



Urbanization

Course: Environmental Science
Graduate Program in Environmental Science and
Technology

Federal University of ABC – UFABC

Professors:

Angela Terumi Fushita

Vitor Vieira Vasconcelos

Victor Fernandez Nascimento

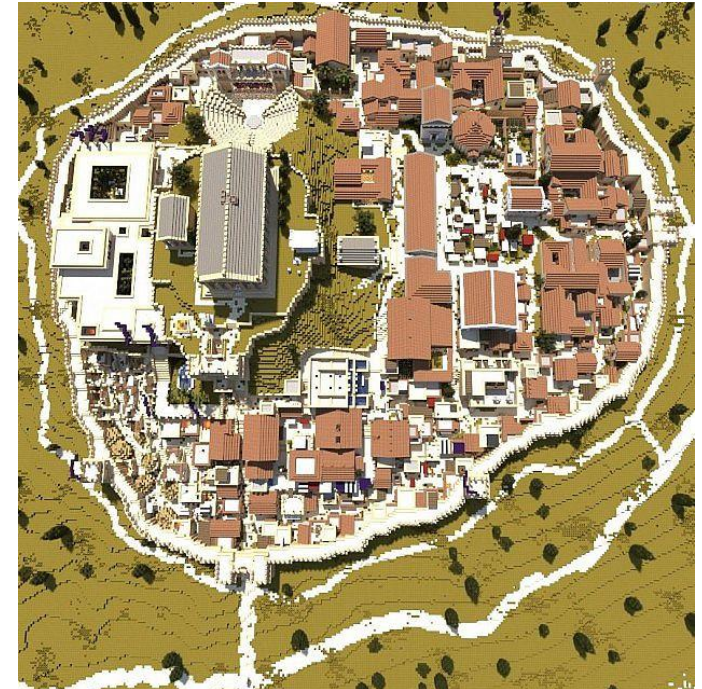
August, 2026

Content

- Definition of urban area
- Urbanization Process
- Cities and Environment
 - Natural Disasters
 - Environmental Justice
 - Urban Ecology
 - Climate Change



Greek City-State



City	Nature
Apollo	Dionysius
Reason	Emotion
Social Organization	Physis (natural forces)

GLOTZ, Gustave. **The Greek city**. Difel, 1980.

NIETZSCHE, Friedrich W. Die Geburt der Tragödie aus dem Geiste der Musik [The Birth of Tragedy from the Spirit of Music]. **Kritische Gesamtausgabe**, v. 3, n. 1, p. 4-152, 1872.

Urban area

- Definition as an entity
 - Demographic
 - Number and density of people
 - Economical
 - Percentage of non-agricultural employment
 - Administrative
 - Definition of the urban area by the municipal government
 - Functional
 - Centers of government, transportation, services, information, energy flows
 - Extension beyond administrative boundaries
 - Conurbations
 - Metropolitan Regions
 - Megalopolises

Urban area

- Lei Federal nº 9.636, de 1998, Art. 16-C

§ 2º A consolidated urban area is:

I - Included in the urban perimeter or in an urban area by the Master Plan or by a specific municipal law;

II - with a road system in place and paved circulation routes

III - organized into blocks and predominantly built lots

IV - of predominantly urban use, characterized by the existence of residential, commercial, industrial, institutional, mixed or service-oriented buildings

V - with the presence of at least three of the following urban infrastructure equipment implemented:

a) rainwater drainage

b) sanitary sewage

c) drinking water supply

d) distribution of electricity, and

e) urban cleaning, collection and management of solid waste.

Urban area

- Definition by quality
 - Cultural criteria

Rural	Urban
Low formal education	High formal education
Homogeneous	Heterogeneous
Religious	Secular
Family oriented	Individualized
Personalized social relationships	Depersonalized social relationships

- Recent phenomenon of Rururbanization

REDFIELD, R. (1953). Primitive world and its transformations . Ithaca: Cornell University Press.

CARDOSO, Maria Mercedes; FRITSCHY, Blanca Argentina. Revisión de la definición de espácio rururbano y sus criterios de delimitación. **Contrib. Científ**, v. 241, p. 27-39, 2012.

Urban area

- Definition in Environmental Studies
 - Built area (impermeable)
 - Minimum area, texture and connectivity criteria
 - They tend to give the impression of a dichotomy between (artificial) city X nature
 - Disregards urban ecosystems
 - Urbanization as an expression of the increase in environmental impacts
 - Is it the fault of demographic density or consumer culture?
 - Integration between urban and rural systems

Reflection

- If people lived scattered throughout rural areas, but maintained the same urban lifestyle as today, would the environmental impact be greater or less?
- Considering the same standard of living and consumption, would a city of houses cause more environmental impact or less environmental impact than a city of buildings?

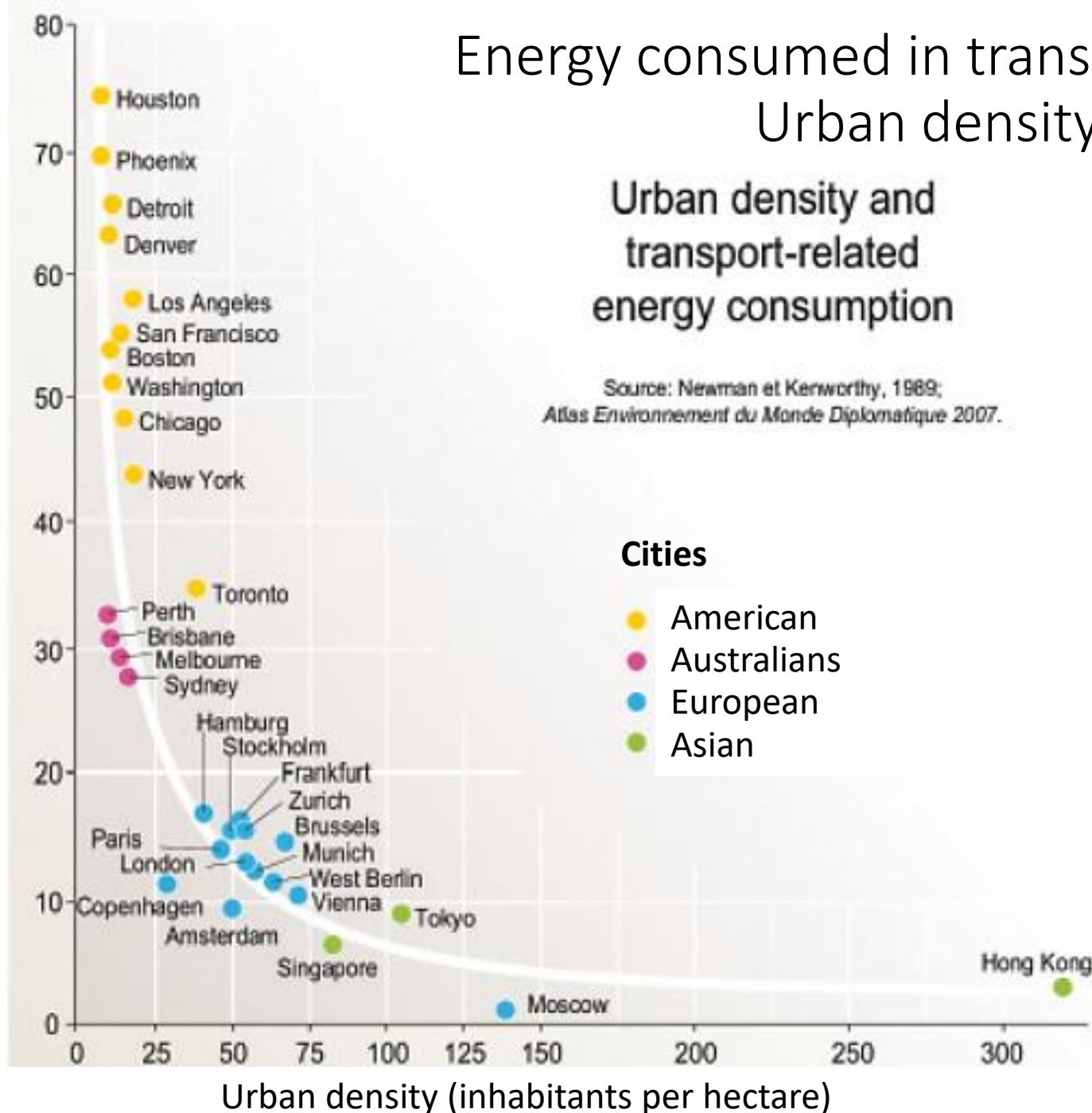
Energy consumed in transportation vs. Urban density

Urban density and transport-related energy consumption

Source: Newman et Kenworthy, 1989;
Atlas Environnement du Monde Diplomatique 2007.

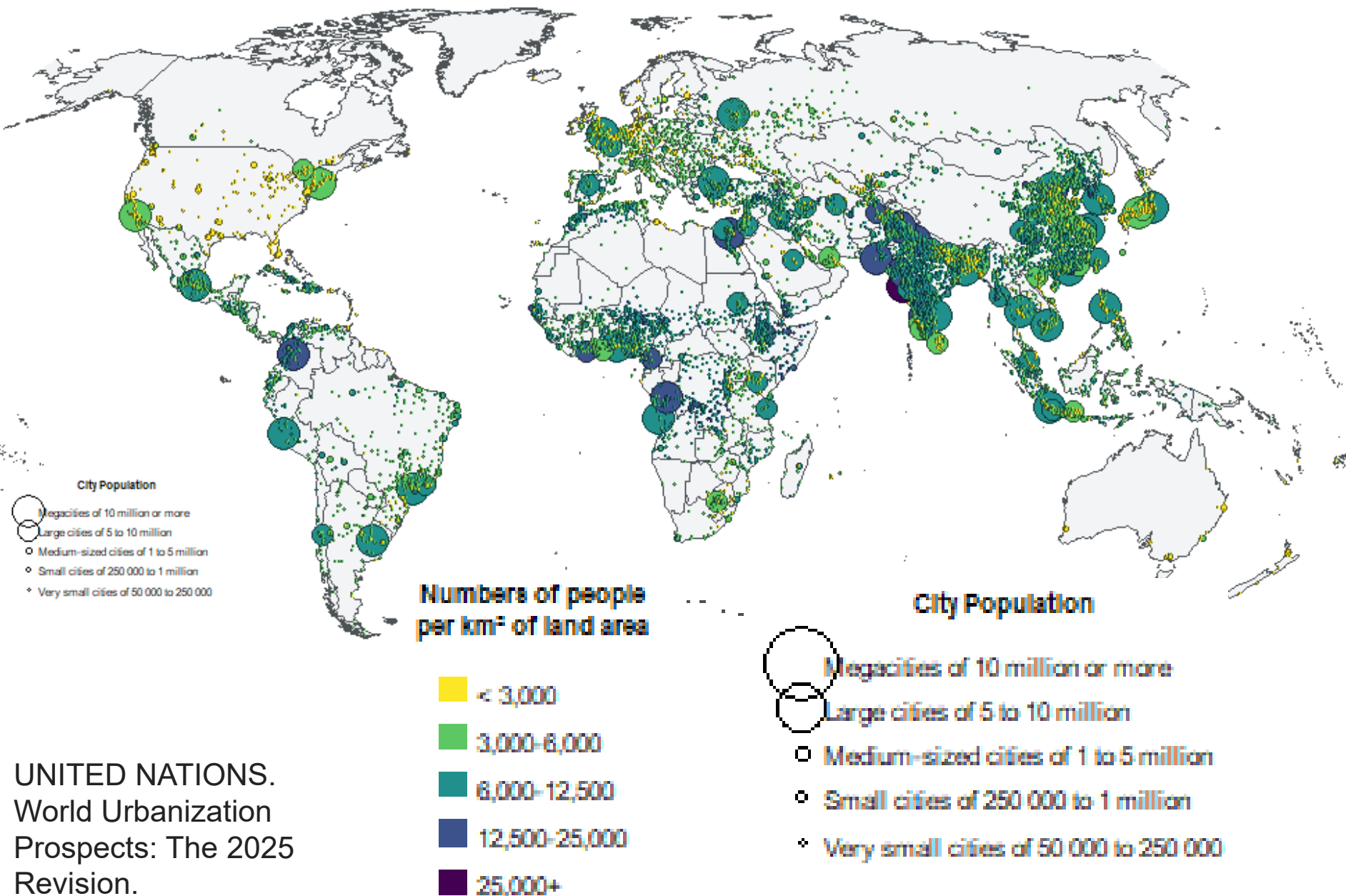
Cities

- American
- Australians
- European
- Asian



Kirby, Alex. 2008. Kick the Habit: A UN Guide to Climate Neutrality. Nairobi: United Nations Environment Programme

City population density (2025)



