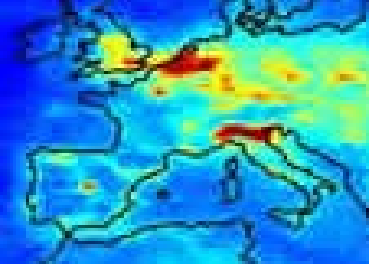
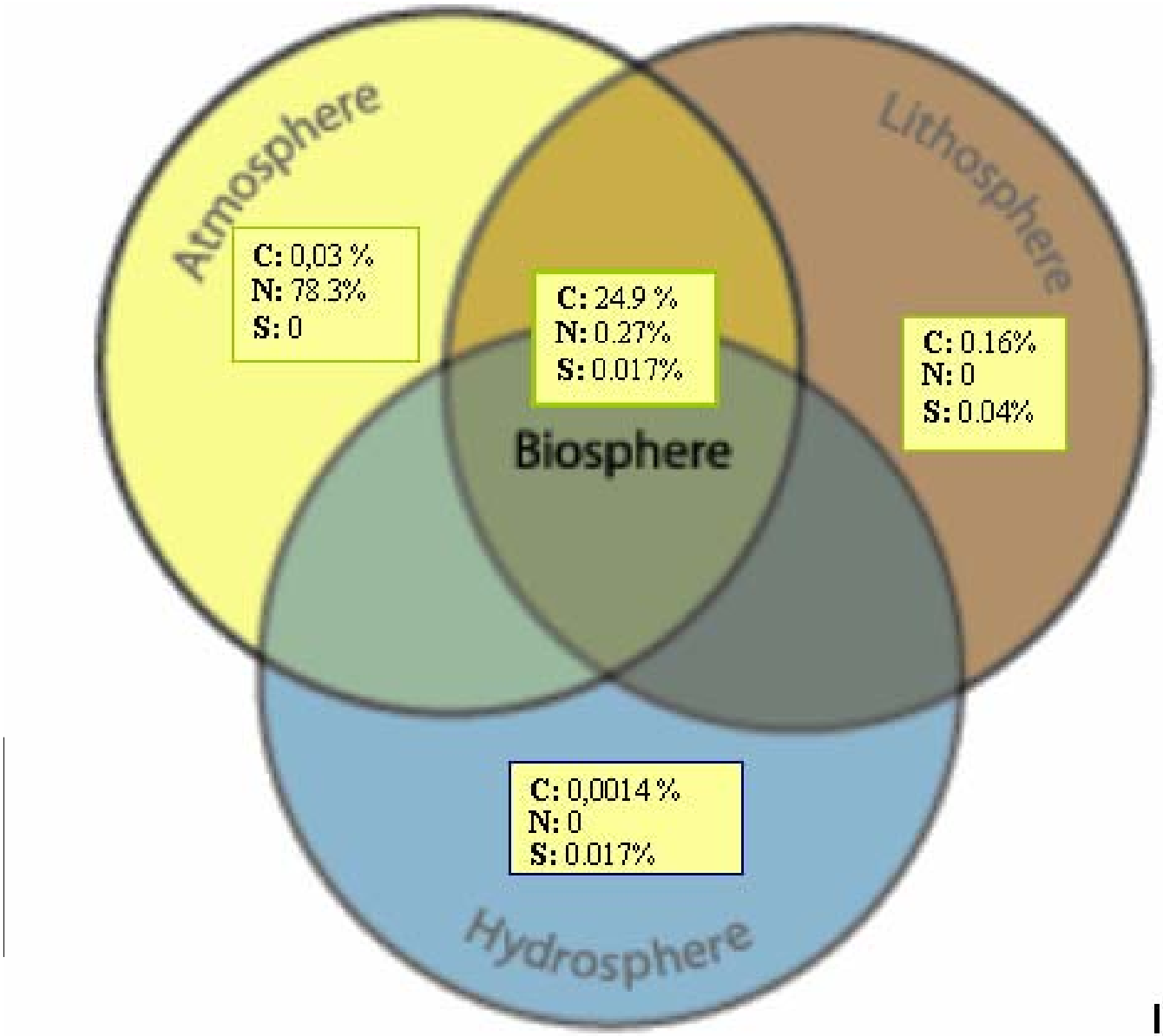


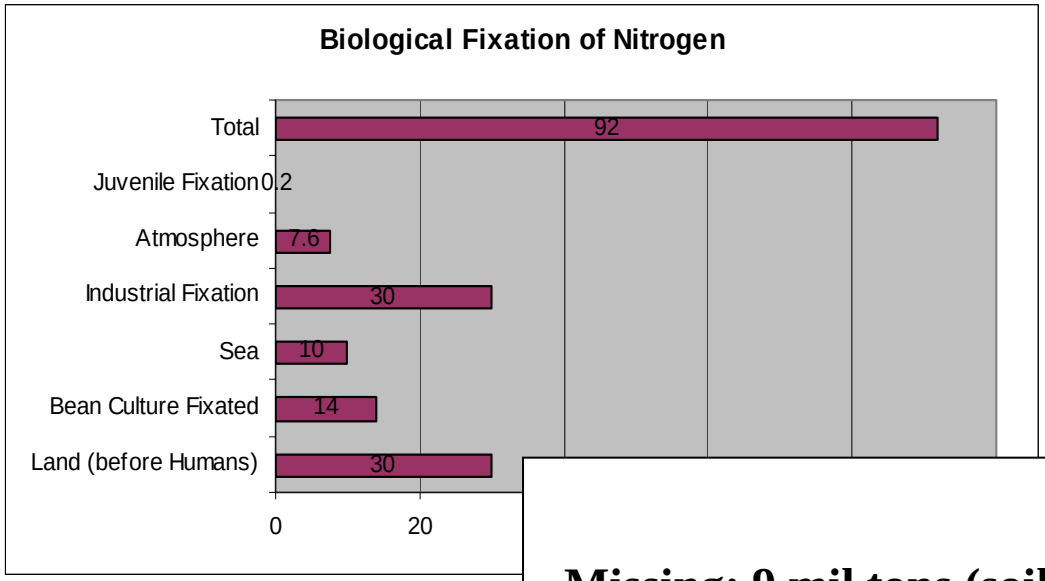
Plan of presentation:

1. One of the main cycles in "*Biosphera Machina*"
2. Human alteration – population trends, drivers
4. Urban area growth models
5. Complex interactions within city sub-systems
6. Fluxes of N in and out of City
7. Sao-Paolo metropolitan mass ballance of Nitrogen
8. Conclusions and management implications

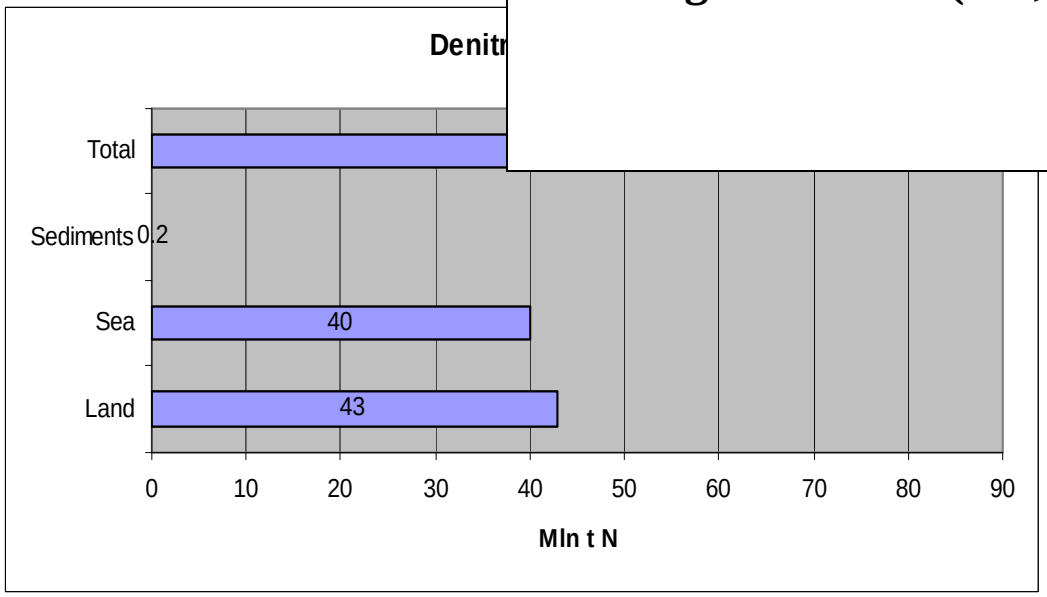
1st Meeting Task Force on Reactive Nitrogen

