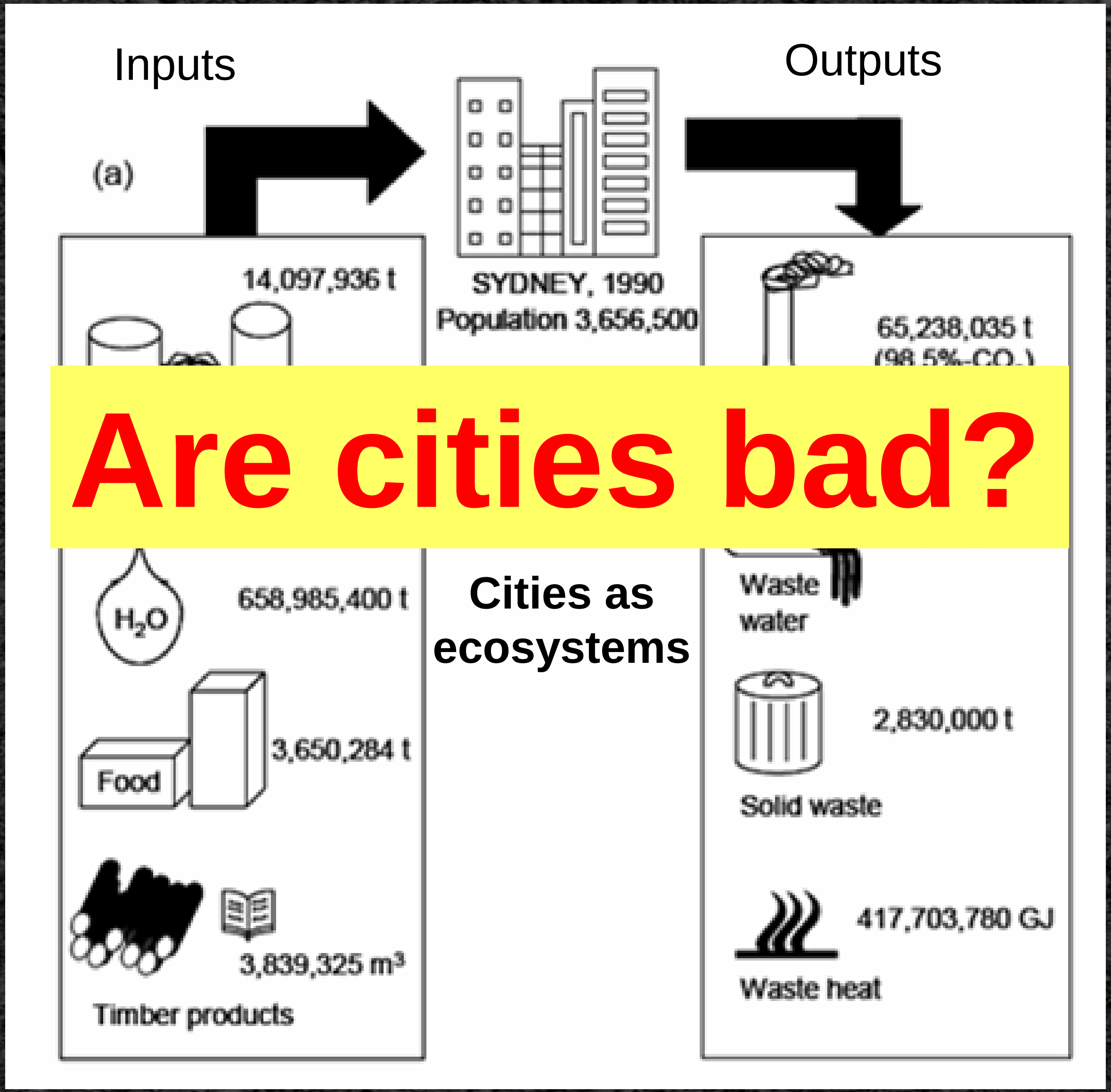








Sustainability?



Are cities bad?

Cities as ecosystems

Ecological Footprint?

Newman 1999

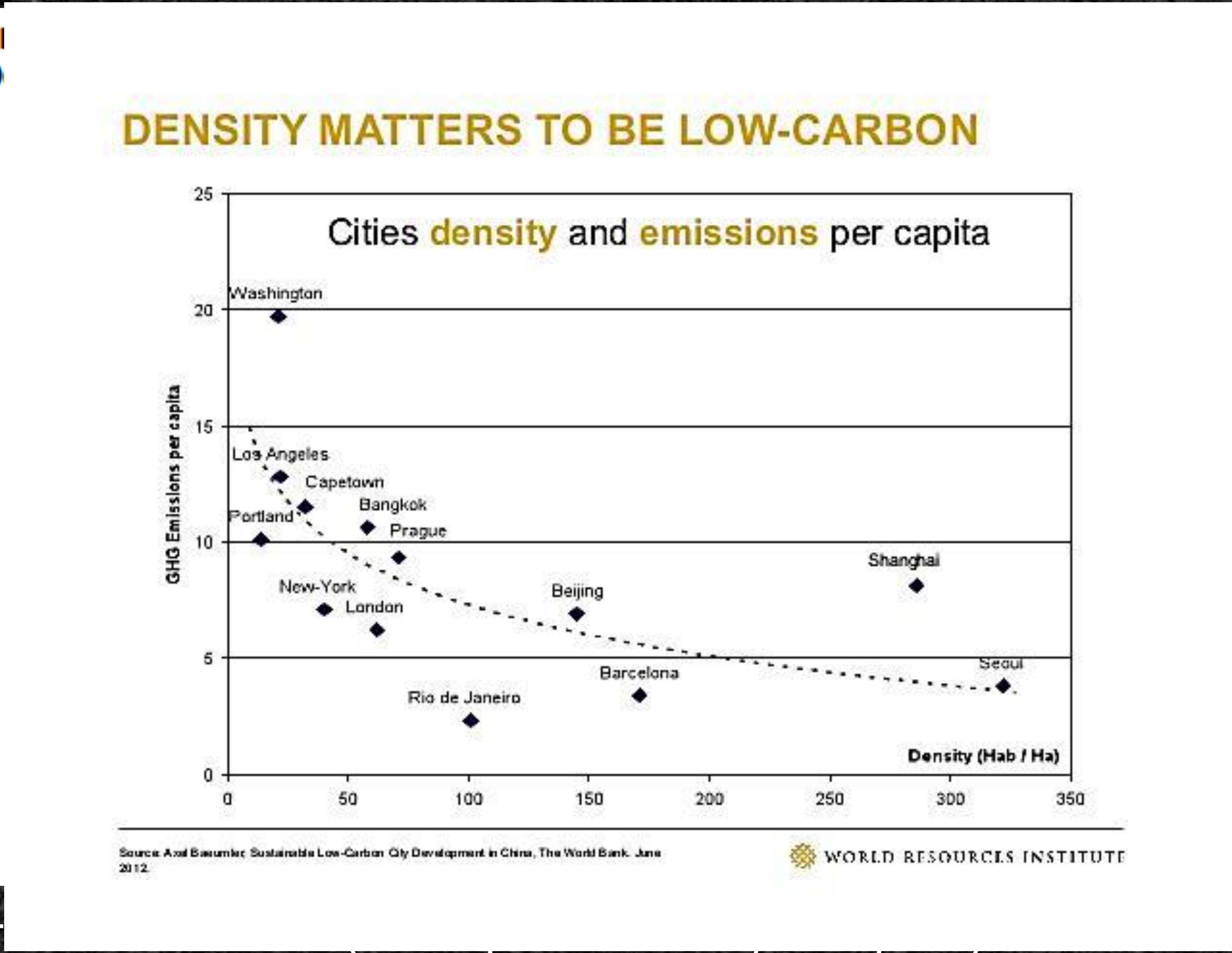
No: Cities are part of the solution!

Per Capita Basis?

Suburbia

Cities

Higher Densities → Smaller Footprints



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Trade-off: Diminished services

- Many pollution sources
- Fragmented habitats
- Built structures / impervious
- Soil disturbance / compaction
- Disrupted nutrient / water cycles
- Loss of native biodiversity (soil?)

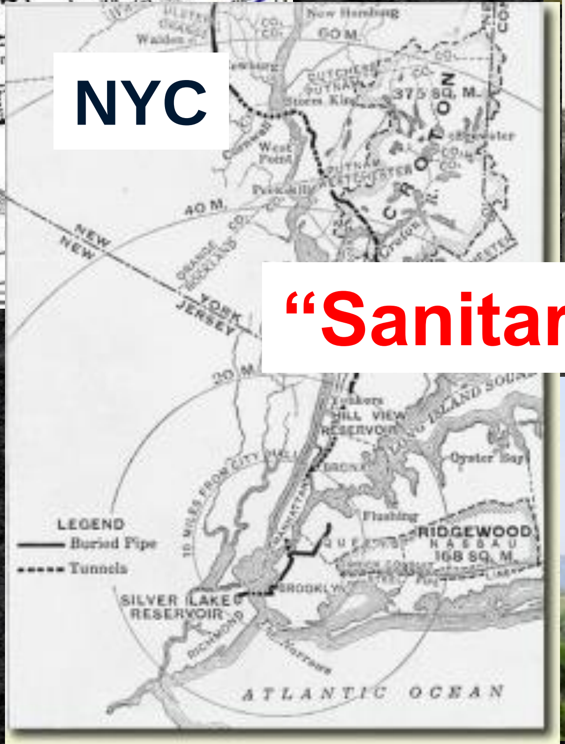
Gray Infrastructure

ROMA

Engineers are way ahead of us!