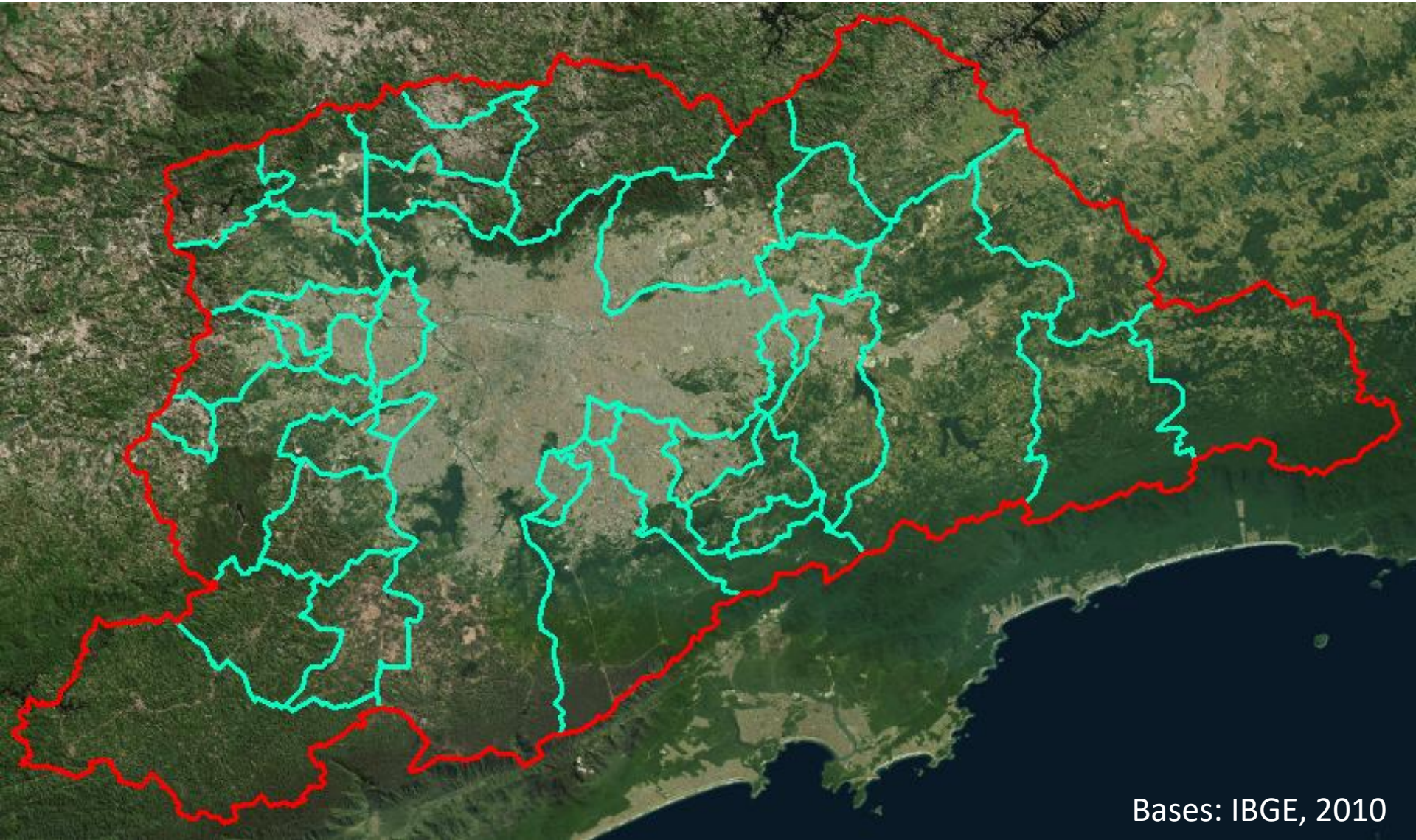
Metropolitan Region of São Paulo



Bases: IBGE, 2010

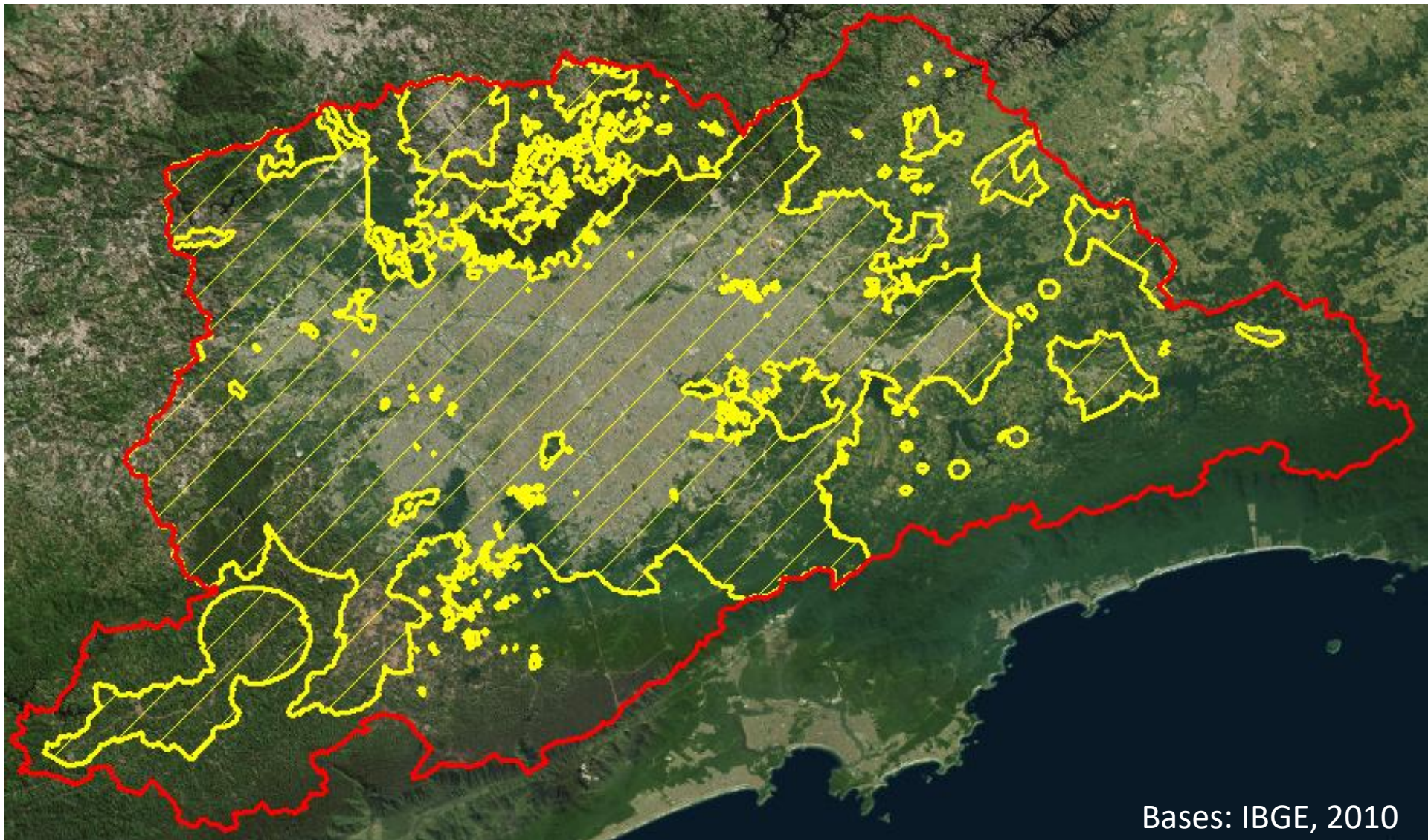
Metropolitan Region of São Paulo

Municipal boundaries



Metropolitan Region of São Paulo

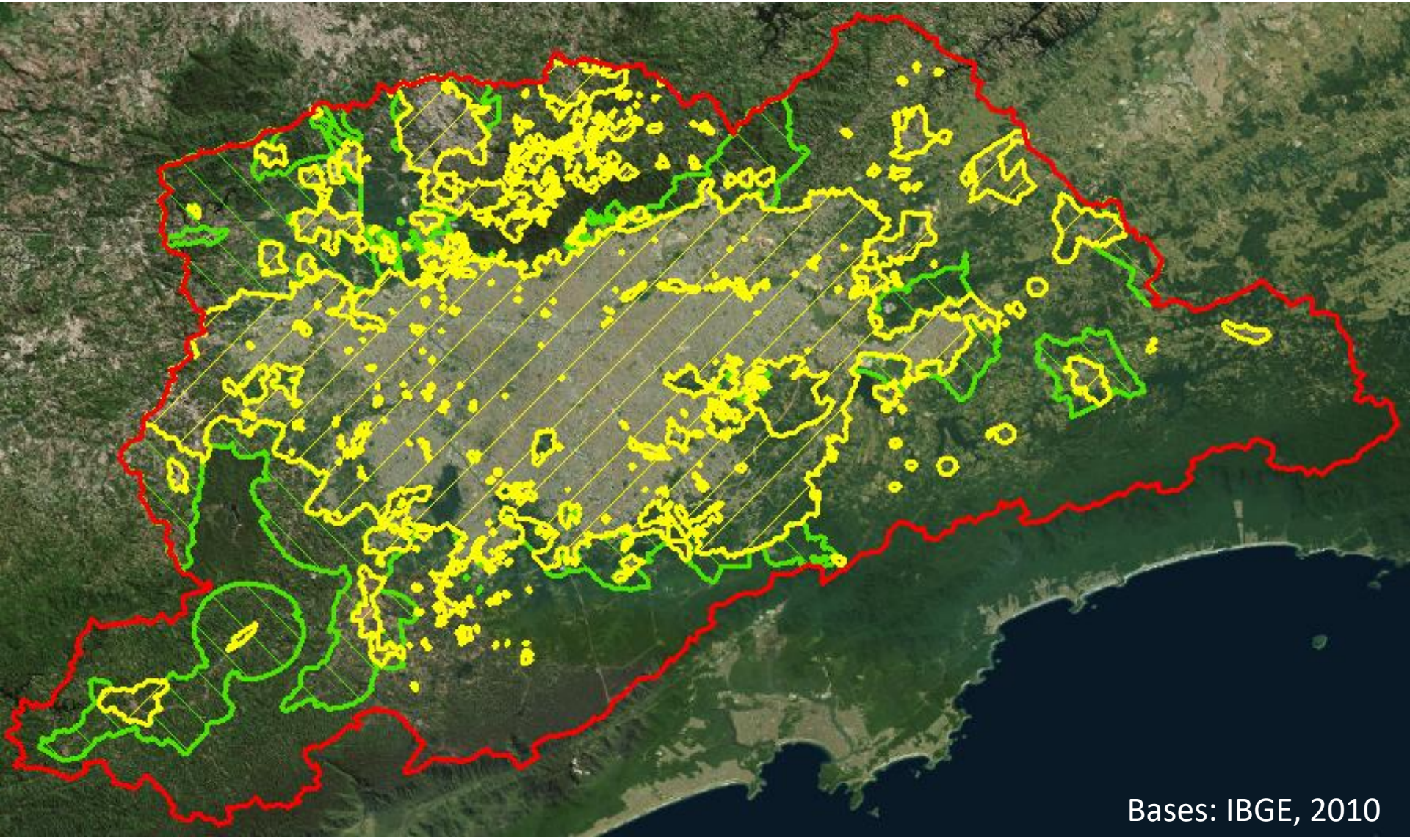
Legal urban boundaries



Bases: IBGE, 2010

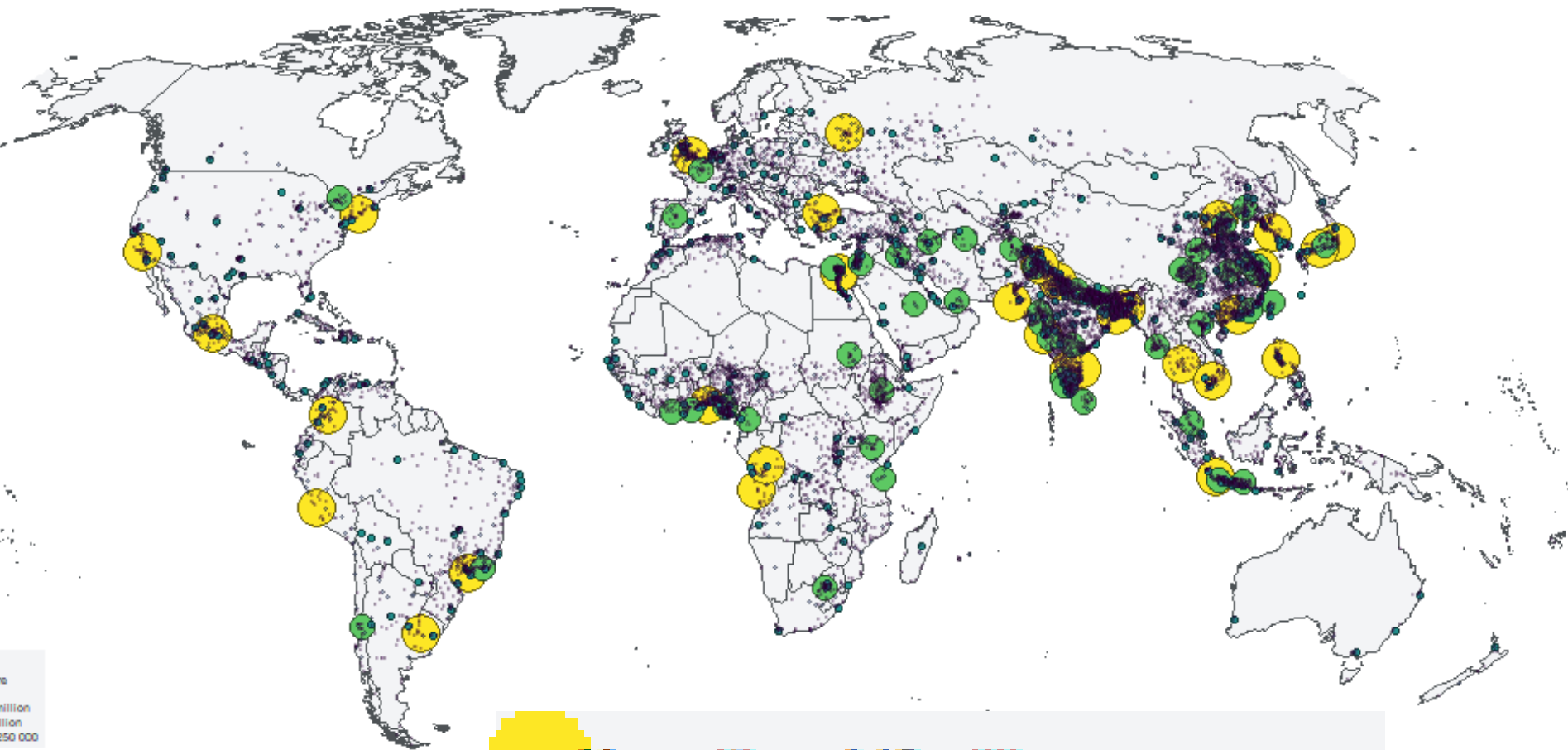
Metropolitan Region of São Paulo

Urbanized or non-urbanized areas in cities



Bases: IBGE, 2010

Urban Population (2025)