Wageningen, The Netherlands, 21 – 23 May 2008


Atmosphere
C: 0,03 %
N: 78.3%
S: 0
Lithosphere
C: 0.16%
N: 0
S: 0.04%
C: 24.9 %
N: 0.27%
S: 0.017%
Biosphere
C: 0,0014 %
N: 0
S: 0.017%
Hydrosphere



Missing: 9 mil tons (soil, ground water, lakes , ocean)



Two of 5 Identified key threads in ENA

- water quality
- air quality particulate matter

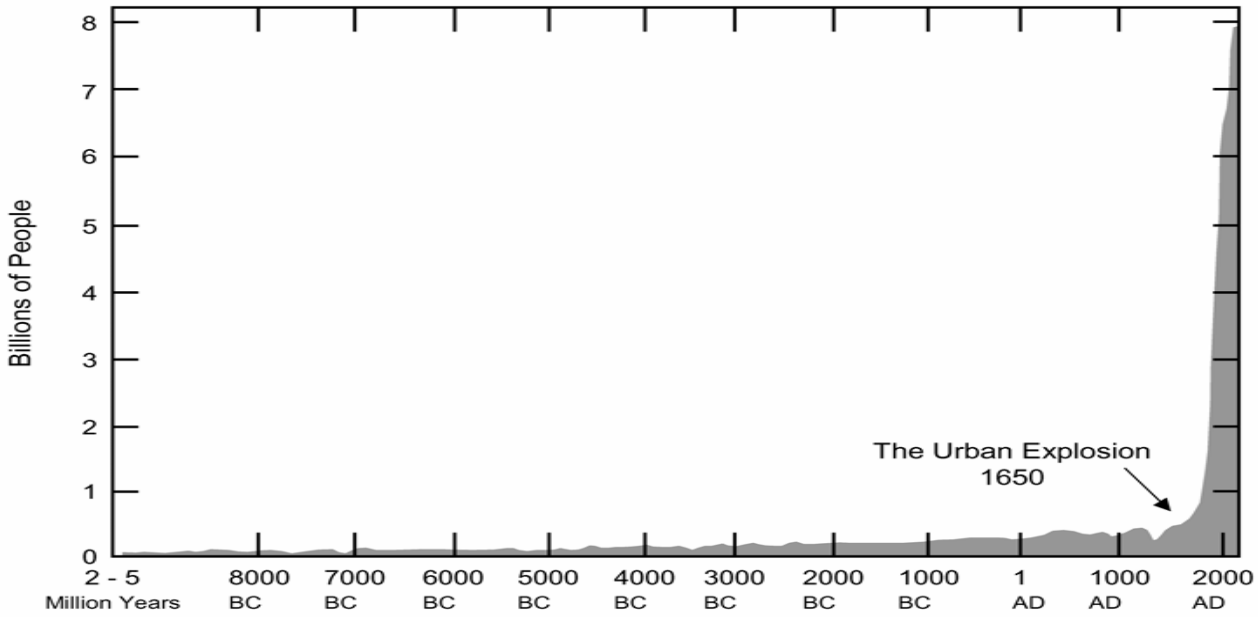
WHO: particulate pollution - the most important contributors to ill health within Europe. heat waves exacerbate the effect of aeorsoles, size of particles, travel distance

Particulate matter is ubiquitous urban pollutant. In North America, Western Europe rarely exceed 50 µg/m3. In Central and Eastern European cities and in many developing nations, levels are much higher - exceeding 100 µg/m3

The disruption of the Nitrogen cycle by human activity in cities:

1. production of tropospheric smog;
2. perturbation of stratospheric ozone
3. the contamination of groundwater, air: NO_x
4. Production of fertilizer (industrial fixation - 80 Tg per year)

Dynamics of the world population (from Heinke (1997))



12% of the World‘s population lived in urban centers in 1940, but 33% in 1980, 45% in 1995.

The absolute number of city dwellers has increased from 18 million in 1800 to 2.3 billion in 1990 - a 128 fold increase!

More then 1.4 billion live in less-developed countries.

Projections are uncertain: the global population will grow by 2-3 billion people, mostly in poor countries. It will increase less rapidly than before and will become more urban.

Civilization is the art of living in towns of such size the everyone does not know everyone else.

***Julian Jaynes** in "The Origin of Consciousness"*

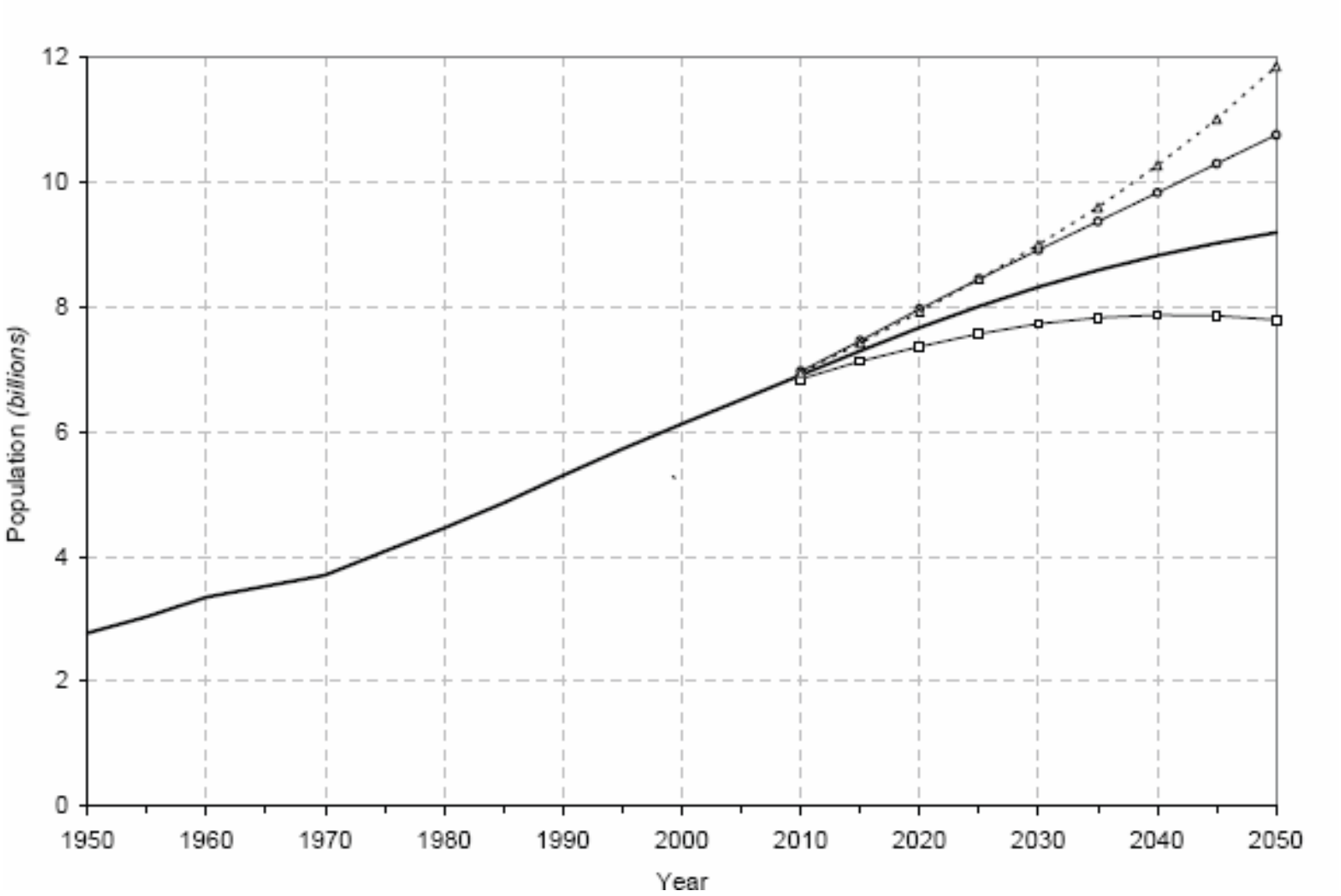
First time in History:

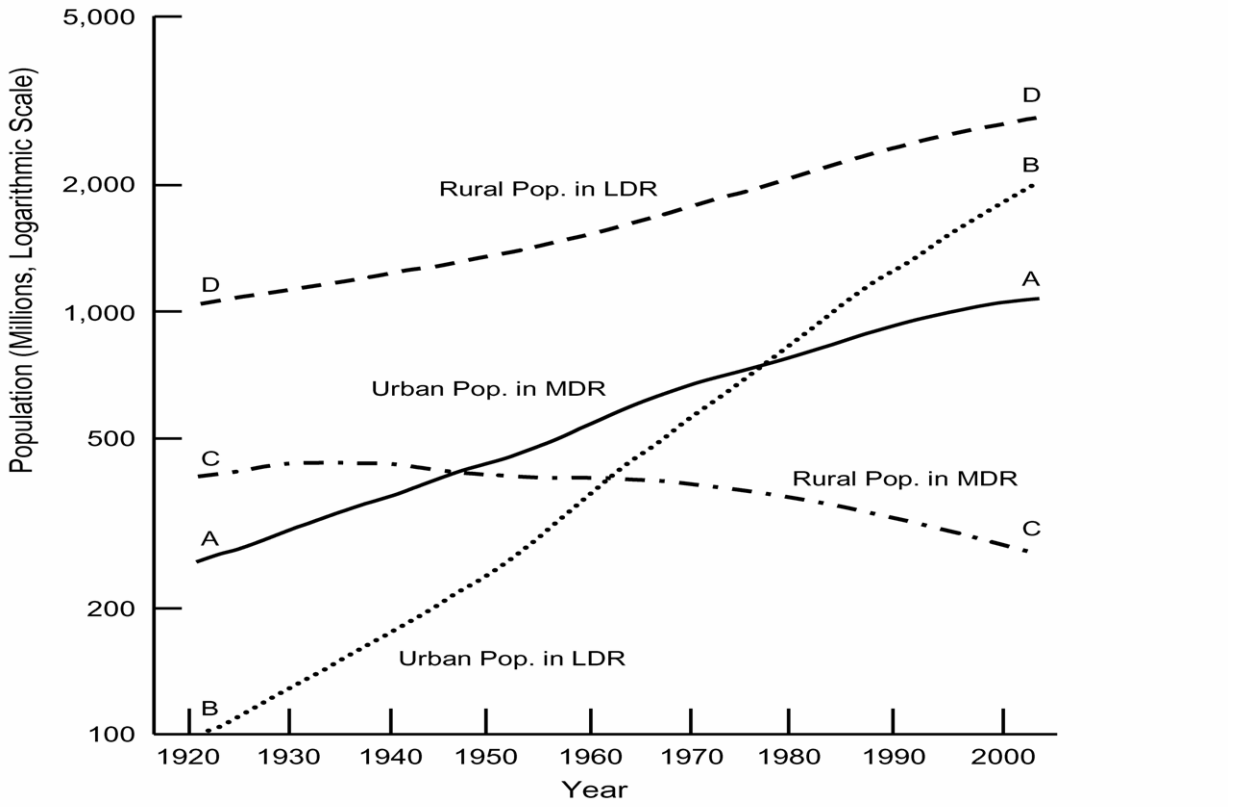
Same number of people living in cities as in rural

UN: Next 30 years- cities will absorb most of pop. Growth

Attention: 500,000 inhabitants

Study by L. Bettencourt et al., 2008 (proceedings of the National Academy of Science, USA) : Large cities –more economically distributing resources (infrastructure growth is behind population growth)


12
10
8
6
4
2
0
Population (billions)
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Year

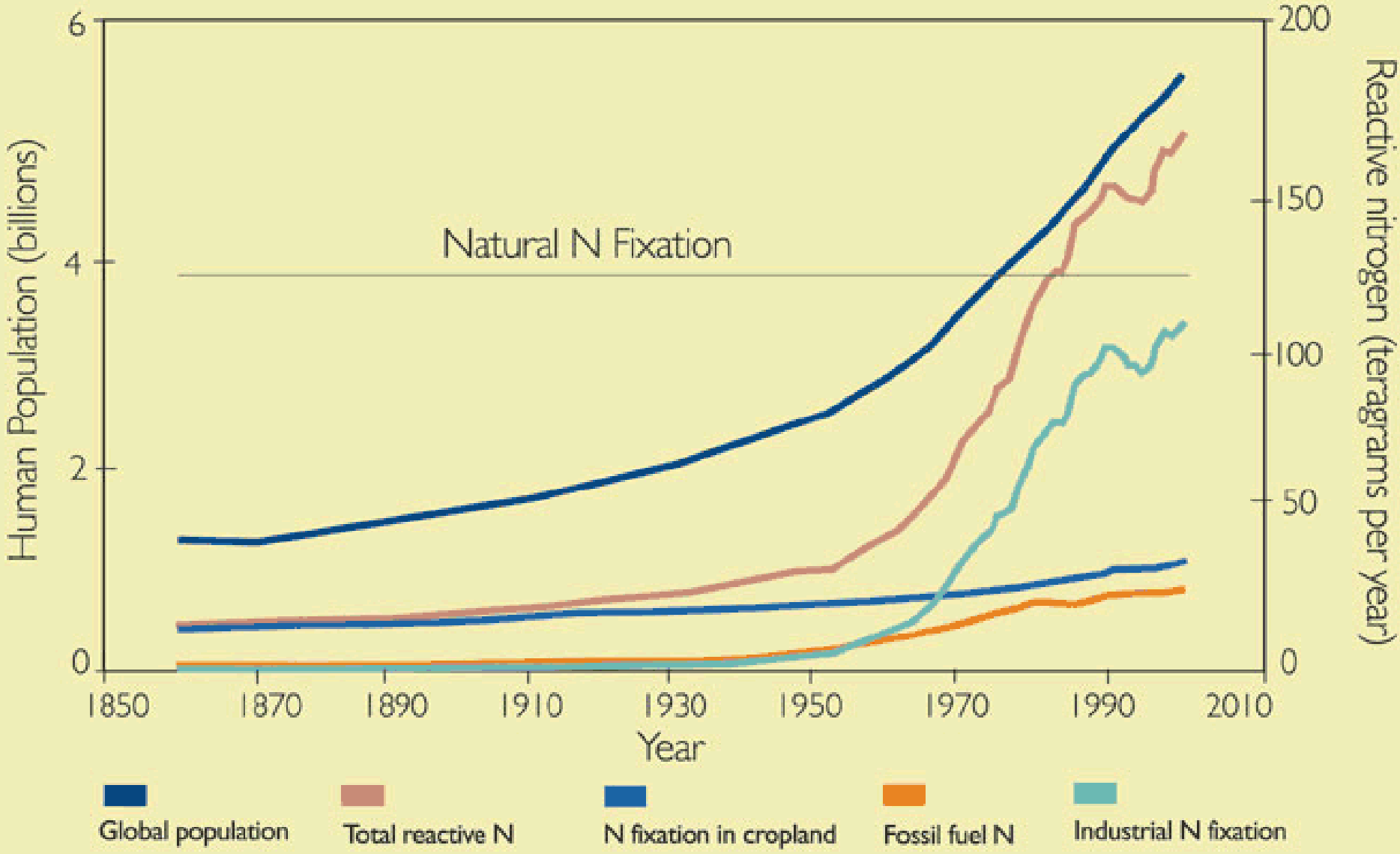


Urban and rural population in more developed (MDR) and less developed regions (LDR).
Source: UN, World Urbanisation Prospects, 1990, 1991. Here, urban population is defined as settlements of 20,000 people and above.

