Urban Systems in the Anthropocene

Prospects for transforming problems into solutions?

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CLIMATTERS Symposium—2017

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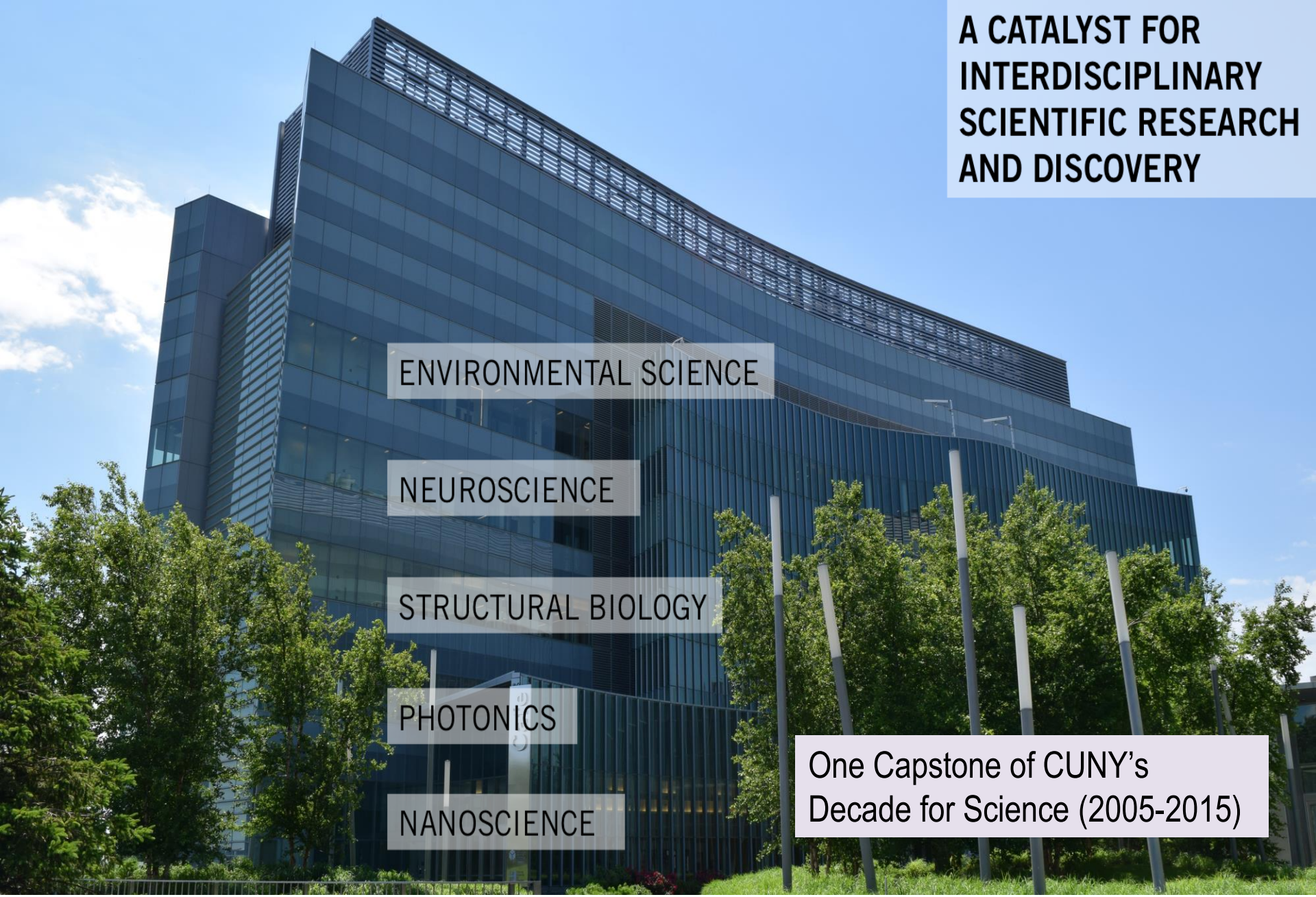
Goals for This Discussion

- Brief Introduction to New Technologies for Studying the 21st Century City
- Urban Systems in Broader Perspective
- The Critical Role of Nature in Managing an Increasingly Urban Planet


A CATALYST FOR INTERDISCIPLINARY SCIENTIFIC RESEARCH AND DISCOVERY
ENVIRONMENTAL SCIENCE
NEUROSCIENCE
STRUCTURAL BIOLOGY
PHOTONICS
NANOSCIENCE
One Capstone of CUNY's Decade for Science (2005-2015)

ENVIRONMENTAL SCIENCES INITIATIVE

Broadly, we study human-environment / environment human interactions in the Anthropocence

…to inform authoritative and creative solutions to environmental challenges

…using integrated data sets and models to depict our world now and in the future

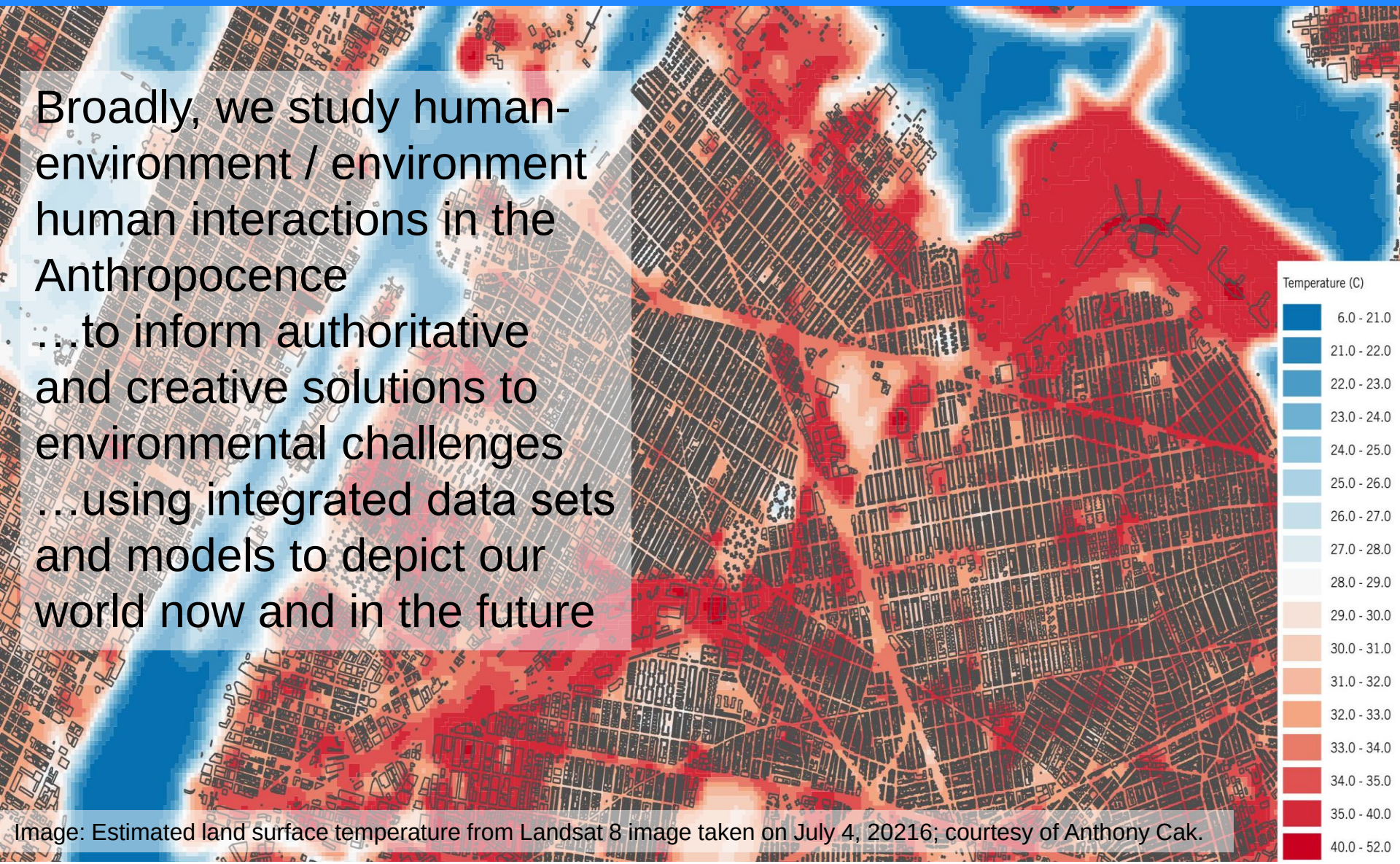


Image: Estimated land surface temperature from Landsat 8 image taken on July 4, 20216; courtesy of Anthony Cak.