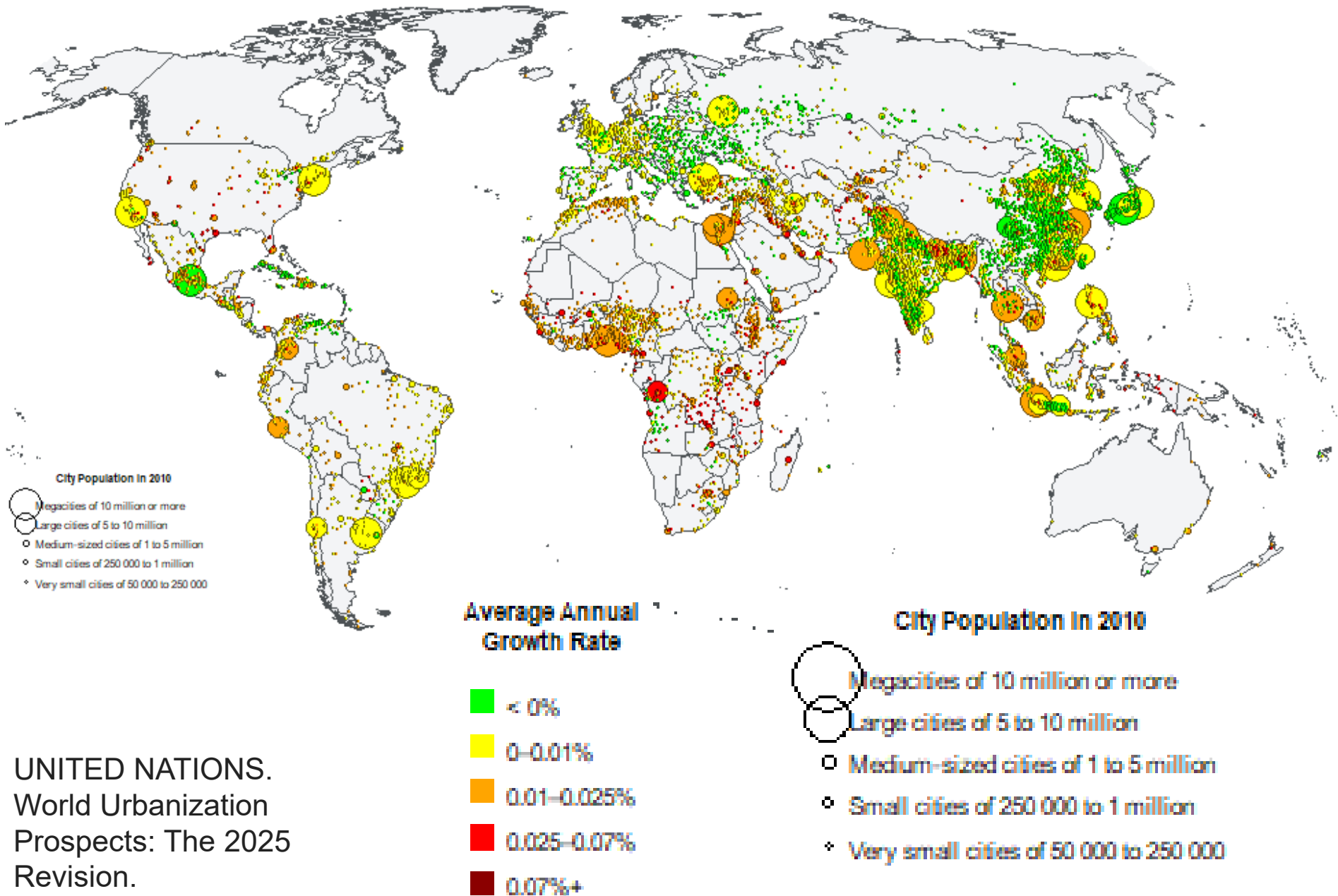


million
million
250 000



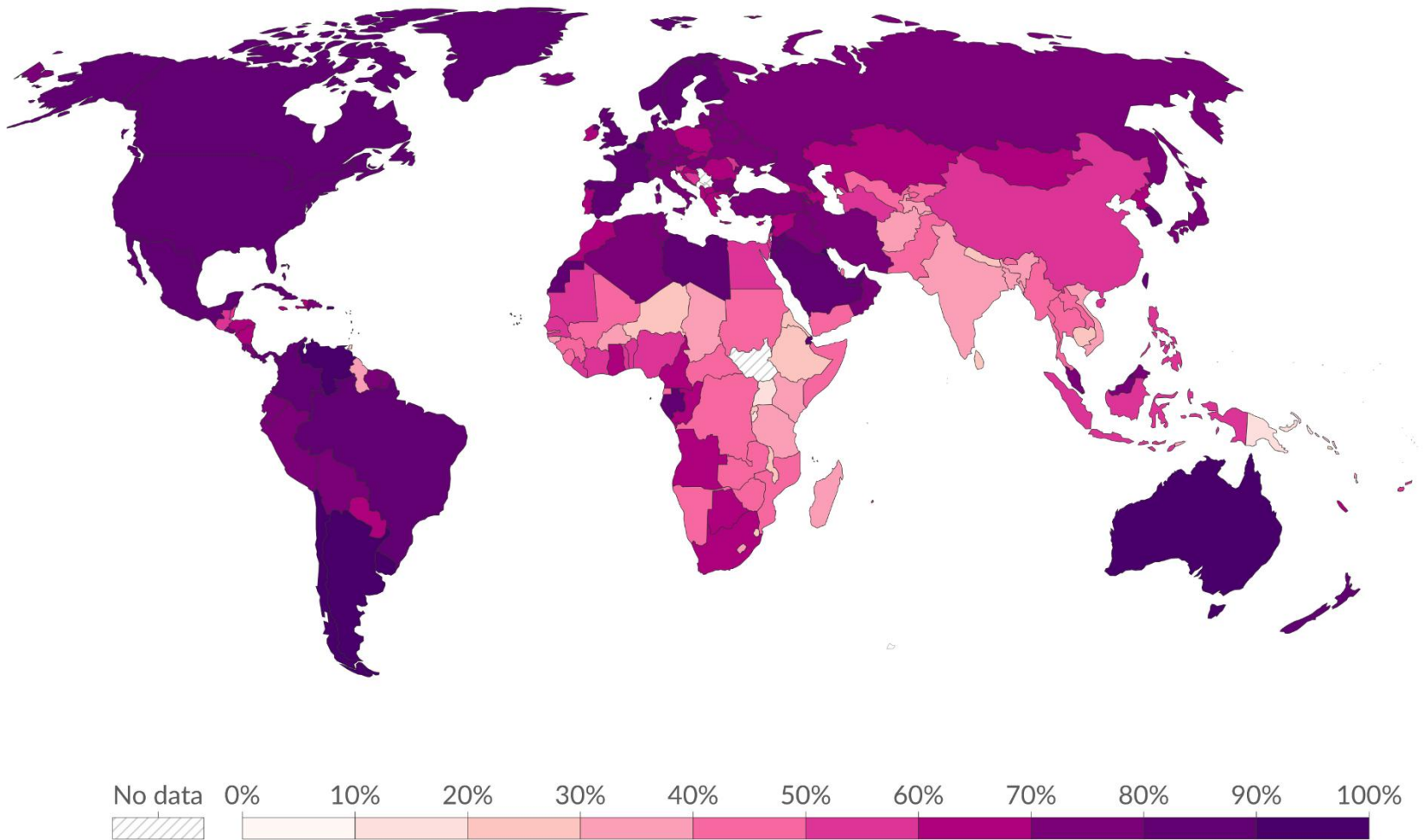
UNITED NATIONS.
World Urbanization
Prospects: The 2025
Revision.

City population growth rate (2010-2025)



Share of population living in urbanized areas 2025

Share of population living in urban areas in a country over time.

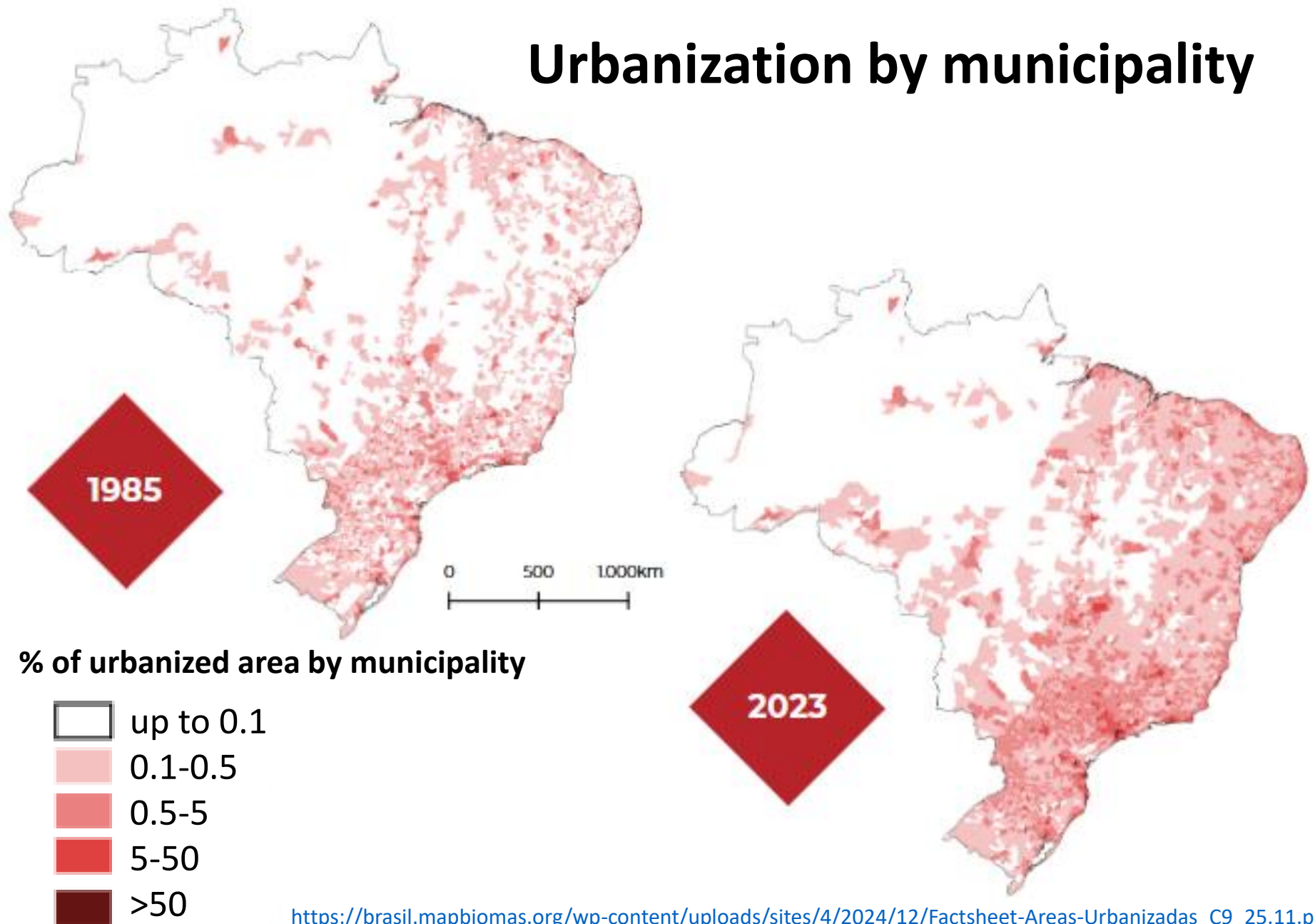


Data source: HYDE (2025)

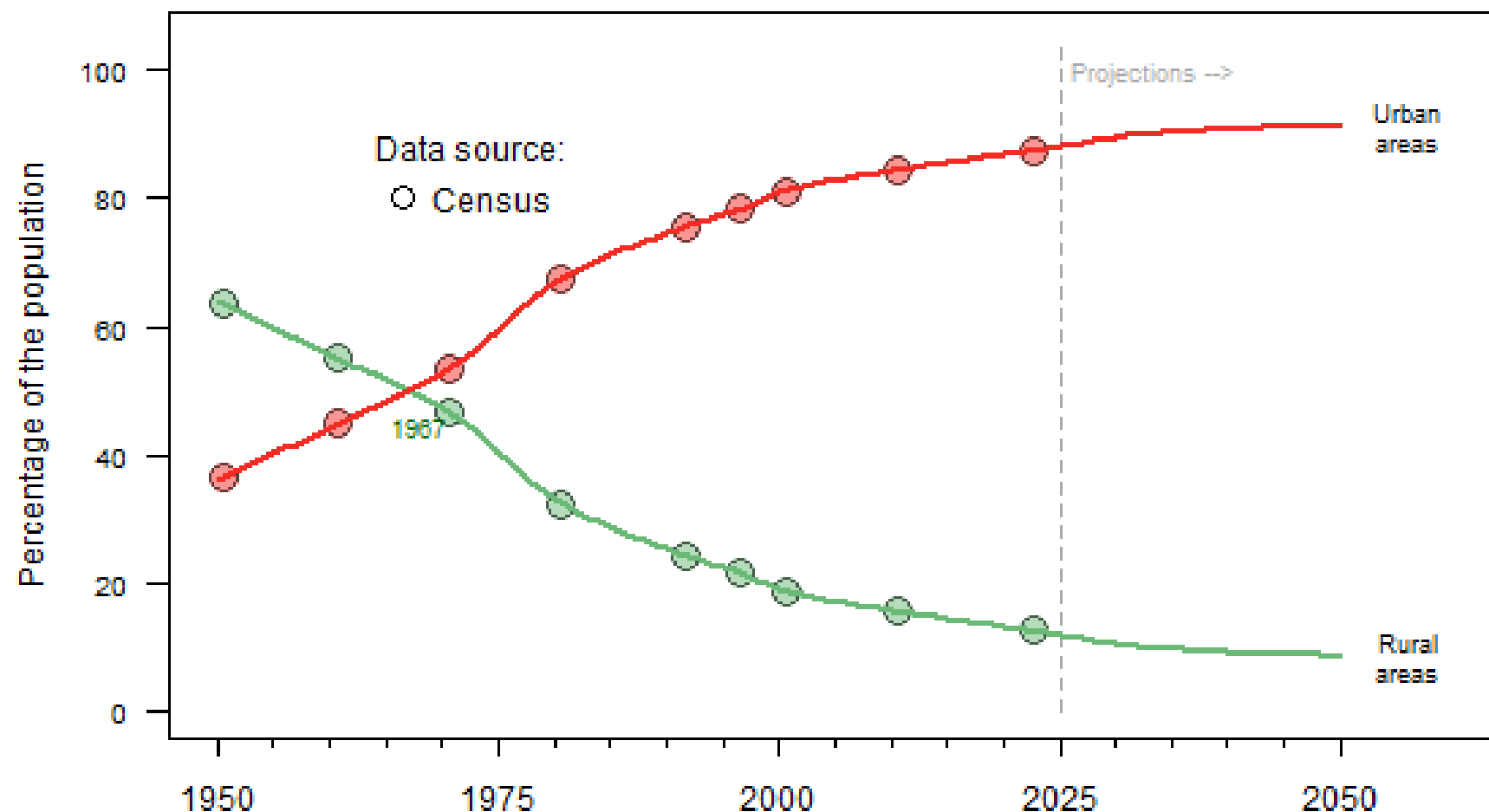
OurWorldinData.org/urbanization | CC BY

<https://ourworldindata.org/grapher/long-term-urban-population-region?tab=map>

Urbanization by municipality

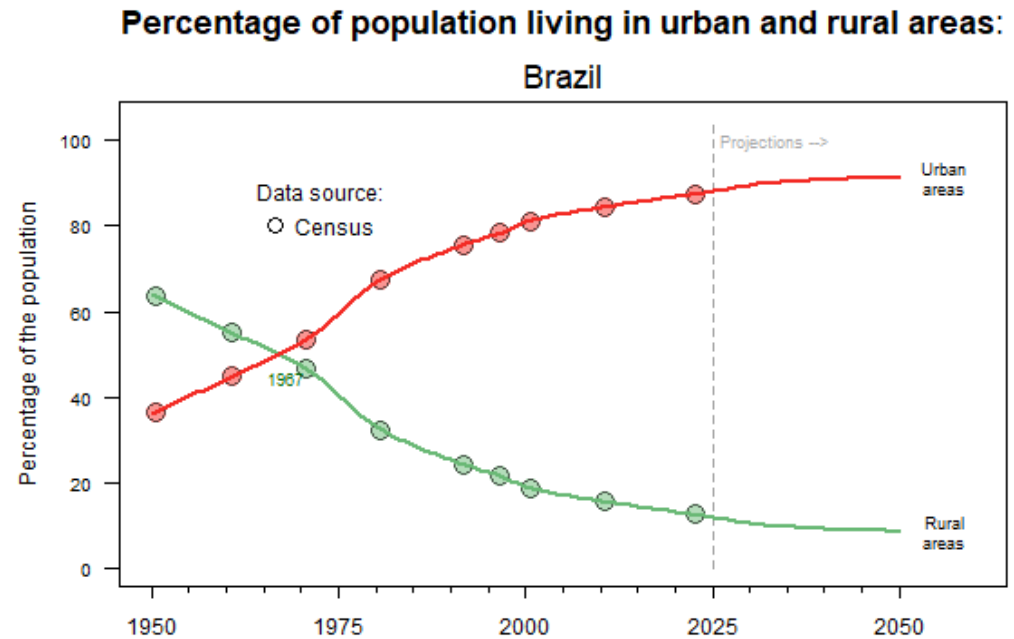


Percentage of population living in urban and rural areas: Brazil

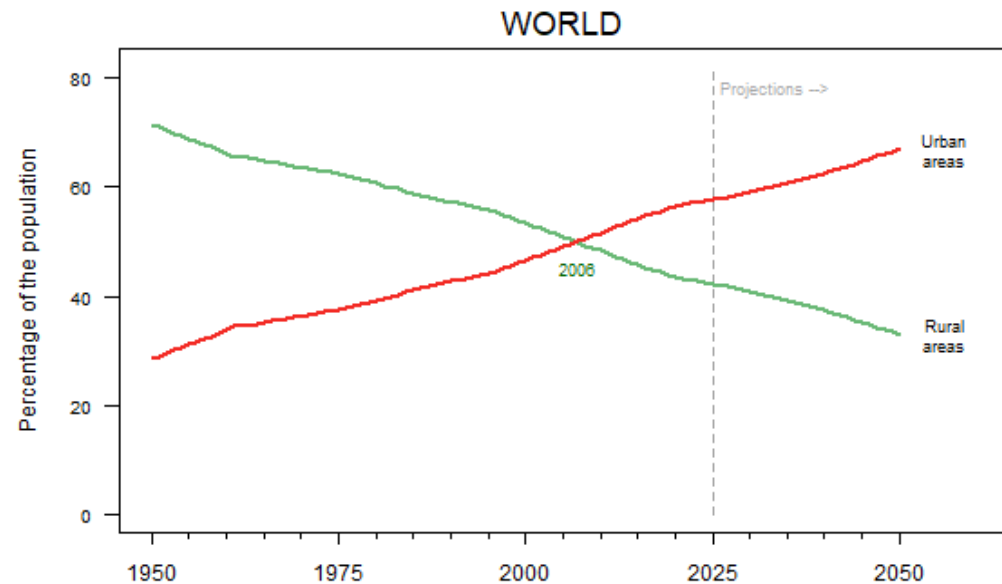


© 2025 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.
United Nations, DESA, Population Division. *World Urbanization Prospects 2025*. <https://population.un.org/wup/>