Population Migration – also a driver:

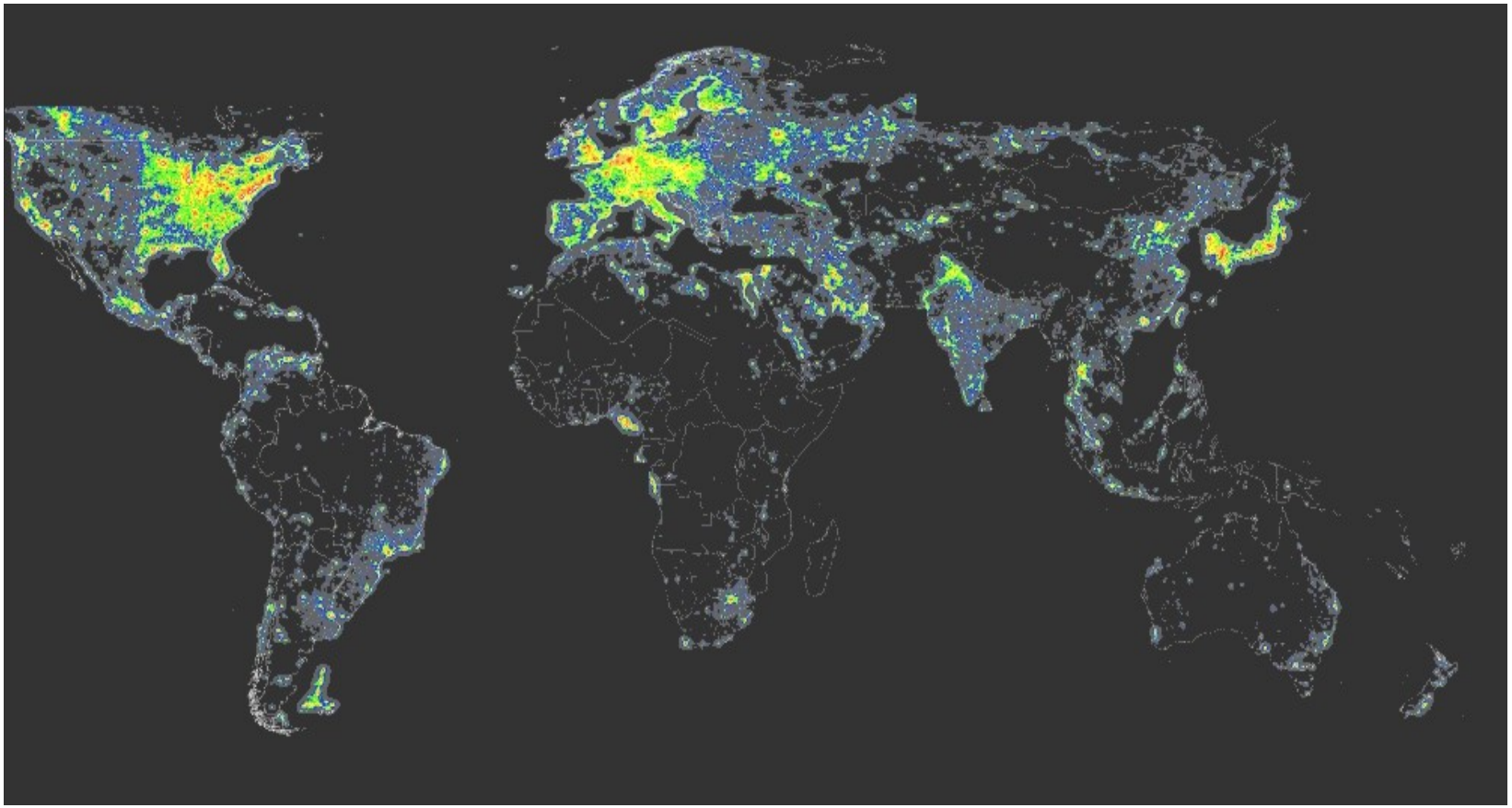
1. Rural-Urban Exodus
2. Emigration from Developing countries

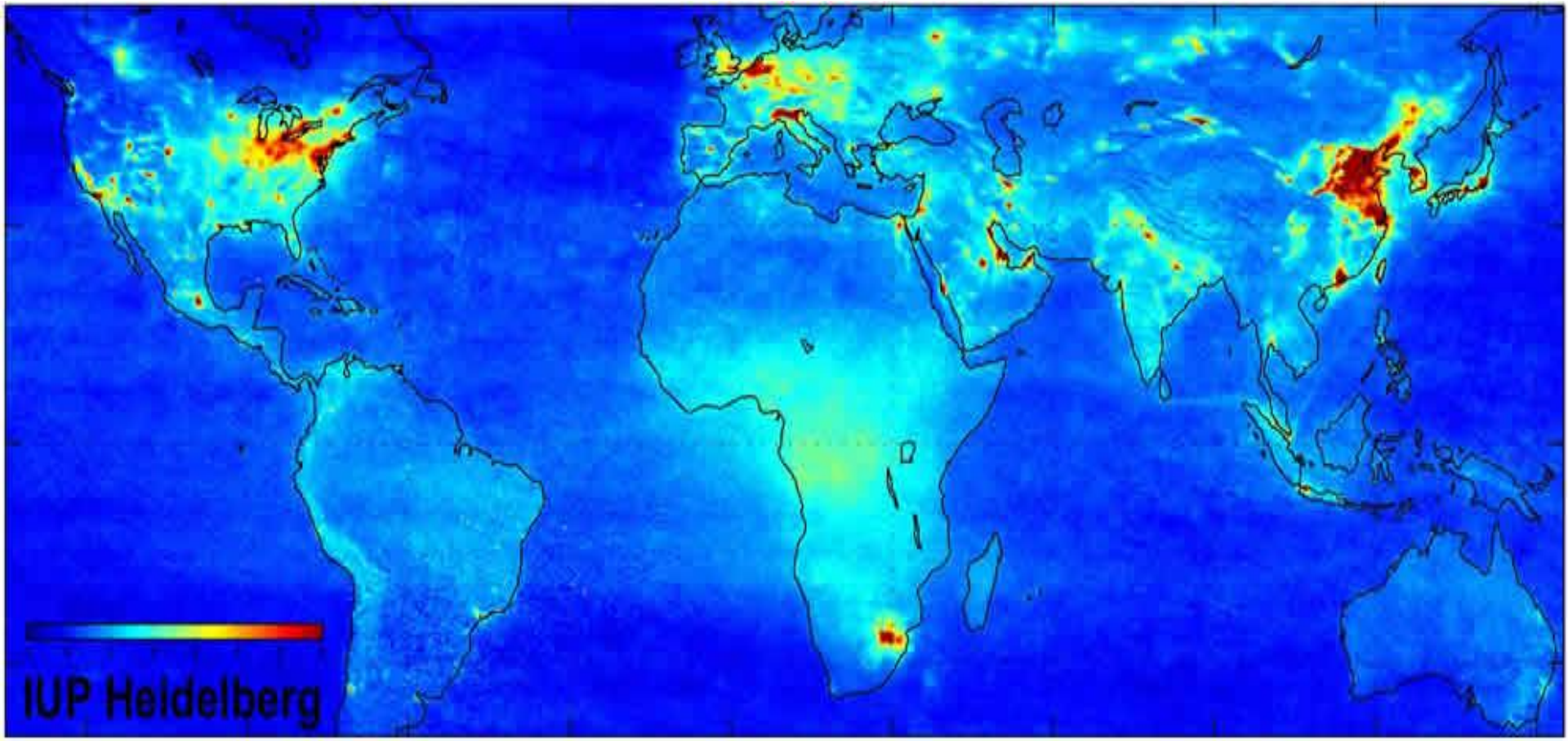
Global Population & Reactive Nitrogen Trends



Source: Lambert KF, Driscoll C. 2003. Nitrogen Pollution: From the Sources to the Sea. Hanover, NH: Hubbard Brook Research Foundation; 4.

“Earth by Night”: the Night Illumination Map (NASA)





Global mean tropospheric nitrogen dioxide (NO_2) vertical column density (VCD)

between January 2003 and June 2004, (measured by the SCIAMACHY instrument on ESA's Envisat)

The scale is in 10^{15} molecules/cm^{-2}.

Image produced by S. Beirle, U. Platt and T. Wagner of the University of Heidelberg's Institute for Environmental Physics.