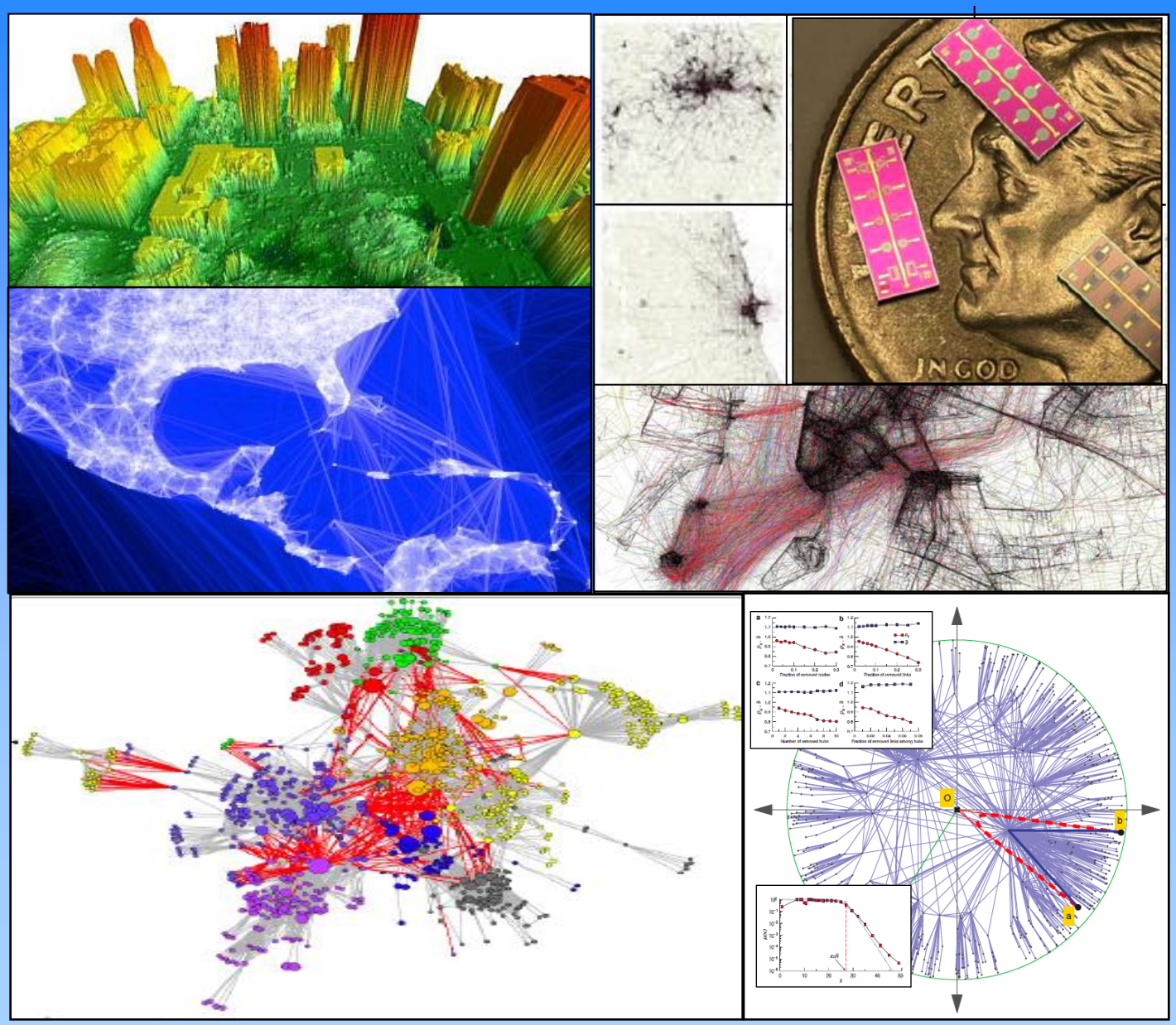
The Urban Century

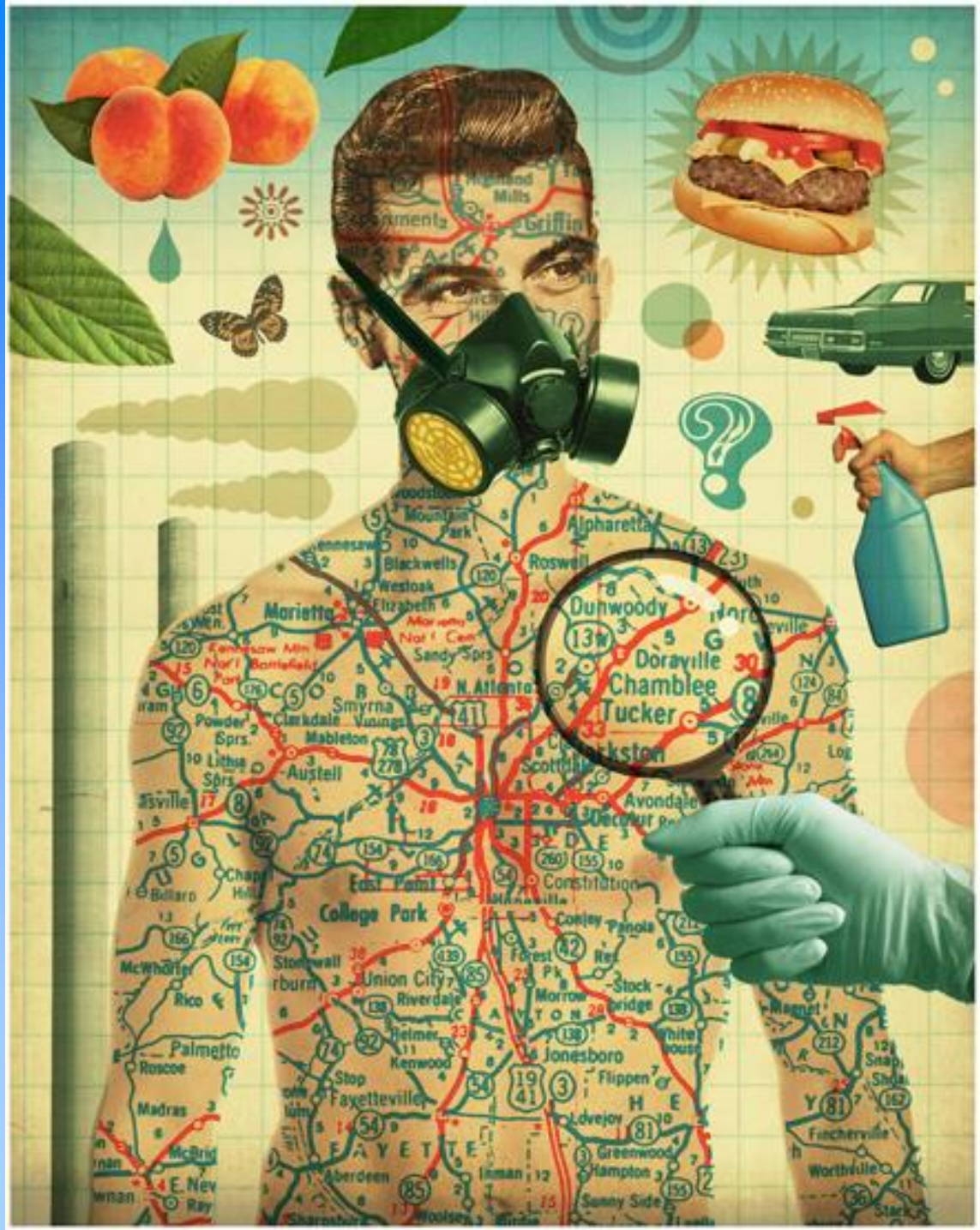
A Planetary-Scale Experiment and Emblem of the Anthropocene

- **2007** was the urban-rural (50-50) tipping point
- In **2016**:
  - >500 cities with 1M+ people and 20% of the world's population lives there
  - 31 Megacities with 10M+ people, with 2/3 in poor countries
  - More than 55% are vulnerable to natural disasters
- By **2050**:
  - 2/3 or more of the world will be urban
  - population ~ 7B equal to world population in

Source: UNDESA, 2014 & Update

Cyber-enabled toolkits, sensor data, and metrics enable a new era of study for urban-environment complexes

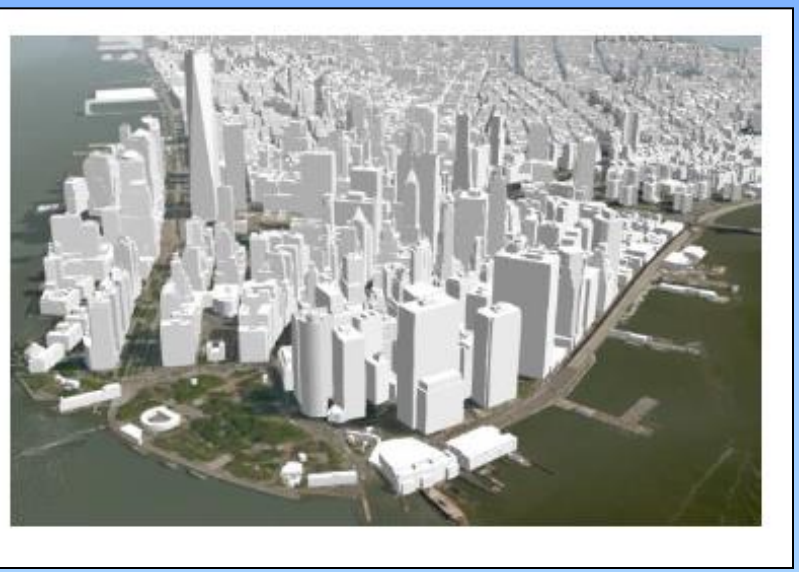




One example: The concept of an "EXPOSOME, like a "GENOME"…a kind of human fingerprint

To study, we need…….
A unique combination of environmental surveillance, chemistry, biology, human health, GIS, systems dynamics and modeling, big data analysis

We can start with high resolution digital templates onto which multi-dimensional themes can be overlain