Brazil

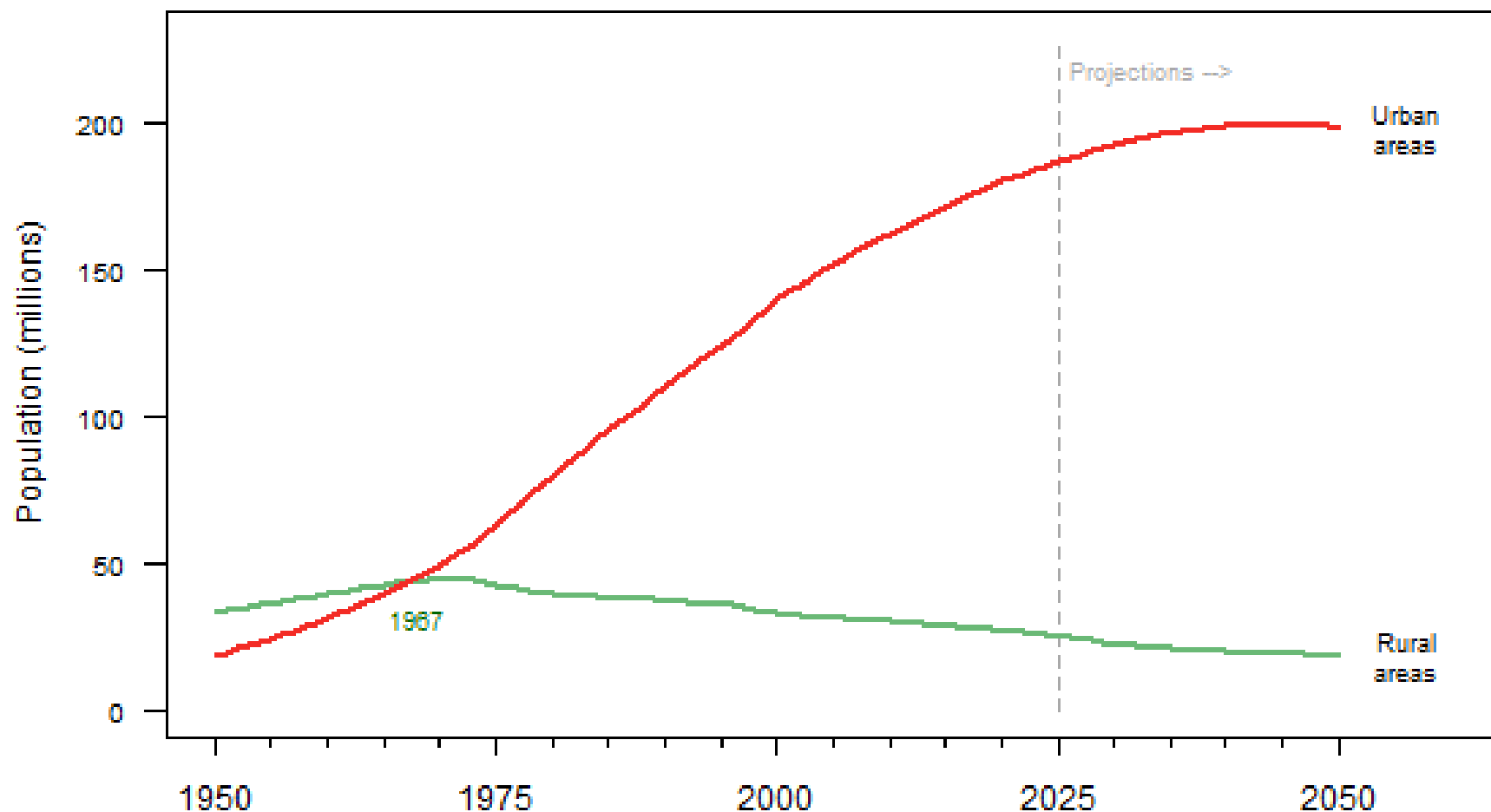


World



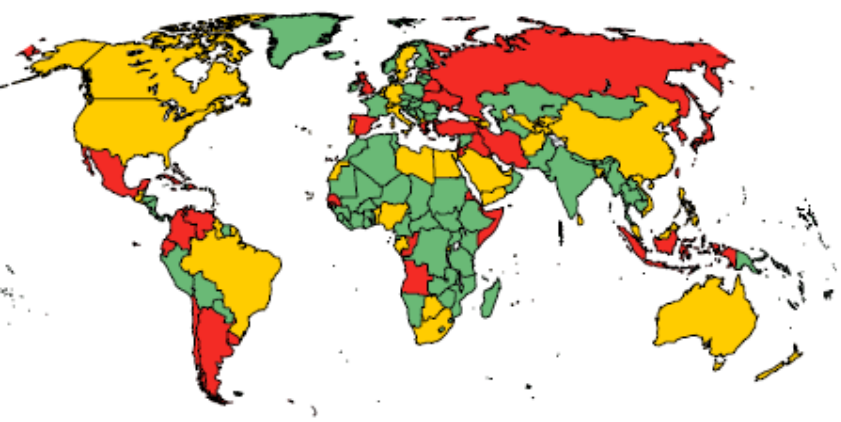
© 2025 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.
United Nations, DESA, Population Division. *World Urbanization Prospects 2025*. <https://population.un.org/wup/>

Population living in urban and rural areas: Brazil

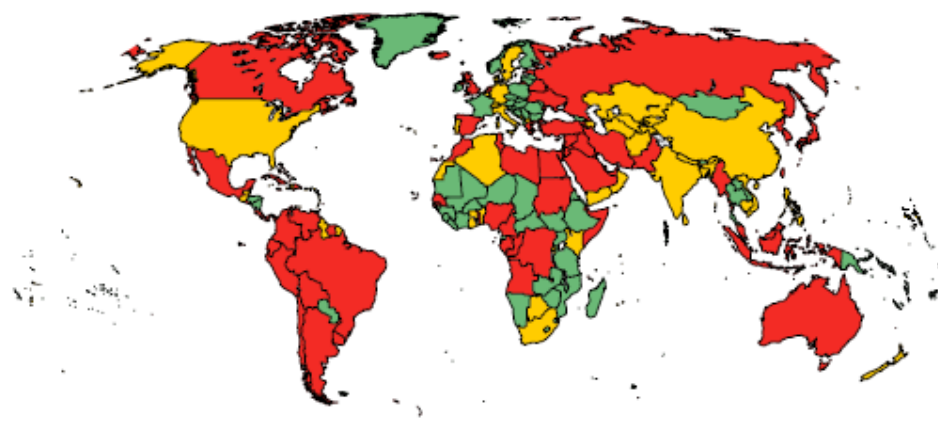


© 2025 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.
United Nations, DESA, Population Division. *World Urbanization Prospects 2025*. <https://population.un.org/wup/>

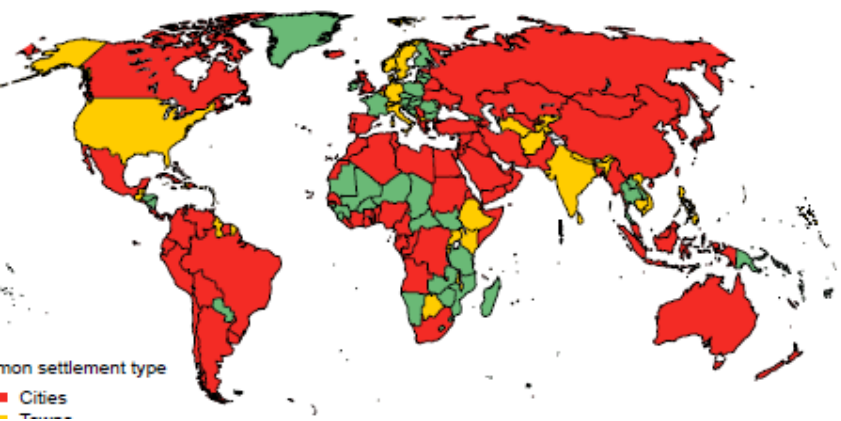
1975



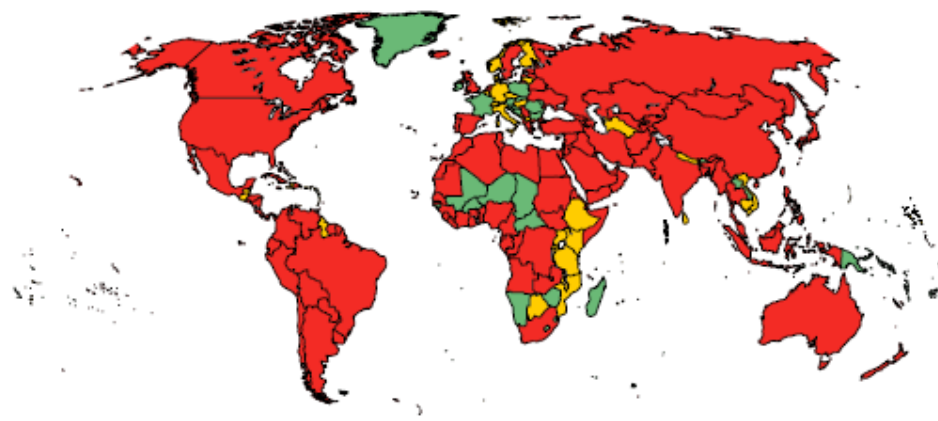
2000



2025



2050



Most common settlement type

■ Cities
 ■ Towns
 ■ Rural
 ■ No data

- Cities population > 50,000 inhabitants, density > 1500 people/km²
- Towns population > 5,000 inhabitants, density > 300 people/km²
- Rural
- No data

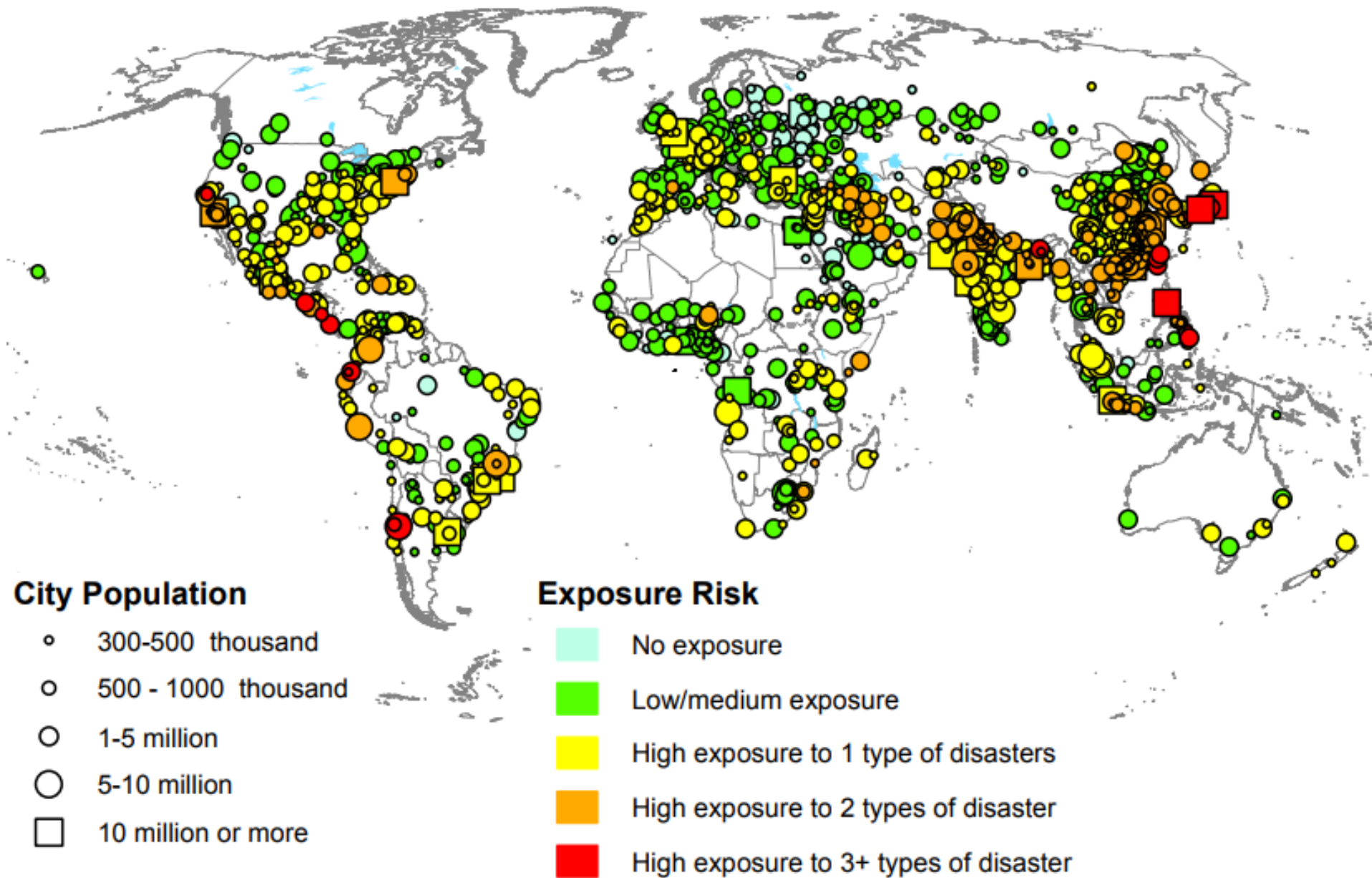
UNITED NATIONS. World Urbanization Prospects: The 2025 Revision.

