Servicios Ecológicos en Areas Urbanas

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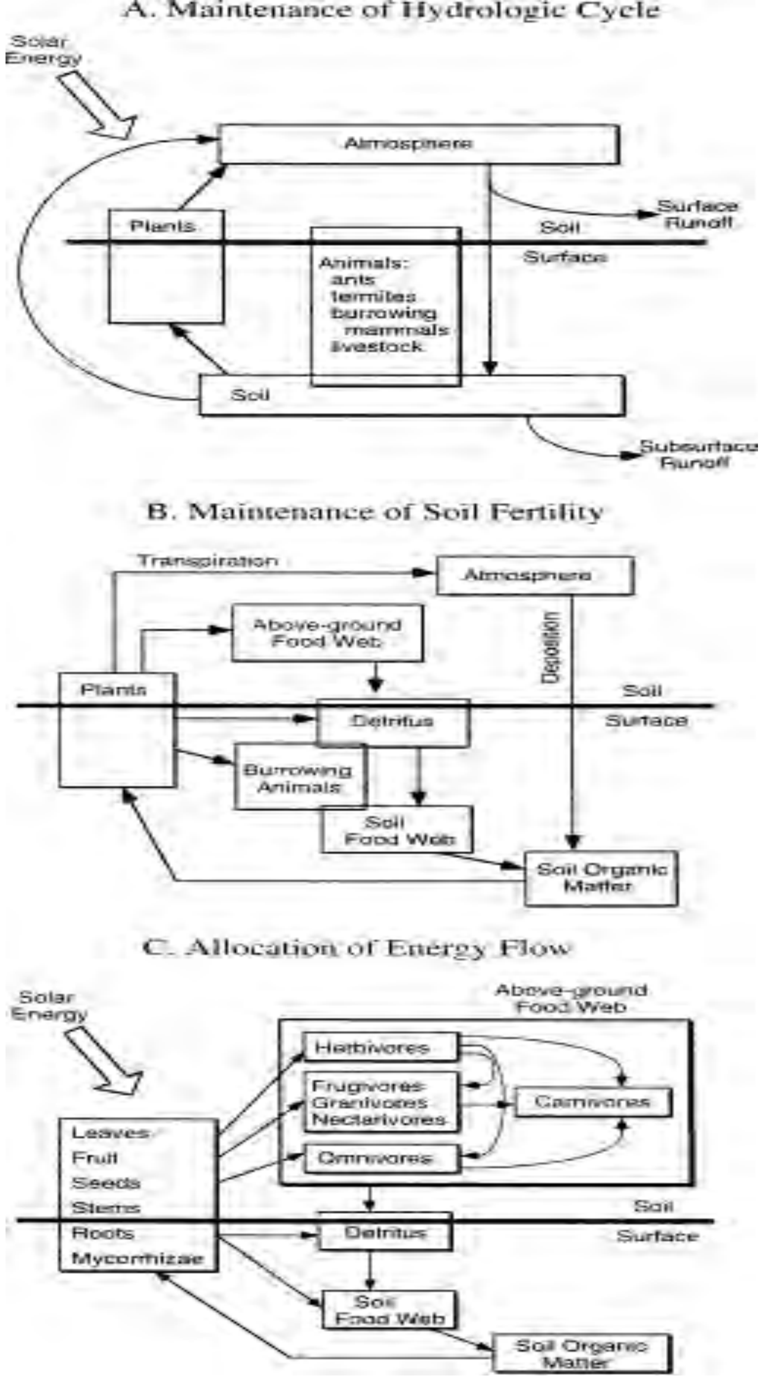
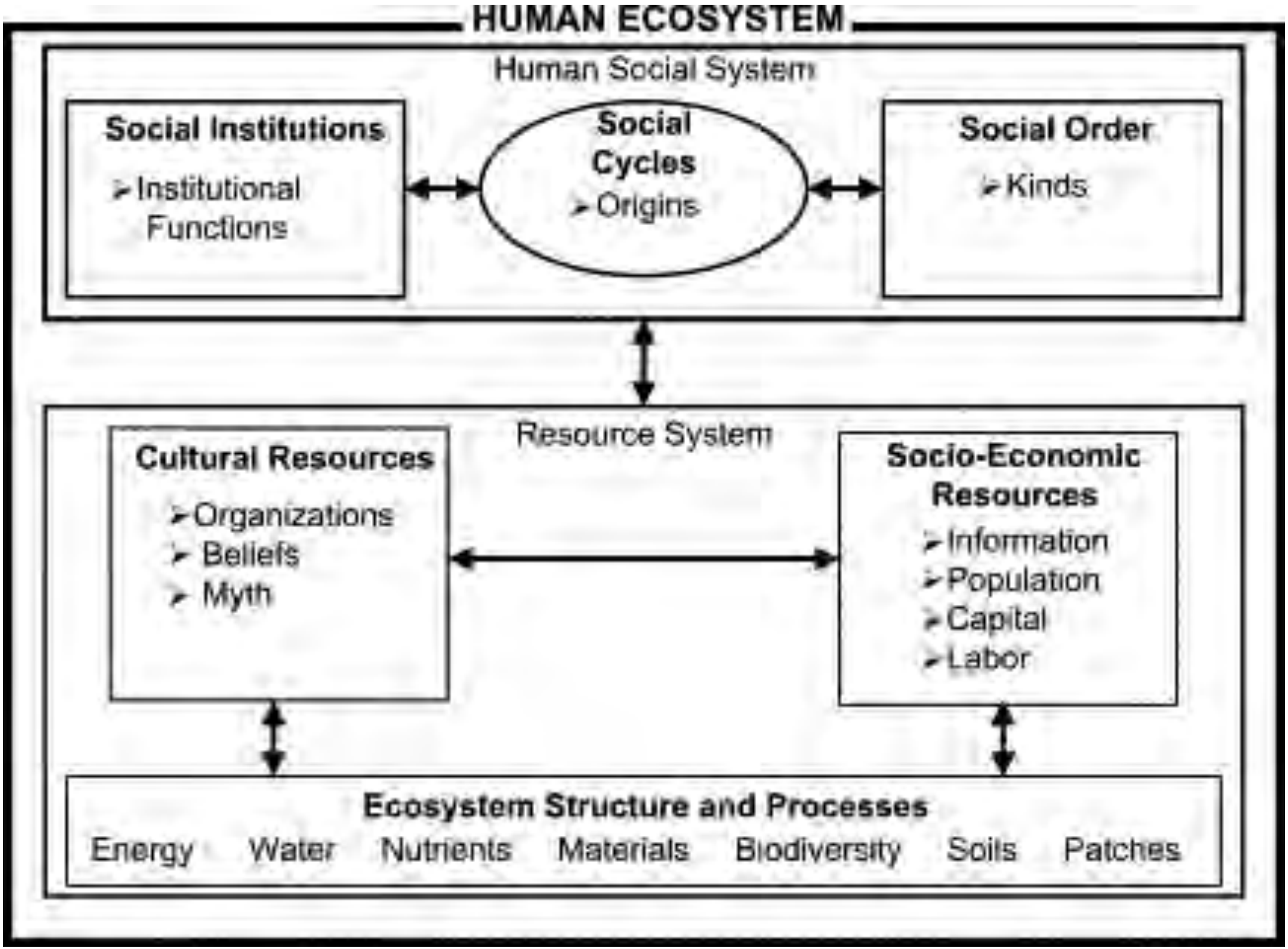
Universidad de California, Riverside



Source: Brussard et.al. 1998


HUMAN ECOSYSTEM
Human Social System
Social Institutions
➢Institutional Functions
Social Cycles
➢Origins
Social Order
➢Kinds
Resource System
Cultural Resources
➢Organizations
➢ Beliefs
➢ Myth
Socio-Economic Resources
➢Information
➢Population
➢Capital
➢Labor
Ecosystem Structure and Processes
Energy
Water
Nutrients
Materials
Biodiversity
Soils
Patches

Effects of Urbanization on Wetlands

Hydrology
Decreased surface storage of stormwater results in increased surface runoff (=increased surface water input to wetland)
Increased stormwater discharge relative to baseflow discharge results in increased erosive force within stream channels, which results in increased sediment inputs to recipient coastal systems
Changes occur in water quality (increased turbidity, increased nutrients, metals, organic pollutants, decreased O_2, etc)
Culverts, outfalls, etc. replace low-order streams; this results in more variable baseflow and low-flow conditions
Decreased groundwater recharge results in decreased groundwater flow, which reduces baseflow and may eliminate dry-season streamflow
Increased flood frequency and magnitude result in more scour of wetland surface, physical disturbance of vegetation
Increase in range of flow rates (low flows are diminished; high flows are augmented) may deprive wetlands of water during dry weather
Greater regulation of flows decreases magnitude of spring flush
Geomorphology
Decreased sinuousity of wetland/upland edge reduces amount of ecotone habitat
Decreased sinuosity of stream and river channels results in increased velocity of stream water discharge to receiving wetlands
Alterations in shape of slopes (e.g. convexity) affects water-gathering or water-disseminating properties
Increased cross-sectional area of stream channels (due to erosional effects of increased flood peak flow) increases erosion along banks

Source: Ehrenfeld 2000

Interdisciplinary Approaches

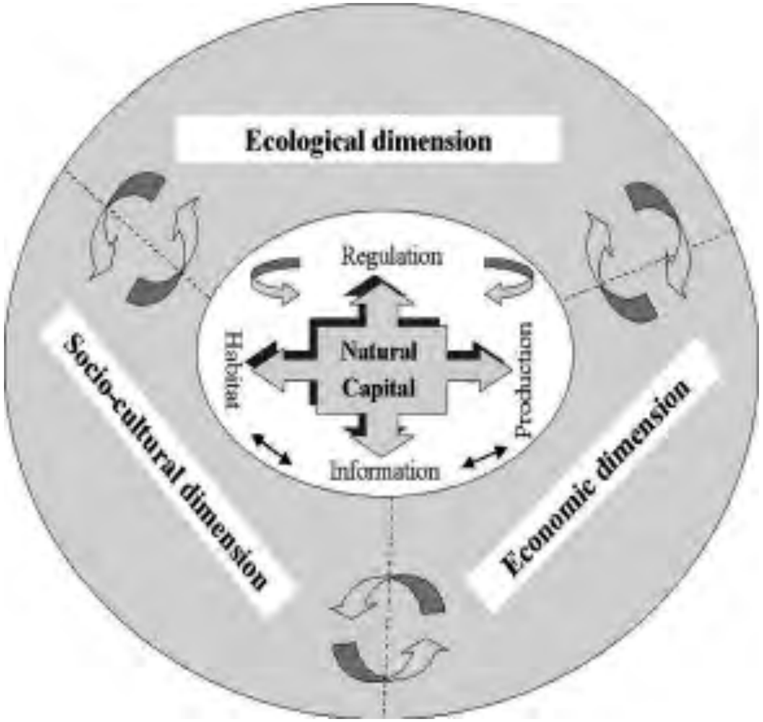
Socio-Ecological Resilience

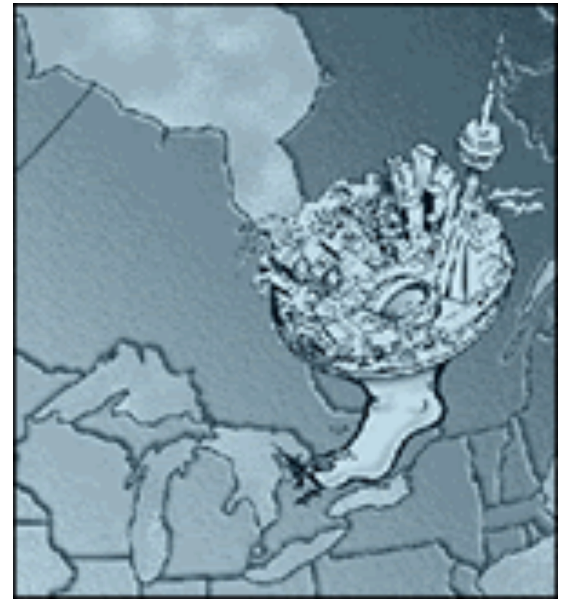
"The complexity of social-ecological systems makes it necessary to abandon the perception of a global steady state. Instead, managing complex coevolving social- ecological systems for sustainability requires the ability to cope with, adapt to and shape without losing options for future development. It requires resilience - the capacity to buffer perturbations, self organize, learn and adapt. When massive transformation occurs, resilient systems contain the experience and the diversity of options needed for renewal and redevelopment. Sustainable systems need to be resilient (Folke et.al. 1998, 28)."

Ecological Services

Landscape Planning

"Since thefate of our landscapes lies so squarely on the lap of society, it is imperative that our research move beyond our traditional descriptions of space, our academic divisions, and our rational methods" (Linehan et.al. 1998; 209).





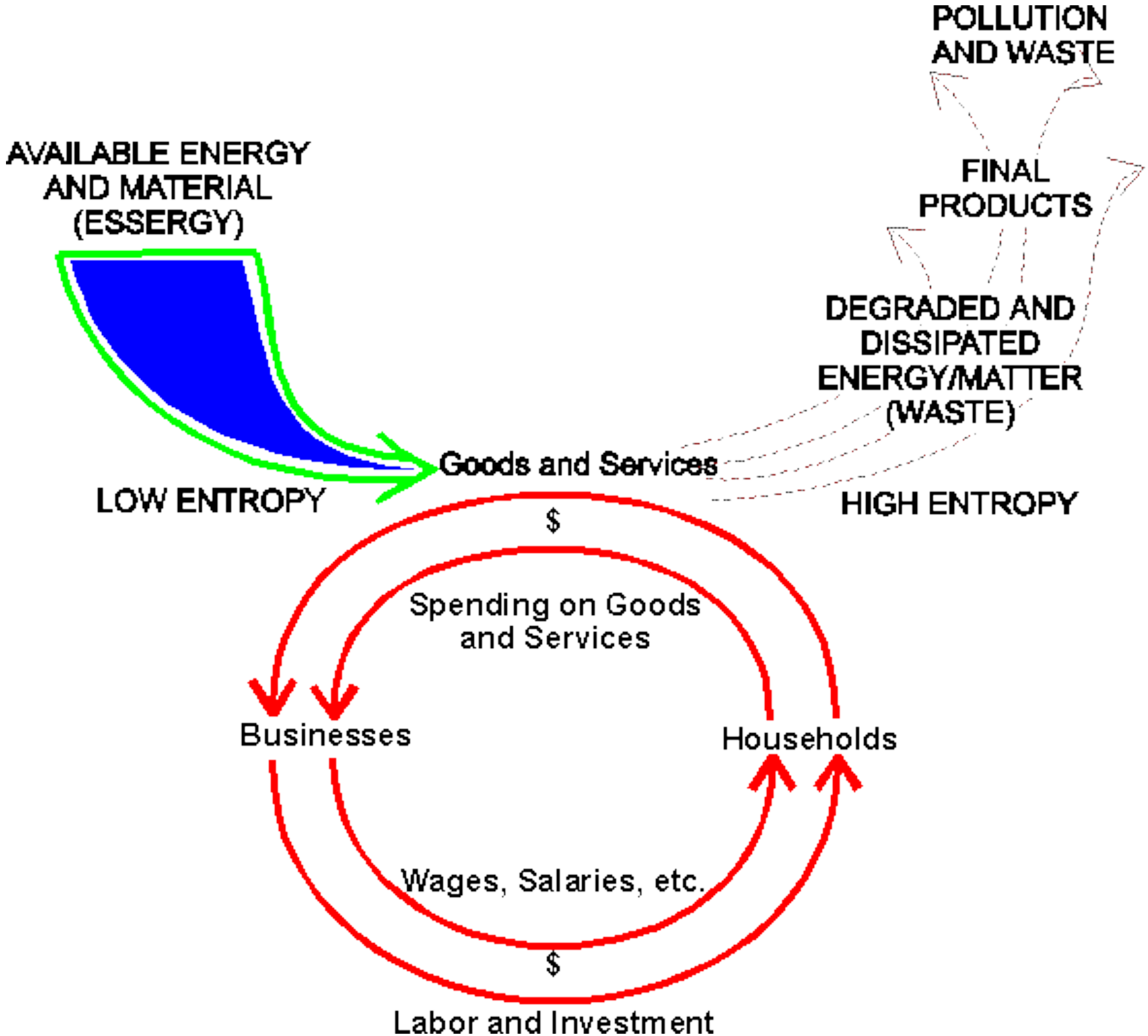
Economic Objectives
Growth, Equity, Efficiency