Cloaca Maxima

NYC

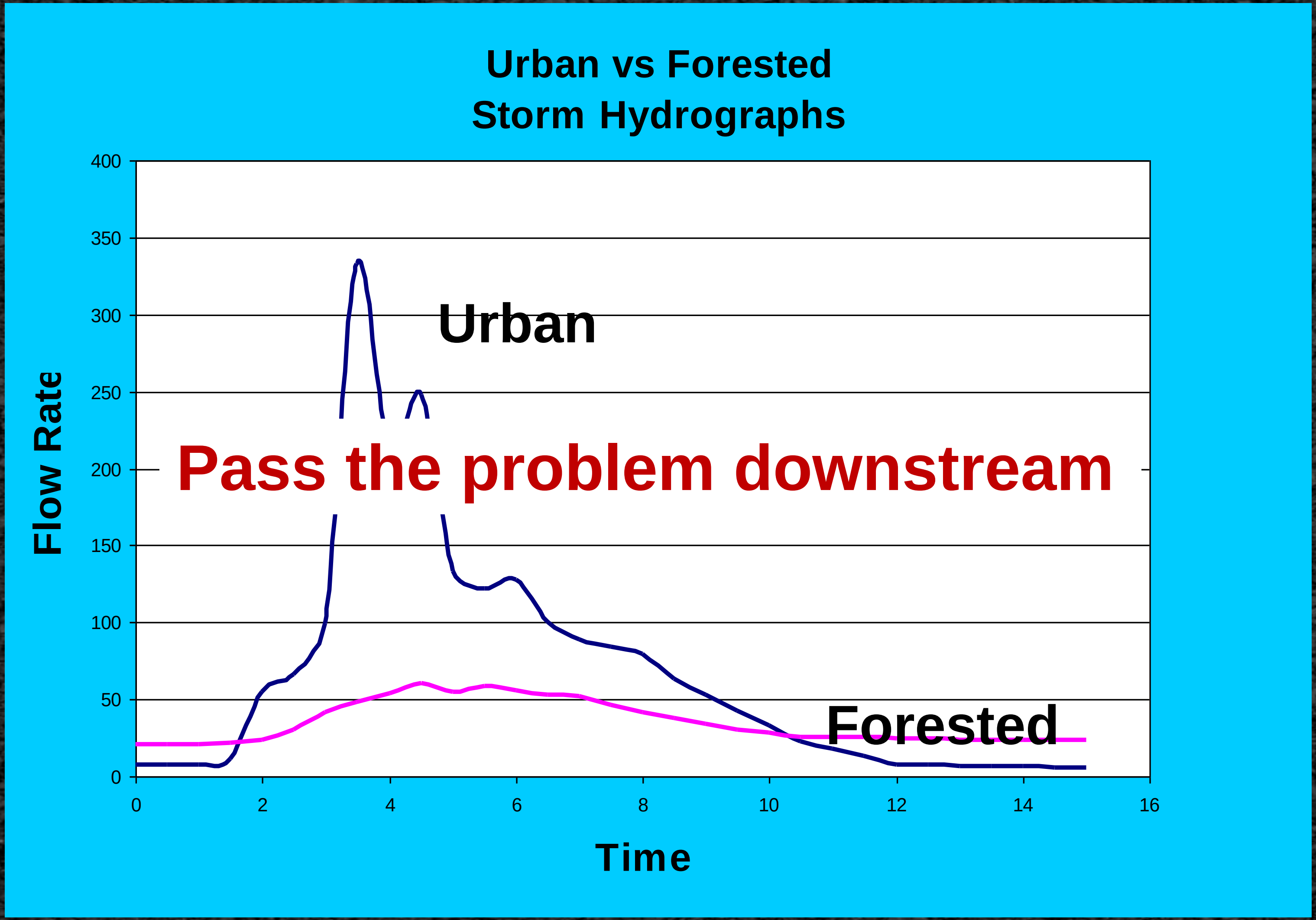


“Sanitary Cities”

Gray infrastructure & sustainability?

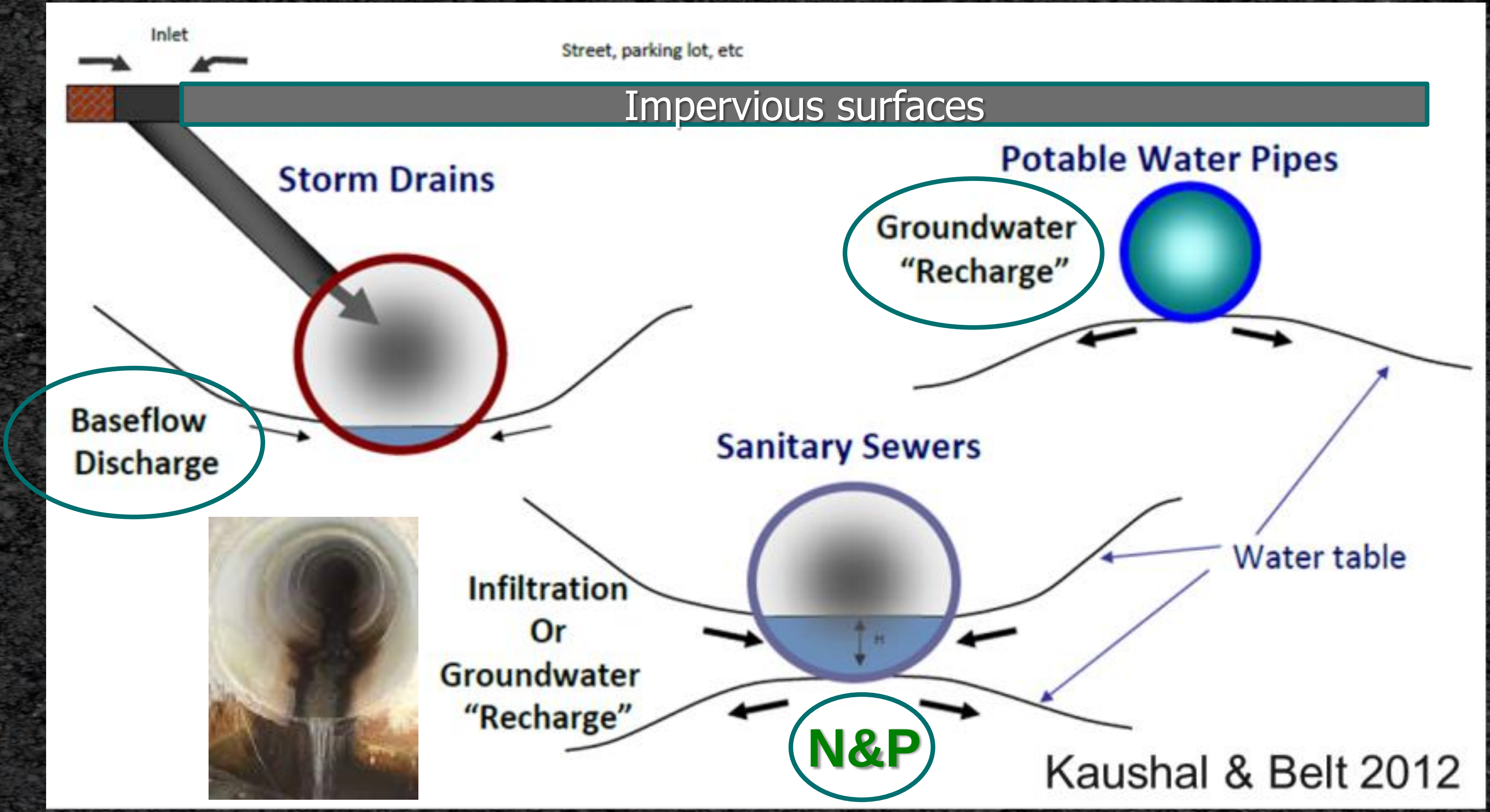
- Imperfect & degrades (Kaushal & Belt 2012)
- Requires intense use of resources

Side effects!



Interrupts natural flow paths (gases, H_2O)

Impervious surfaces impedes water & gaseous flows



And it leaks!

Types of Ecosystem Services

Provisioning	**Regulating**	**Cultural**
Food	Climate	Aesthetics
Fiber	Water	Recreation
Fuel	Habitat	Spiritual

Supporting

Nutrient cycling

Soil formation

Primary productivity

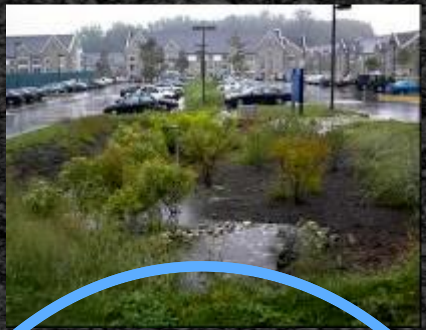
(enable other Ecosystem Services)

Typology from Millennium Ecosystem Assessment, 2005

Ecosystem Services: Sustainable Cities?