Why it is important to consider Urban areas as a part of ENA

1. **Urban territories 2% of the total land areas**

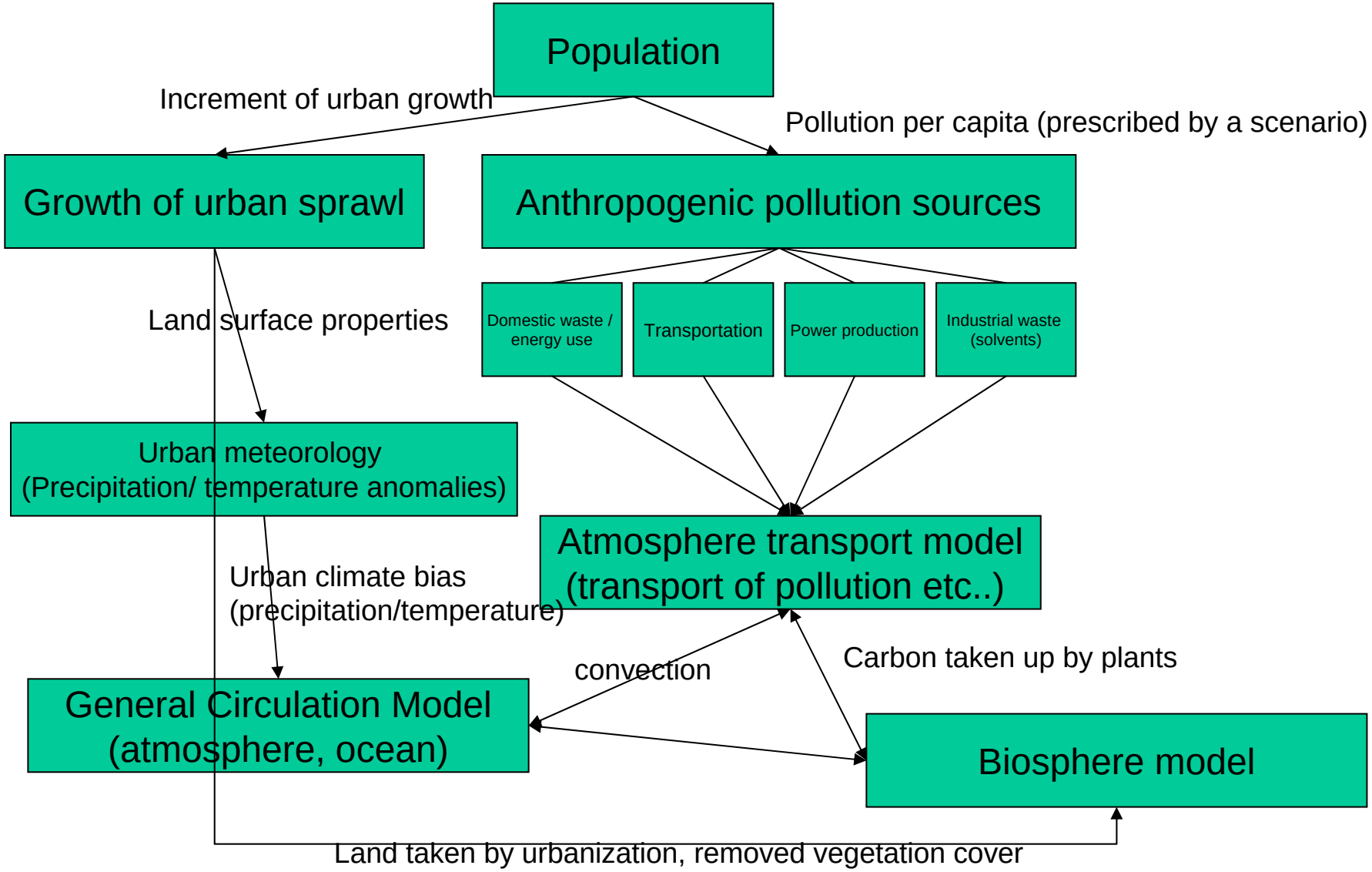
2. **These territories are generating large quantities of water and air N pollution,that also has a direct impact on densely populated areas.**
3. **They transform the structure of local matter flows on considerably larger territories than their own.**

Existing Earth system models do not take into account an influence of such factor as urban territories and their growth on the global dynamics of Carbon and Nitrogen

If the growth tendecies stay the same, then the half of the total territory of a region will be covered by Urban territory (Svirejeva-Hopkins, 2004, 2005)

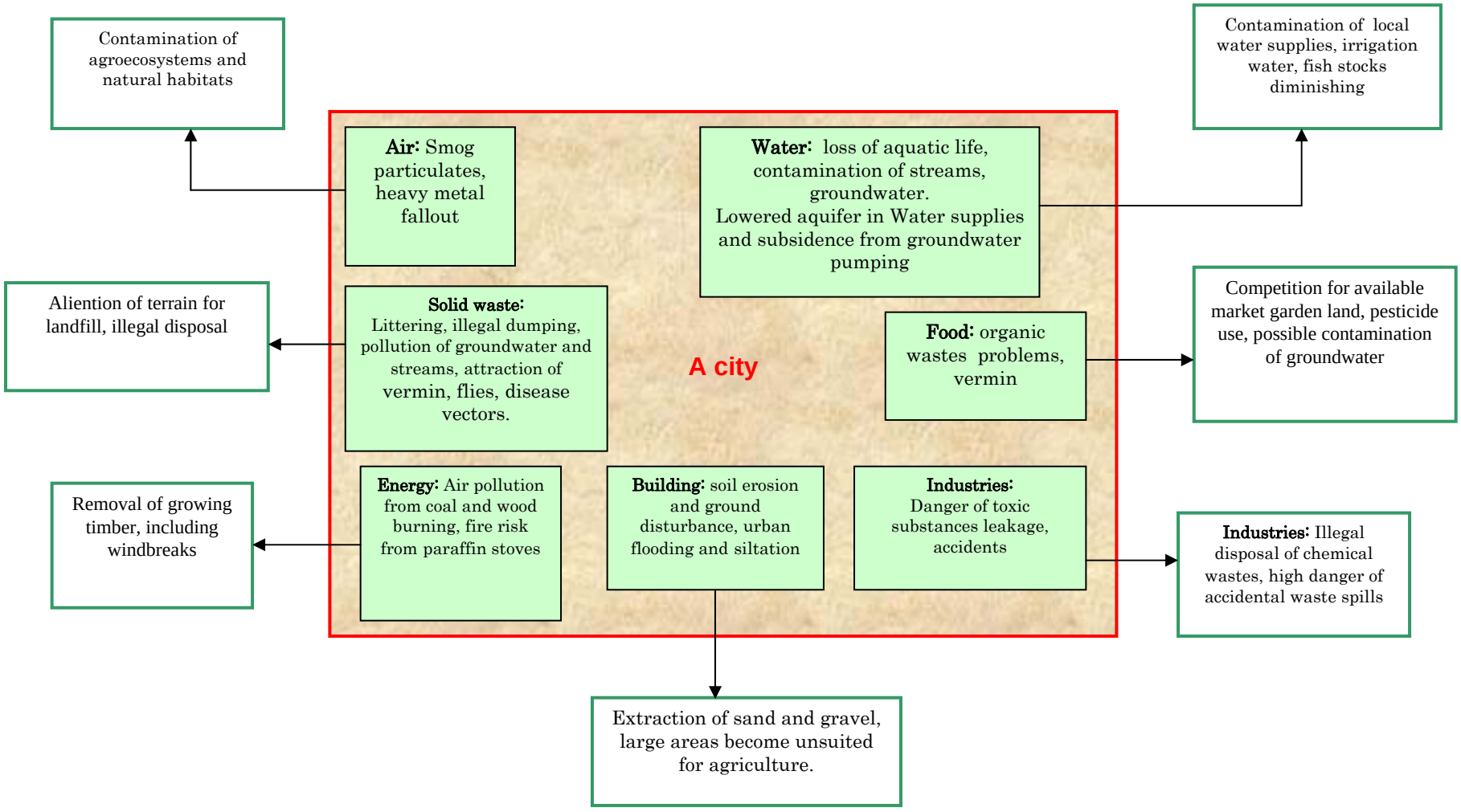
For Asia (in present 1% is urban) - in 60 years