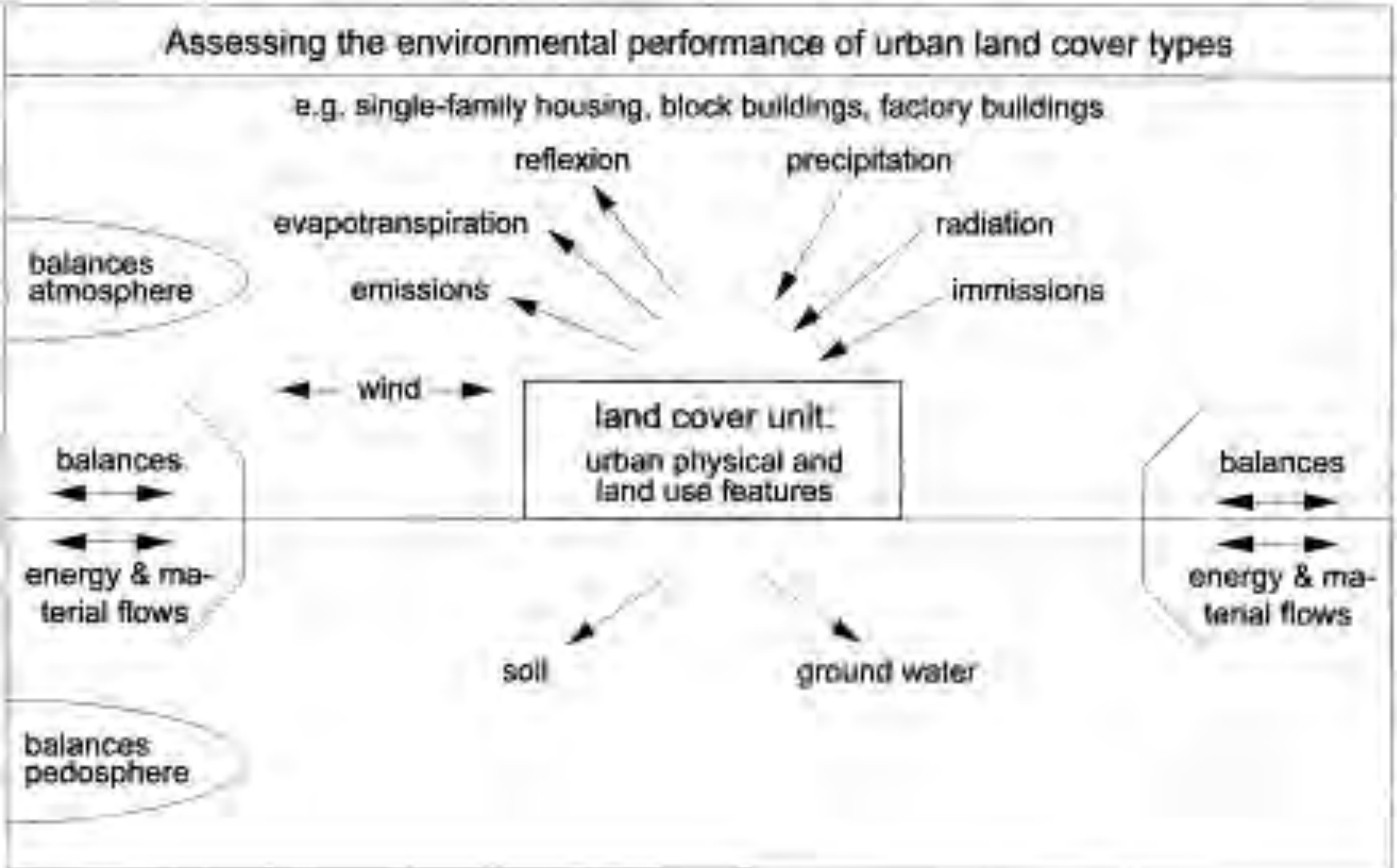
Sustainable Development

Social Objectives
Empowerment, Participation
Social Mobility and cohesion
Institutional development

Ecological Objectives
Ecosystem integrity
Carrying capacity, Biodiversity
Global issues

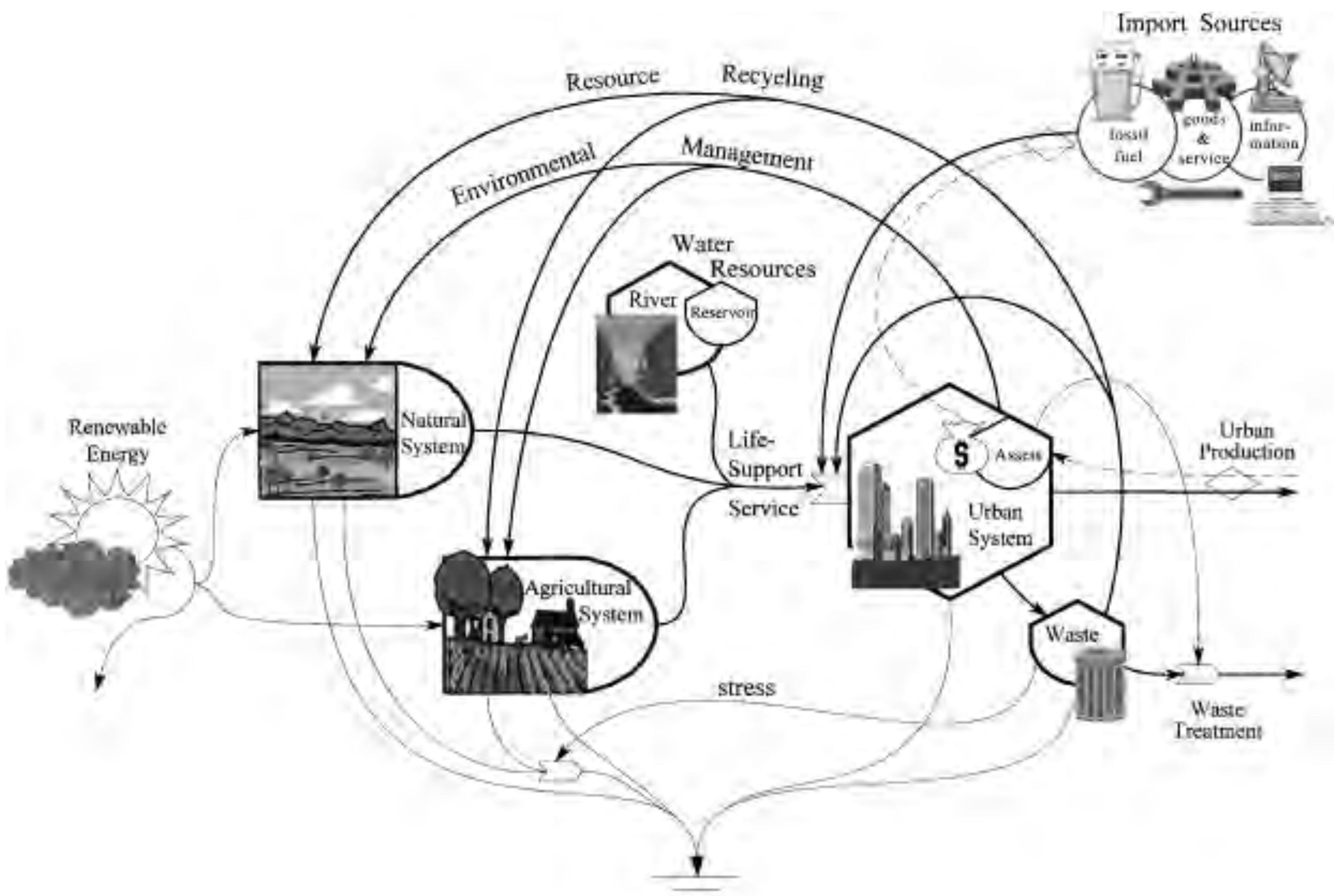
(Source: Serageldin and Steer 1994)


POLLUTION AND WASTE
AVAILABLE ENERGY AND MATERIAL (ESSERGY)
FINAL PRODUCTS
DEGRADED AND DISSIPATED ENERGY/MATTER (WASTE)
Goods and Services
LOW ENTROPY
HIGH ENTROPY
$
Spending on Goods and Services
Businesses
Households
Wages, Salaries, etc.
$
Labor and Investment

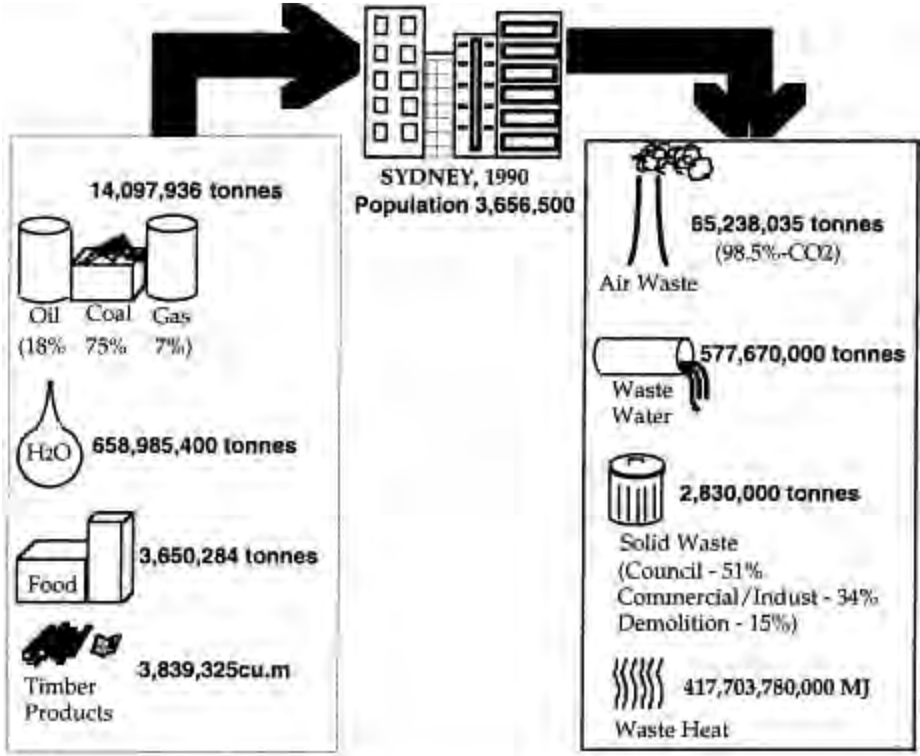


Assessing the environmental performance of urban land cover types
e.g. single-family housing, block buildings, factory buildings
reflexion
precipitation
evapotranspiration
radiation
emissions
immissions
balances atmosphere
wind
land cover unit:
urban physical and land use features
balances
energy & material flows
balances
energy & material flows
soil
ground water
balances pedosphere

Urban Metabolism



Sydney, Australia



Notes:
Waste water data do not include stormwater
Timber products and food data derived from national per capita data

Source: Newman 1999


Guangdong, China
Hong Kong
SAR
Deep
Bay
Mai Po
Marsh
New Territories
Mirs Bay
Kowloon
Victoria
Harbour
PRC
Hong Kong
1000
km
Lantau
Island
Hong Kong
Island
0
km
10

HONG KONG

Material	Material input			Transformations			Waste Output
	Import	Local	Total	To air	To water	Stored	
Food	4.5	0.5	5.0	3.7	0.3	—	1.0
Fossil fuels	13.0	—	13.0	12.0	—	—	1.0
Construction materials	6.5	18.5	25.0			22.0	3.0
Other goods	3.5	—	3.5	—	0.2	0.3	3.0
Total	27.5	19.0	46.5	15.7	0.5	22.3	8.0

	10^6 t yr^{-1}			kg cap^{-1} yr^{-1}		
Type of material	1971	1997	% change	1971	1997	% change
Food	2.4	5.0	+108	570	680	+20
Fossil fuel	4.0	13.0	+225	1000	2000	+100
Construction materials	4.0	25.0	+525	1000	3800	+280
Other goods	1.0	3.5	+250	250	530	+112
Total solids	11.5	46.5	+304	2920	7027	+141
Fresh water	390	913	+134	99 010	137 976	+39
Salt water	1302	9323	+616	330 500	1 410 000	+327
Air (O_2)	32.5 (6.5)	105 (23)	+223	8250 (1650)	15 870 (3475)	+92
Total solid waste	3.0	13.8	+245	762	2086	+174
Sewage	288	677	+153	73 115	102 311	+40
BOD_5	0.13	0.20	+54	33	31	–6
CO_2 emissions	9.0	31.6	+250	2285	4776	+119
Air pollutants	0.26	0.33	+27	65	50	–23

Note: Hong Kong's year-end population was 3 939 000 in 1971 and 6 617 100 in 1997.

1971 Fuel type	Domestic	Commercial	Industrial	Local transport	Total
Solid	840	490	1094	0.0	2424
Liquid (inc LPG)	8134	9716	14 788	21 611	54 249
Electricity	4278	6399	7279	56	18 012
Town gas	541	385	93	0.0	1019
Final Energy Supply	13 793	16 990	23 254	21 667	75 704
Conversion losses	11 946	17 418	19 519	146	49 029
TOTAL (PES)	25 739	34 408	42 773	21 813	124 733
TJ cap^{-1} yr^{-1}	0.007	0.009	0.011	0.006	0.032
MJ cap^{-1} day^{-1}	18	24	30	15	87

1997 Fuel type	Domestic	Commercial	Industrial	Local transport	Total
Solid	87	206	57	0.0	350
Liquid (inc LPG)	3564	3197	33 861	113 334	153 956
Electricity	28 937	68 172	18 965	0.0	116 074
Town gas	12 465	10 529	911	0.0	23 906
Final Energy Supply	45 054	82 104	53 794	113 334	294 286
Conversion losses	44 986	104 323	28 844	0.0	178 153
TOTAL (PES)	90 040	186 427	82 638	113 334	472 439
TJ cap^{-1} yr^{-1}	0.014	0.028	0.012	0.017	0.071
MJ cap^{-1} day^{-1}	37	77	34	47	196

(a). Phosphorus, 1971 and 1997.

Category	Material inputs						Waste outputs			
	Imports and local		Exports and losses		Retained total		Water		Land	
	1971	1997	**1971**	1997	**1971**	1997	**1971**	1997	**1971**	1997
Human food	**6.7**	24.8	**0.8**	10.9	**5.9**	13.9	**4.4**	12.5	**1.5**	1.4
Animal feed	**4.1**	9.9	**0.5**	3.0	**3.6**	6.9	**3.3**	2	**0.3**	4.9
Fertilizers	**2.4**	10.3	—	3.4	**2.4**	6.9	—		**2.4**	6.9
Detergents	**2.4**	7.4	—	4.1	**2.4**	3.3	**2.4**	3.3	—	
Other	**8.4**	—	—	—	**8.4**	—	**8.4**	—		
Total	**24.0**	52.4	**1.3**	21.4	**22.7**	31	**18.4**	17.8	**4.3**	13.2

Notes:

(i) Some totals may not add up due to rounding.

(ii) Waste outputs to land are either stored, runoff or recycled.

(iii) Of the 1.5 t P day^{-1} human food waste outputs in 1971, 0.1 t P day^{-1} were stored in human bones and 1.4 t P day^{-1} were recycled (mainly as bonemeal fertilizers). By 1997, 0.3 t P day^{-1} were stored in human bones, with the remaining food wastes disposed of in landfills (i.e. none is recycled).

(iv) In 1971, the 0.3 t day^{-1} of animal feed to land was recycled as fertilizer from animal sewage. In 1997, 4.9 t P day^{-1} of animal manure was disposed of on land, and an estimted 1.3 t P day^{-1} was illegally discharged to surface waters. It should be noted that government statistics only recorded approx. 1 t P day^{-1} of imports of animal feed. Thus, the import/export figures have been adjusted to reflect the waste generation outputs, which are more easily and accurately estimated.)