Working Ecosystems

- Managed provisioning services
  - Food
  - Fiber
  - Fuel
- Profit, subsistence motive
- Agriculture, plantation, short rotation, urban agriculture



Eco-engineered Ecosystems

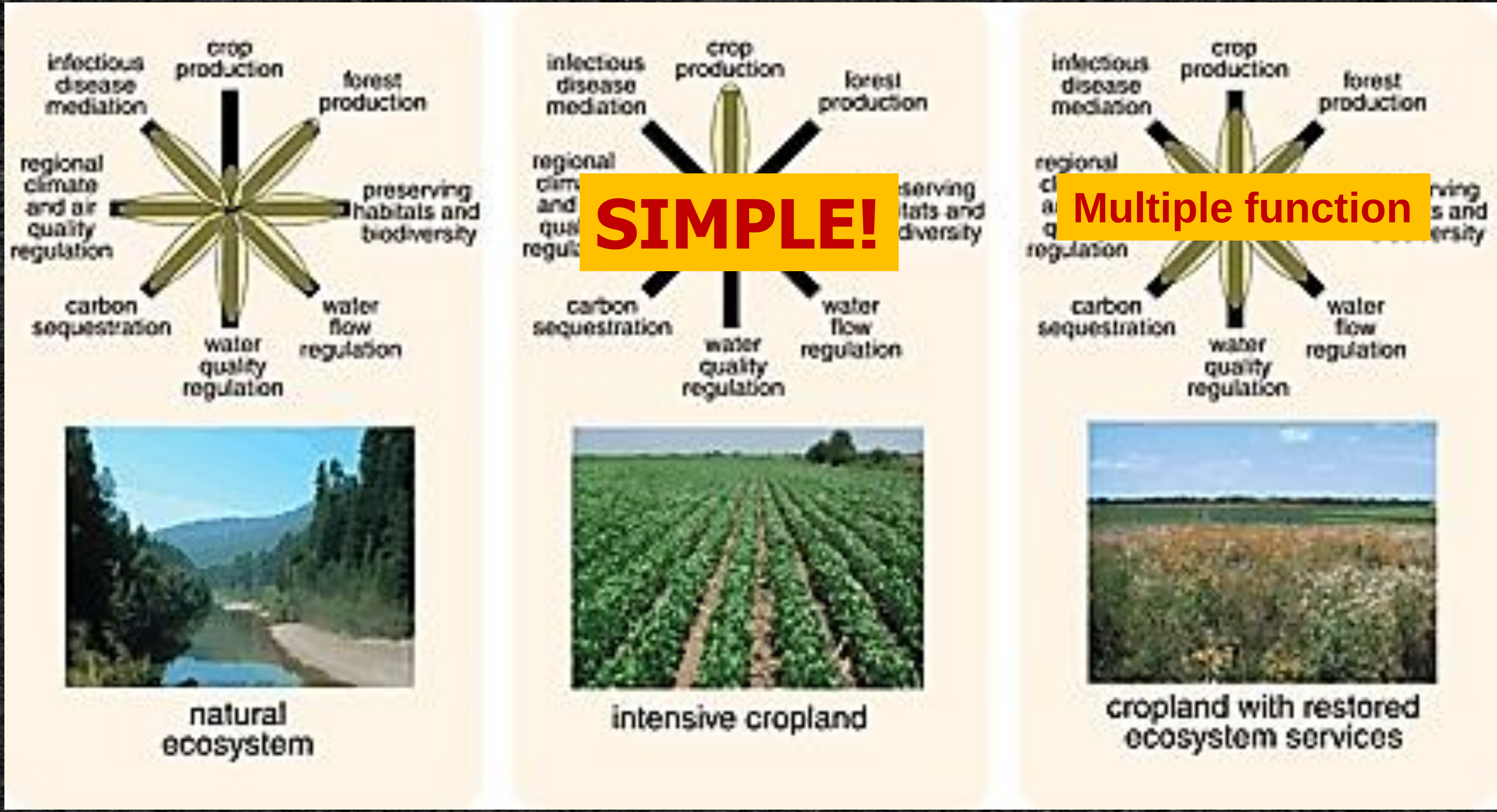
- Managed regulating services
  - Climate
  - Flood
  - Water purification
  - Disease regulation
- Regulatory & service motive
- Restoration, storm water retention, bioremediation…

Amenity Ecosystems

- Managed cultural services
  - Recreational
  - Aesthetic
  - Spiritual
  - Educational
- Consumptive, leisure motive
- Public lands (parks, wildlife areas, ornamental gardens, golf courses)

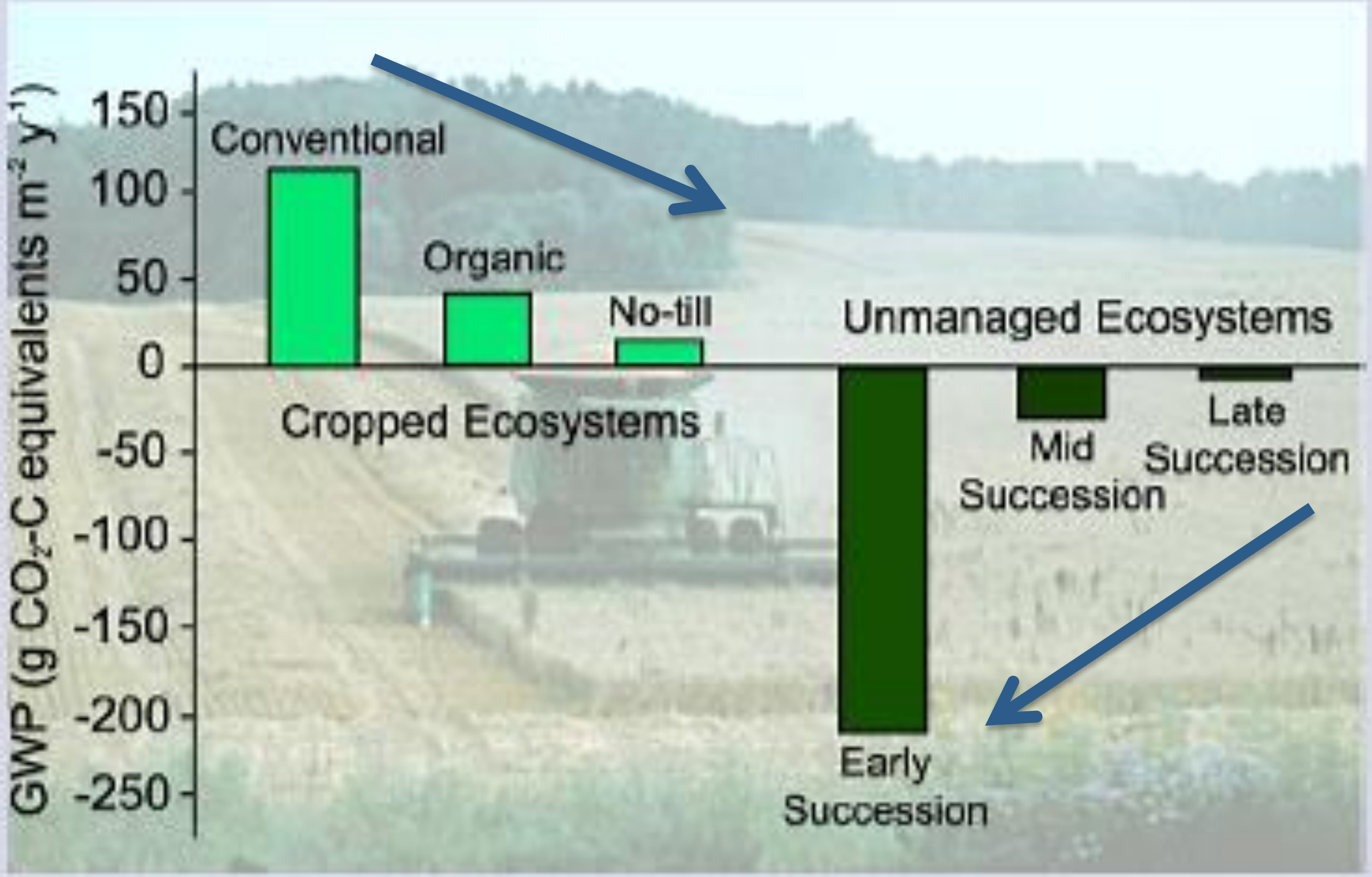
Supporting ecosystem services: nutrient cycling, soil formation, etc.

Tradeoffs: Land-Use Change?



Foley et al. 2005

Reduce Tradeoffs?