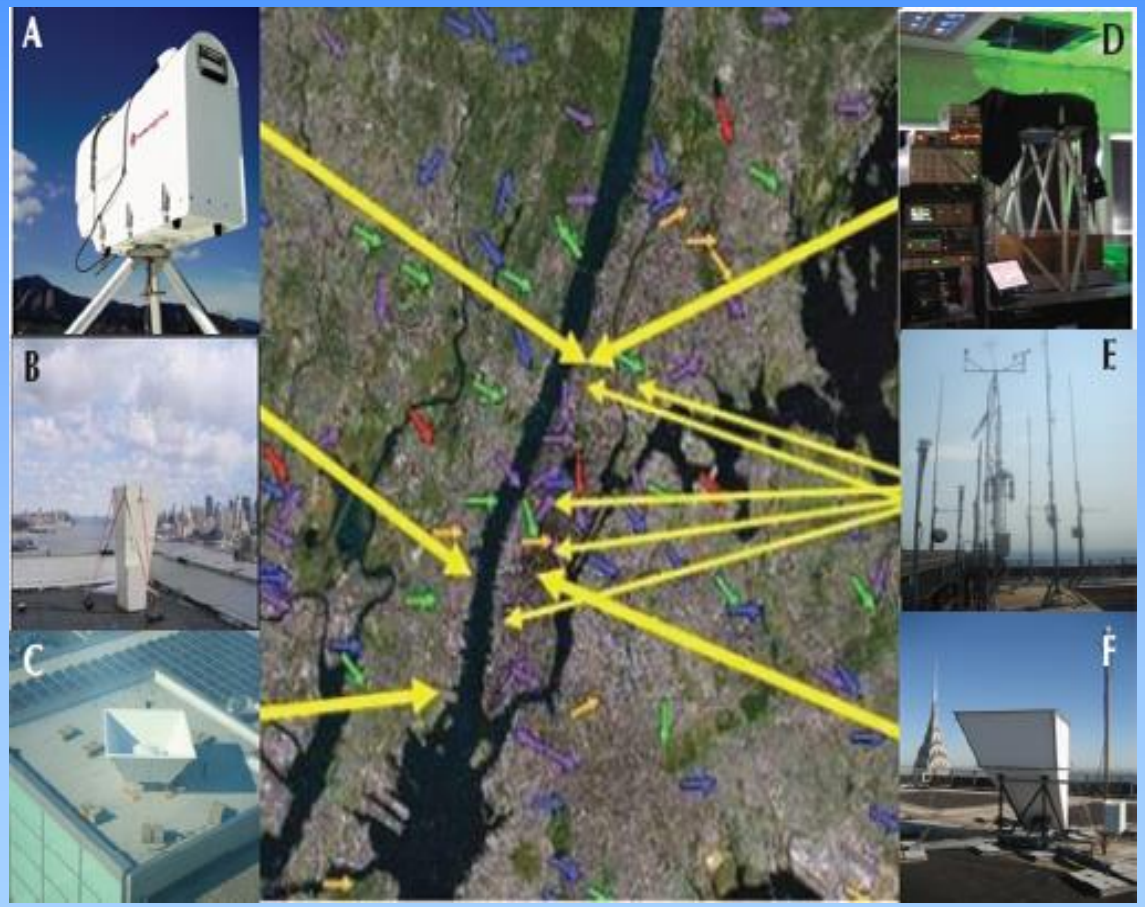
CityGML

FOOD *Indicators:* Quality, sustainable production, security of supply, land use, energy footprint, CO_2 footprint	**FOOD → WATER** • Impact of food production and food waste treatment on water quality • Climate change impact on food production and water demand	**FOOD → ENERGY** • Use of waste food for energy production • Impact of urban farming on transport and processing energy
WATER → FOOD • Water treatment for irrigation • Water treatment for food process water • Water treatment for potable water	**WATER** *Indicators:* Water quality, water quantity and long term sustainability, resilience, land use, water footprint	**WATER → ENERGY** • Energy requirements in wastewater treatment for different water quality and possible reuse • Wastewater sewage sludge treatment for thermal energy generation, phosphorous recovery
ENERGY → FOOD • Smart micro grids for resilient food refrigeration chain and food logistics • Demand side management potential of food chain refrigeration (supermarkets) • Energy efficiency of food production	**ENERGY → WATER** • Smart grids and renewables for resilient water supply and treatment • Wastewater plant efficiency and demand side management (DSM), reuse • Energy efficiency of water supply	**ENERGY** *Indicators:* CO_2 emissions, reliability and resilience, land use footprint

A Collaboration of the University of Stuttgart and City University of NY

Example of consortium-based laboratory design Multi-scale Air-Climate-Energy Observatory (MACEO)

Locations and pictures of various instruments of the NYCMetNet



(A) Temperature, humidity and liquid water vertical profiler (to 2 km).

(B) & (F) Sodar wind profiler to 300/450 m.

(C) Radar wind profiler vertical profiler (to 2 km).

(D) CCNY Aerosol Raman lidar (to 10 km) and Vaisala ceilometer.

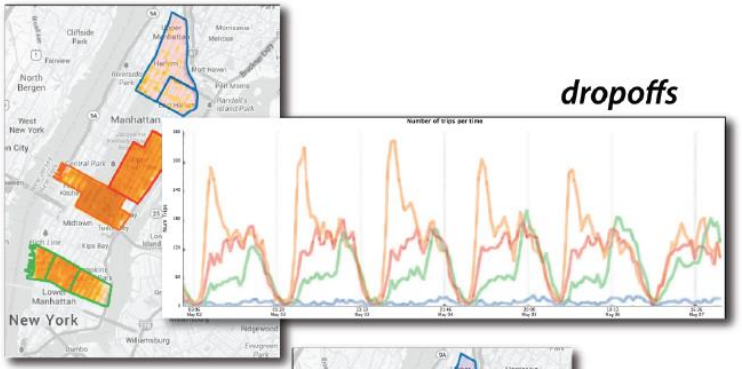
(E) Skyscraper-mounted weather stations.

(F) Not shown: Portable eye safe Doppler Lidar, radiation flux instruments, Nephalometer & other particulate matter stations

AN INTERDISCIPLINARY LABORATORY AT THE CUNY ADVANCED SCIENCE RESEARCH CENTER

THE ADVANCED ANALYTICS & VISUALIZATION CENTER

TaxiVis: Comparing Neighborhoods



"Metabolism"

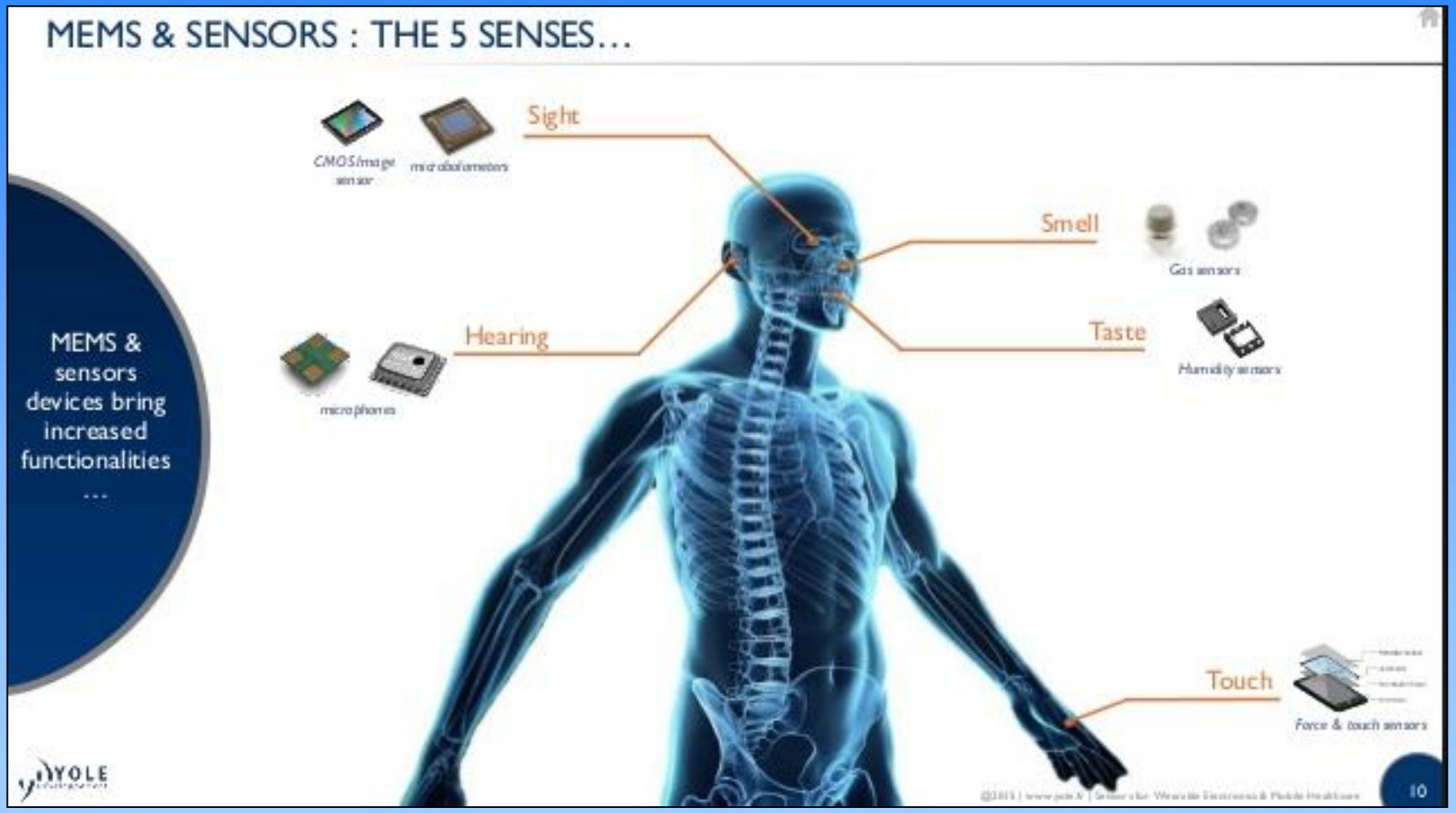
or "Pollution Fingerprint" of the City

(especially when linked to per vehicle carbon and pollutant emissions)

Collaboration w/: Huy Vo, CCNY

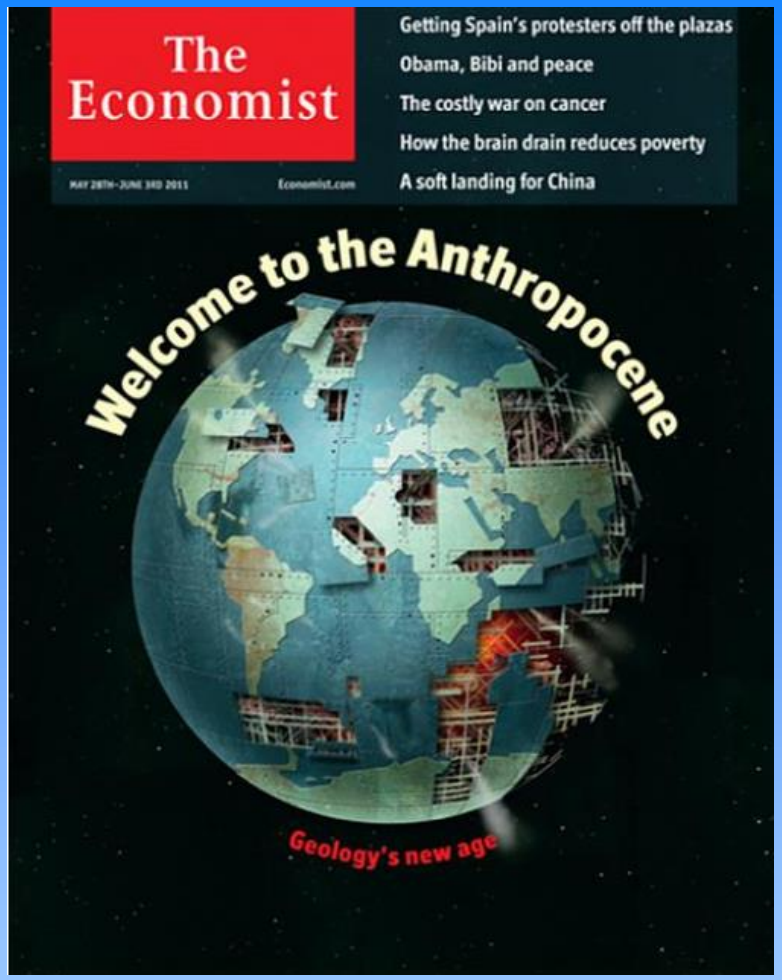
HUMANS GENERATING EXPOSOME “VECTORS”