(v) In 1971, of retained fertilizers, approximately 2.2 t P day^{-1} were stored in soil and groundwater and 0.1–0.2 t P day^{-1} was recycled. For 1997, Hong Kong trade statistics indicate a much higher amount of fertilizers being imported, exported and retained (6.9 t day^{-1}). This equates to about 2 500 t P yr^{-1} being applied to only 61 km^2 of arable land. Another use of these fertilizers may exist, since typical values are usually about 8–10 kg P ha^{-1}, or 0.13 t P day^{-1}. Our value may thus be an overestimate. Approximately 1 t day^{-1} of the total retained fertilizers to land (6.9 t day^{-1}) is stored in plants.

(vi) Hong Kong trade statistics show detergent use as 11 kg cap^{-1} yr^{-1}. P content can vary from 1% to 5%, which gives a range of estimated P in detergents of 2.0 to 9.9 t P day^{-1} (0.3 to 1.5 g cap^{-1} day^{-1}). We use a mid-range value of 0.5 g cap^{-1} day^{-1}.

(b). Nitrogen, 1997.

Category	Material inputs			Waste outputs		
	Imports & local	Exports & losses	Retained total	Water	Air	Land
Human food	240	108	132	115	4.0	13.0
Drinking water	8	0	8.0	8.0		
Animal feed	9.6	2.7	6.9	1.3	0.7	4.9
Fish farms				4.0		
Fertilizers	10.0	4.7	5.3	1.8		1.8
Combustion					114	
Landfill leachate						3.3
Total	268	115	153	130	119	23

Notes:

(i) Some totals may not add up due to rounding.

(ii) Depending on the statistical sources used (e.g., Hong Kong trade statistics versus FAO) and assumptions regarding N content in food, a range of 16 to 25 g N cap^{-1} day^{-1} was obtained. We have chosen the mid-range value of 20 g N cap^{-1} day^{-1}.

(iii) Incoming drinking water imported from the Dongjiang River in Guangdong (698 Mm^3 in 1997) contained 4.17 g N m^{-3}, for an estimated total of 8 t N day^{-1}.

(iv) Based on the number of animals in Hong Kong in 1997, an estimated 1522 mt N yr^{-1} is produced by pigs, 5 t N yr^{-1} from cows and 728 t N yr^{-1} by chickens. Based on EPD solid waste data (30), about 4.9 t N day^{-1} is collected and landfilled, of which about 13% is composted. The remaining 1.3 t N day^{-1} is assumed to be discharged to surface waters. Fish farms contribute an additional 1453 t N yr^{-1}, which is discharged directly to the marine environment.

(v) Approximately 1/3 of fertilizer (1.8 t day^{-1}) is assumed to be uptake by plants, with the remaining 2/3 discharged evenly to land and water.

(vi) Atmospheric deposition values vary between 0.4–4.0 g m^{-2} yr^{-1}. We chose a mid-range value of 2.0 g m^{-2} yr^{-1}, which would add 6.9 t day^{-1} to imports and which would potentially be deposited to marine waters.

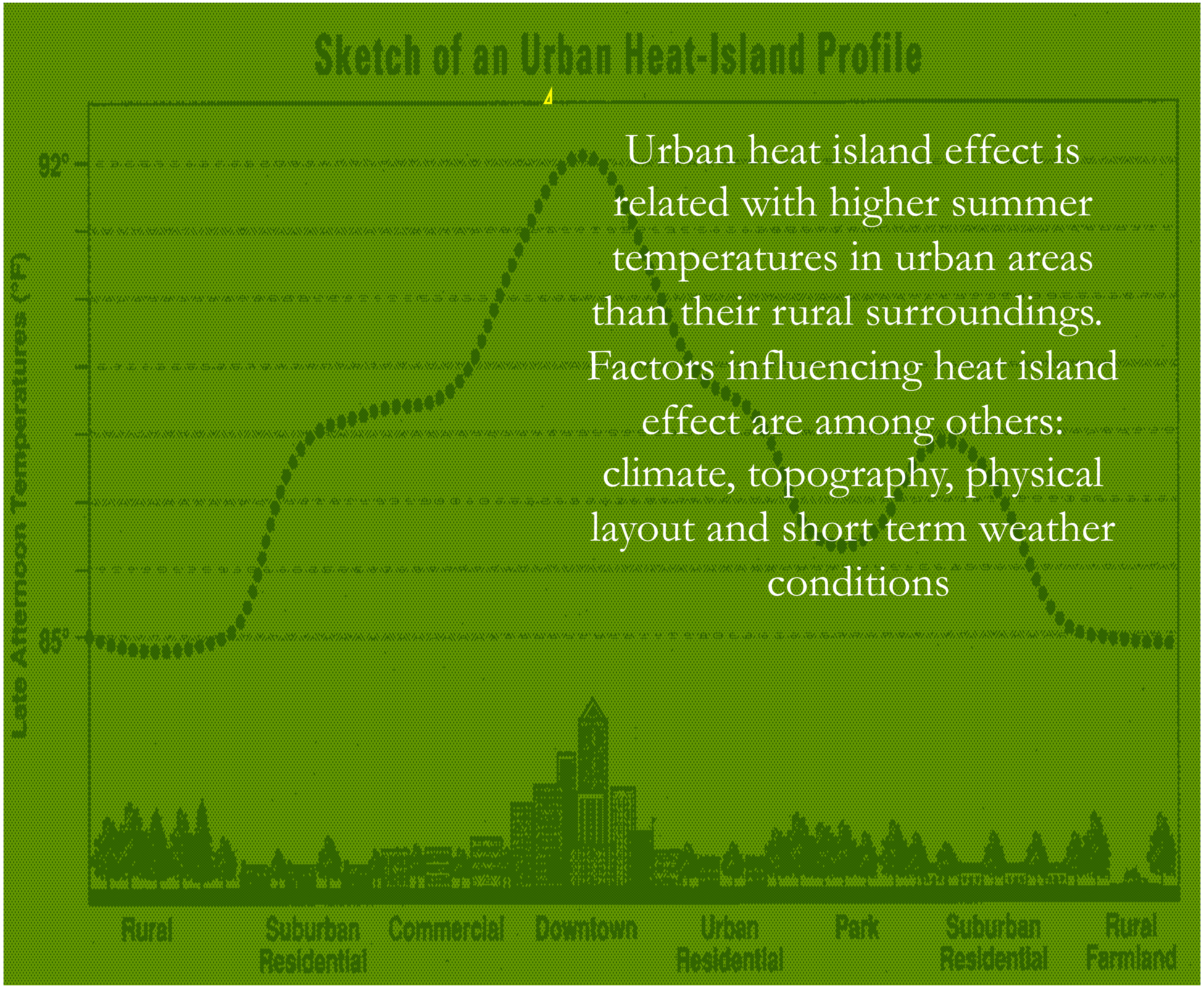
(vii) Based on Barron and Steinbrecher (6), total inorganic N input into Hong Kong from the Pearl River Delta is approximately 143 t N day^{-1}. Other estimates range from 465–1315 t TIN day^{-1}; thus our figures may be underestimates.

Vegetation and Ecological Services in Urban Areas

- purification of air and water
- mitigation of droughts and floods
- generation and preservation of soils and renewal of their fertility
- maintenance of habitats
- protection of slopes from erosion
- protection from the sun's harmful ultraviolet rays
- partial stabilization of climate
- moderation of weather extremes and their impacts
- psychological needs and social function

(Constanza 1992, Ehrlich and Ehrlich 1981).

Heat Island

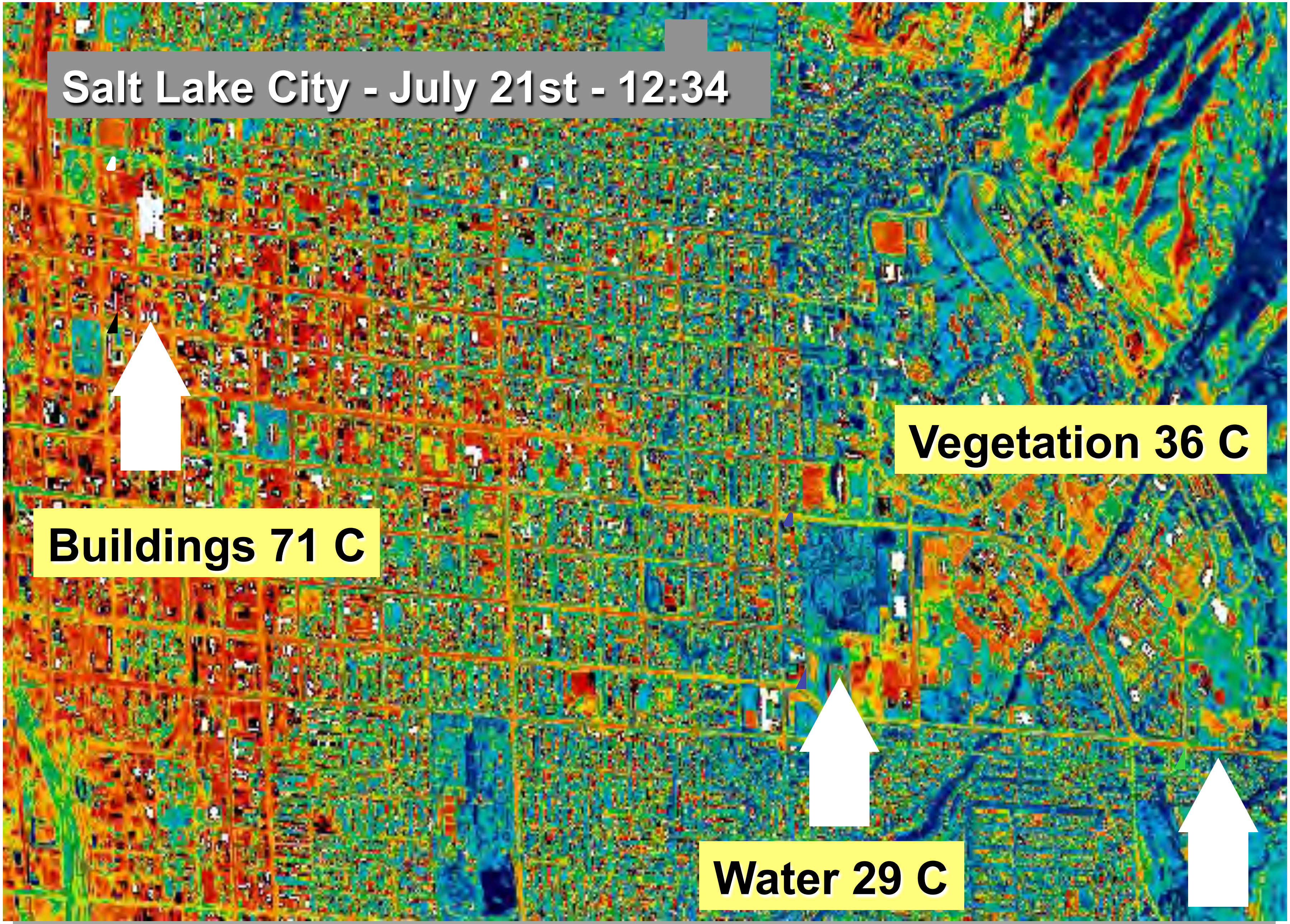


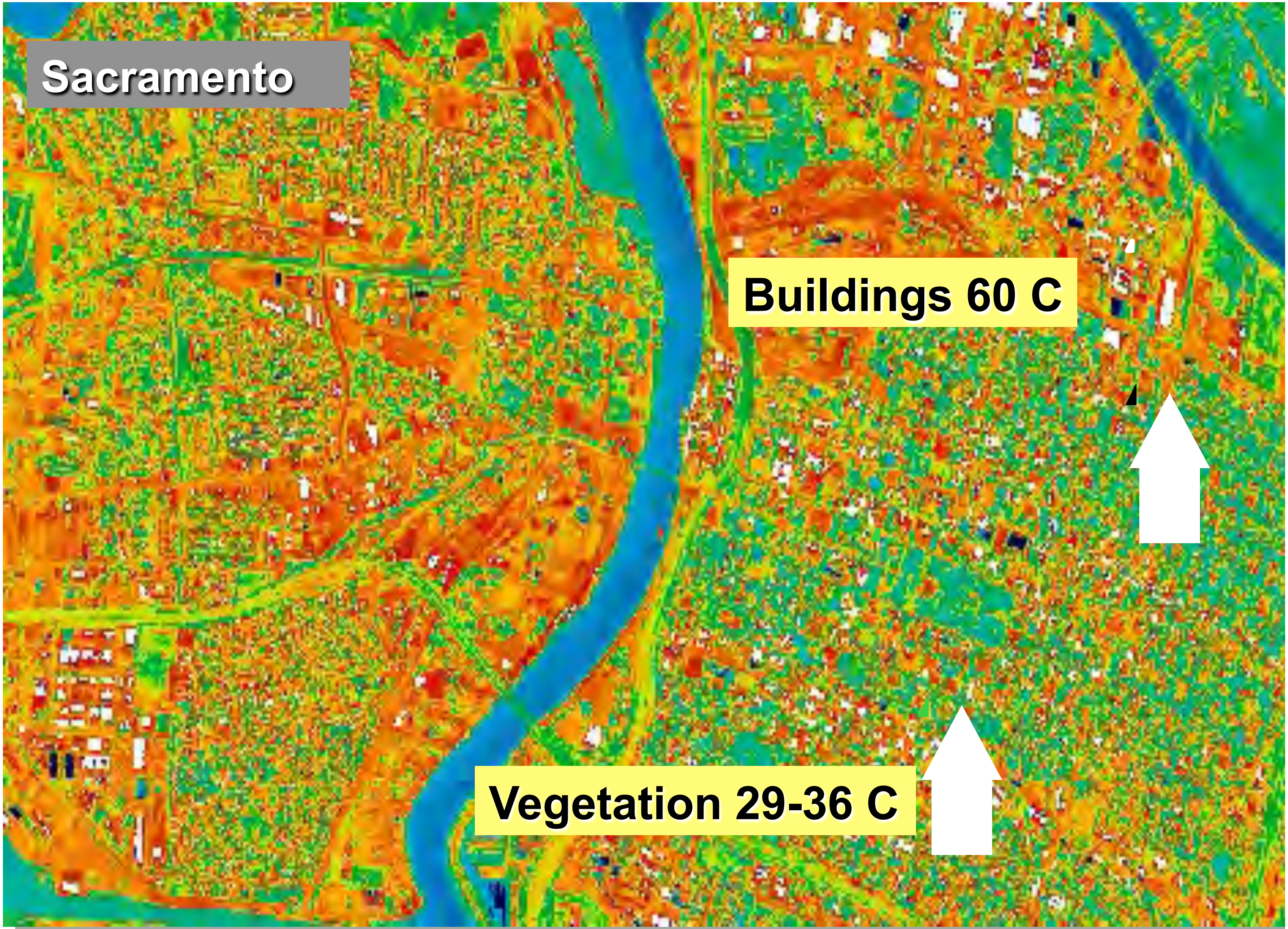
Urban heat island effect is related with higher summer temperatures in urban areas than their rural surroundings. Factors influencing heat island effect are among others: climate, topography, physical layout and short term weather conditions