Environmental impact in cities

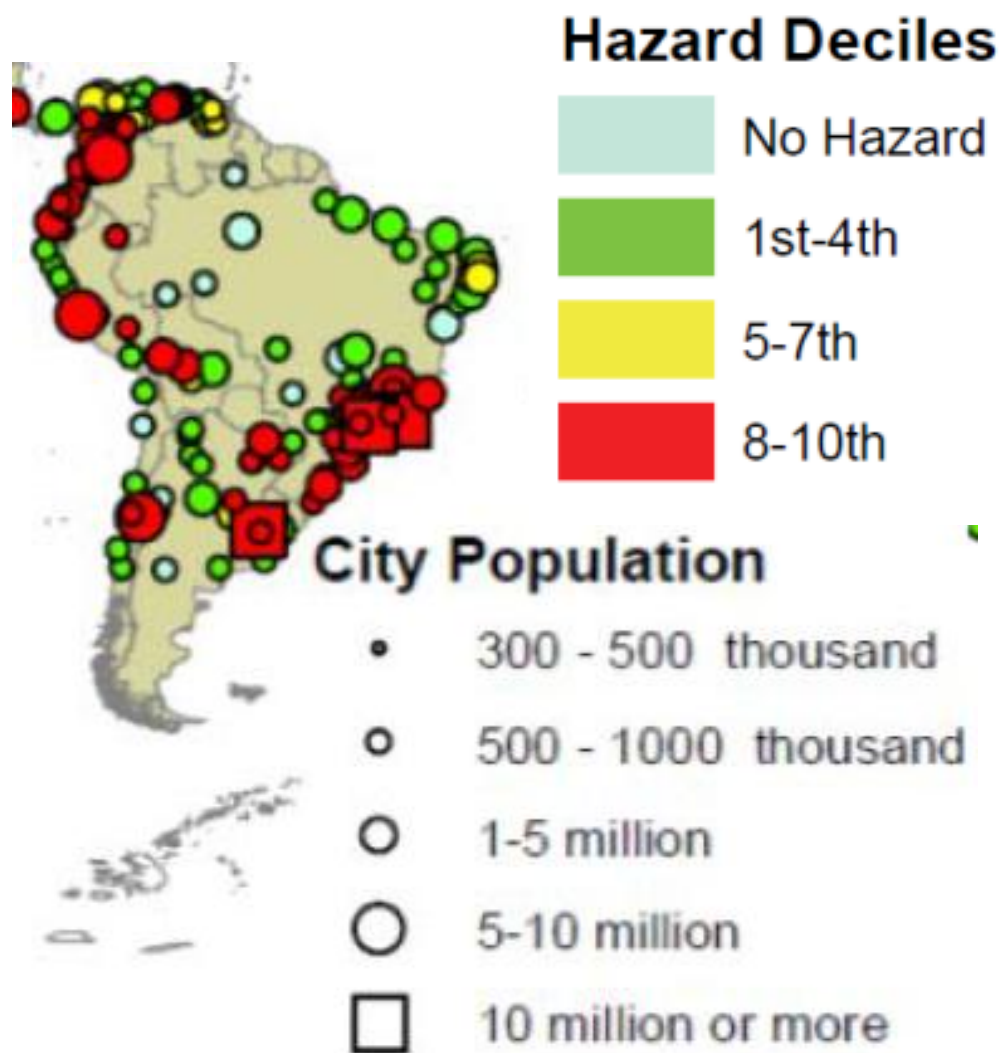
- 2% of the earth's surface
- 80% of energy consumption
- 75% of CO₂ emissions
- 1.3 to 1.9 billion tons of garbage annually
- 880 million people in slums, with precarious basic sanitation

Cities and Natural Disasters

Cyclones, floods, droughts, earthquakes, earth movements, and volcanic eruptions

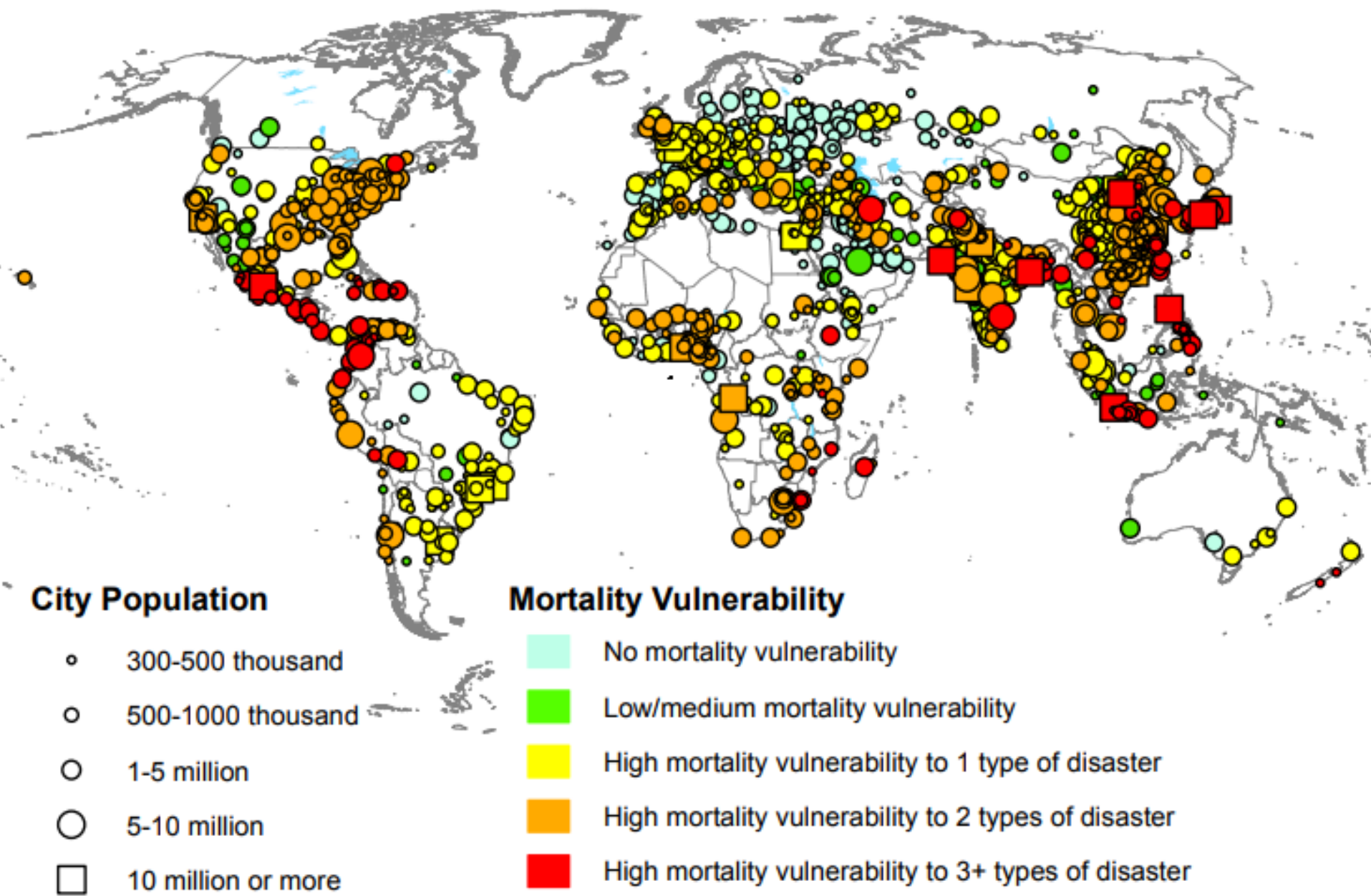


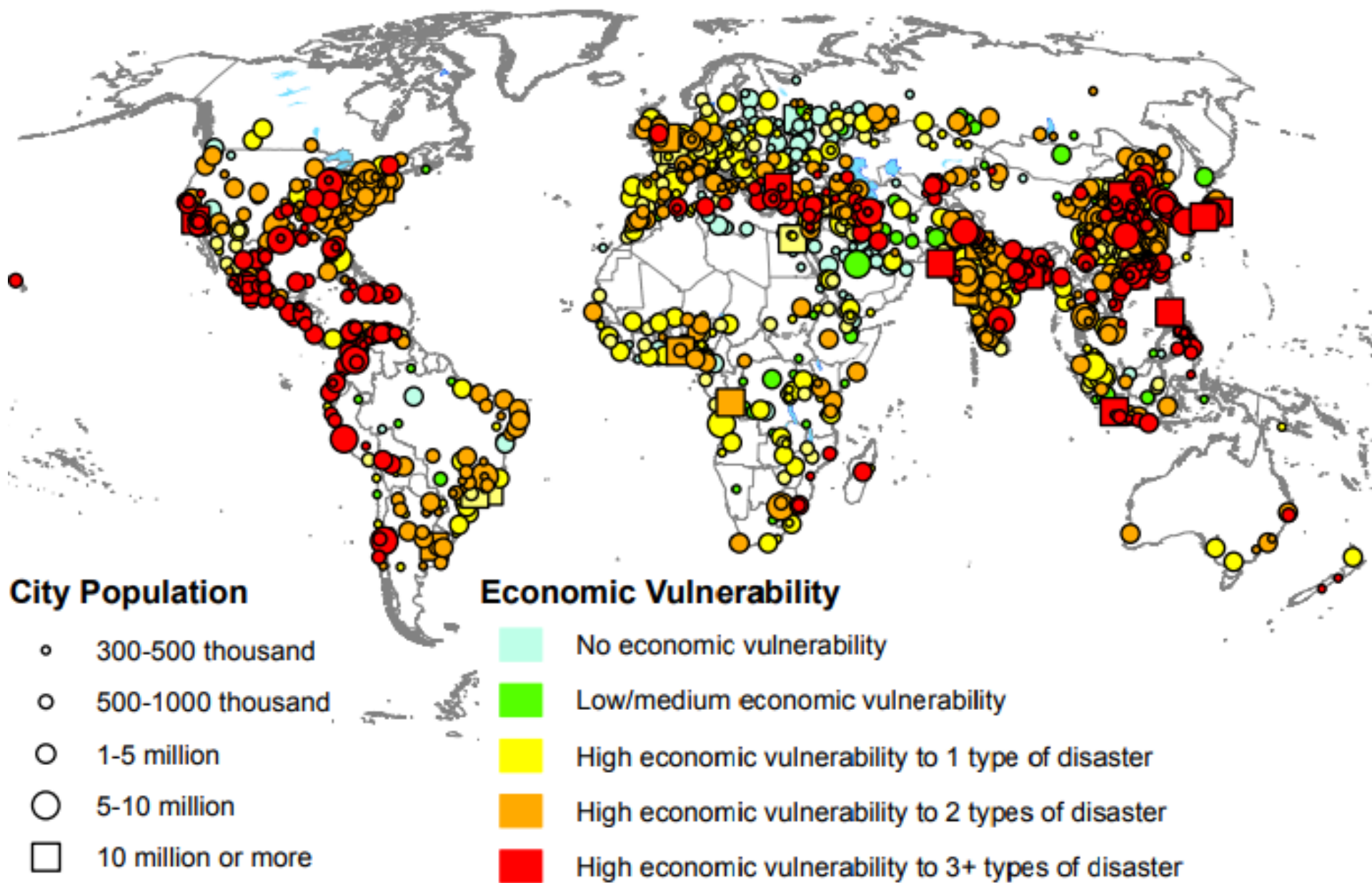
Flood Risk



Drought Risk







Urbanization and Environment

- Main areas of study
 - Environmental Justice
 - Urban Ecology
 - Global changes

Environmental Justice

- Articulation between:
 - Activists
 - Academia
 - Government departments
- Distributive injustice
 - Poorer populations, or ethnically discriminated against, are allocated to areas with poorer environmental quality
 - Pollution
 - Natural disaster risks
 - Measurement
 - Environmental amenities and inamenities
 - Costs and Benefits
 - Distribution of Risks
(Damage X Frequency X Vulnerability X Resilience X Adaptation)
- Participatory injustice
 - Poorer or ethnically discriminated populations have less voice in the means of discussion and decision-making

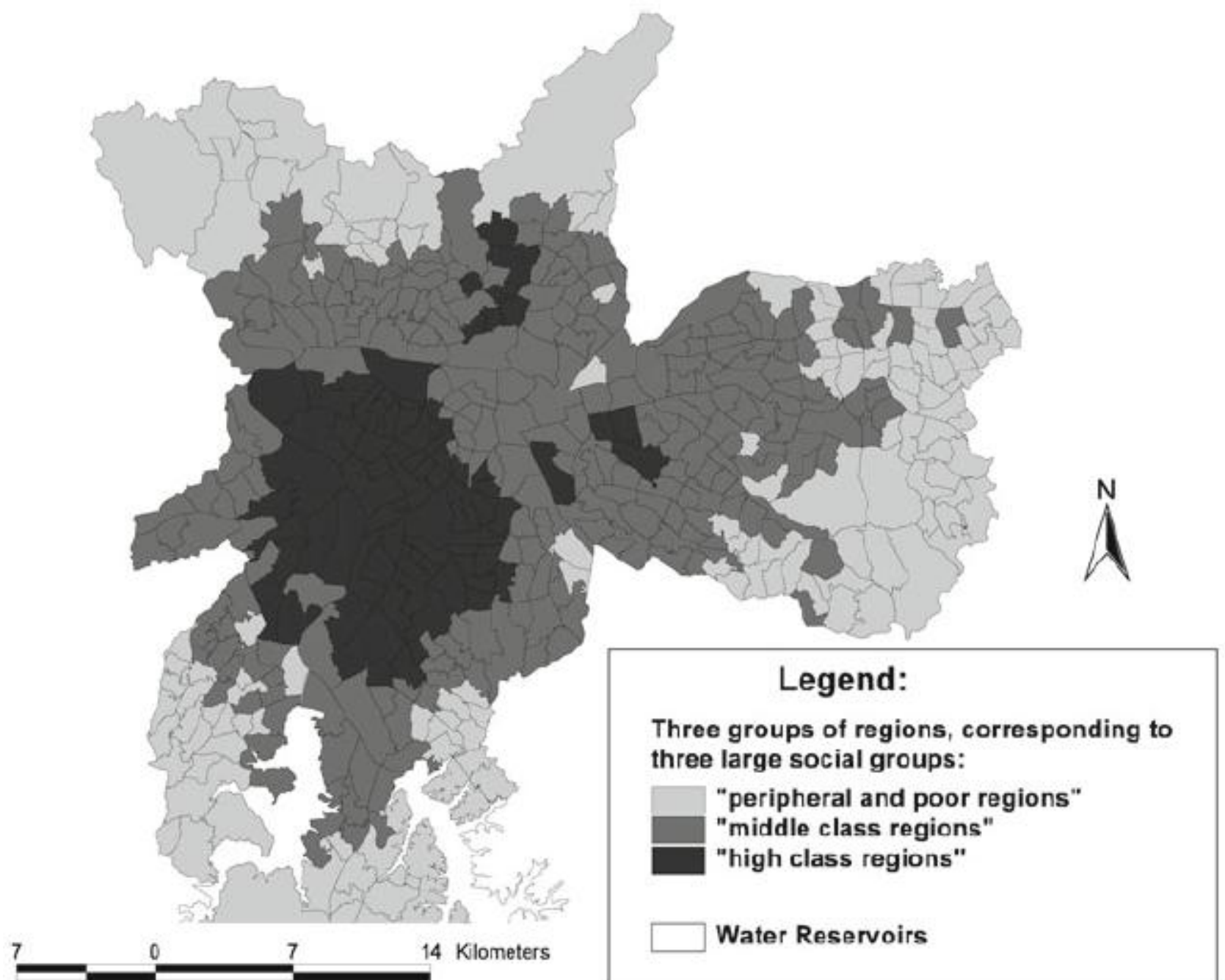
PICKETT, Steward TA; BOONE, Christopher G.; CADENASSO, Mary L. Ecology and Environmental Justice: Understanding Disturbance Using Ecological Theory. In: **Urbanization and Sustainability**. Springer Netherlands, 2013. p. 27-47.