4 dimensions: X, Y, Z and Time

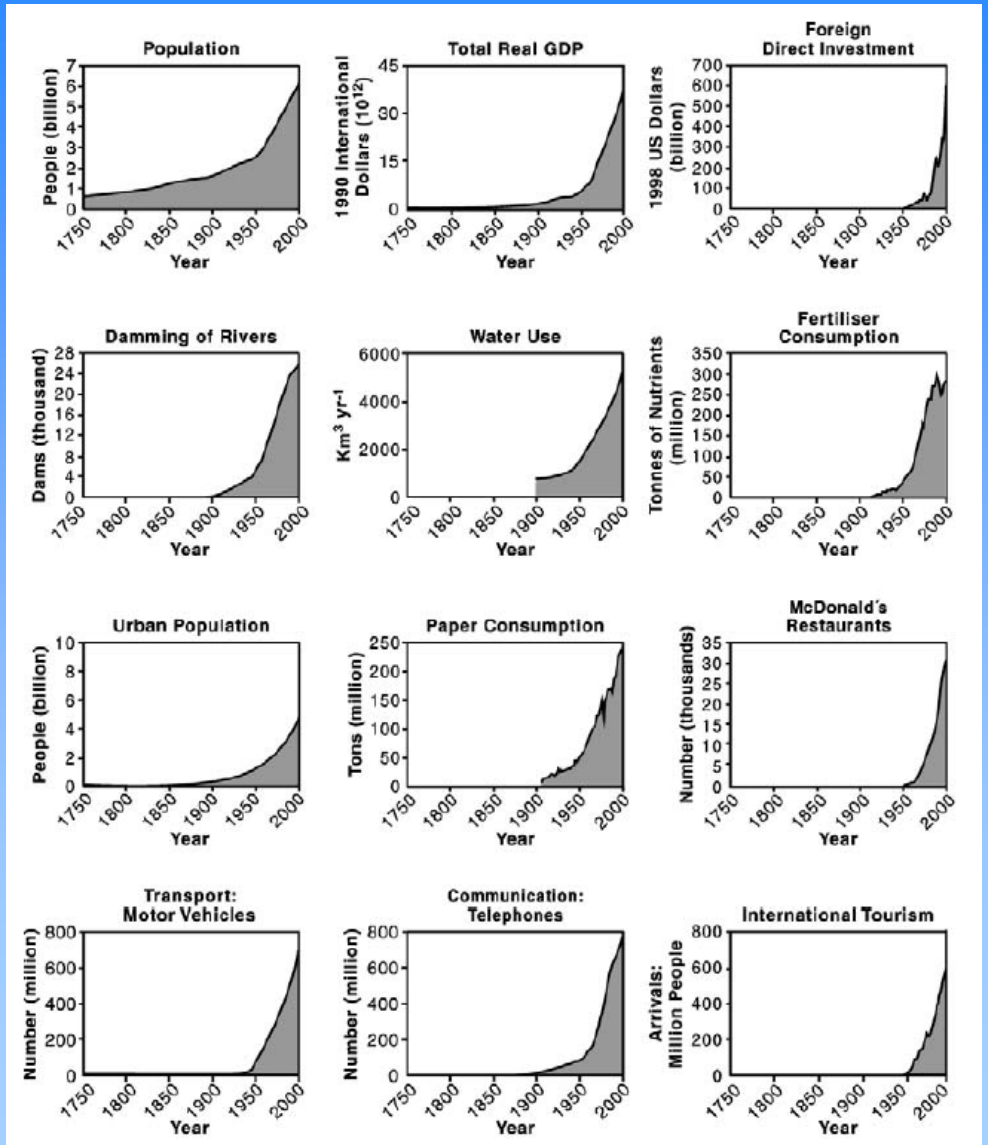


The Urban Planet

….and managing cities in light of global change and global climate change



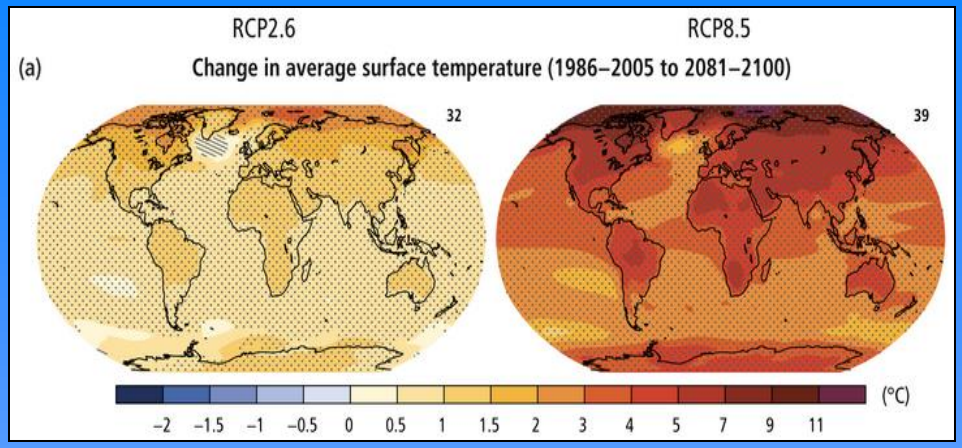
Human Resource Behaviors over a Multi-Century Timescale



Trends driven ultimately by population growth and economic development….<u>and much of it is urban</u>