Heat Island

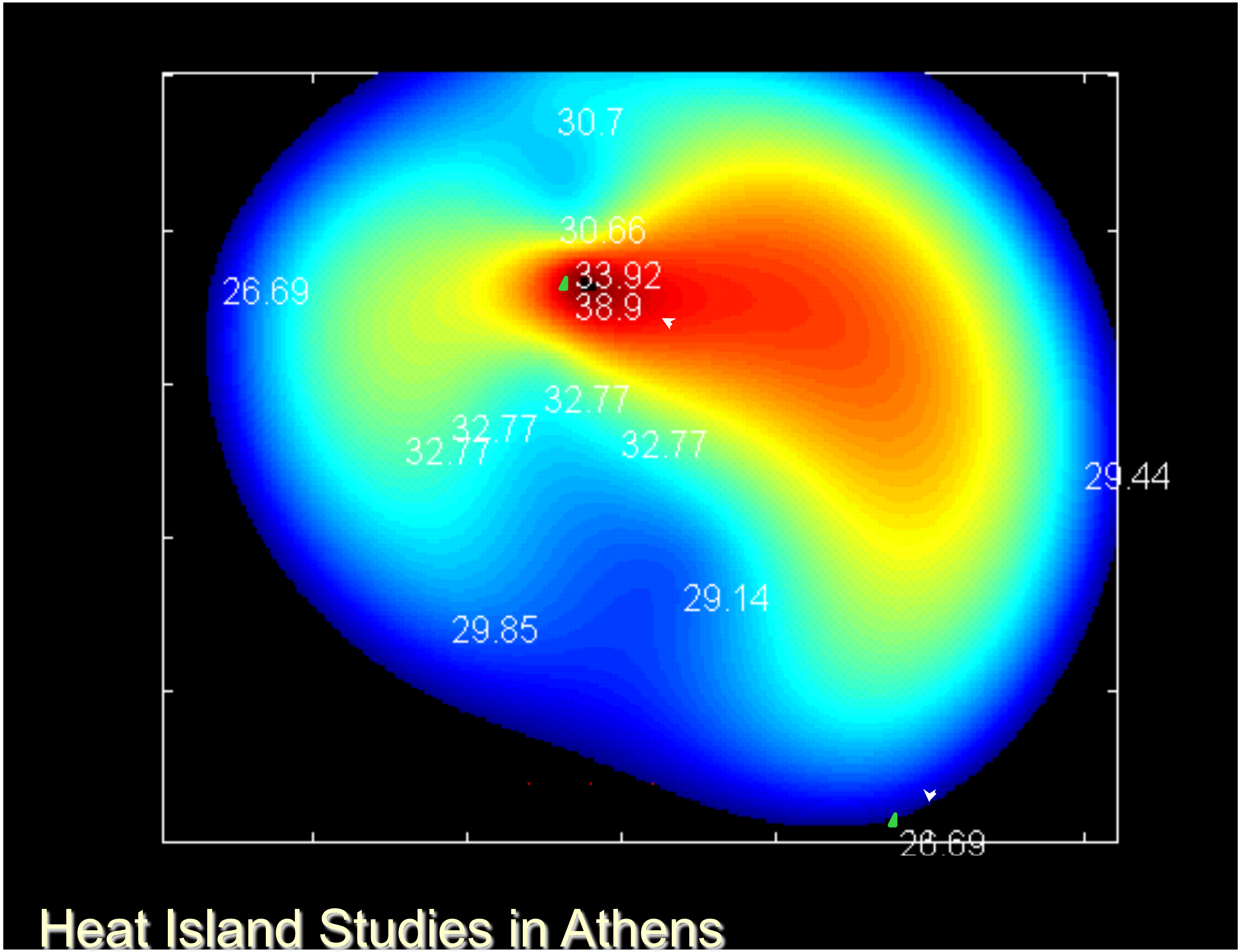
Thermal Balance in the Urban Environment

The thermal balance in the urban environment differs substantially than that of rural areas. Anthropogenic heat released by cars and combustion systems, higher amounts of solar radiation stored, and blockage of the emitted infrared radiation by urban canyons makes the global thermal balance more positive and contributes to the warming of the environment.