BOONE, Christopher G.; FRAGKIAS, Michail. Connecting environmental justice, sustainability, and vulnerability. In: **Urbanization and Sustainability**. Springer Netherlands, 2013. p. 49-59.

Environmental Justice in São Paulo



YOUNG, Andrea Ferraz. Urbanization, environmental justice, and social-environmental vulnerability in Brazil. In: **Urbanization and Sustainability**. Springer Netherlands, 2013. p. 95-116.



YOUNG, Andrea Ferraz. Urbanization, environmental justice, and social-environmental vulnerability in Brazil. In: **Urbanization and Sustainability**. Springer Netherlands, 2013. p. 95-116.

Disaster Risk	% of Population by regions		
	Poor	Middle class	Rich
Risk-Free Areas	71.71	85.24	90.11
Areas at Risk	28.29	14.76	9.89

Disaster Risk	Population growth between 1991 and 2000 (%)		
	Poor	Middle class	Rich
Risk-Free Areas	3.26	-0.41	-1.1
Areas at Risk	4.81	0.56	-1.2

Disaster Risk	Average income (R\$)	% sewage collection	% of population in slums
Risk-Free Areas	1,421.05	90.58	5.68
Areas at Risk	888.24	71.94	21.60

YOUNG, Andrea Ferraz. Urbanization, environmental justice, and social-environmental vulnerability in Brazil. In: **Urbanization and Sustainability**. Springer Netherlands, 2013. p. 95-116.

Common limitations in urban environmental justice studies

- Focus on the problems of the here and now (for social mobilization)
- Little focus on the social roots that generated the problem
- Focus on short-term resolution
- Little focus on regional or global processes
- Focus on people
- Little focus on how pollution and disasters affect ecological processes in urban areas

PICKETT, Steward TA; BOONE, Christopher G.; CADENASSO, Mary L. Ecology and Environmental Justice: Understanding Disturbance Using Ecological Theory. In: **Urbanization and Sustainability**. Springer Netherlands, 2013. p. 27-47.

BOONE, Christopher G.; FRAGKIAS, Michail. Connecting environmental justice, sustainability, and vulnerability. In: **Urbanization and Sustainability**. Springer Netherlands, 2013. p. 49-59.



Ecologia Urbana

Ecology in Cities

- Plants, insects, stray animals, pets
- Biogeochemical fluxes in urban areas
- Area Comparison
 - Different vegetated areas in the city
 - Urban X Natural
 - Gradient (urban center -> distance from the city)
 - Diffuse border between Urban and Natural

CICERO, C. (1989) Avian community structure in a large urban park: Controls of local richness and diversity. *Landscape and Urban Planning* 17, 221–240.

MCPHEARSON, Timon et al. Advancing urban ecology toward a science of cities. **BioScience**, v. 66, n. 3, p. 198-212, 2016.

Ecology of Cities

- Socio-ecological systems
 - Dialogue with sociology
- Socio-techno-ecological systems
 - Dialogue with architecture and engineering
- Comparative studies between cities
 - Generalization of theories
 - Urban typologies

Ecology for Cities

- Emphasis on urban environmental management
 - Decision-making
 - Participatory methods (managers and population)
- Interdisciplinary theories
 - Ecological footprint
 - Ecosystem services
 - Urban metabolism
 - Green infrastructure

Case Study – Urban Forestry

How could it be studied by:

○ Ecology in Cities?

- Energy and nutrient flows through trees
- Tree-Soil-Climate Relationship
- Tree-Insect-Bird Relationship

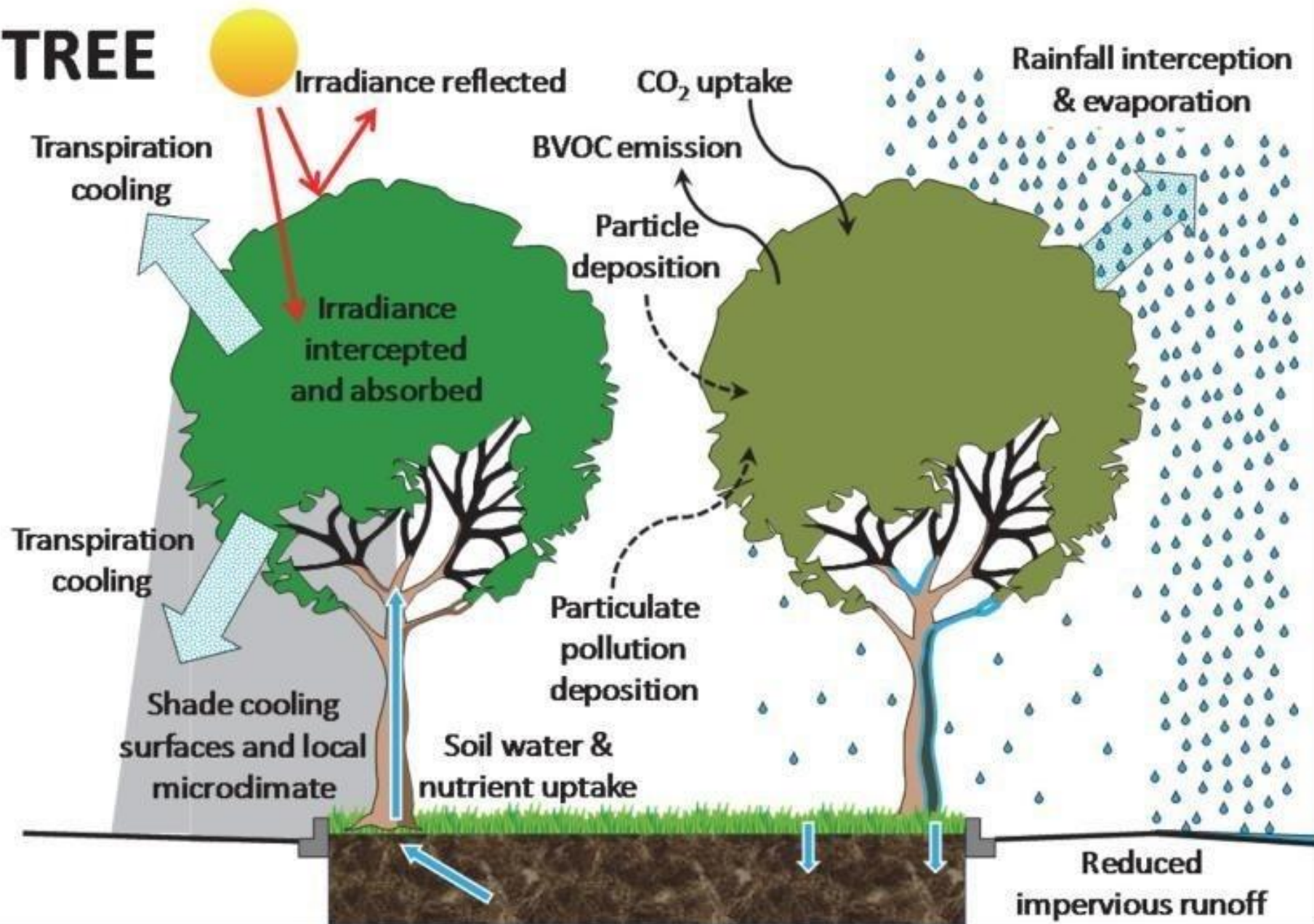
○ Ecology of Cities?

- People's interaction with trees
 - Planting and behavior around trees
 - Vandalism
- Effect of traffic, pollution, and heat islands on tree growth
- Effect of afforestation on real estate prices
- Root damage in pipes, wiring, and sidewalks
- Comparison between different cities vs. tree species

○ Ecology for Cities?

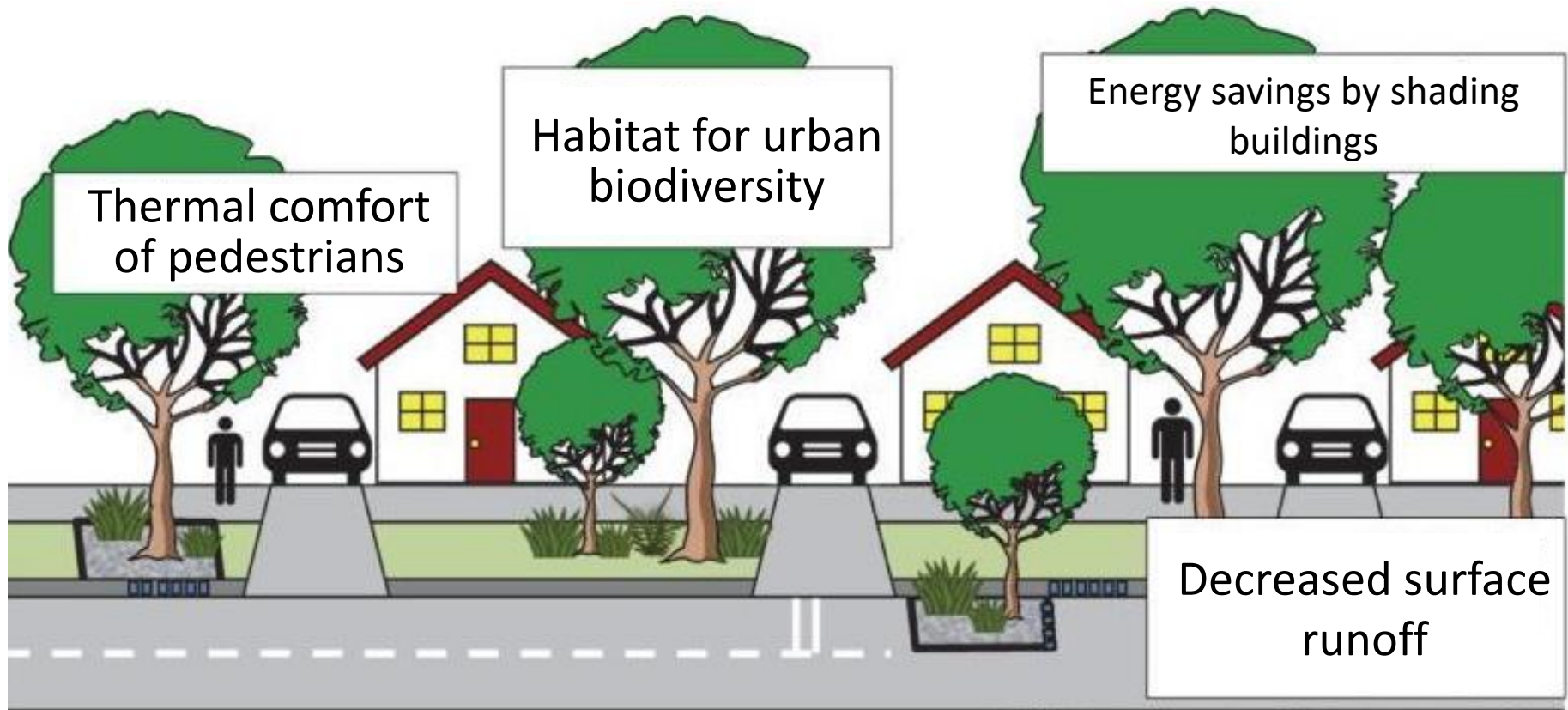
- Tree ecosystem services
- Urban afforestation policy
 - What species:
 - Are they best adapted to each part of the city?
 - Have lower maintenance costs?
 - Generate better ecosystem services?
 - Pruning and maintenance technologies
 - Urban landscaping

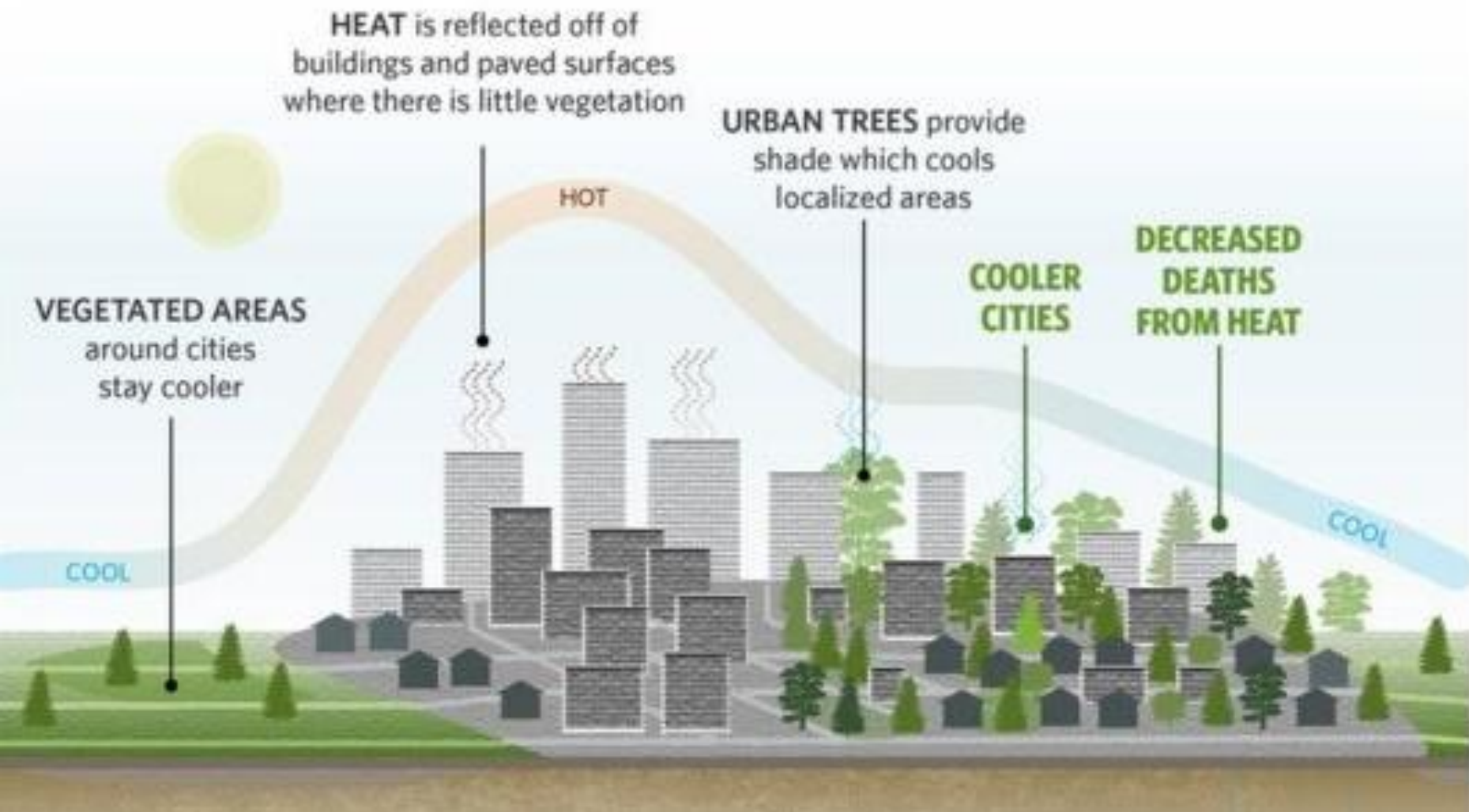
TREE



BVOC = Biological volatile organic compounds

Urban Afforestation



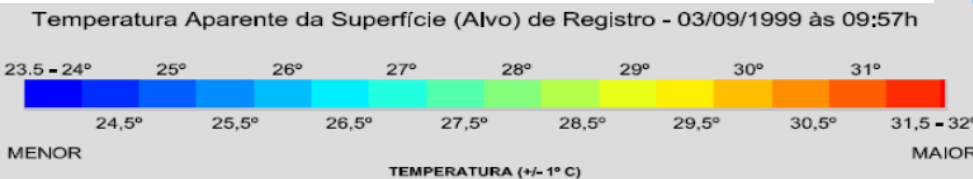


MCDONALD, R. et al. Planting healthy air: a global analysis of the role of urban trees in addressing particulate matter pollution and extreme heat. **The Nature Conservancy**: 2016.