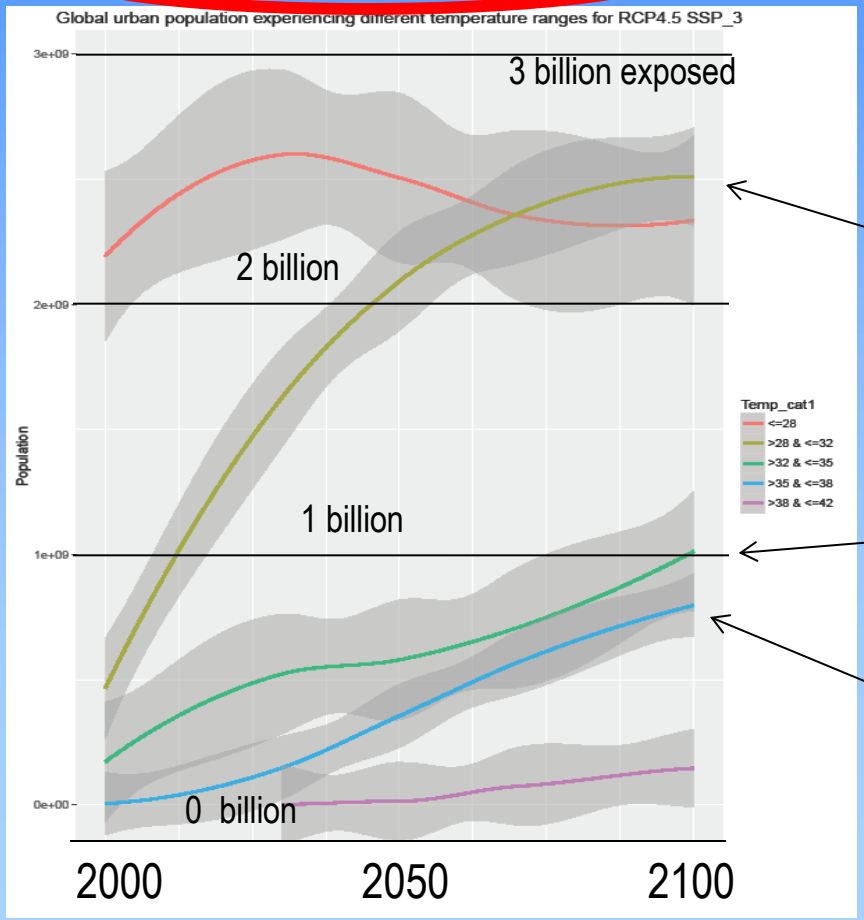
From: Steffen et al. (2007), Ambio

In Addition to All These Other Stressors: Future Sustained Heat Waves



Middle of the road estimates

3-month mean temperatures



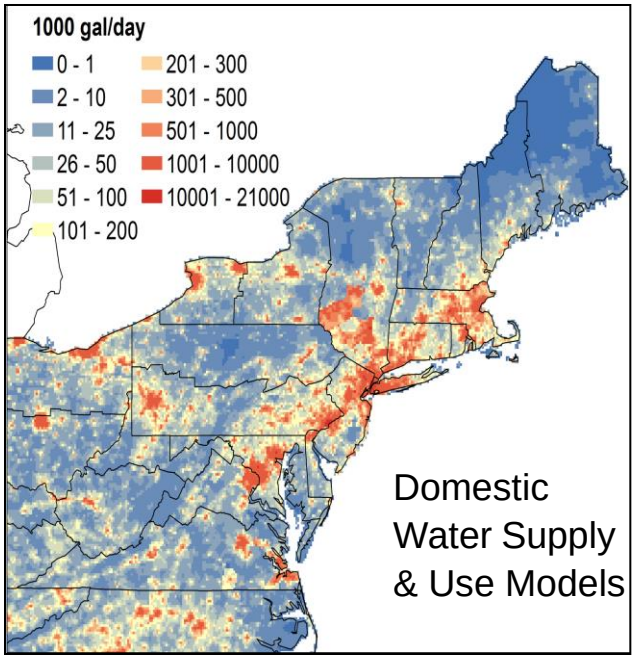
28-32 C

32-35 C

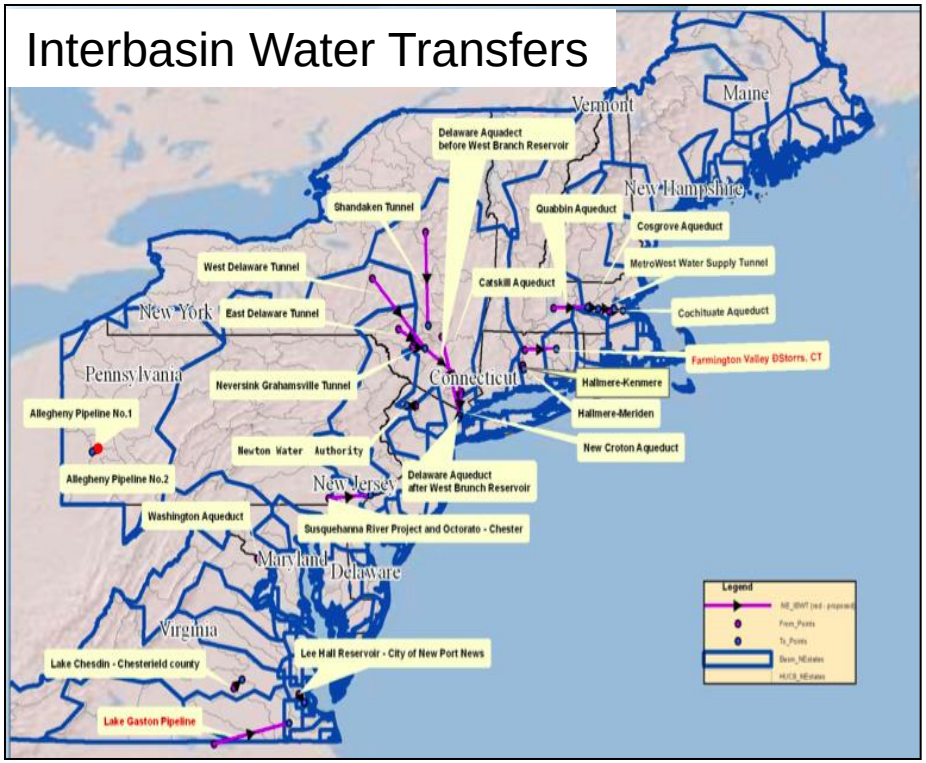
35-38 C

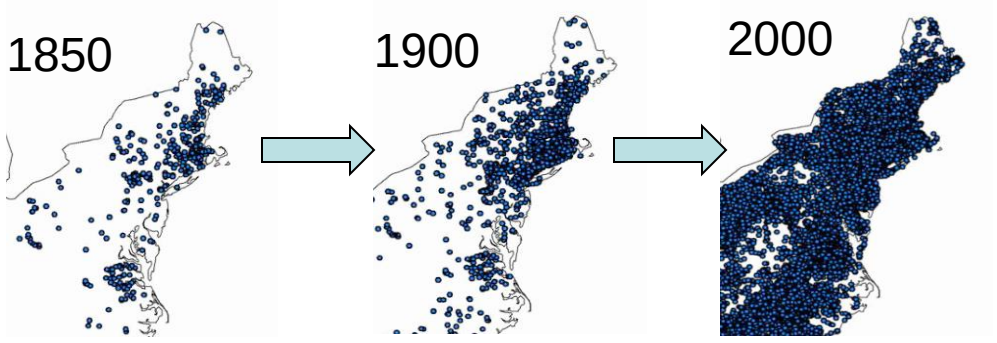
Collaboration with P. Marcotullio (Hunter)

Strategies Needed to Optimize Water Use and Infrastructure Management under Climate and Development Scenarios



Domestic Water Supply & Use Models





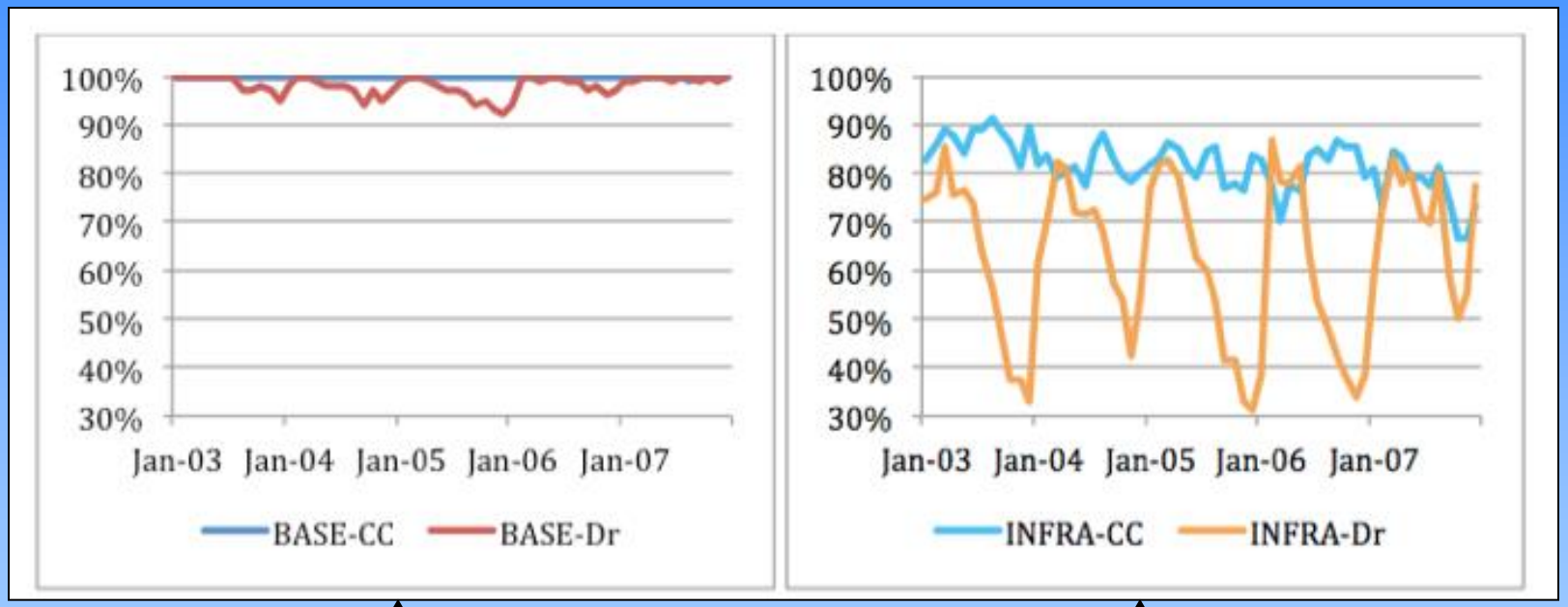
Dams & Reservoirs

Prolific, Uncoordinated Regional Runoff Control

ROLE OF EVOLVING INFRASTRUCTURE AND TECHNOLOGICAL EFFICIENCIES IS CLEAR

CC=contemporary (2000s) climate
Dr = mid-1960s intensity drought

Percentage of monthly regional water demands met



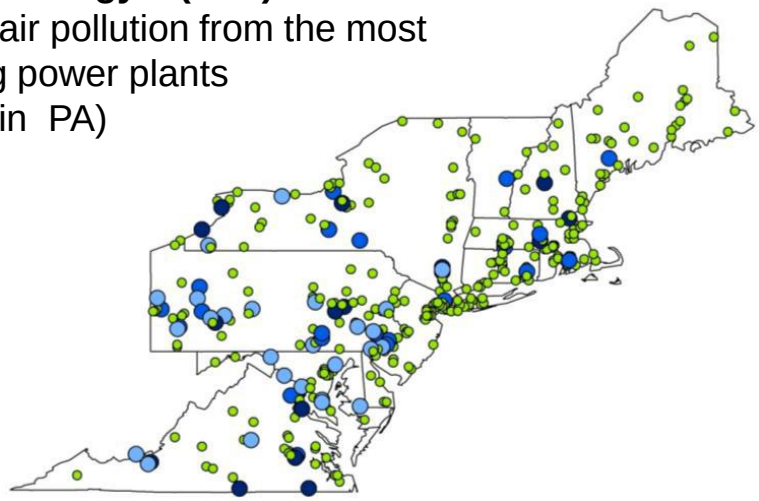
Modern water supply systems

1960s vintage technology

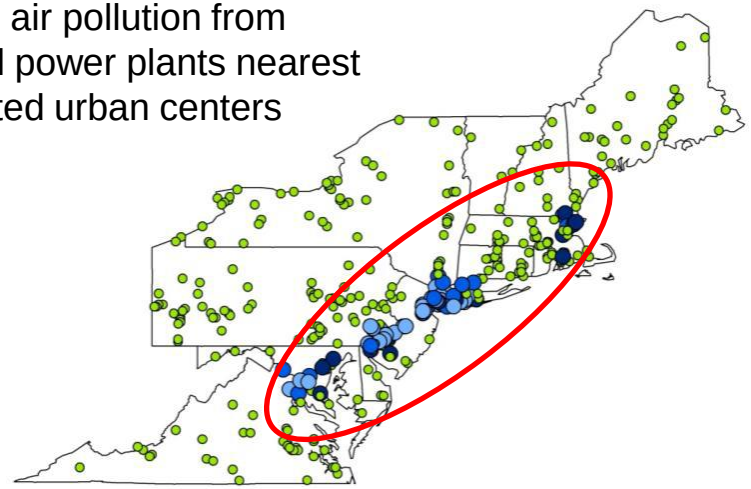
From: Vörösmarty et al., in prep.