Salt Lake City - July 21st - 12:34
Vegetation 36 C
Buildings 71 C
Water 29 C

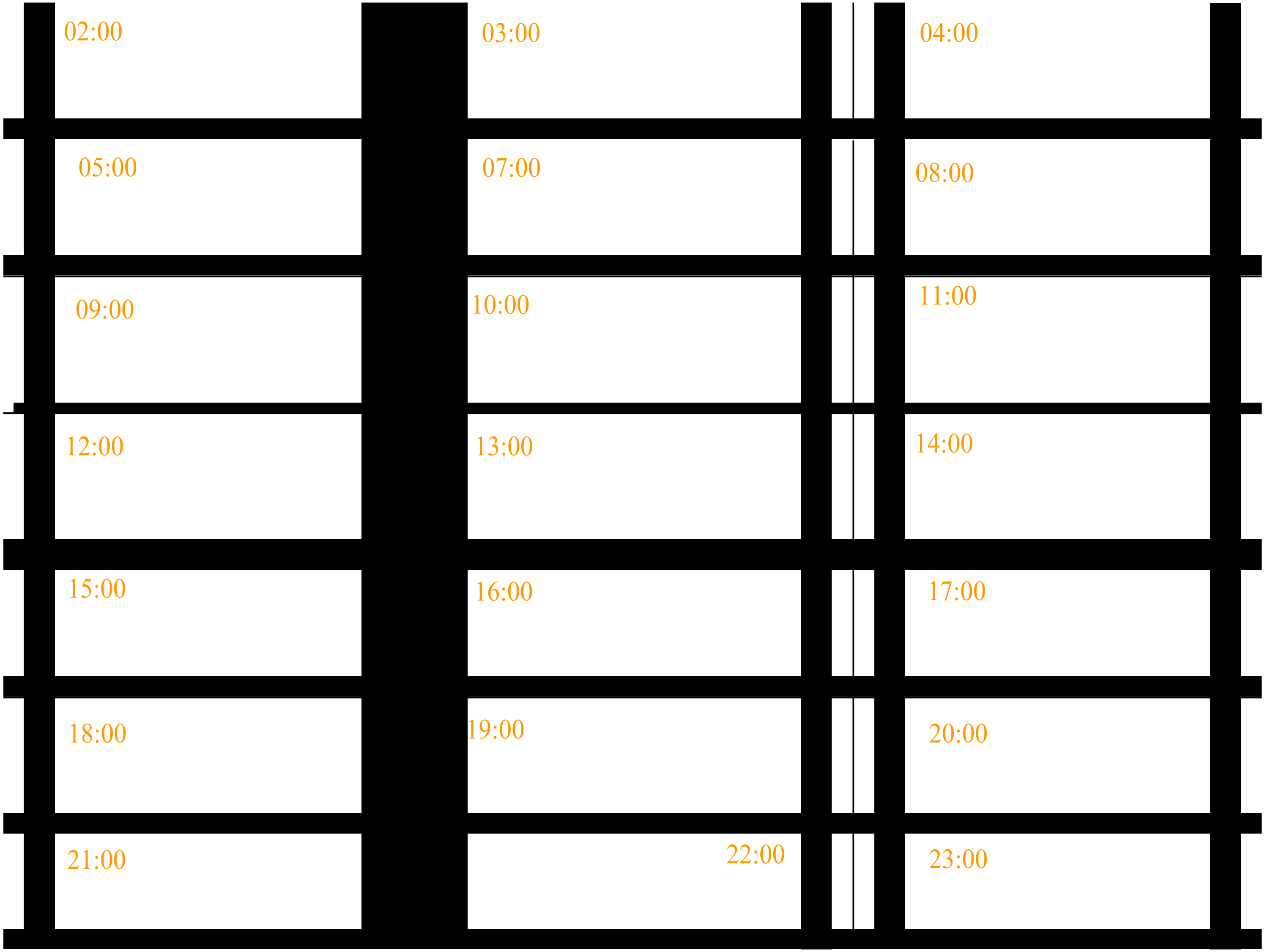


Sacramento
Buildings 60 C
Vegetation 29-36 C



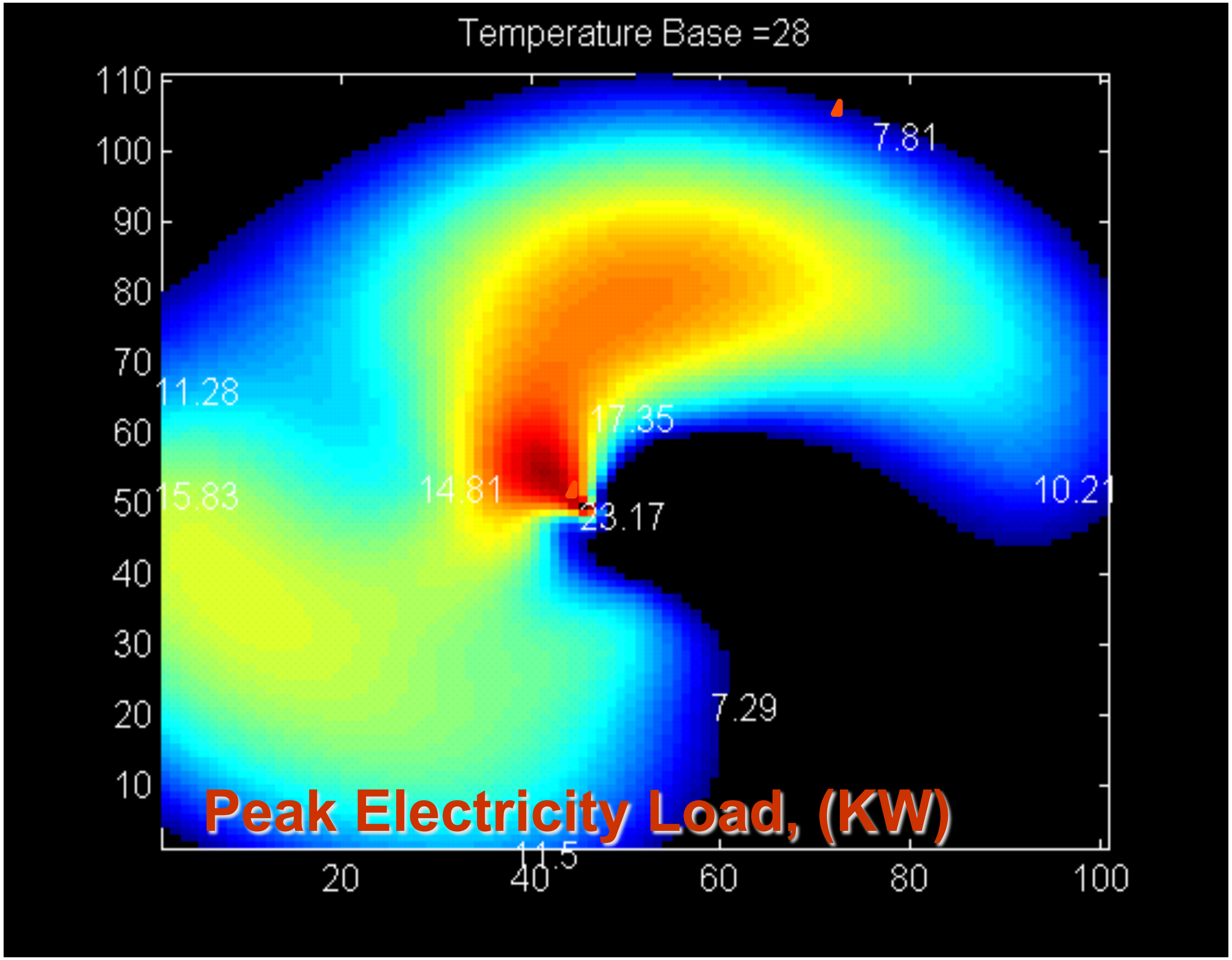
Source: Santamouris 2000

Heat Island



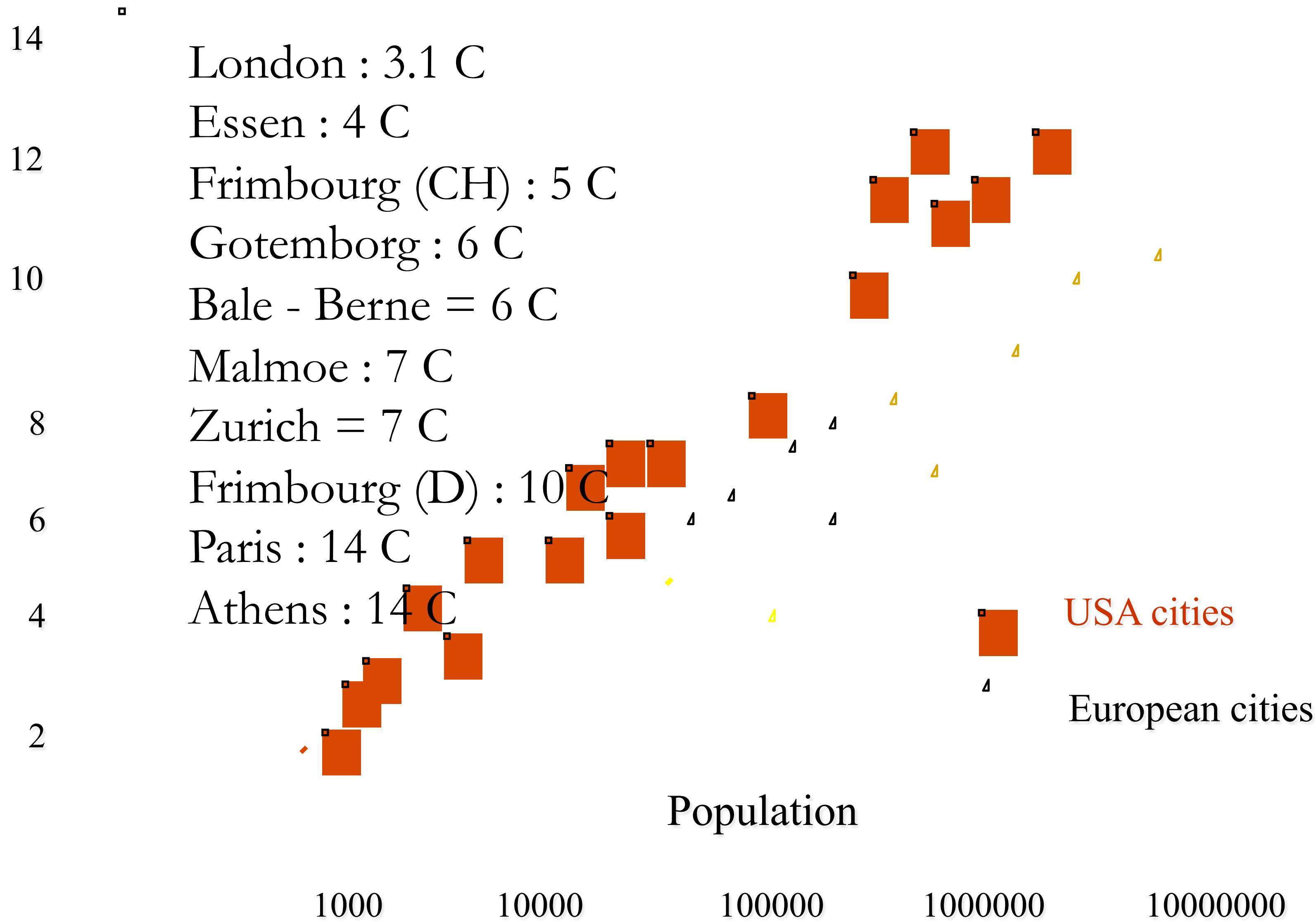
Source: Santamouris 2000

Energy Impact



Source: Santamouris 2000

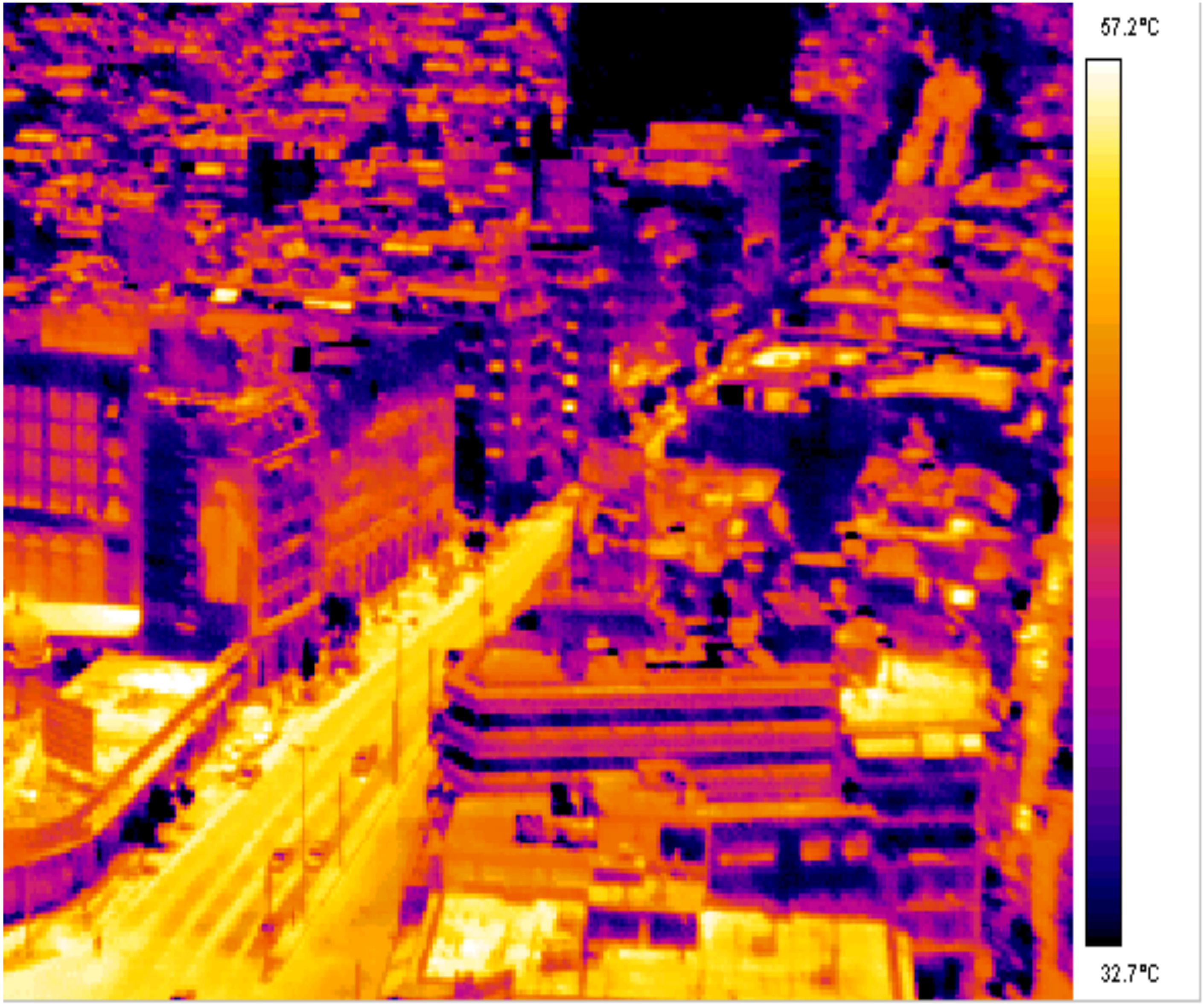
Heat Island



Source: Santamouris 2000

Heat Island

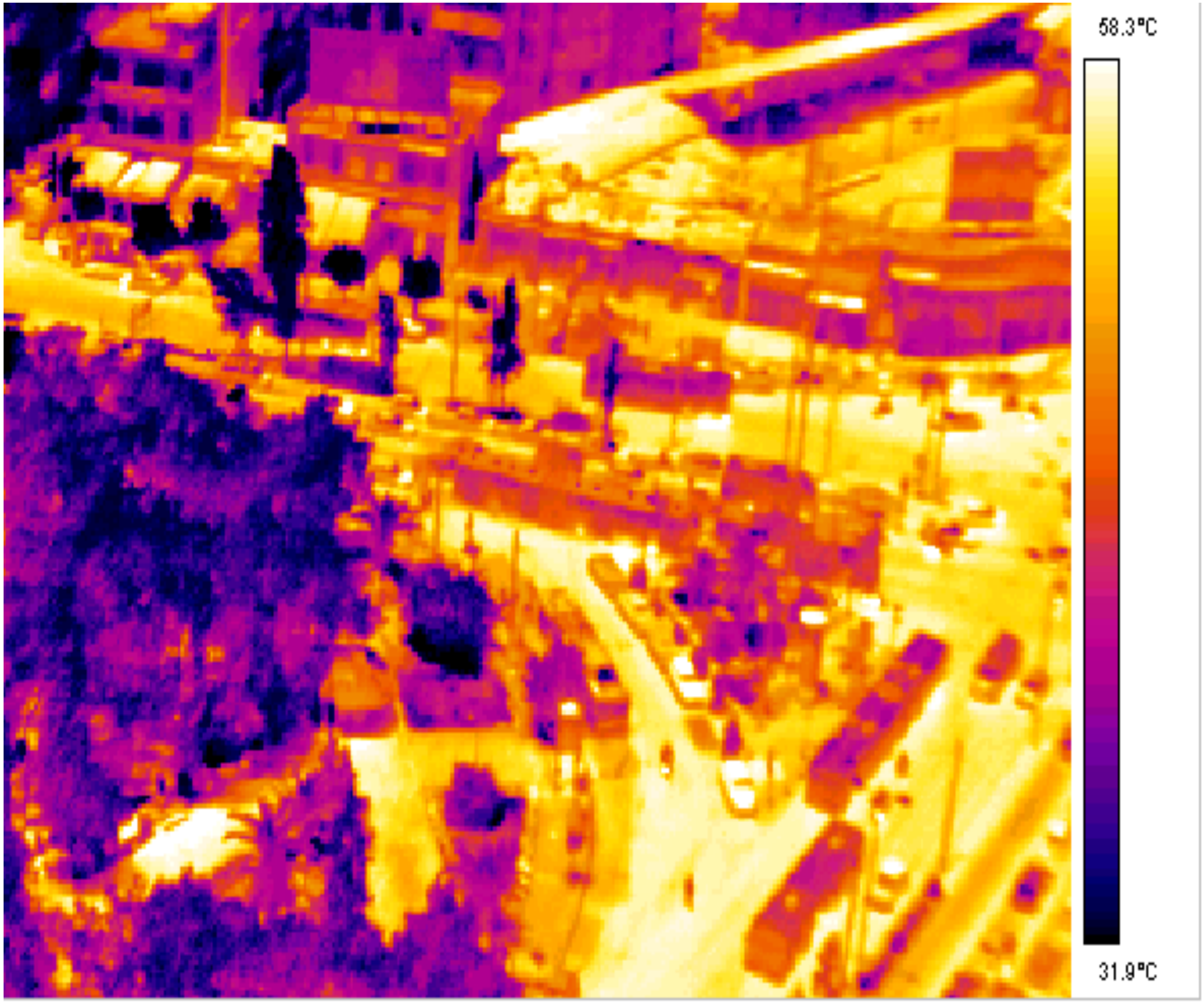
Data on the heat island in Shanghai, China show that the urban area is always warmer than the countryside, and on calm clear nights the temperature difference is about 6 C. Studies on the heat island intensity in Singapore show that the intensity of heat island is close to one degree. For Havana Cuba a heat island intensity between 1-3 C is measured, while studies for Cairo, Egypt show a heat island intensity close to 4 C occurred during the night and the early morning hours of the summer period. Similar studies on the heat island in Dhaka, of Bangladesh, shows an intensity between 0.5 to 6 C that occurs during the night. The intensity during the summer period was relatively low, (0.6 C), due to the high relative humidity and strong surface wind.



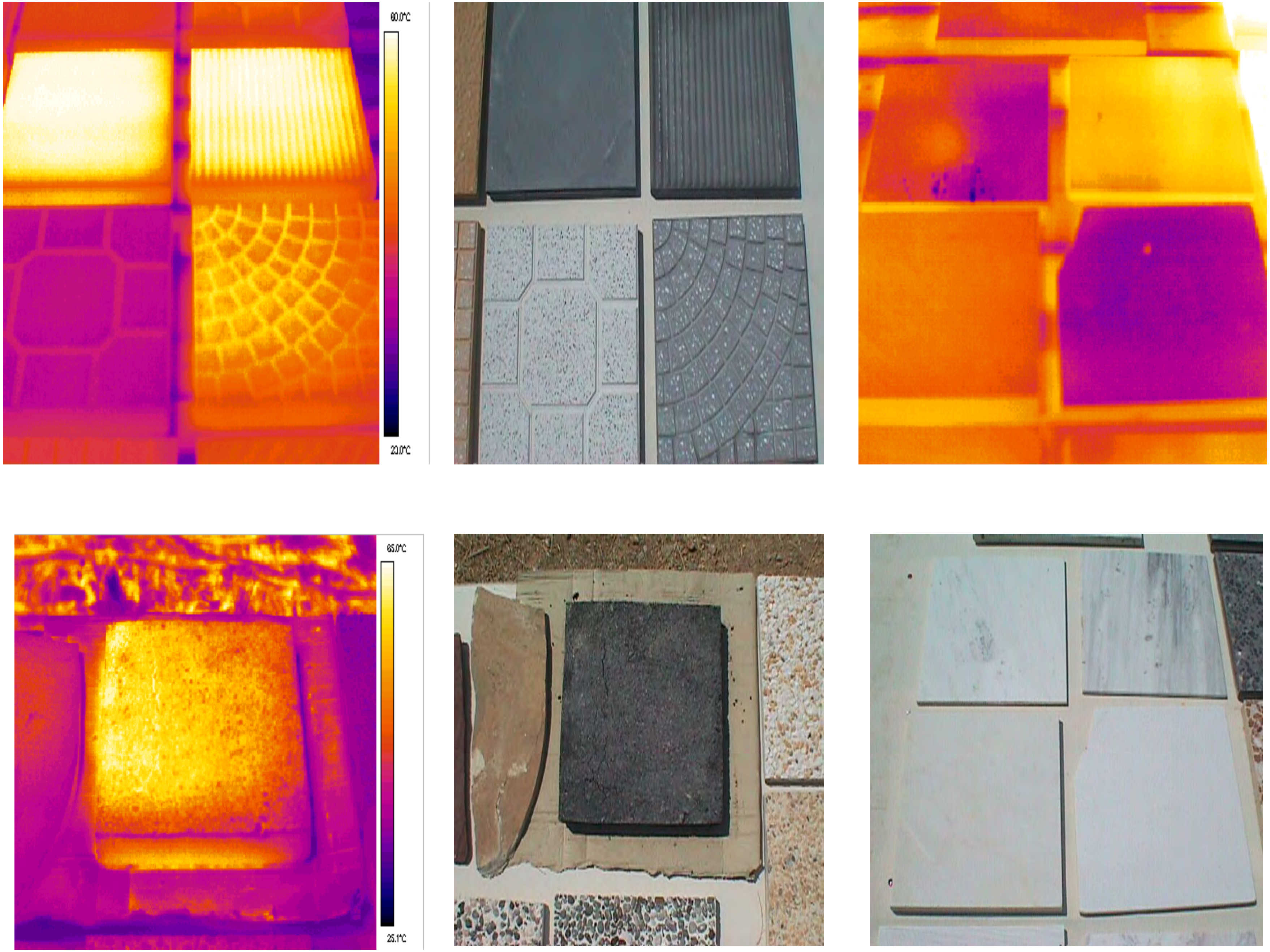
Heat Island Microclimate

Source: Santamouris 2000

Heat Island Microclimate



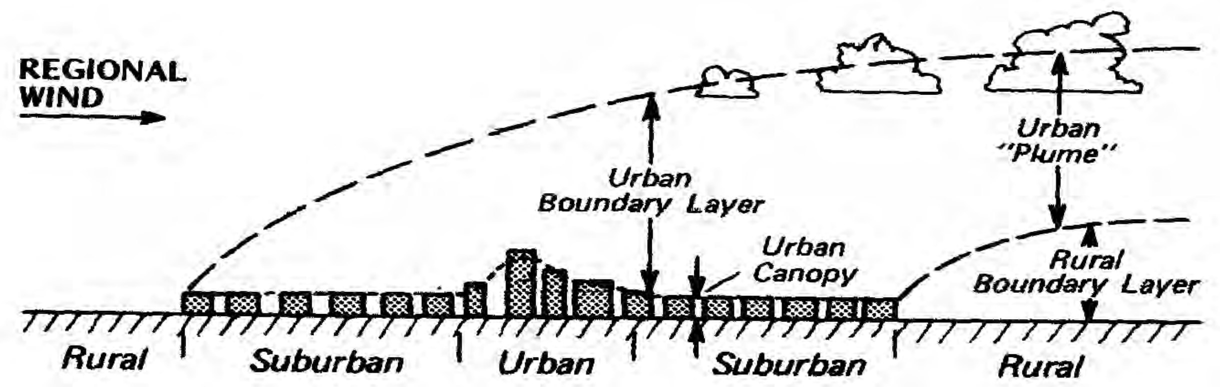
Source: Santamouris 2000



Source: Santamouris 2000

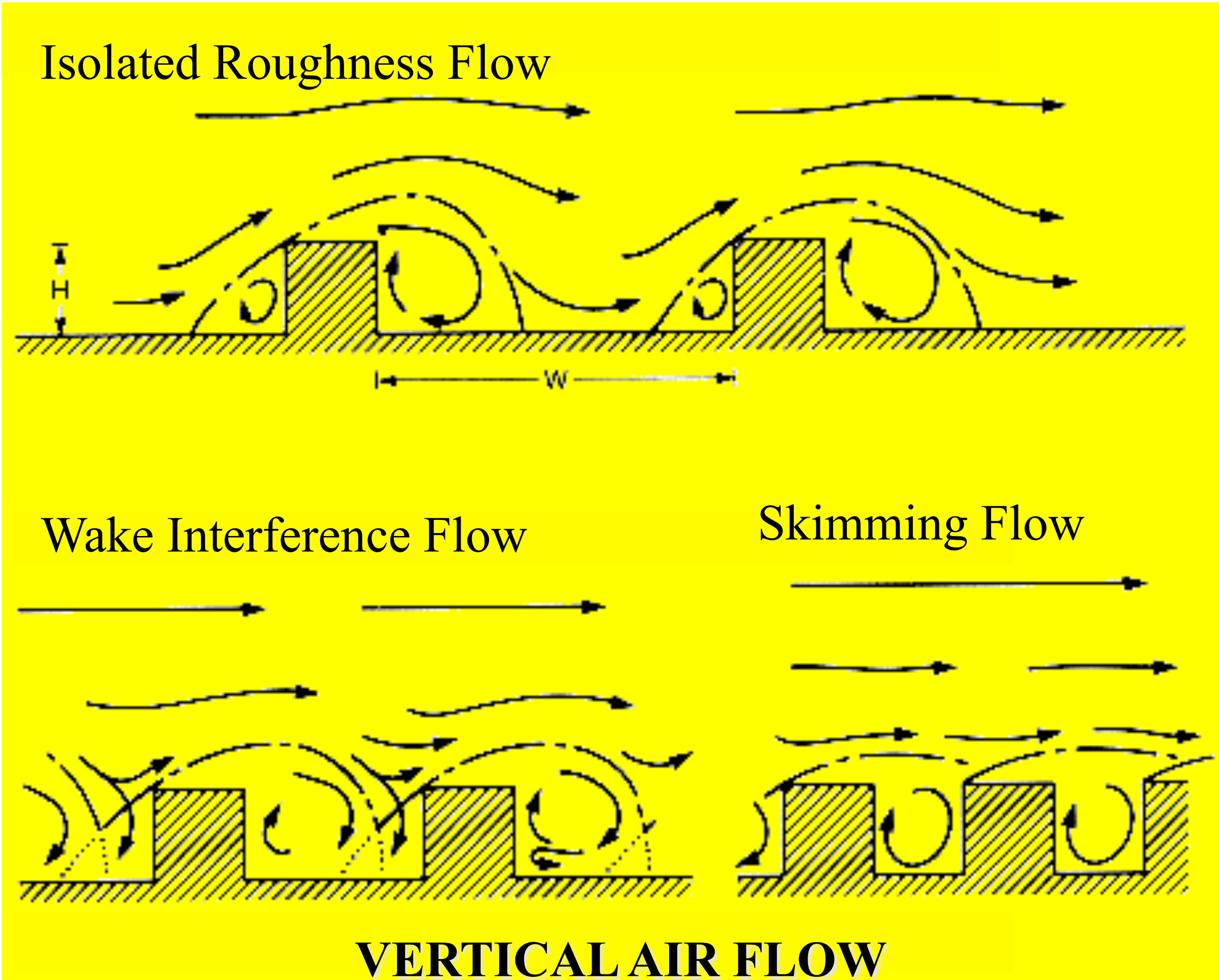
Wind Patterns

The urban wind field is complicated. Small differences in topography may cause irregular air flows. As the air flows from the rural to the urban environment, it must adjust to the new boundary conditions defined by the cities. This results to the development of a two layers vertical structure. Oke, has characterized the wind variation with height, over cities by defining two specific sub-layers. The so called 'obstructed sub-layer', or urban canopy sub-layer which is extended from the ground surface up to the buildings height, while the so called 'free surface layer' or urban boundary layer, is extended above the roof tops.