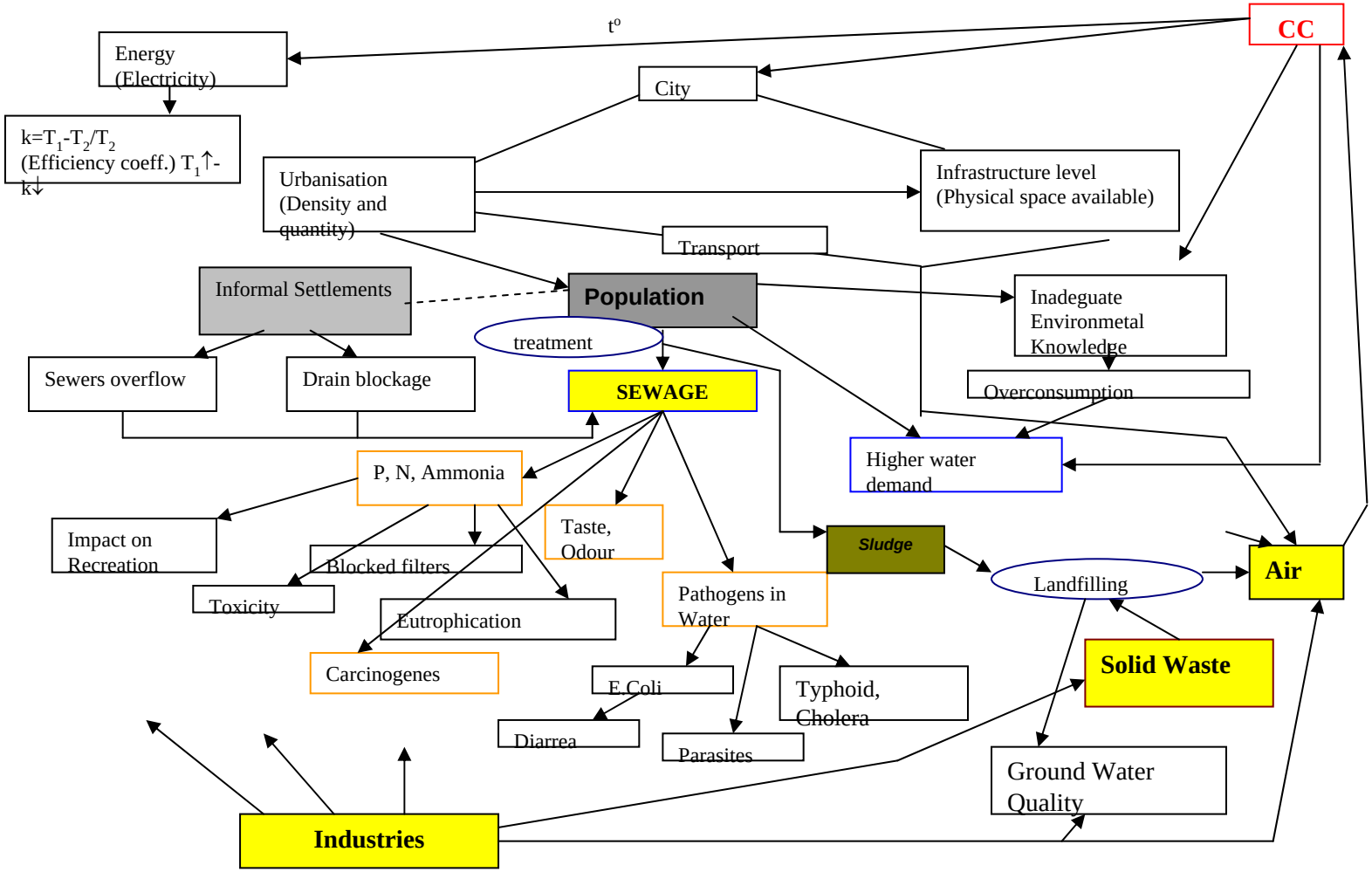
For Africa (at present 0.15%) - in 90 years



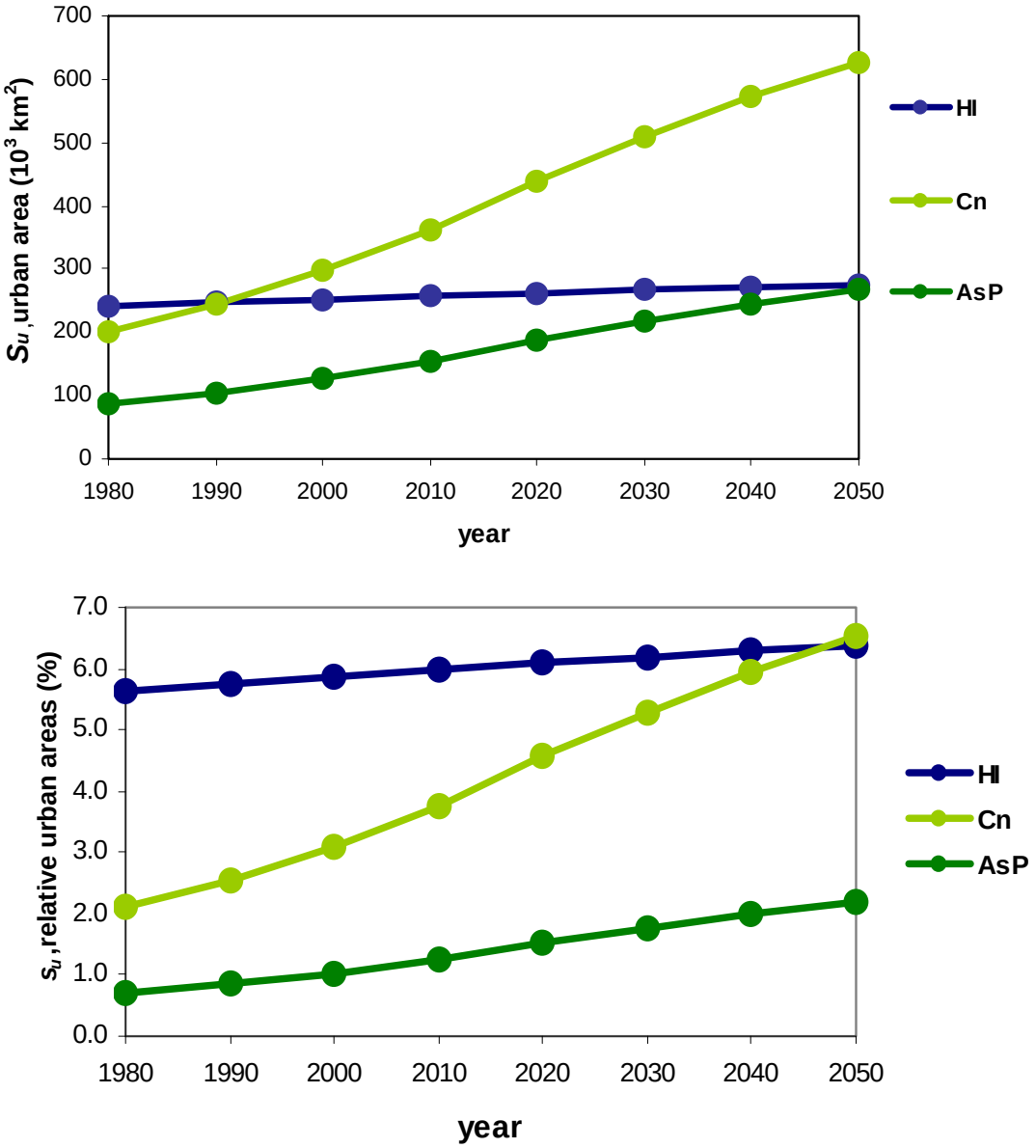
Expected outputs:
Aerosol and dust distribution (in space, vertical and horizontal)
Ozone depletion pattern
Effect of aerosols (through cloud formation) on precipitation

Urban system's alteration of the environment (within a city and around it) and long distance (including trans-frontier).