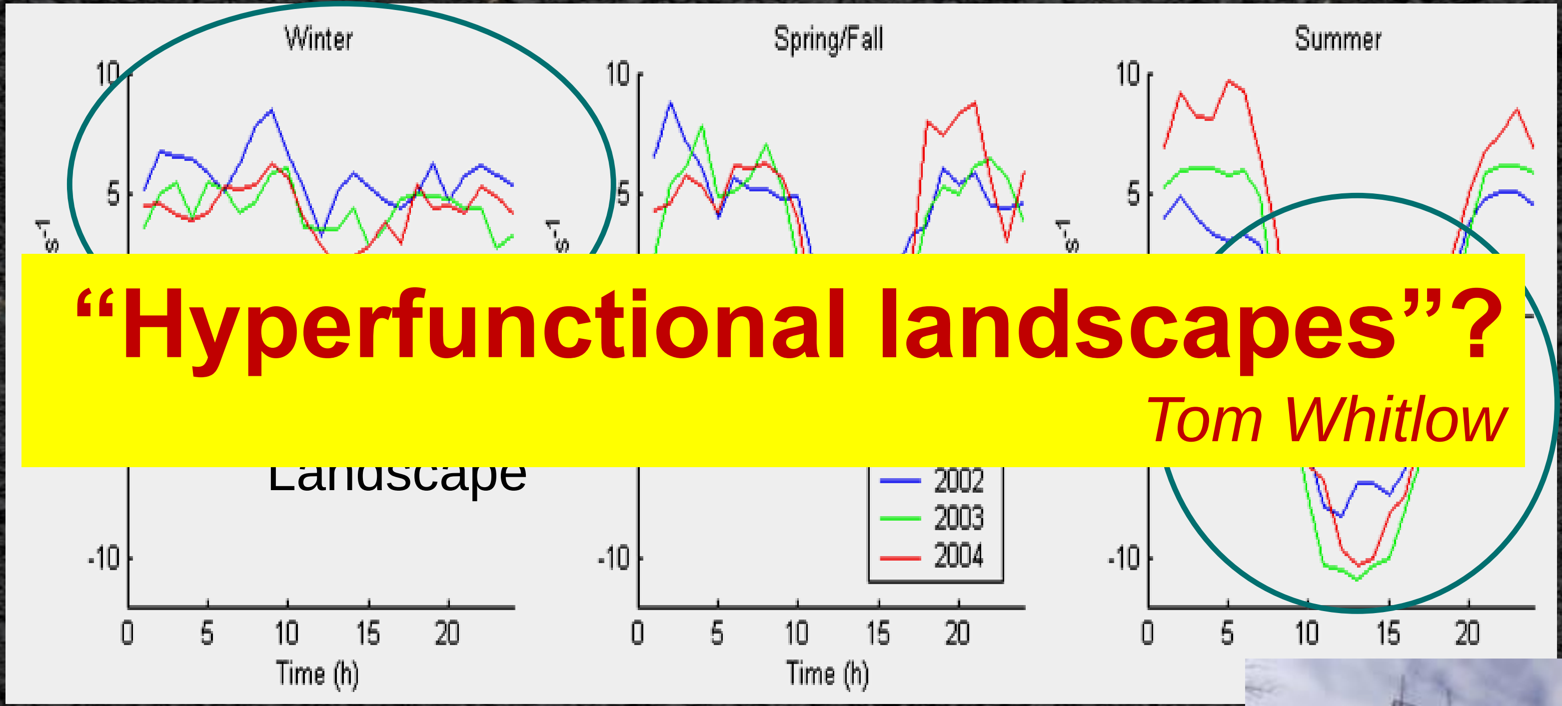
Source: G.P. Robertson et al. (2002), *Science* – Kellogg Biol. Sta. LTER

Reduce Tradeoffs?

turfgrass

- Residential 40% of land area of major metro areas (Nowak et al. 1996)
- 40 million acres of managed lawn in lower 48 USA (Milesi et al., 2005)
- More than acreage of largest irrigated crop (corn)
- Up to 200 kg N/ha/yr

C sink in urban landscapes?



“Hyperfunctional landscapes”?

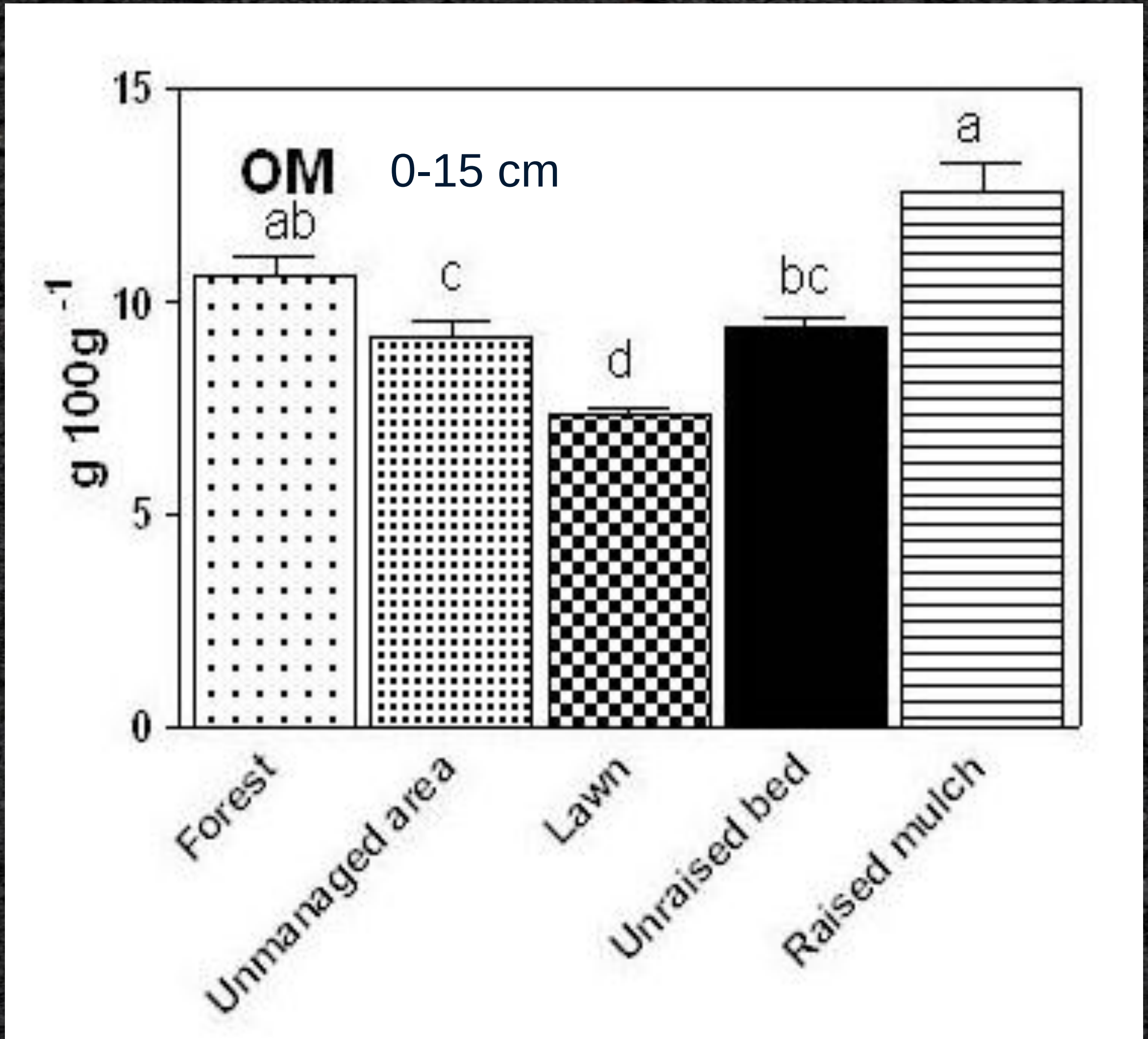
Tom Whitlow

- Surprising amount of carbon fixation
- Varies by season and year (drought)
- However, sources swamp sink