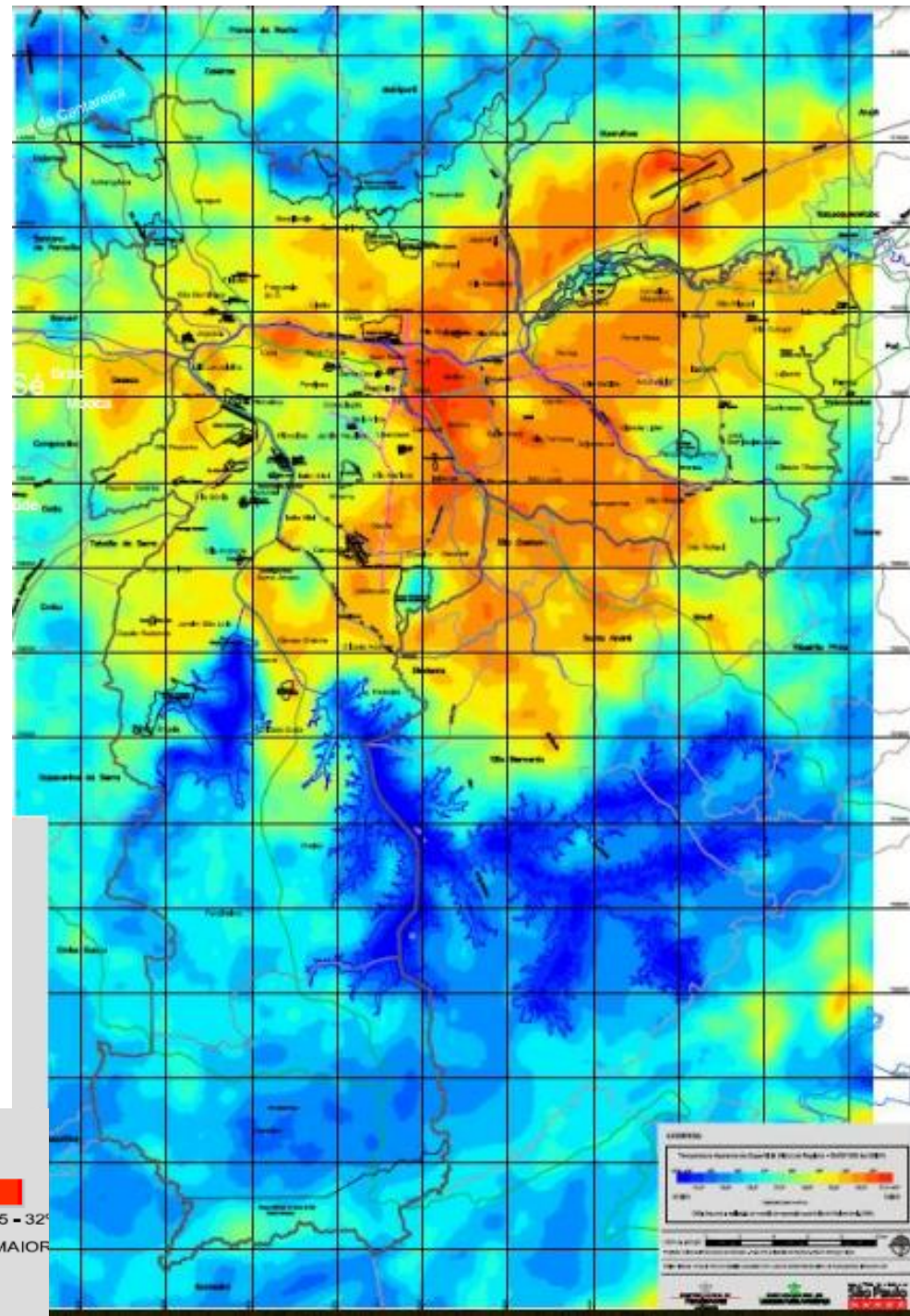
<http://www.bbc.com/news/science-environment-37813709>

Heat Island in São Paulo

Up to 10° difference between downtown and urban edges



OBS: Segundo a aplicação do modelo de regressão quadrática de Malaret et al. (1985)



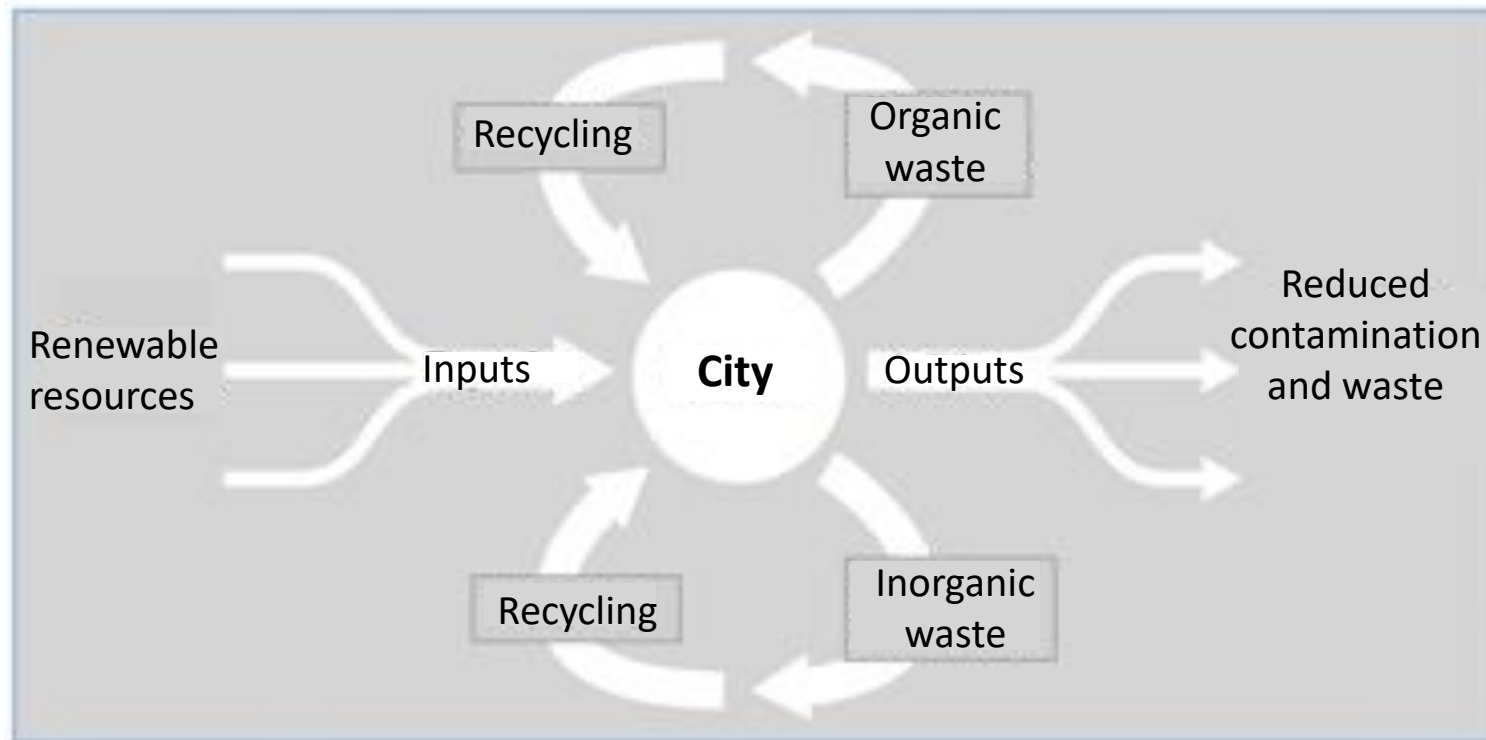
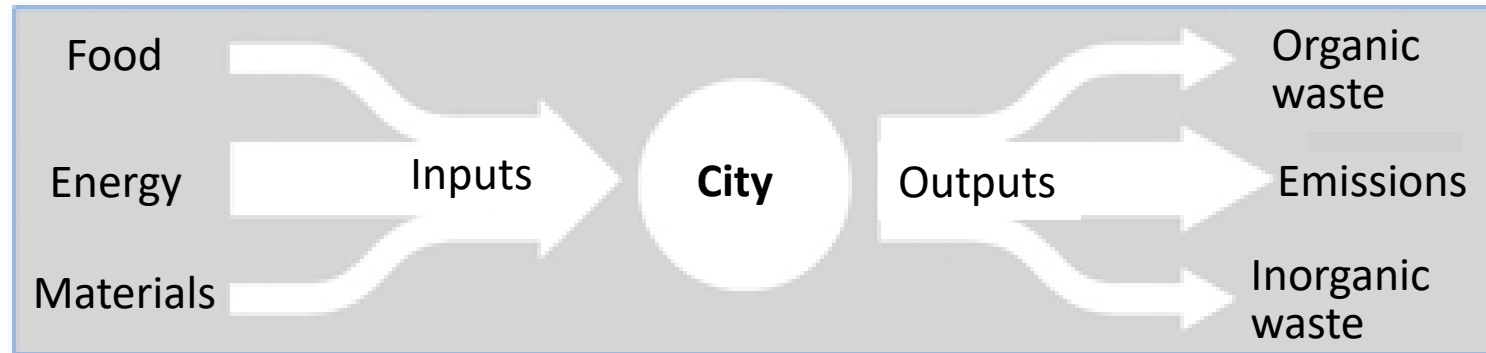
Activity

How could urban afforestation be studied by environmental justice?

Urban Afforestation and Environmental Justice

- More afforestation in rich neighborhoods - injustice?
- Social causes for this unequal distribution
- Sanitation policies include service charges
 - Fees for environmental afforestation?
 - Population does not accept well the creation of fees for the environmental service of afforestation
- Alternative system:
 - Public-private partnerships
 - Sponsors + NGOs + Owners\Local Residents
 - How to make this system transparent and participatory?
- Wealthy neighborhoods better embrace initiatives
- Poor neighborhoods are against tree planting
 - High maintenance cost - other priorities
 - Shadows shelter thieves - insecurity

Urban Metabolism

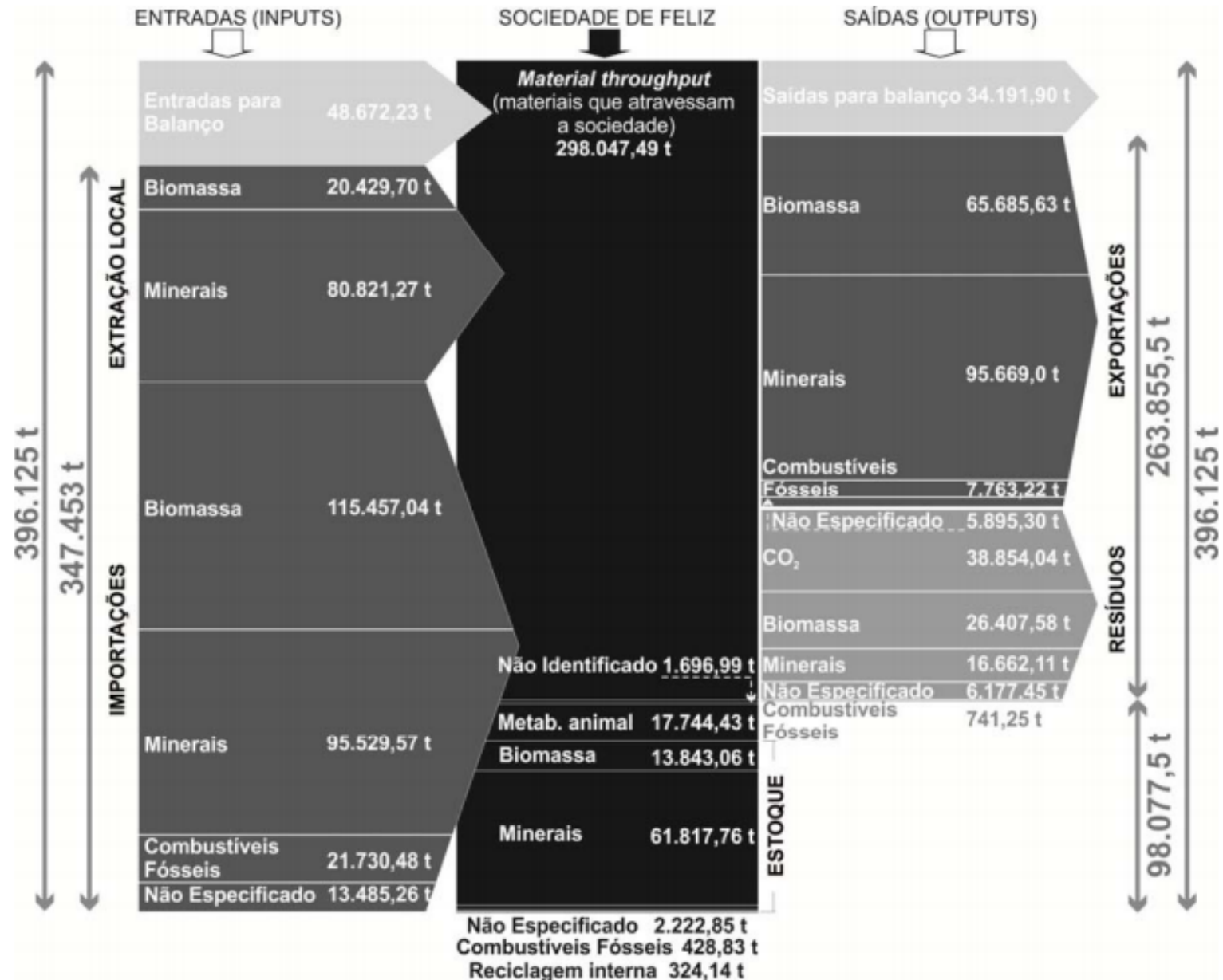


Urban metabolism of Curitiba

Material Category	Unit	2000	2010	%
Inputs				
Food intake ^a	ton	503,535	567,457	13
Electricity consumption (total)	GW/h	3423	4239	24
Residential	GW/h	1251	1498	20
Industrial	GW/h	931	1057	14
Commercial	GW/h	897	1314	46
Public Services	GW/h	332	358	8
Other	GW/h	12	12	-7
Energy consumption (total)	TJ	58,010	76,255	32
Natural gas	TJ	1969	6748	243
Fossil fuels ^b	TJ	47,184	52,949	12
Coal (mineral + vegetable)	TJ	6	330	5878
Biomass/biofuels	TJ	8851	16,228	83
Construction materials (use)	ton	4,221,841	7,308,036	73
Cement	ton	371,432	628,935	69
Steel	ton	146,985	239,836	63
Aggregates (sand, gravel)	ton	3,703,424	6,439,265	74
Water consumption	ML	90,906	103,529	14
Production				
Food	ton	2394	1303	-46
Wood	m ³	4,110 ^c	2738	-33
Construction materials	ton	940,993	1,256,202	33
Cement	ton	680,506	953,570	40
Steel	ton	260,487	302,632	16
Minerals (clay, gold, crushed stones)	ton	30,368	15,173	-50
Water production (surface water)	ML	162,771	169,086	4
Stocks				
Minerals (clay, gold, crushed stones)	ton	1,427,256	560,409	-61
Landfill waste (accumulated)	ton	3,607,122	8,711,683	142
Outputs				
Municipal solid waste	ton	702,974	728,453	4
Domestic and public waste	ton	532,135	462,587	-13
Recyclable waste	ton	132,173	193,470	46
Healthcare waste	ton	3807	2704	-29
Toxic waste	ton	7286	8495	17
Tree and junk waste	ton	27,573	61,197	122
Wastewater	ML	58,594	90,486	54
GHG emissions ^d	t-CO _{2eq}	3,174,630	3,515,890	11
Air emissions	µg/m ³	158	107	-32
Total suspended particulate (TSP)	µg/m ³	86	36	-58
Smoke	µg/m ³	22	16	-29
Inhalable particles	µg/m ³	15	27	79
Sulfur dioxide (SO ₂)	µg/m ³	11	3	-71
Nitrogen dioxide (NO ₂)	µg/m ³	24	25	3

CONKE, L. S.;
 FERREIRA, T. L. Urban
 metabolism: Measuring
 the city's contribution to
 sustainable
 development.
**Environmental
 Pollution**, v. 202, p.
 146-152, 2015.