Source: Santamouris 2000

Wind Patterns



Perpendicular Flow

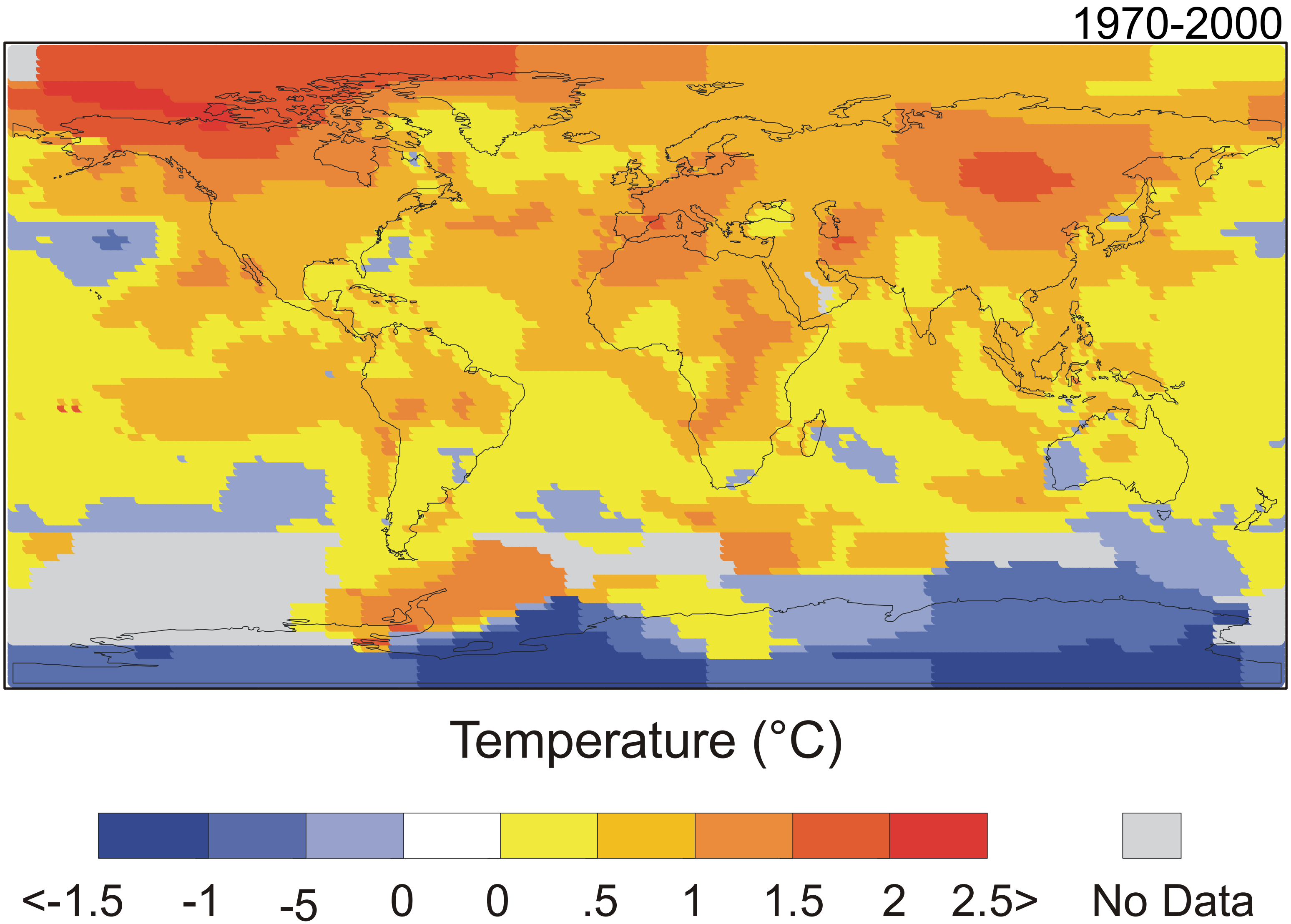
Wind Patterns

Street canyon climate is an important topic of urban climatology while it is of considerable practical concern. Air circulation and distribution within canyons is of significant importance for pollutant dispersion studies, heat and mass exchange between the buildings and the canyon air including studies on the potential of natural ventilation techniques for buildings, pedestrian comfort, etc. It is clear that buildings in canyons without a high climatic quality use more energy for A/C in summer and even more electricity for lighting.