Cub Hill
Flux Tower

Saliendra et al. in revision

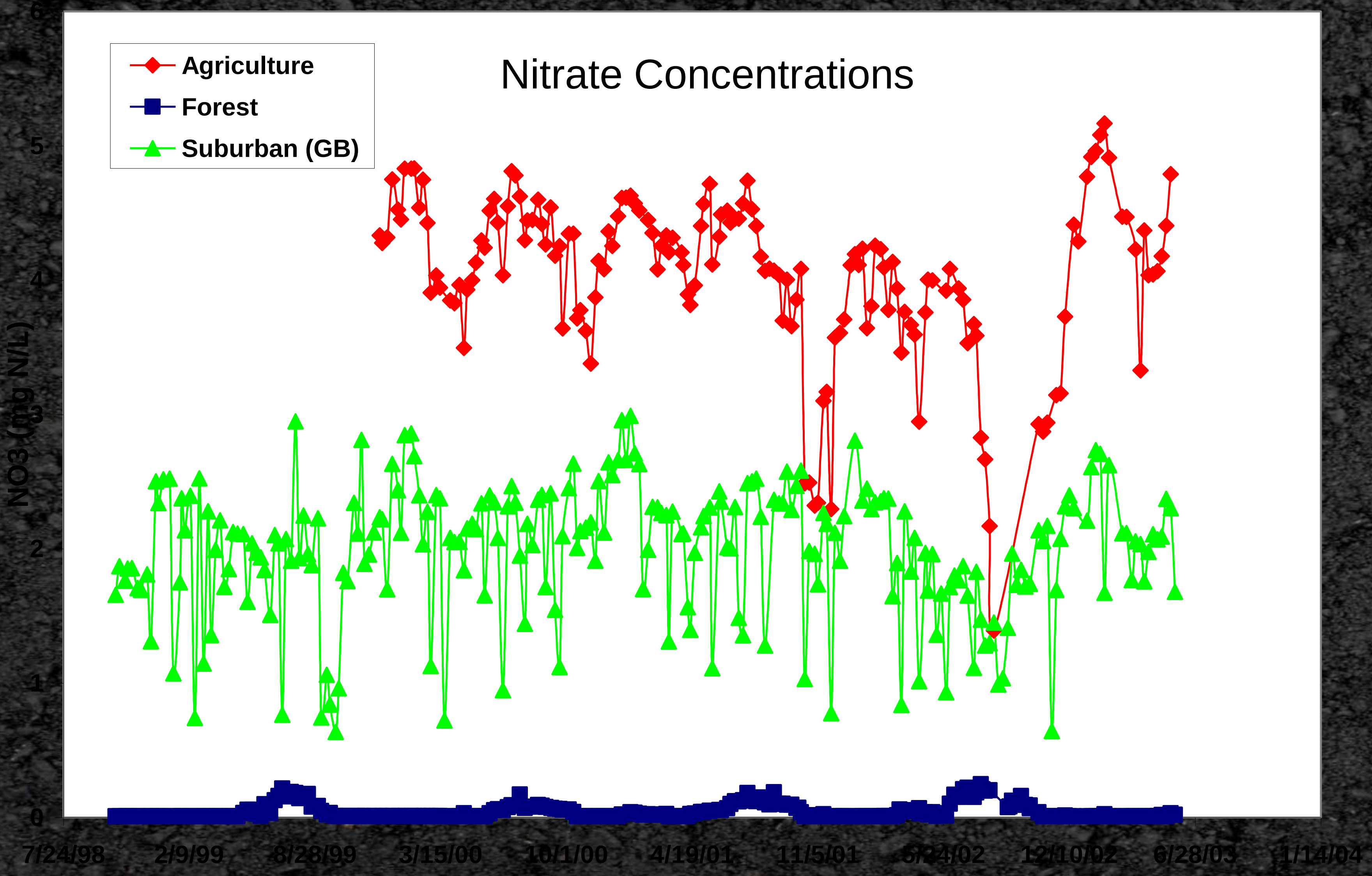
Enhance C Sinks?



Yesilonis et al. 2015

Potential for “good”

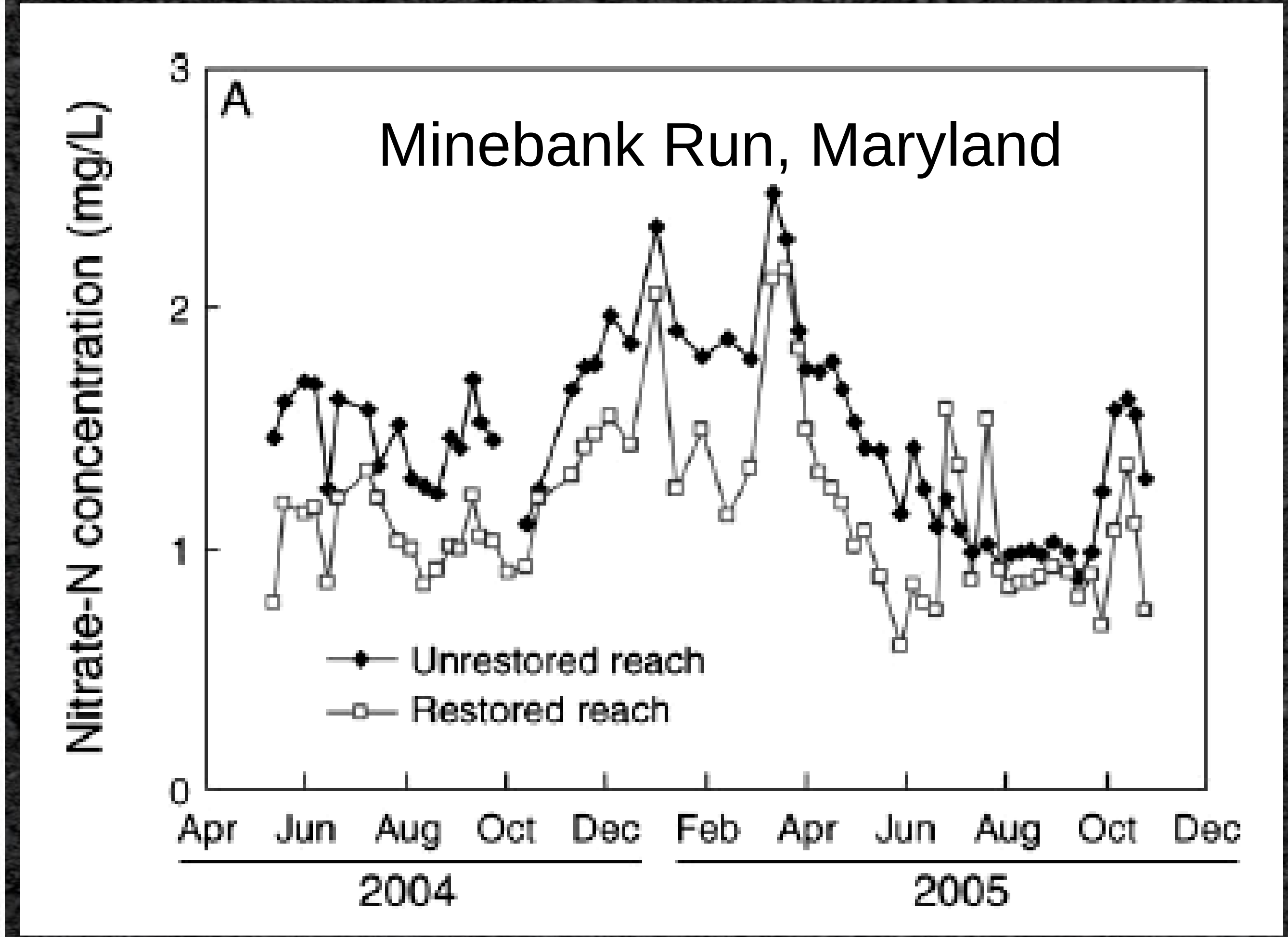
Sources of nitrate greater than sinks for suburban



More “Bad”

Groffman et al. 2004

Enhance N Sinks?

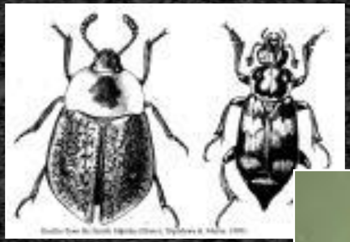


More "good"

Kaushal et al. 2008

Invasive Species (Soil)

- On the taxon :
  - 0 % (Silphidae)
  - 54 % (Diplopoda)
  - 100 % (Isopoda)