Urban Metabolism of Feliz - RS



Green Infrastructure



Green Infrastructure

Green Roofs

Edifício Matarazzo, Viaduto do Chá - SP



Green Infrastructure

Vertical Gardens

Minhocão - SP



Green Infrastructure

Urban Agriculture

Shopping Eldorado - SP



Criticism by Environmental Justice

- Green infrastructure and sustainable technologies (solar panels, water reuse, etc.) used as environmental marketing of buildings
 - Only the richest can afford it
- Further increase the spatial inequality of environmental impacts
 - Poor areas vs. rich areas within and between cities
- Trend of urban per-capita resource consumption continues to increase

"Bosco verticale" building in Milan

Services of the "Vertical Forests"

- Temperature Decrease
- Pollution Filtration
- Reduction of CO₂ in the atmosphere
- Increased air humidity

Critical reflection

- Unequal distribution of benefits
- Consumption of natural resources
- Cost-effectiveness in relation to ecosystem services



Water Sensitive Urban Design

Rain Gardens
New York

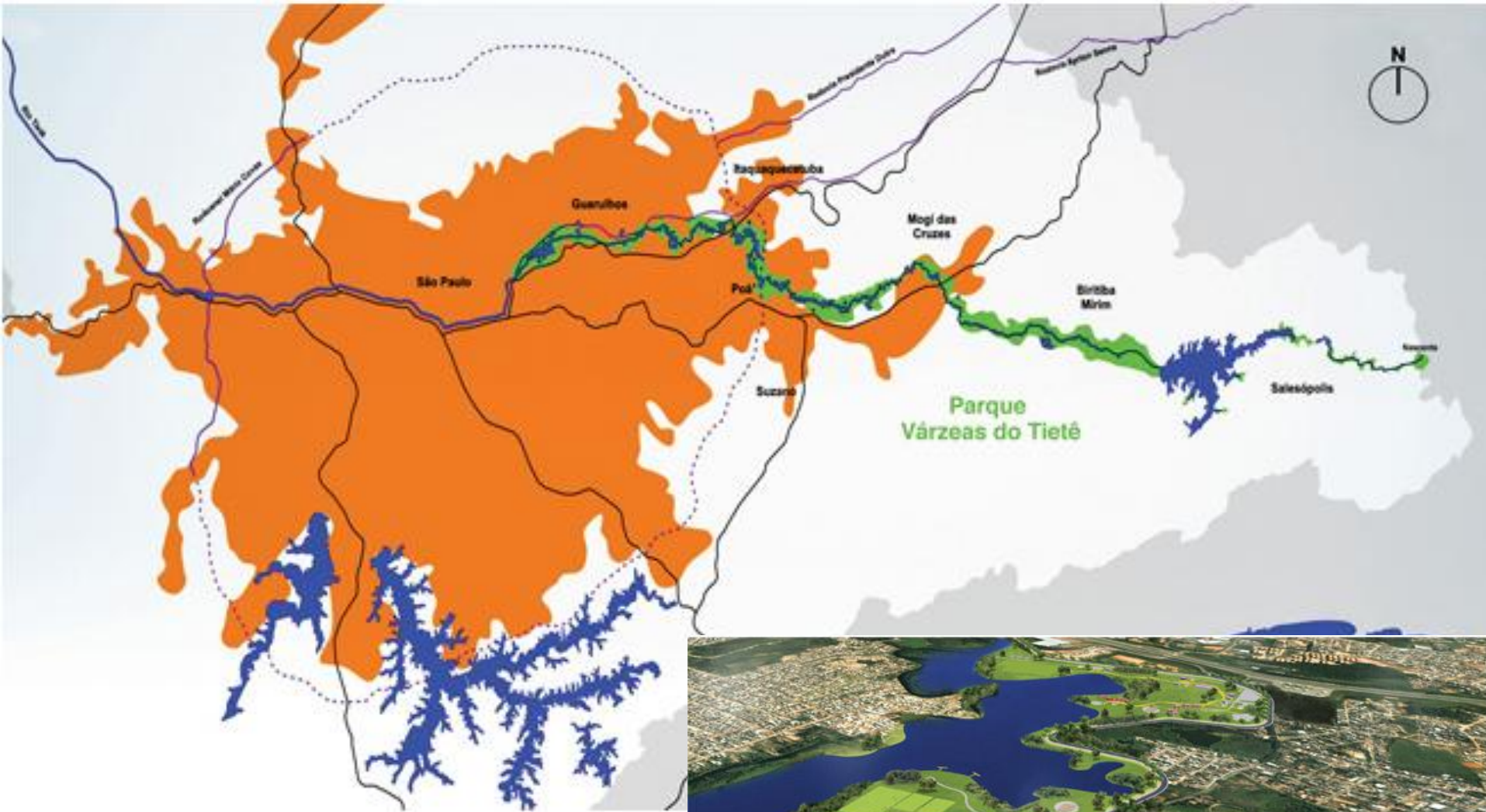


Water Sensitive Urban Design

Castelo Linear Park - SP

Guarapiranga Dam Waterfront





Linear Park Tietê floodplains

75km extension and area of 107km²



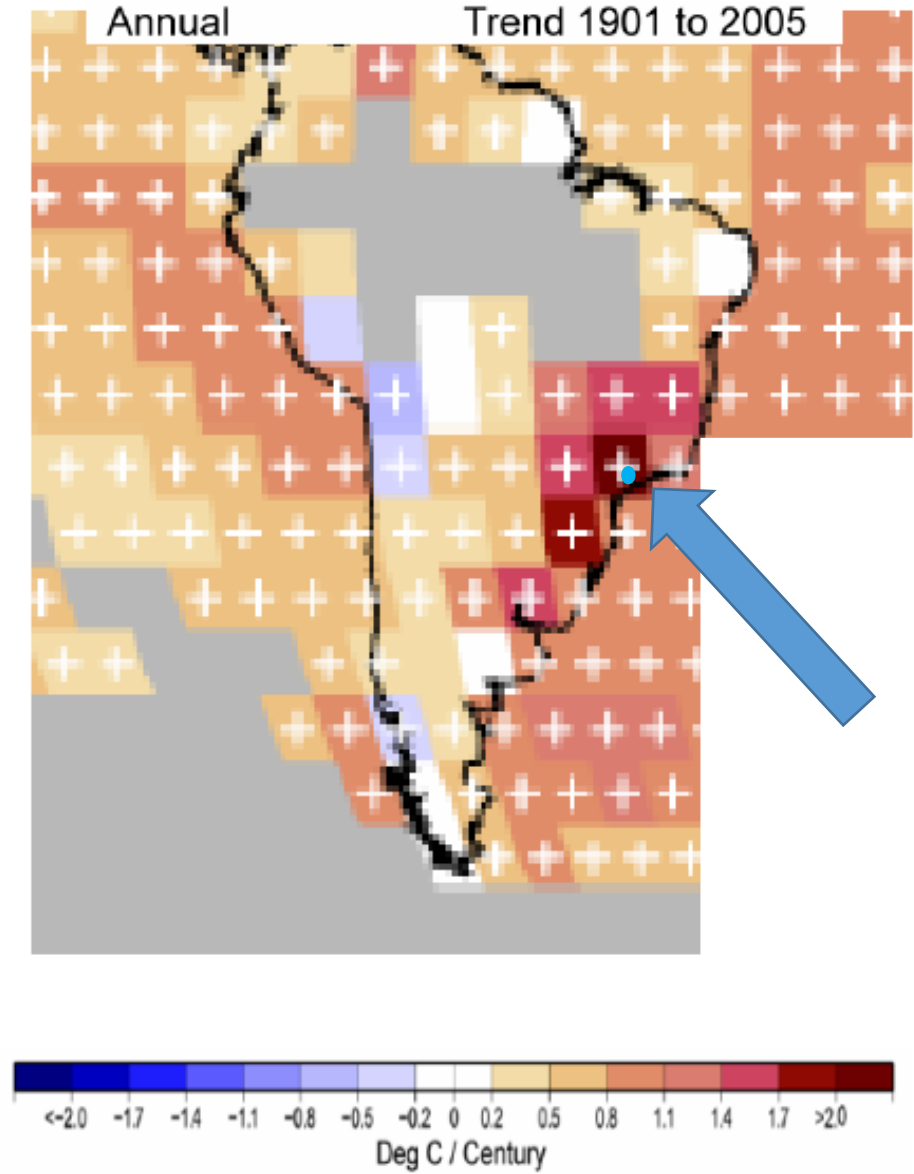
Cities and Global Change

Impact of Cities on Global Warming

- They consume 75% of energy and emit 80% of greenhouse gases (GHG)
- Main emission activities in cities
 - Developed countries-> Air conditioning (cooling and heating)
 Mitigation: Building standards for thermal insulation
 - Developing countries -> transportation
 Mitigation: public transportation
- Denser cities emit less GHG per capita
 - More efficient air conditioning and transport

Impact of Global Warming on Cities

Resolution limits of
climate models



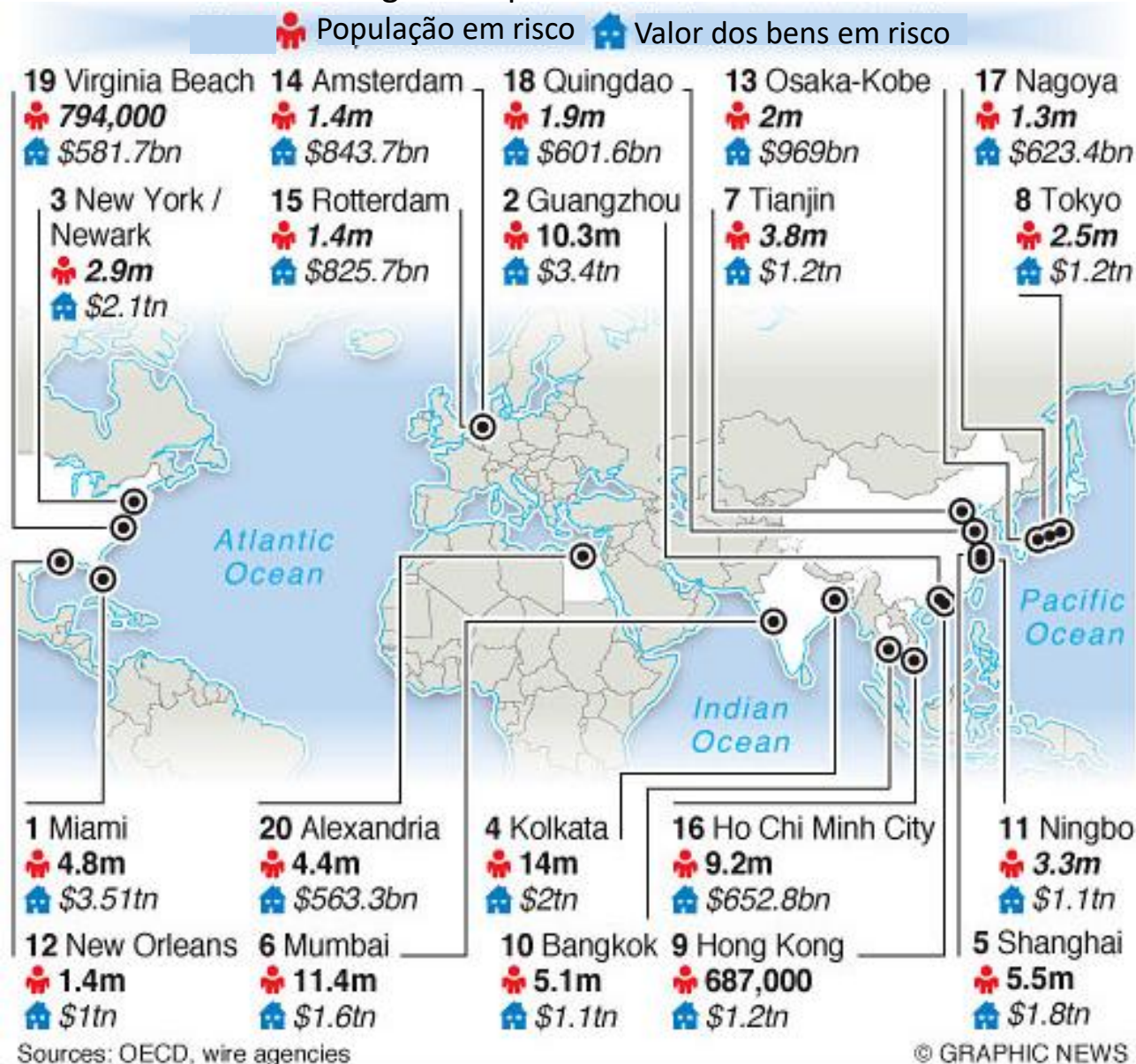
Climate projections of the Eta-CPTEC 40km regional model for the MRSP

	Presente Observ.	Presente Simulado	2030-40	Conf.	2050-60	Conf.	2080-90	Conf.
TEMP				Alta		Alta		Alta
NOITES QUENTES				Alta		Alta		Alta
NOITES FRIAS				Alta		Alta		Alta
DIAS QUENTES				Alta		Alta		Alta
DIAS FRIOS				Média		Alta		Alta
ONDAS DE CALOR	Não observado			Média		Média		Alta
CHUVA TOTAL				Alta		Alta		Alta
PRECIP. INTENSA				Média		Média		Alta
PRECIP. > 95th				Média		Média		Alta
DIAS PRECIP. > 10 MM				Média		Média		Alta
DIAS PRECIP. > 20 MM				Média		Média		Média
DIAS SECOS CONSECUTIVOS				Média		Média		Alta

The 20 cities most vulnerable to extreme weather events

Estimated exposure of port cities to coastal flooding for 2070

20 cities with the highest exposure in terms of assets at risk



Doubts?

Comments?

Thank you!

Vitor Vieira Vasconcelos

vitor.v.v@gmail.com