Optimizing Environmental and Social Benefits through Demand-Side-Management

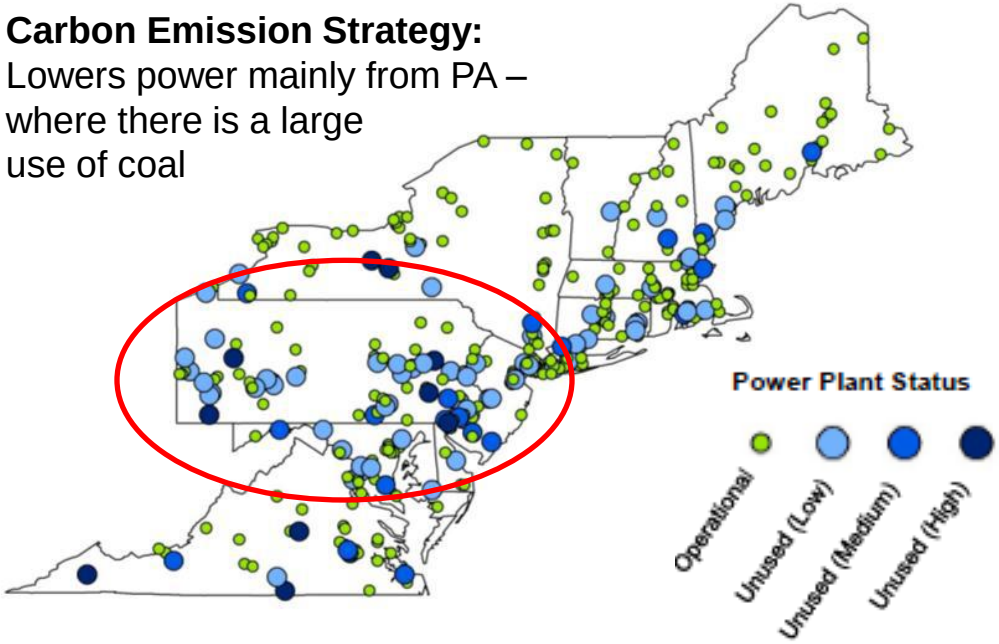
Social Strategy 1 (SS1):
Lowers air pollution from the most polluting power plants (mostly in PA)



Social Strategy 2 (SS2):
Lowers air pollution from harmful power plants nearest populated urban centers



Carbon Emission Strategy:
Lowers power mainly from PA – where there is a large use of coal

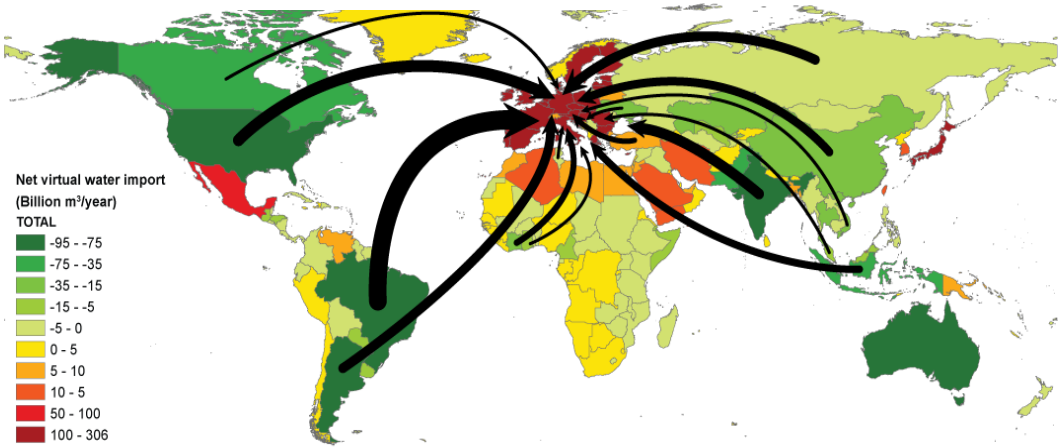


Different optimization targets require different curtailment strategies and yield clearly different societal benefits

(*from Miara et al. 2014*)

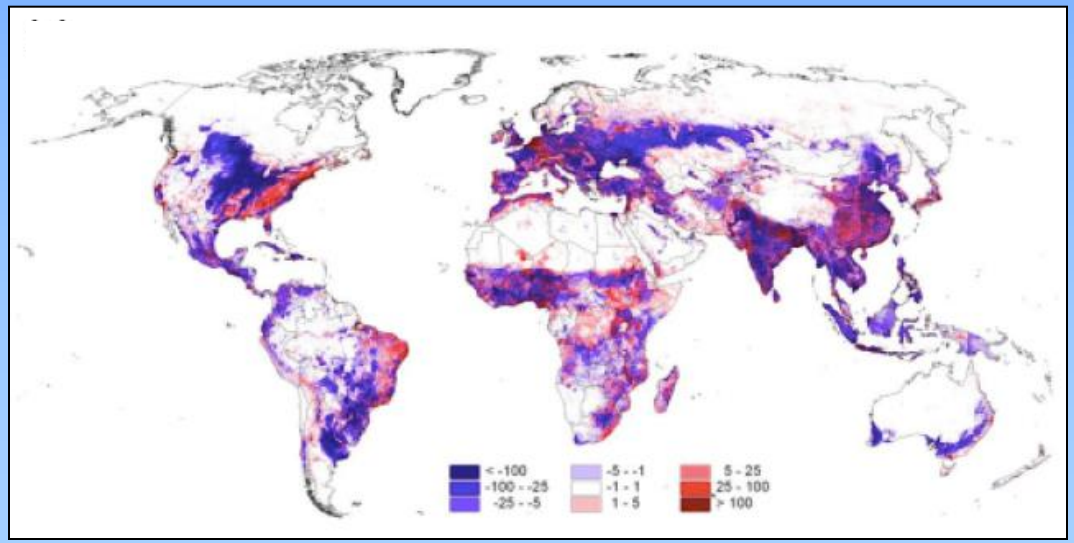
MANAGE NOT ONLY REGIONAL INFRASTRUCTURE BUT CLIMATE-SENSITIVE ECONOMIC RESOURCES FLOWING INTO URBAN REGIONS

Virtual Water in Food Trade



Courtesy: A. Hoekstra

NEW CAPABILITIES PINPOINT SPECIFIC IMPORT/EXPORT AREAS



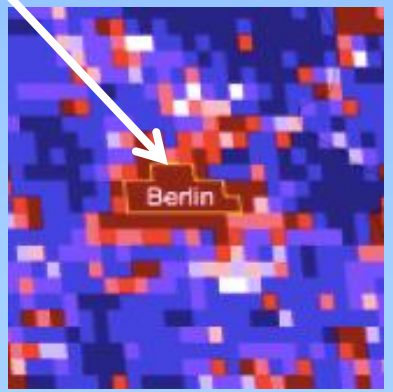
Hoff et al. 2014, HESS

Virtual Water

Export

Import

BERLIN



Manage Using Only Traditional Infrastructure?

Particularly relevant to the SDGs and the palpable "tension" as the water targets were formulated

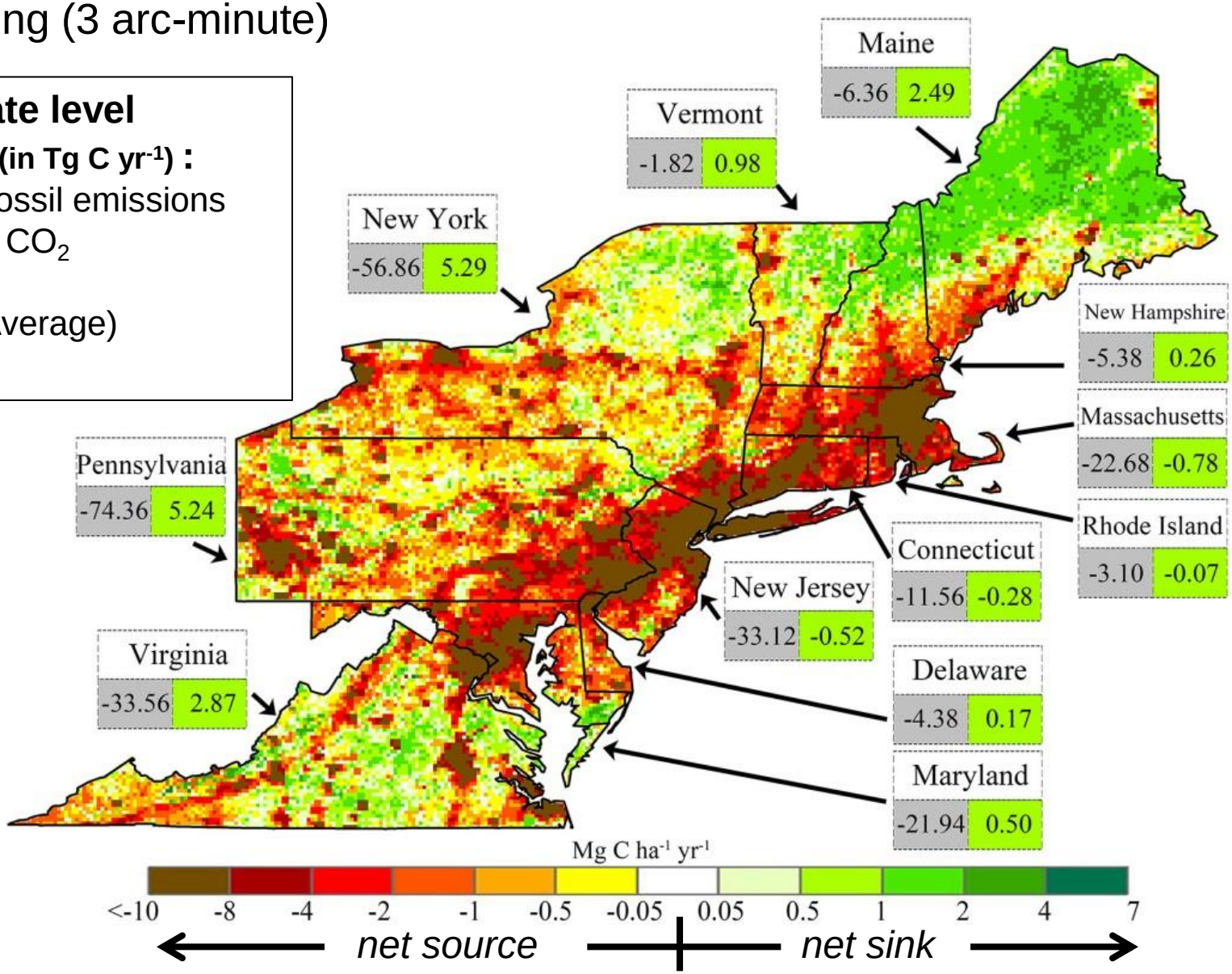
WATER

Water security: Gray or green?