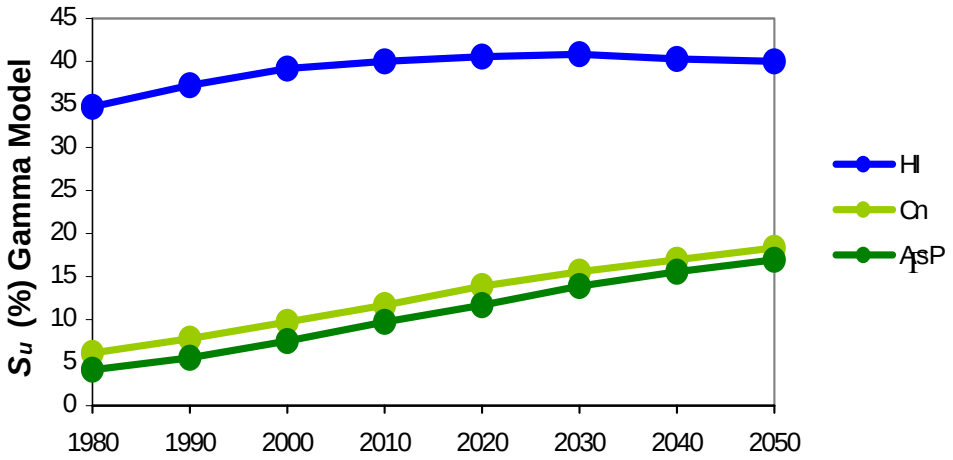


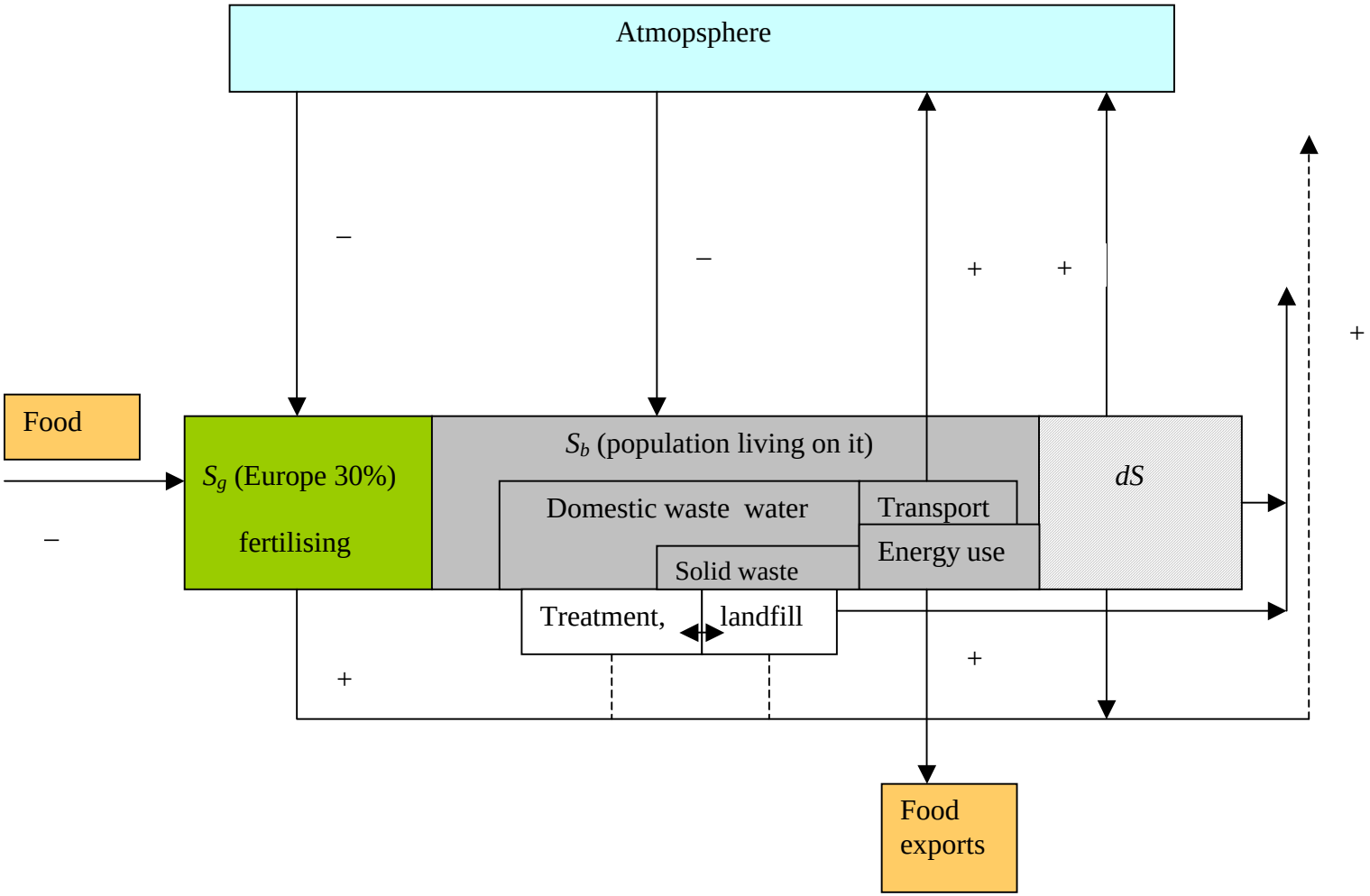

t°
CC
Energy (Electricity)
City
k=T1-T2/T2 (Efficiency coeff.) T1↑-k↓
Urbanisation (Density and quantity)
Infrastructure level (Physical space available)
Transport
Informal Settlements
Population
Inadeguate Environmetal Knowledge
treatment
Sewers overflow
Drain blockage
SEWAGE
Overconsumption
Higher water demand
P, N, Ammonia
Impact on Recreation
Taste, Odour
Sludge
Blocked filters
Toxicity
Pathogens in Water
Landfilling
Air
Eutrophication
Carcinogenes
E.Coli
Typhoid, Cholera
Solid Waste
Diarrea
Parasites
Ground Water Quality
Industries

Dynamics of the regional urban area for the 3 world regions between 1980-2050.

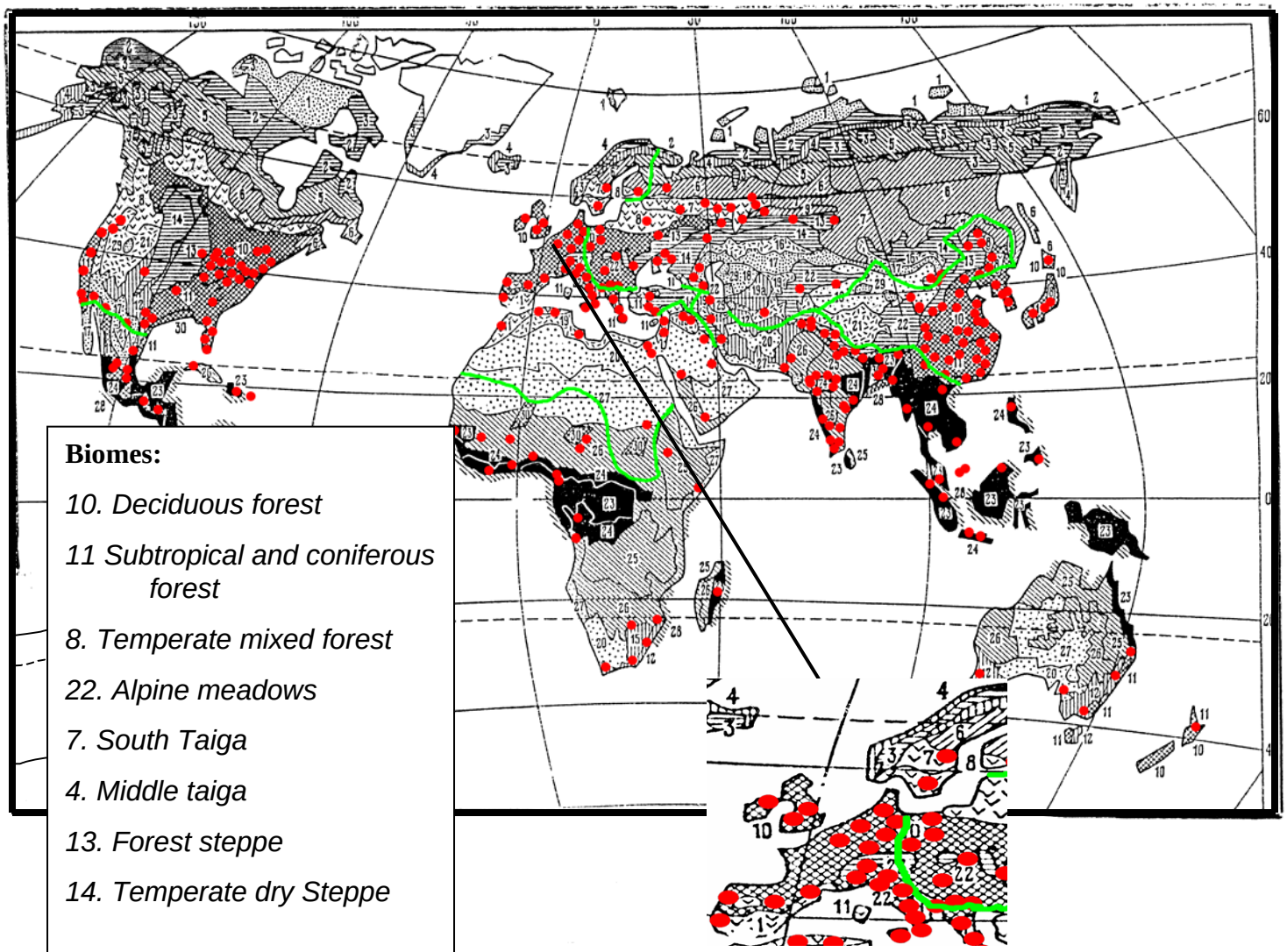


Relative urban area (in % of the total regional area) gamma




Atmopsphere
–
–
+
+
+
Food
–
S_g (Europe 30%)
fertilising
S_b (population living on it)
Domestic waste water
Transport
Energy use
Solid waste
Treatment,
landfill
dS
+
+
Food
exports

Bazilevich's biome map.