Source: Santamouris 2000

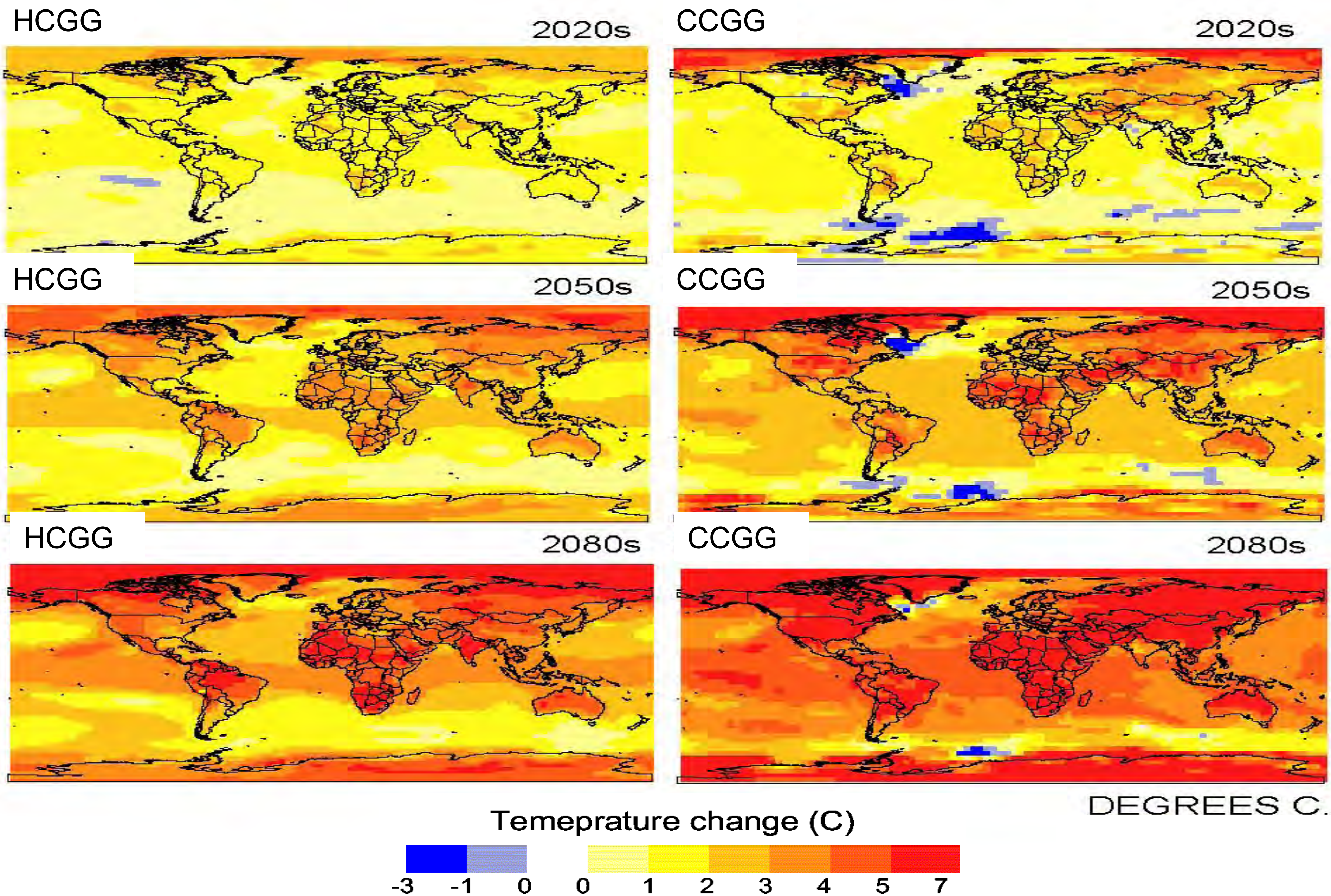
Wind Patterns

IPCC Working Group I

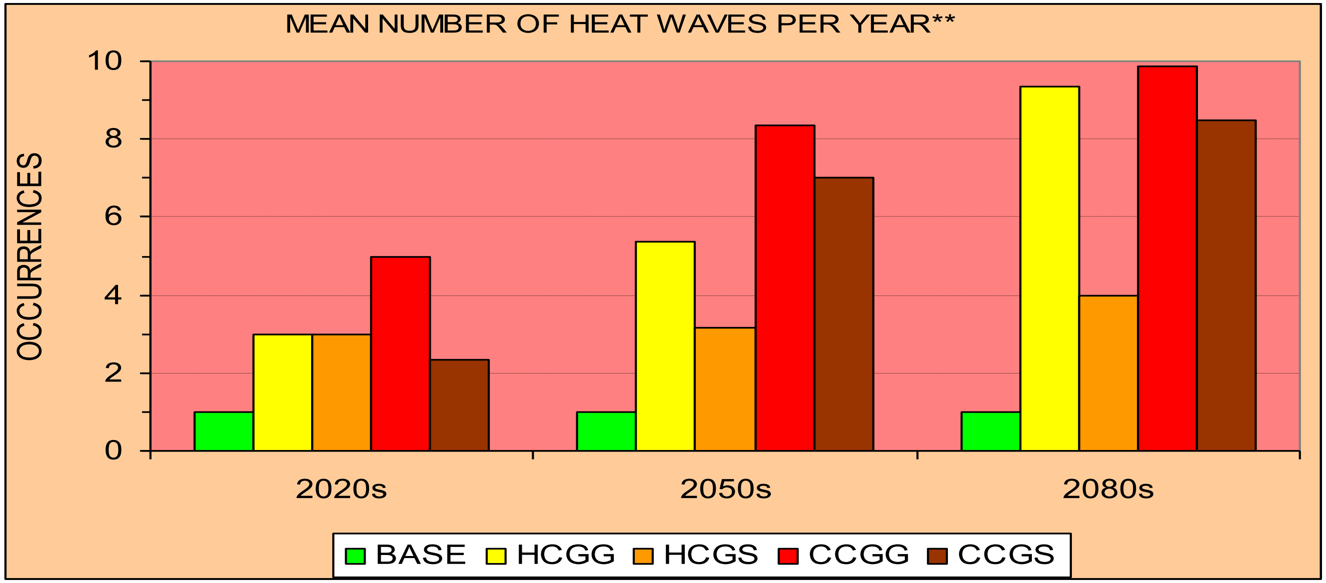


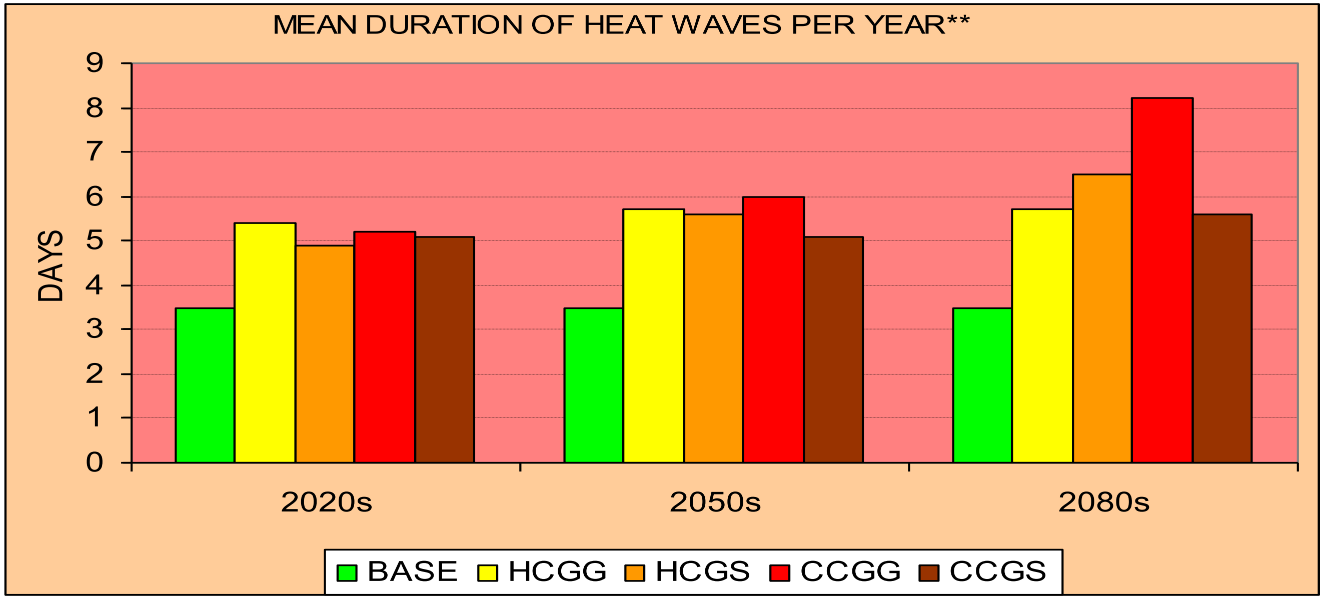
GISS, 2001

PROJECTED CHANGE IN ANNUAL TEMPERATURE

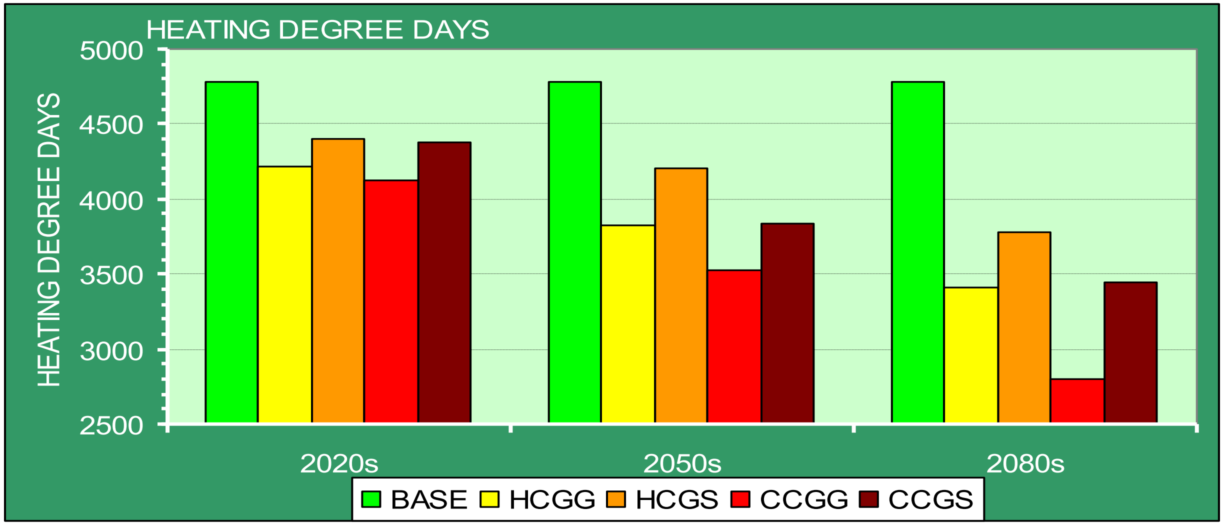


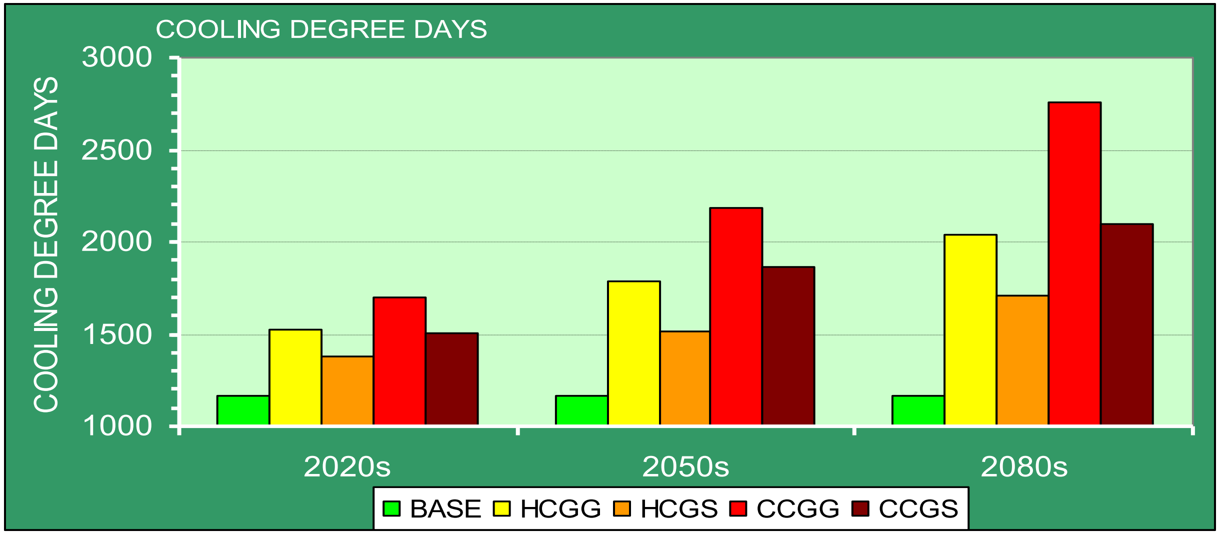
Projected Heat Waves in New York City



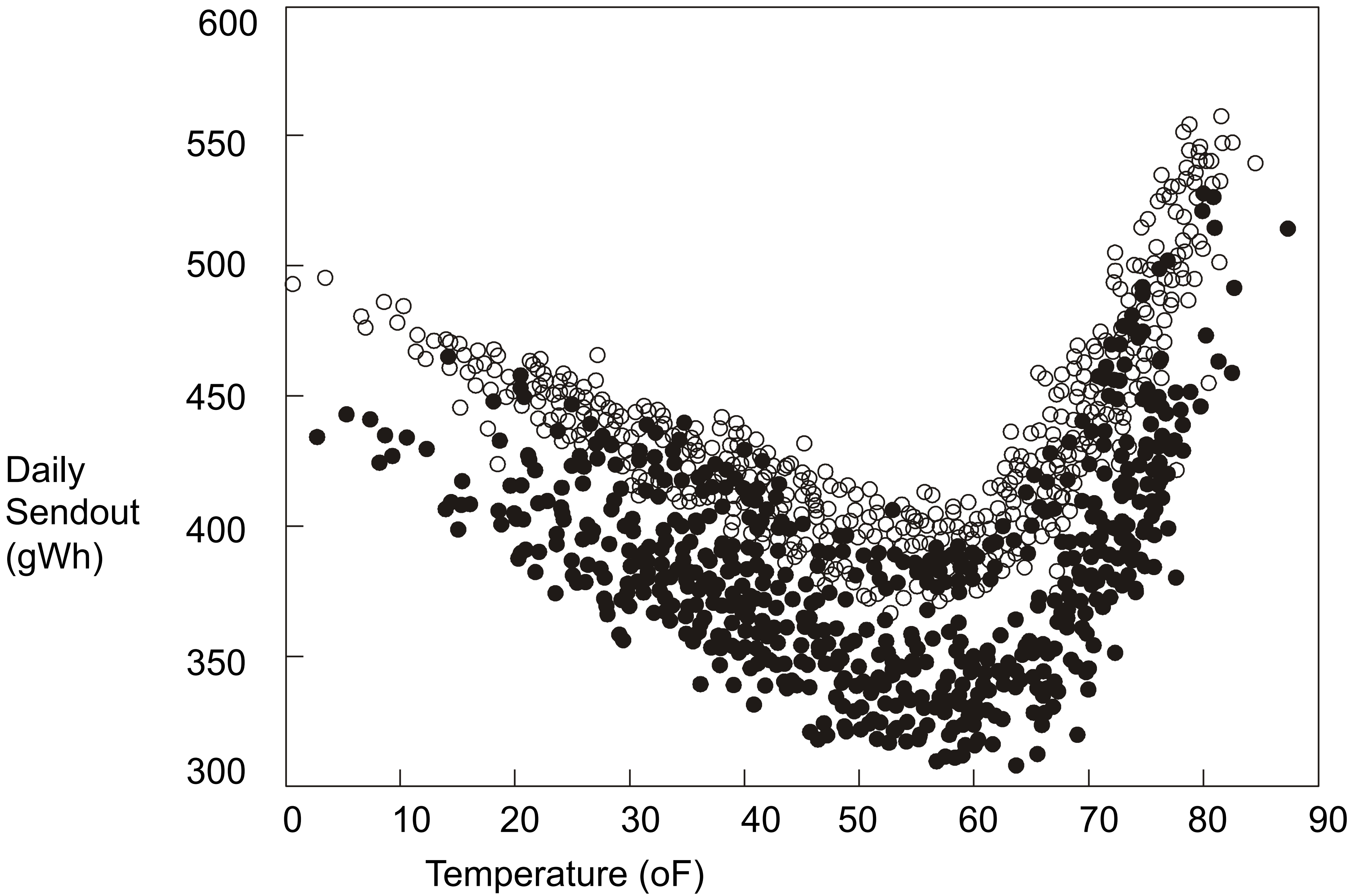


Projected Number of Degree-days in New York City

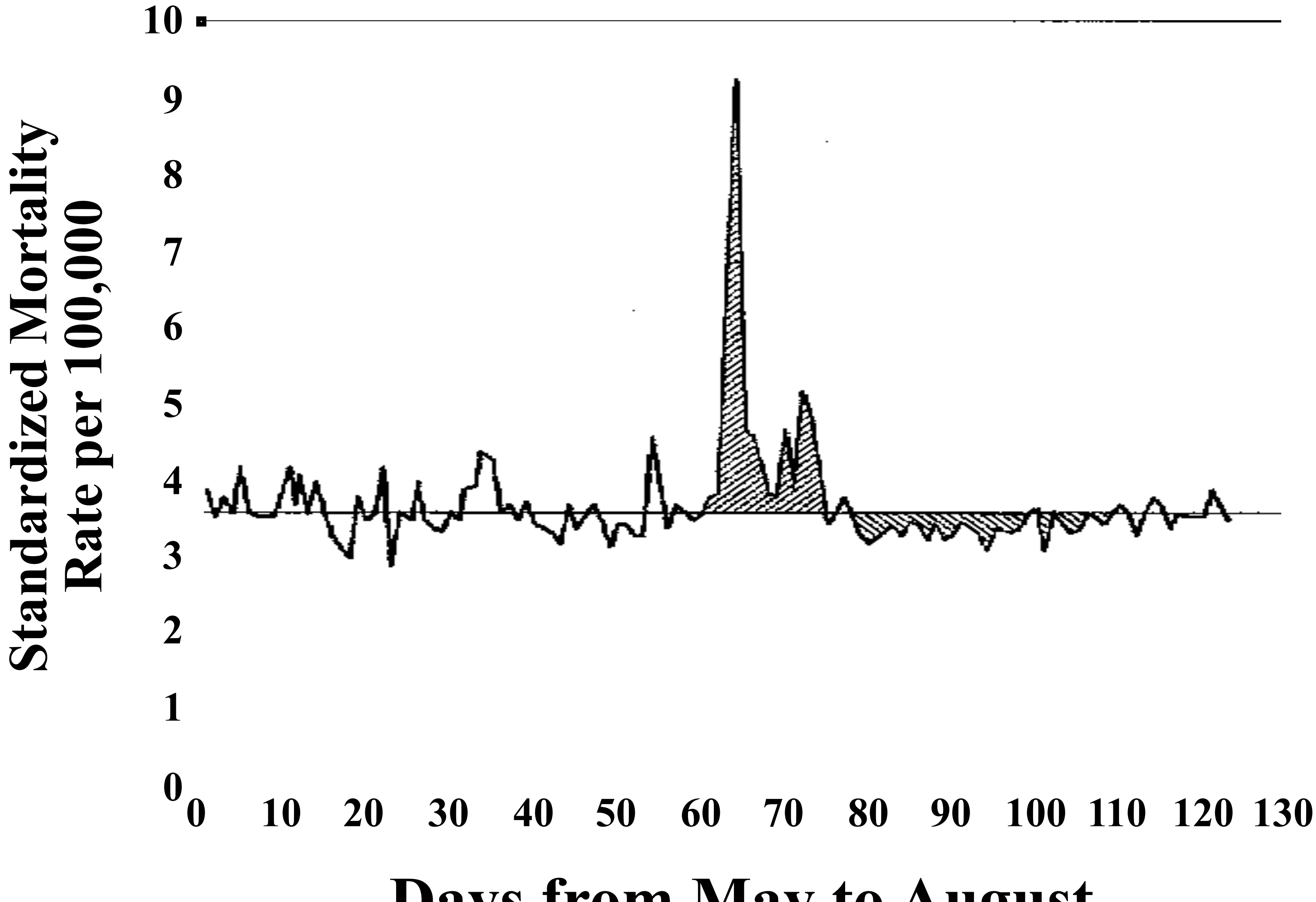




Daily Electric Energy "Sendout"(gwh) vs. Avg. Temp. (°F)
New York State – 1996, 1997

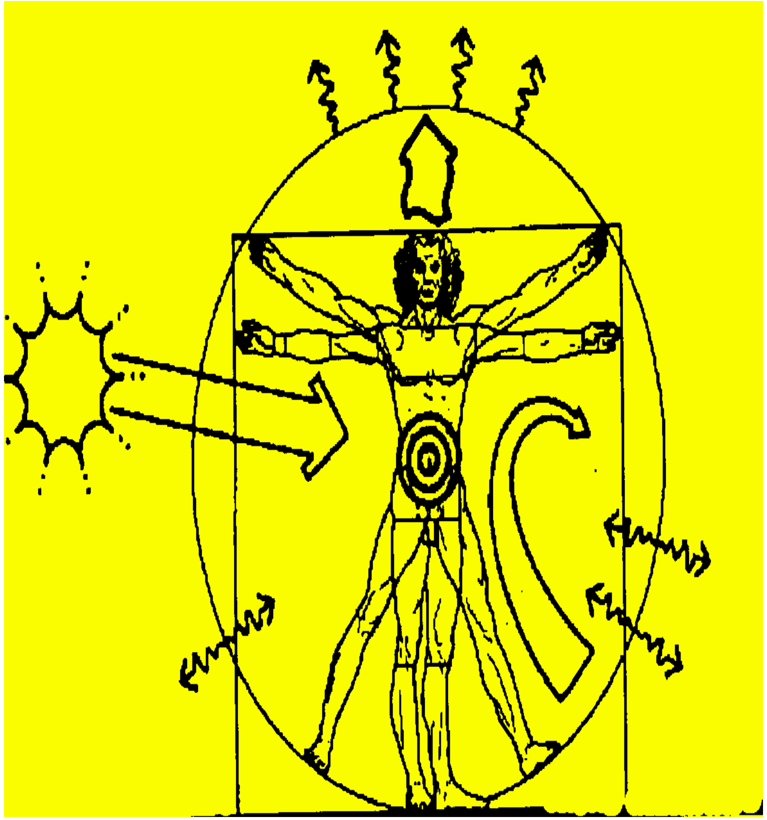


Deaths Associated with the July 1996 Heat Wave, New York City



Source: WHO, 1996

Comfort is defined as the sensation of complete physical and mental well being. Thermal neutrality, where an individual desires neither a warmer nor a colder environment, is a necessary condition for thermal comfort. The factors affecting comfort comfort are divided into personal variables, (activity and clothing), and environmental variables, (air temp, mean radiant temp, air velocity and air humidity).



Techniques to Improve Urban Microclimate

- Trees and green spaces contribute significantly to cool our cities and save energy.
- Trees can provide solar protection to individual houses during the summer period while evapotranspiration from trees can reduce urban temperatures.
- Trees also help mitigate the greenhouse effect, filter pollutants, mask noise, prevent erosion and calm their human observers.

Techniques to Improve Urban Microclimate

Simulations for cities across the US indicate that shade from a single well placed, mature tree can reduce annual air conditioning use 2 to 8 % and peak cooling demand 2 to 10 %. Other studies found that by adding one tree per house, the cooling energy savings range from 12 to 24 %, while adding three trees per house can reduce the cooling load between 17 to 57 percent.

According to this study, the direct effects of shading account for only 10 to 35 % of the total cooling energy savings. The remaining savings result from temperatures lowered by evapotranspiration.

•Trees and green spaces created oasis of 1-5 C during night in Athens, in San Fransisco's heavily vegetated Golden Gate Park average about 8 C cooler than nearby areas that are less vegetated.

•In Tokyo, vegetated zones in summer are 1.6 C cooler than non vegetated spots, while in Montreal, urban parks can be 2.5 C cooler than surrounding built areas. The park in Mexico city was 2-3 C cooler with respect to its boundaries.

•Simulations for cities across the US indicate that shade from a single well placed, mature tree can reduce annual air conditioning use 2 to 8 % and peak cooling demand 2 to 10 %.

•Other studies found that by adding one tree per house, the cooling energy savings range from 12 to 24 %, while adding three trees per house can reduce the cooling load between 17 to 57 percent.

• According to this study, the direct effects of shading account for only 10 to 35 % of the total cooling energy savings. The remaining savings result from temperatures lowered by evapotranspiration.

The American Forestry Association, estimated that the value of an urban tree is close to $ 57000 for a 50 years old mature specimen.

The above estimate includes a mean annual value of $ 73 for air conditioning, $ 75 for soil benefits and erosion control, $ 50 for air pollution control and $ 75 for wildlife habitats.

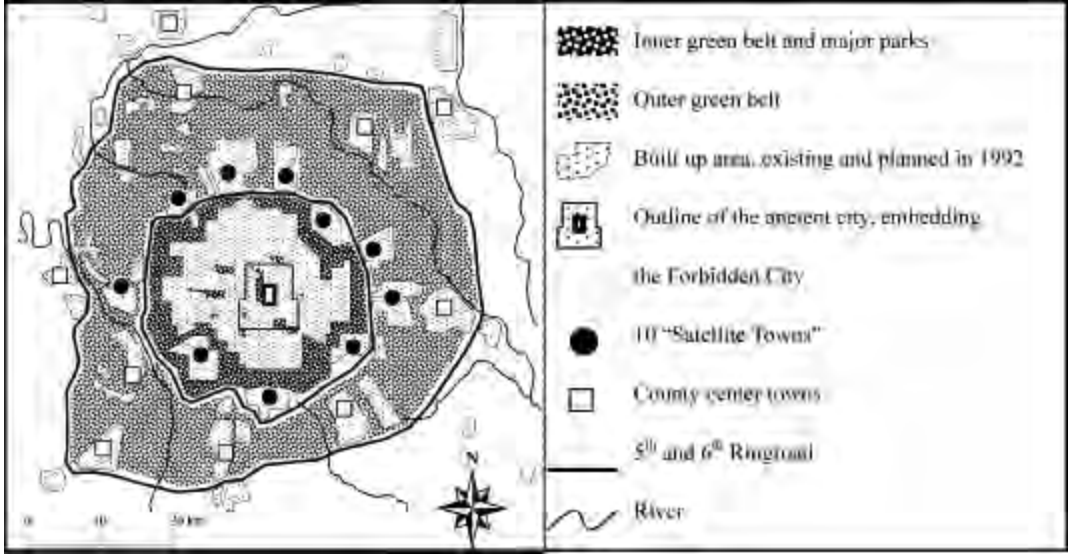
(1) In Summer season, 1 ha of green space can absorb 81.8M joules of heat. Some well-greening urban area has 3-5o C lower temperature than poor or naked urban area (Beijing Institute of Gardening1985,1992).