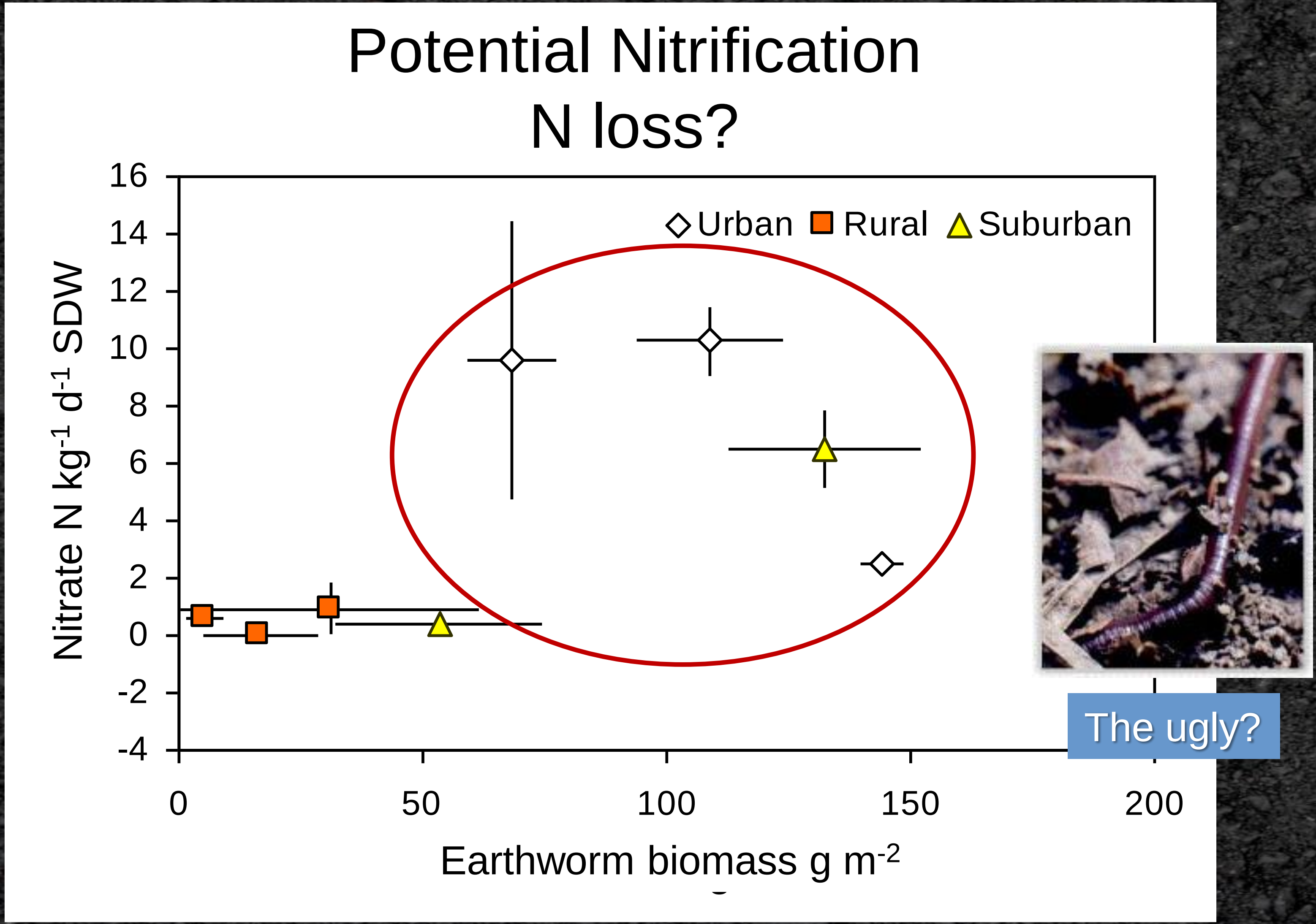


- On the location (invasive earthworms)
  - New York City: 100 %
  - Baltimore: 57 %
  - Budapest: 19 %

“The Ugly”

Szlavecz et al. 2006; Steinberg et al. 1997

Loss of Ecosystem Services

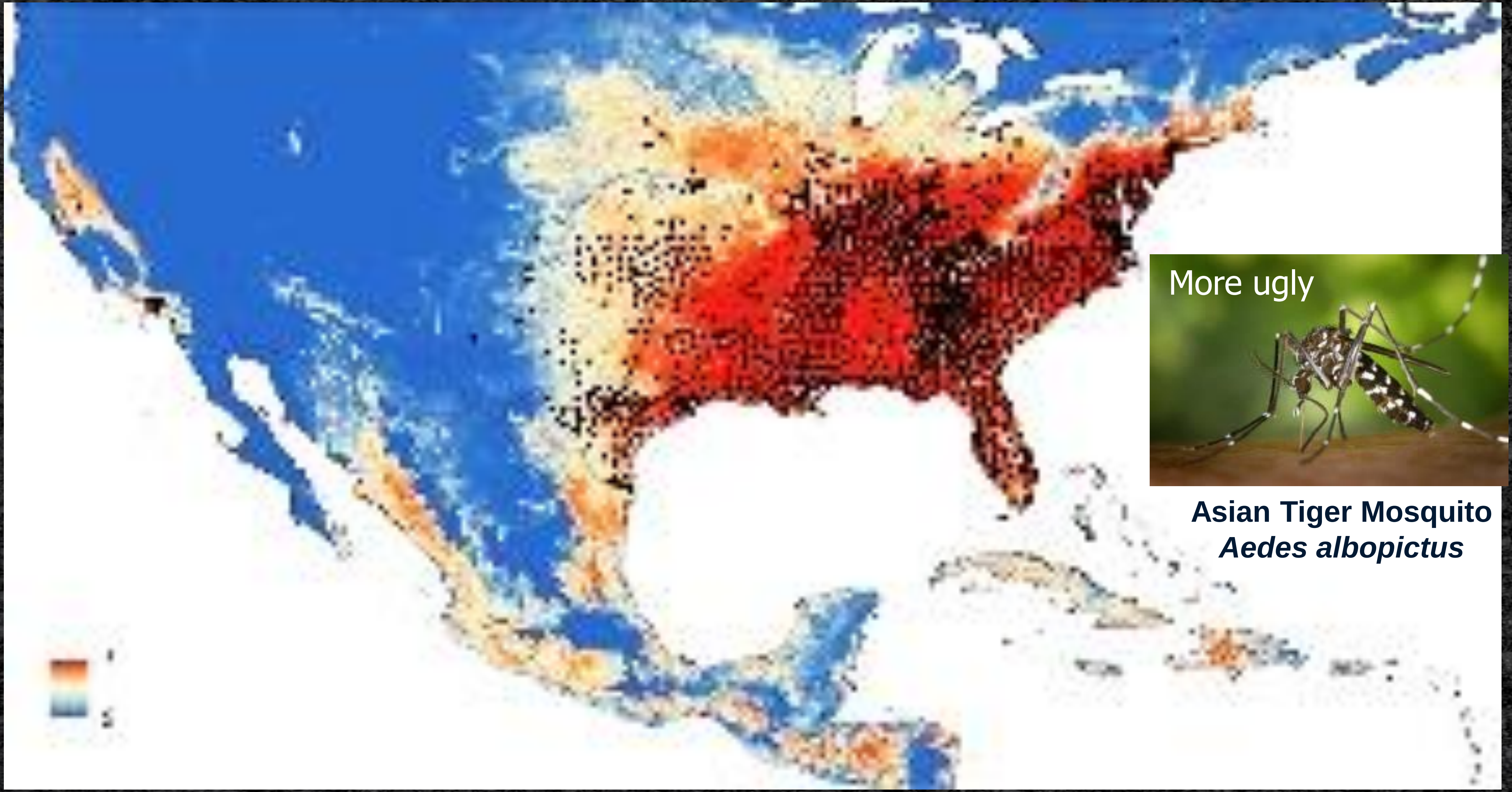


The ugly?

Szlavecz et al. (2006)

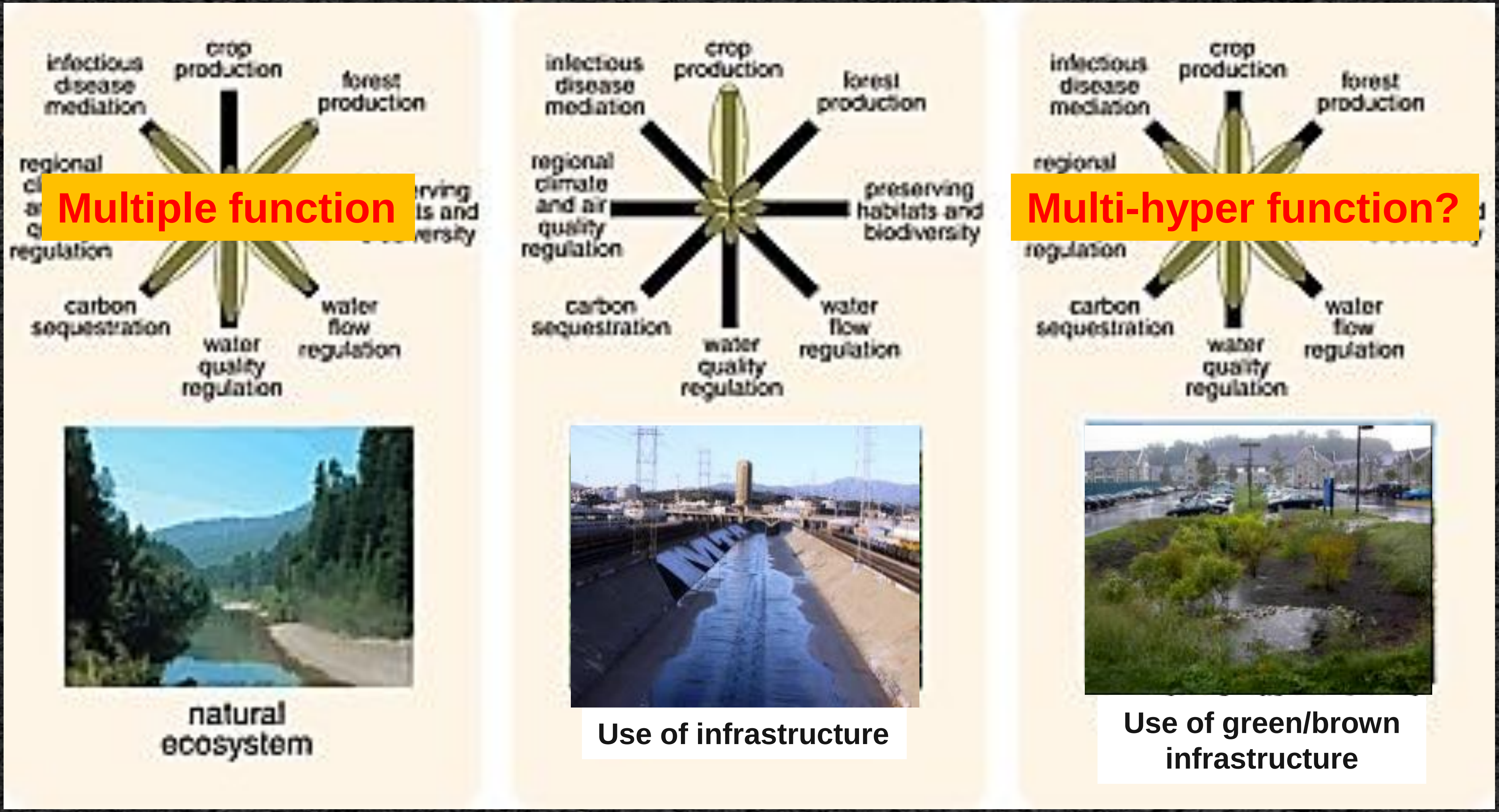
more “Bad”

Invasive species: Leap Frog Suitable Habitats ?