Biomes:

10. Deciduous forest

11 Subtropical and coniferous forest

8. Temperate mixed forest

22. Alpine meadows

7. South Taiga

4. Middle taiga

13. Forest steppe

14. Temperate dry Steppe

Sao Paolo Metropolitan Area: N mass ballance

(Nardoto, Svirejeva-Hopkins, Martinelli, 2008)

Objectives:

To understand urbanization interactions with the Earth System

To characterize the dependence of the urban metabolism upon external inputs (energy and matter) at the whole-ecosystem scale

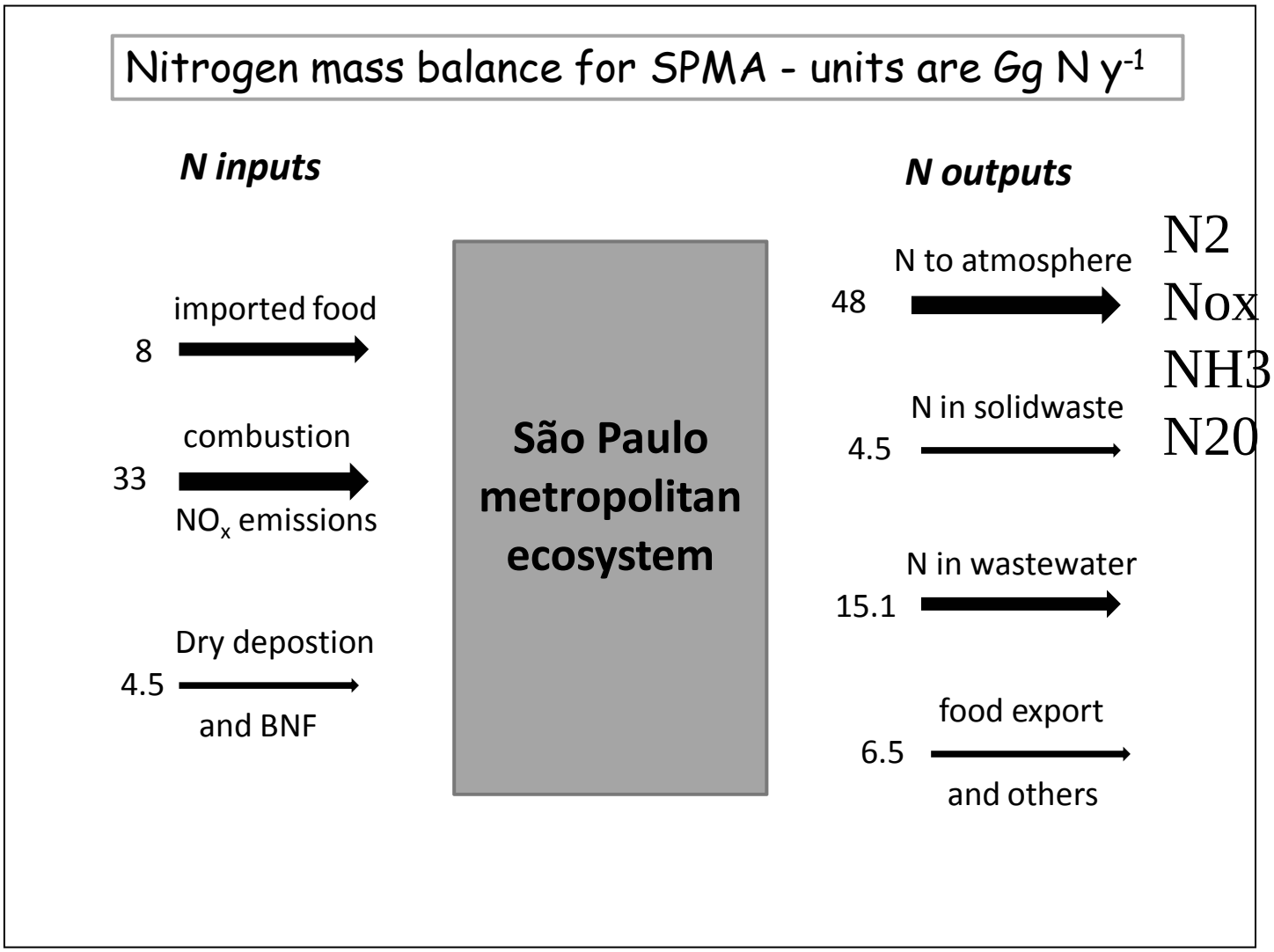
To derive N mass balance for city and to show that single-element studies can reveal specific points of element accumulation and loss.

SAO PAULO

- Population: 18 million people in metro. area
- And 20 million people in 2015
- Area: 8000 km^2
- Average Temp: 19.8^{o}C (15.5 – 25.8 ^{o}C)
- Average Humidity: 80%
- GDP = 5.59 per capita in 2003 (3.55/Brazil)
  Vehicles = 6 millions

CO2 emissions (Osses, 2006)

75% car
5% taxis
5% bus
5% trucks
10% motorcycles


Nitrogen mass balance for SPMA - units are Gg N y-1
N inputs
imported food
8
combustion
33
NOx emissions
Dry depostion
4.5
and BNF
São Paulo metropolitan ecosystem
N outputs
N to atmosphere
48
N2
Nox
NH3
N20
N in solidwaste
4.5
N in wastewater
15.1
food export
6.5
and others

“Carbon and nitrogen stable isotopes as indicative of geographical origin of marijuana samples seized in the city of Sao Paulo (Brazil)”

Shibuya EK, Sarkis JE, Negrini-Neto O, Martinelli LA. .

In this work, it was developed a methodology that can help tracking the traffic routes of marijuana samples seized in the city of Sao Paulo, based on stable carbon and nitrogen isotopes, which are related to the climate and plant growth conditions.

Summary:

food imports were 8 Gg N y^{-1}

33 Gg N y^{-1} of atmospheric N generated by combustion;

these two human-mediated fluxes account for 90% of N input.

Bio-nitrogen fixation rates in the green areas and dry deposition - 10%.

Total fixed N output was 78 Gg N N y^{-1} (where more than half of N leaves the system via the atmosphere, but considered N output leaves via riverine exports, since most of wastewater is not treated.

Conclusions.

- The N mass balance showed SPMA to be a net source of nitrogen, suggesting that **urban air and water N pollution are the main drivers of the urban biogeochemistry.**

- For N cycle, further urban land-use conversion would be adding N from the original biome with higher density of biomass as well as productivity to the atmosphere but mainly to the waters.

Uncertainties.

1. dry-deposition processes in urban systems with patchy vegetation, high NO_x emissions, and
   complex patterns of air flow;

2. soil N dynamics;
3. factors that control denitrification in urban landscapes (as reservoirs and the green areas).

Management:

1. the most effective N management strategies are those that are specifically tailored to

2. e
   management practices that control the fate of N.

Galloway: if half of sewage of 3.2 bil. urban inhab. is treated – 5 m tones of Nr a year is spared.

GENERAL CONCLUSION

Based on scenarios of urban population and area growth and the yearly amounts of carbon, nitrogen and sulfur, produced by a city, we are capable of coming up with what could be called a complex “biogeochemical portrait” of urban territory and its functioning mechanisms; that would allow us to forecast emissions of greenhouse gases and other more accurately. This in turn lets us explore options of sustainable urban development, i.e. closing cycles of nutrients on the city’s territory and thus minimizing cross - boundary pollution. Dense versus speaded settlement, for example.

2 objectives to keep in Mind:

1. Make cities healthy and livable places
2. Control trans-boundary effects of pollution and stop degradation of the ecosystems.

“Think globally, act locally”.

Rene Dubos - 8 UN conference on the Human Environment (1972)