One Green Infrastructure Service: Carbon Sequestration

TEM modeling (3 arc-minute)

BOXES: State level summaries (in Tg C yr^{-1}) :
Gray – 2002 fossil emissions
Green – Land CO_2 sequestration
(2001-2005 Average)



Lu et al., 2013, ES&T

State of Human Water Security

People Served by Riverine Water Sources

Volumetric Water Services →

Impairment

82% served by high threat resource systems

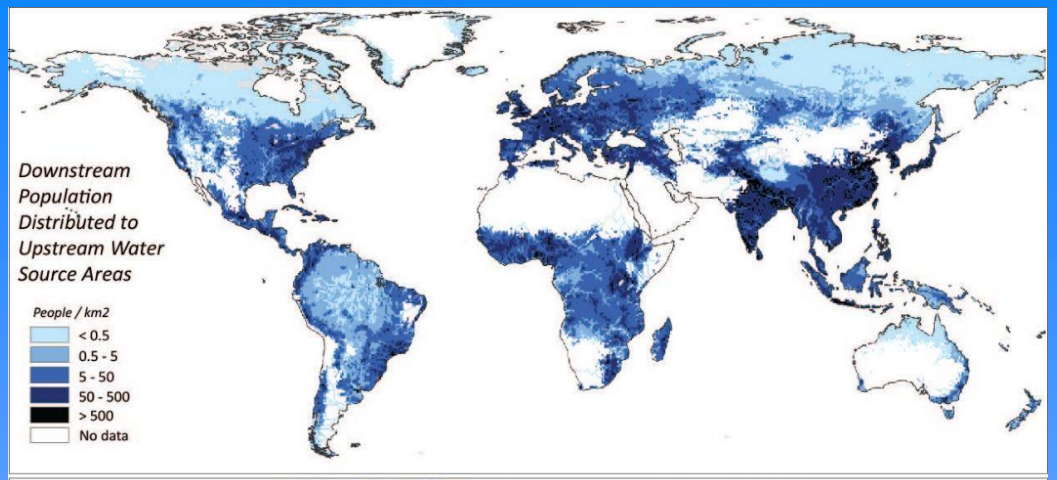
Incident Threat Condition →

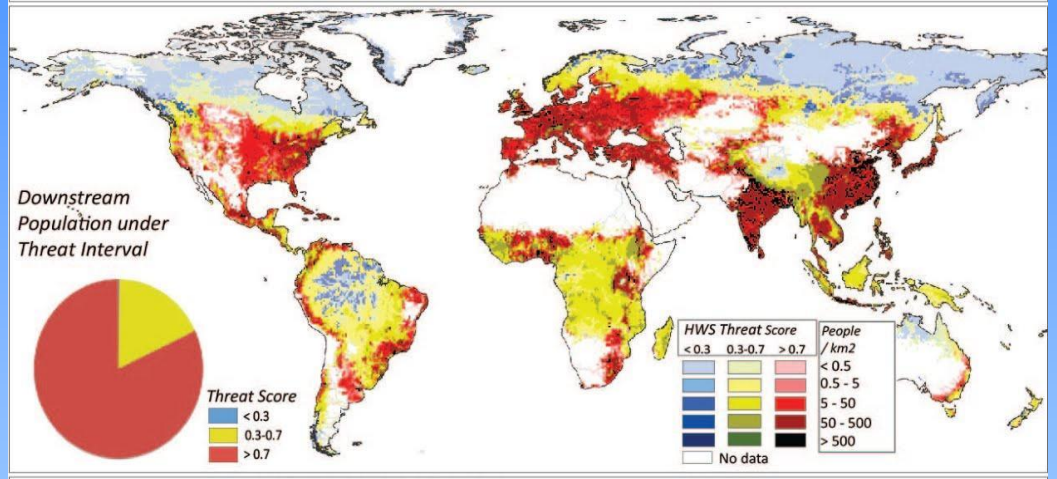
$0.75 Tr per yr

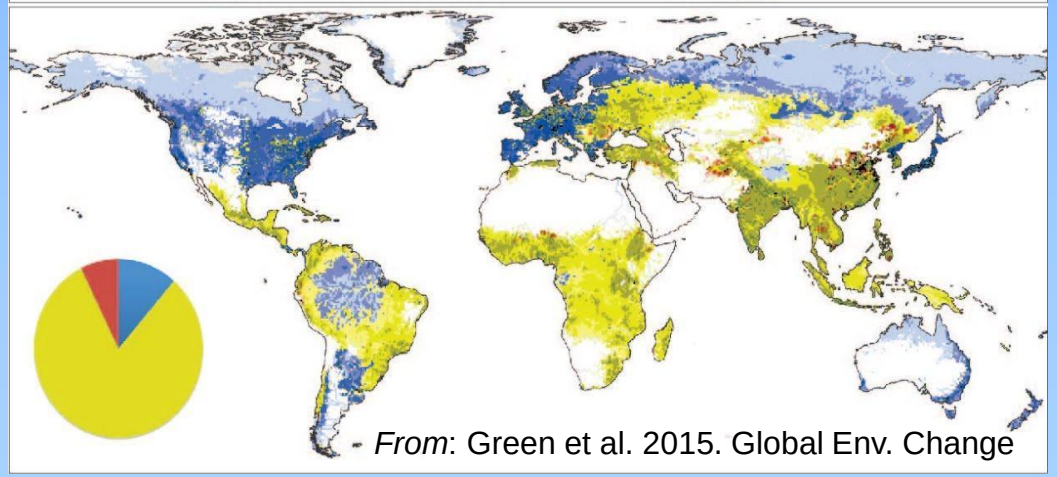
Repair

Reduced Threat after Remediation →

80% live downstream of moderate threats





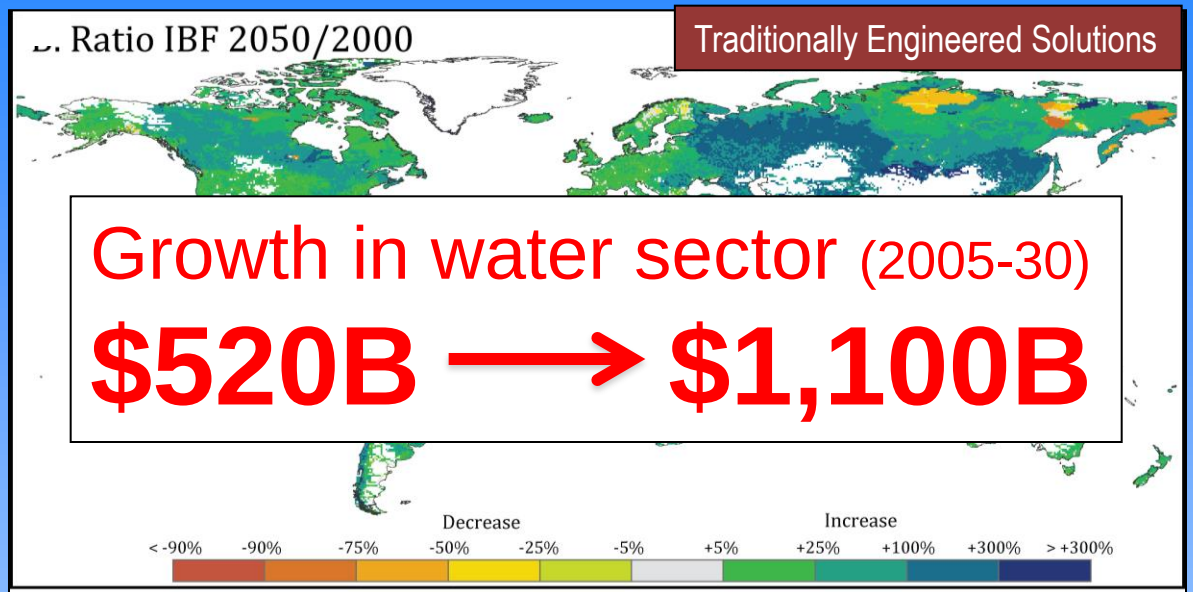


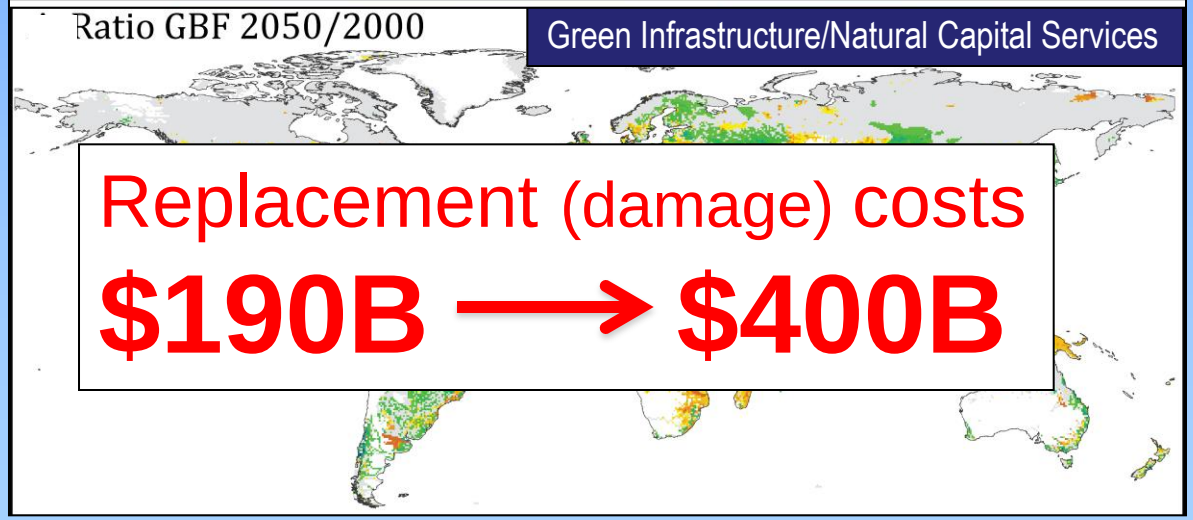
From: Green et al. 2015. Global Env. Change

Future Response under the Business-as-Usual Assumptions on Human Water Security

- Continued, heavy reliance on engineering approaches to new infrastructure and remediation *(costly but effective)*