Asian Tiger Mosquito
Aedes albopictus

Urban land-use change?



Spatial and temporal complexity?

Multifunction?

Need to consider tradeoffs!

Risk?

Unintended effects?

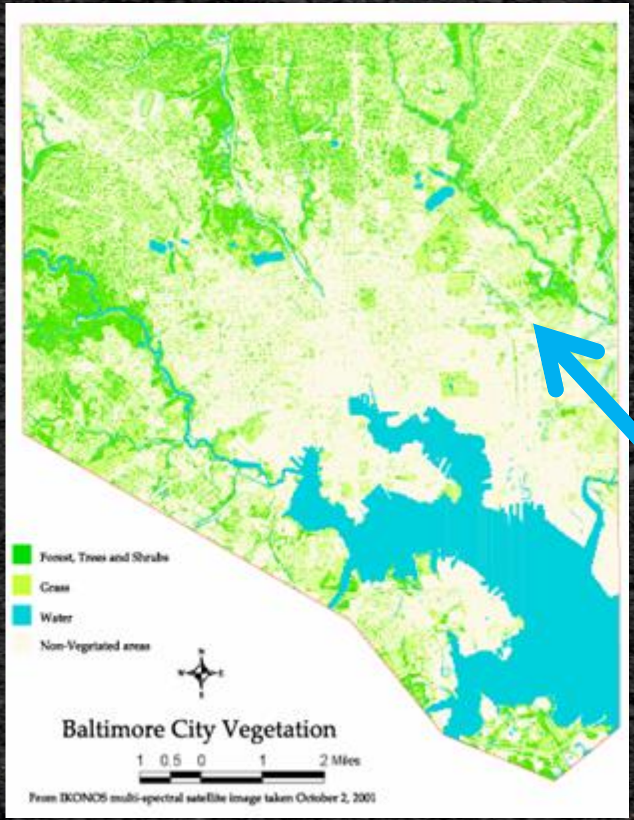
Scale of performance?

Longevity?

Decision making?

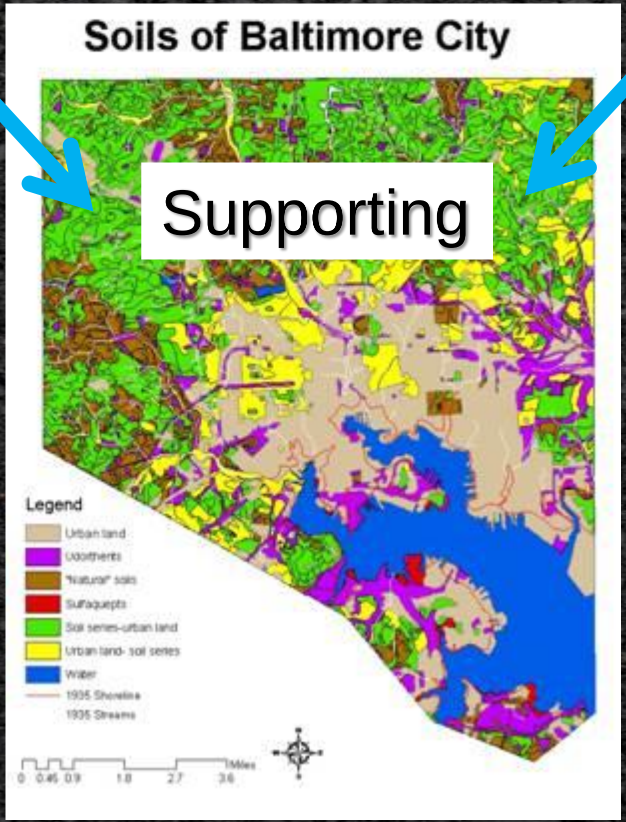
- Bad vs. no decision?
- Optimize x-factors?

How realize multiple function?



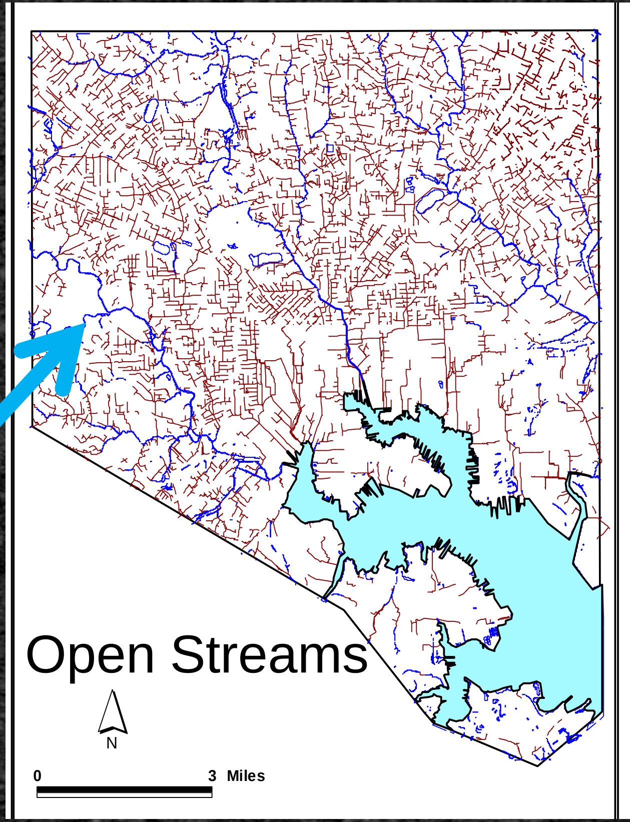
Green Infrastructure

Integrate



Supporting

Brown Infrastructure



Open Streams

Blue Infrastructure

Advantages of blue, brown, and green infrastructure:

- Avoids side effects (e.g., high peak flows)
- Utilizes biological processes (i.e., self-maintaining)
- Preserves function of pre-existing ecosystems
- Work in tandem (series) and multi-hyperfunction

How create multi-hyper functioning landscapes?

Small storm

How integrate?

How engineer?

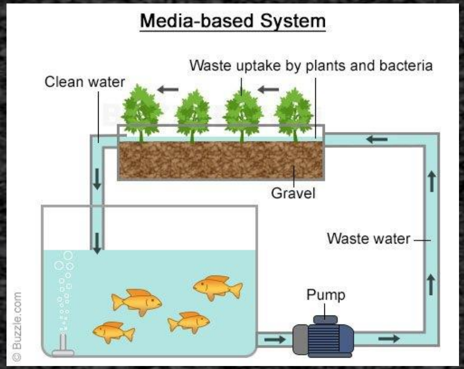
Bigger storm

Even bigger storm

How utilize space?

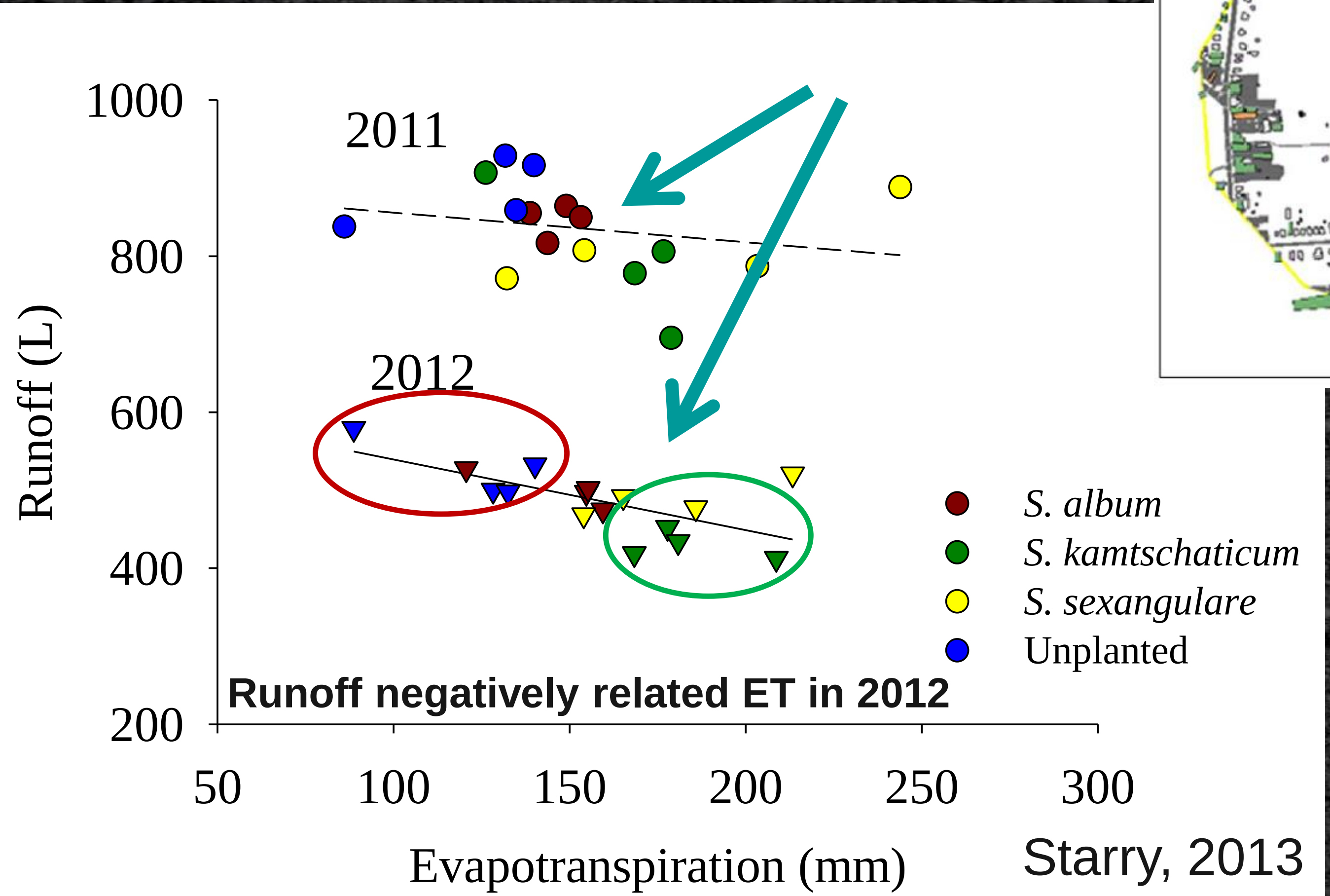
Scale of performance?

Go vertical!

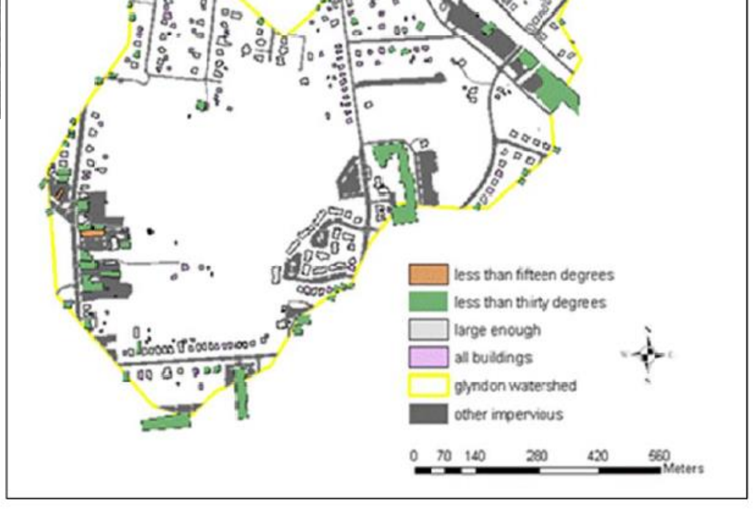


Reuse systems

Context matters!

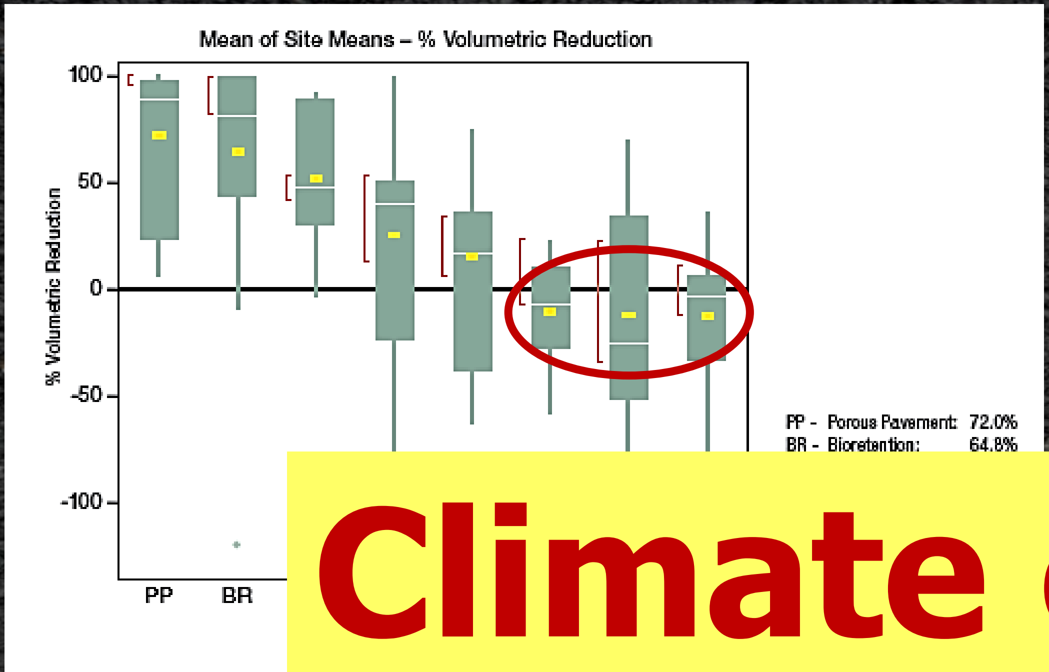


Starry, 2013



Landscape, building, & infrastructure designs must consider spatial-temporal heterogeneity of landscape to optimize function

Must understand performance across all conditions and at a broader scale, e.g., watershed



Need more data!

Recommended citation:

Driscoll, C.T., Eger, C.G., Chandler, D.G., Davidson, C. I., Roodsari, B.K., Flynn, C.D., Lambert, K.F., Bettez, N.D., Groffman, P.M. 2015. Green Infrastructure: Lessons from

Climate change?

PRESENTATION

Data summarized in this report are primarily from the International Stormwater Best Management Practice database, a collection made available to the public by the Water Environment Research Foundation (WERF), Environmental Protection Agency (EPA) and Environmental Water Resources Institute (EWRI; WERF 2013). In addition, data were obtained from the peer-reviewed literature. From these sources, we compiled data from 121 sites involving 4,277 hydrologic and 35,476 water quality observations from individual storm events into an original Microsoft Access database that we created for this study.

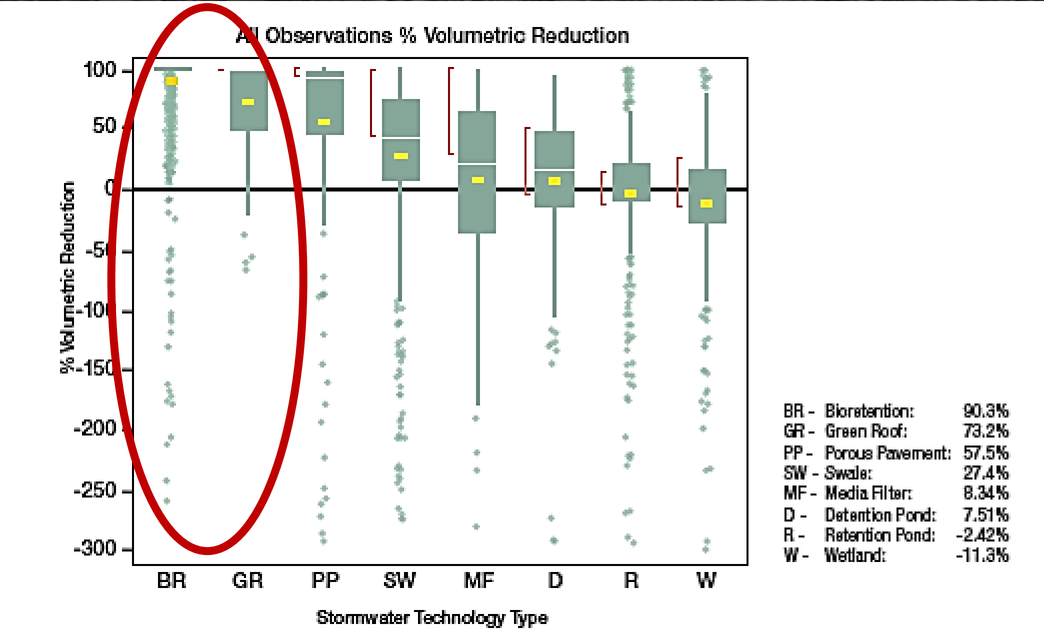


Figure 3. Summary of volumetric stormwater capture, loss and leakage by technology, summarized as percent volume reduction of inflowing water. The values shown are of performance by individual events.

Where to go from here?

Optimal Cities!

Websites for resilient city tools