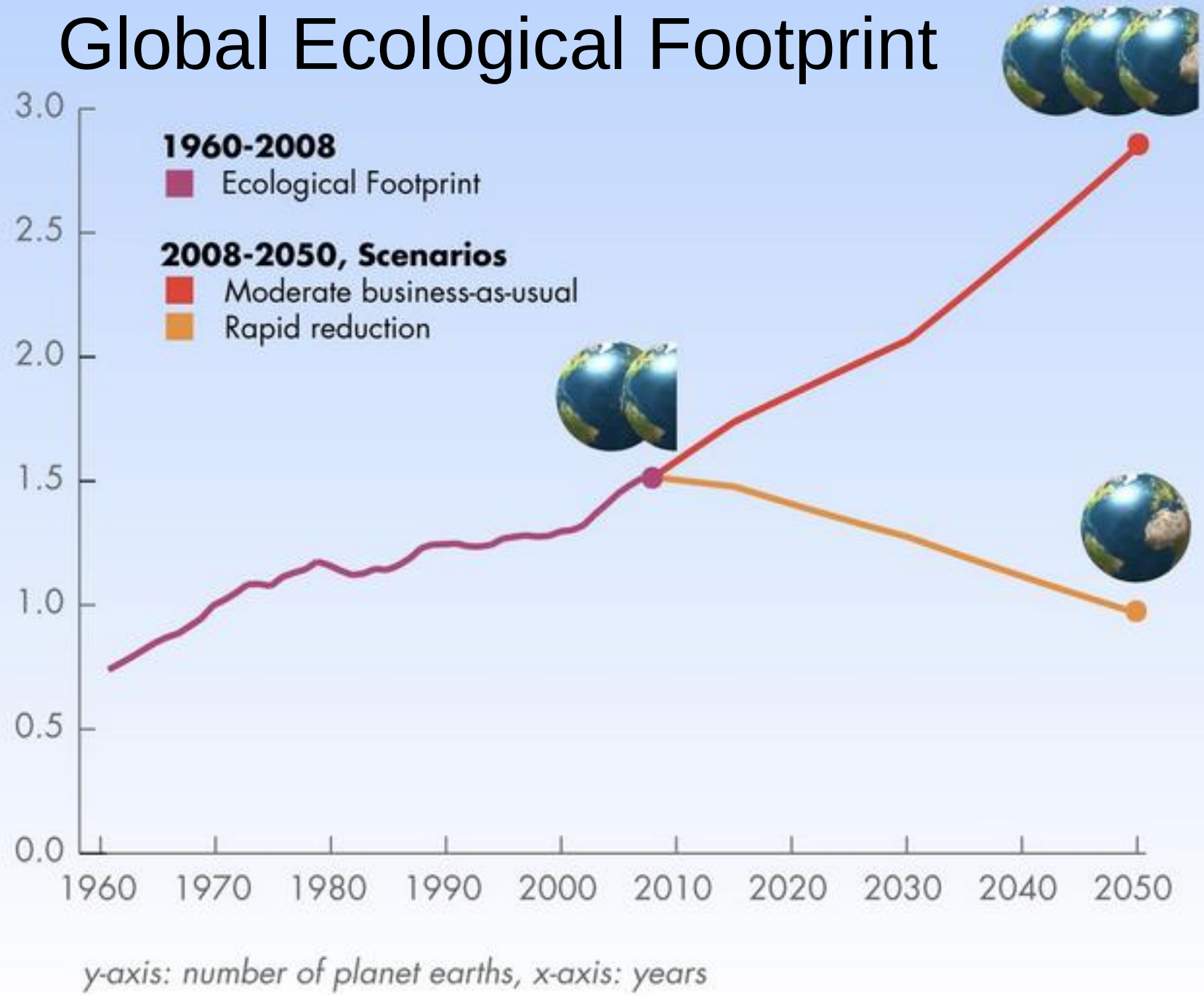
- Loss of natural capital will increase costs of attaining human water security



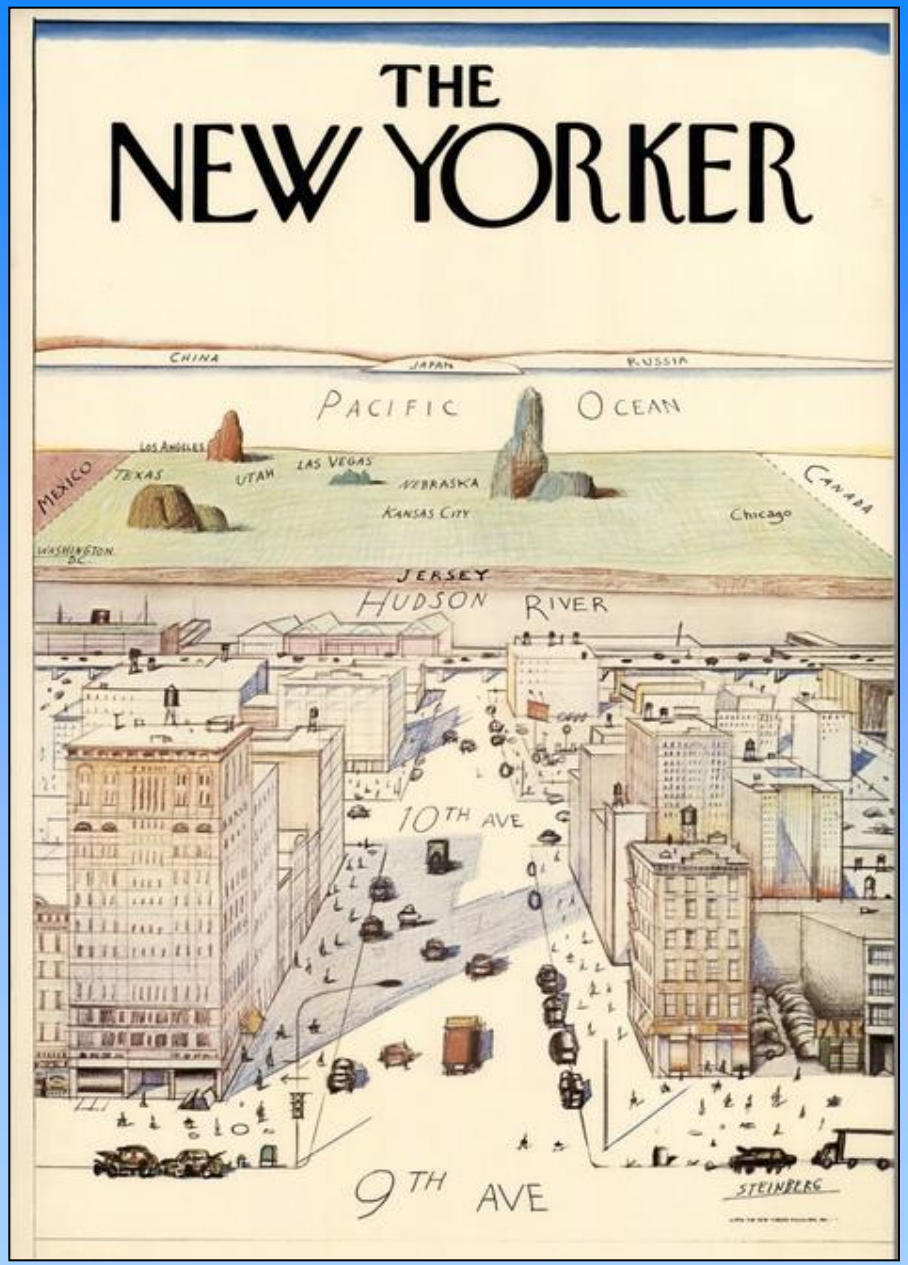


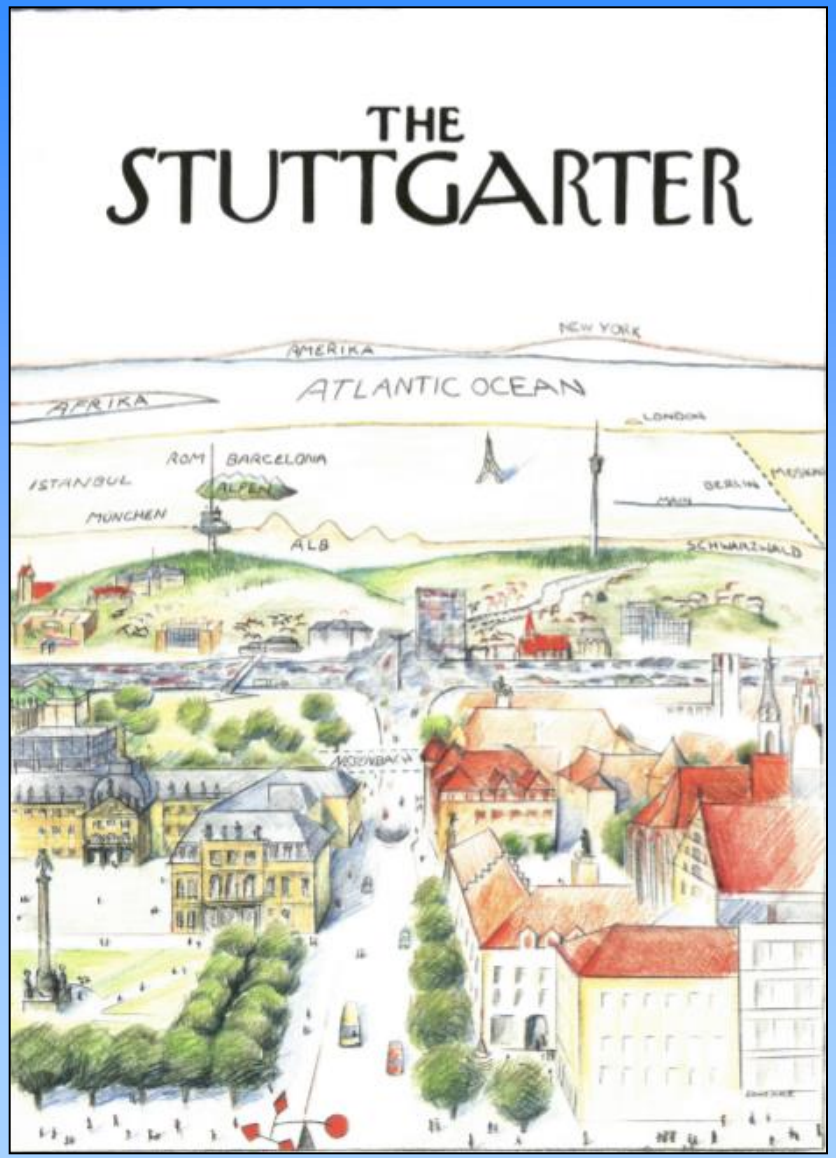
From: Vörösmarty et al. (2016), in pr

Global Ecological Footprint



A Parting Word on the Importance of Perspective





Additional information:

- http://environment.asrc.cuny.edu/

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