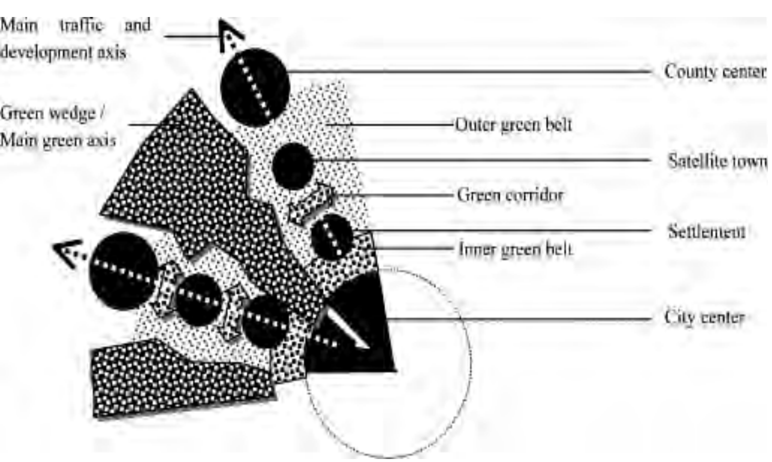
(2) 1 ha of green space can transpire 182 tones of water, taking off 448 M joules of heat. One Japanese pagoda tree (*Sophora japonica*) with a breast diameter of 20cm can transpire 439.46kg of water and absorb 83.9 kwh of heat (Shanghai city gardening bureau, 1994,east China,).

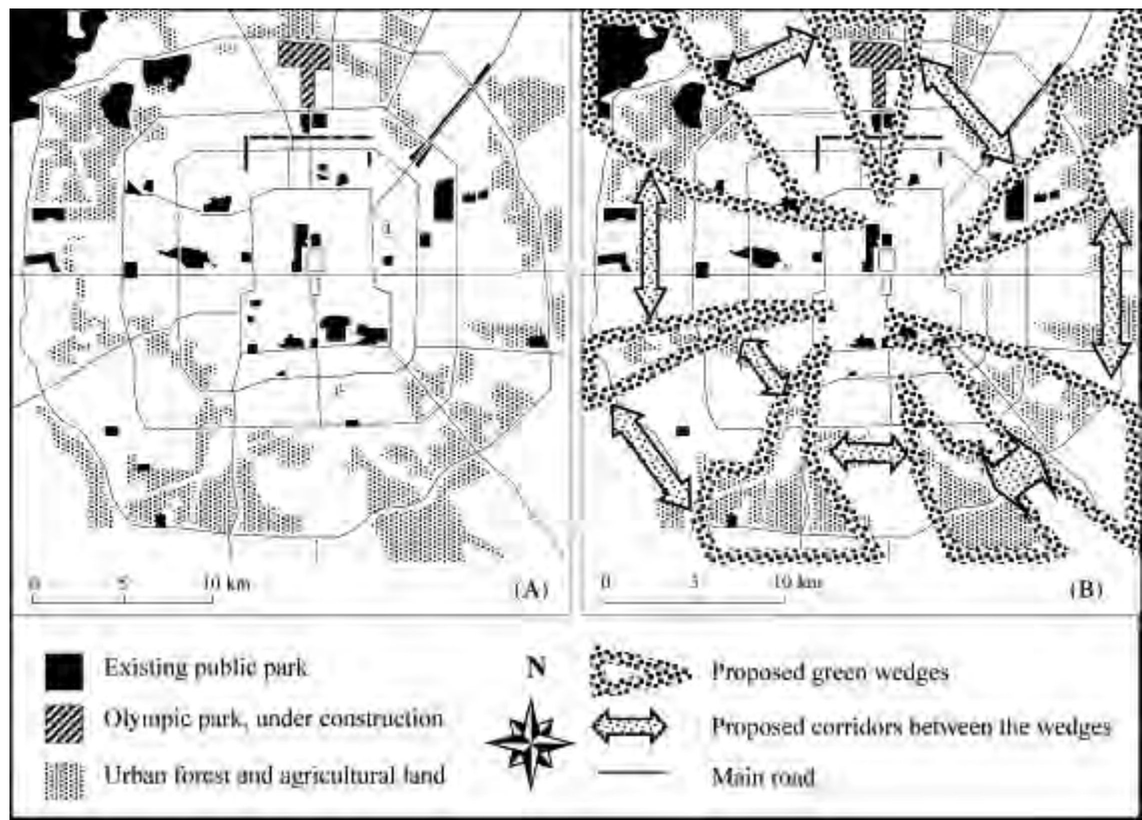
(3) 1ha of forest can absorb one tones of CO_2 daily, releasing 0.73tones of O_2, balancing the concentration of O_2 and CO_2 in the air.

(4)In raining season, the tree crown can intercept 65% of rain water, 35% of it becoming groundwater. Some experiments shows that one 25-year tree can absorb 150mm of rain water per hour, a 22-year artificial forest can absorb 300mm rainfall, 7-8 times higher than that in naked land.

The Planning of Green Areas in Beijing, China





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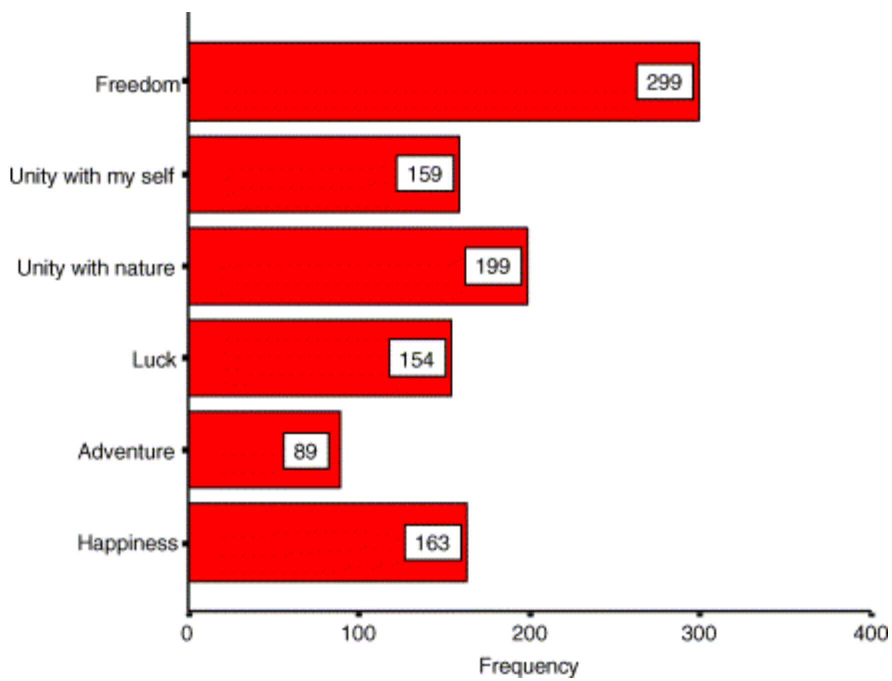
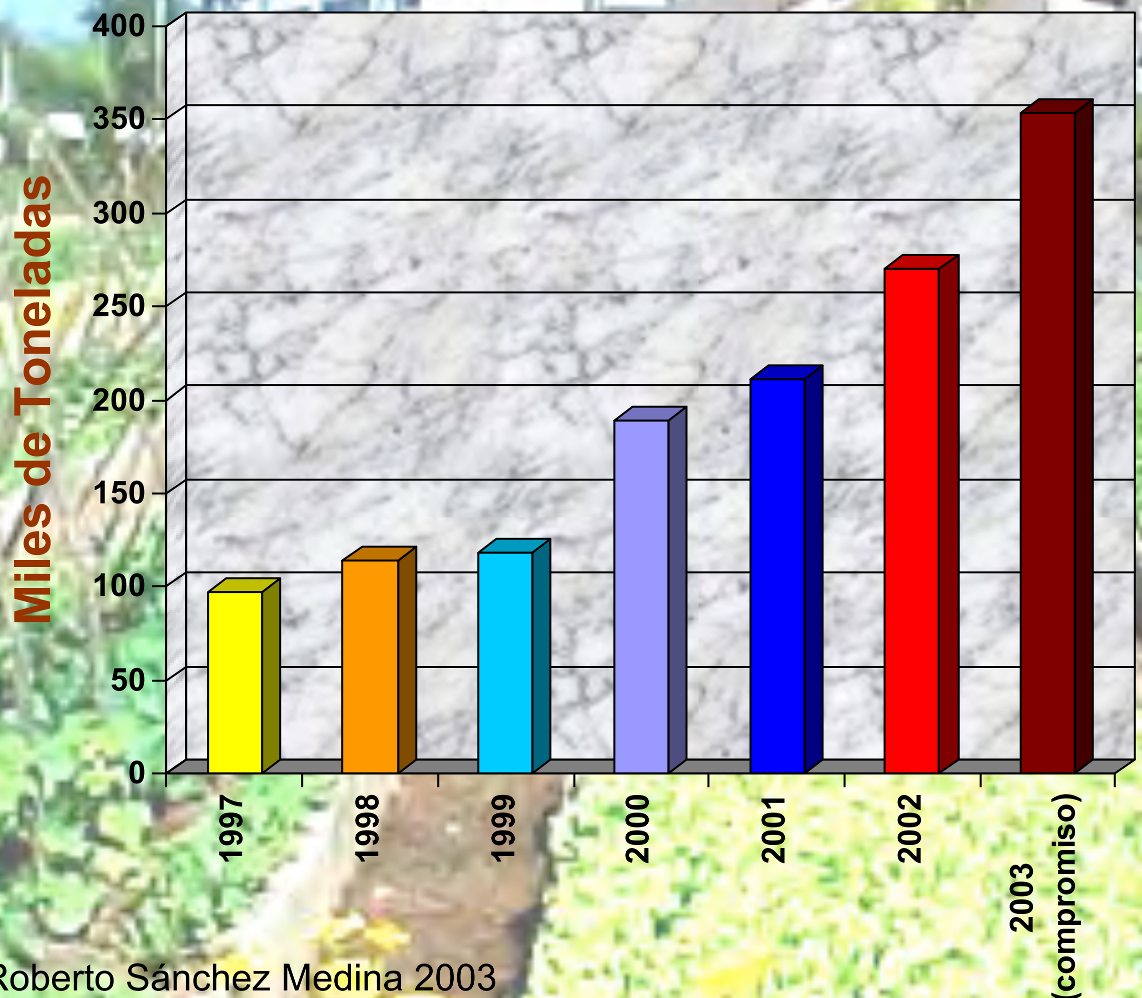
Other Values of Green Areas

	Information functions
Recreation	Space for recreation and escape from urban stress
	Aesthetic enjoyment and 'higher' experiences
	and related therapeutic effects (mental and physical health)
Scientific and educational information	Opportunity for in-situ observations, source of genetic material for scientific research
	Study-material for educational purposes and environmental awareness (books, musea, etc.)
Cultural and historical information	Signs of personal and collective history
	Cultural identity (local habits, traditional practices, cultural landscapes, etc.)
	Heritage values
Religious and artistic information	Source of spiritual experiences and religious meanings
	Source of inspiration for artistic expressions (music, painting, poetry, etc.)



Agricultura Urbana en Cuba 1997-2003



Fuente: Roberto Sánchez Medina 2003

Agricultura Urbana en Cuba

- **A partir de los años 90 se inició un gran esfuerzo para producir en la Ciudad una parte de los alimentos frescos que necesita la población.**
- **En 1994 se crea el Grupo Provincial Agropecuario con funciones estatales que alcanzaba la atención al creciente movimiento popular de Agricultura Urbana en el territorio.**
- **Se organizó el Programa Agropecuario dirigido a poner en producción todos los espacios disponibles.**
- **En 1995 se caracterizó cada barrio, determinando sus condiciones y posibilidades agrícolas.**
- **En 1996 se diseñó el programa de reforestación de la ciudad "Mi Programa Verde".**
- **En 1997 se trabajó con mucha fuerza en la organización del gran potencial productivo que representan los campesinos agrupados en más de 40 Cooperativas de Créditos y Servicios (CCS).**

ESCENARIOS PRODUCTIVOS

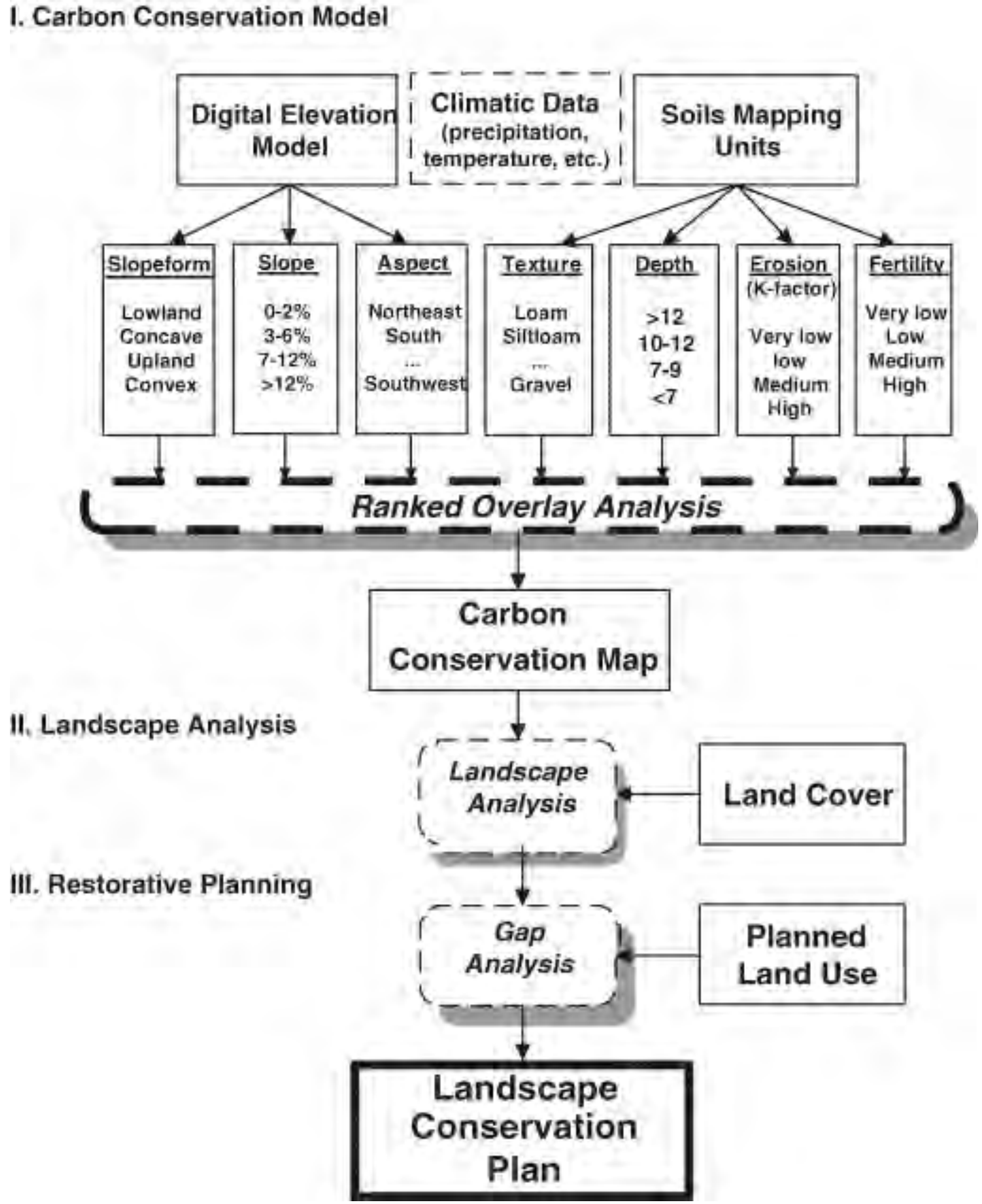
	1997	2002
•C.C.S.	47	68
•U.B.P.C.	12	73
•Fincas Estatales	360	459
•Unidades Pecuarias	-	232
•Autoconsumos de entidades	376	232
•Organopónicos y Huertos Intensivos	451	541
•Parcelas	-	8686
•Patios	-	93536

Fuente: Roberto Sánchez Medina 2003

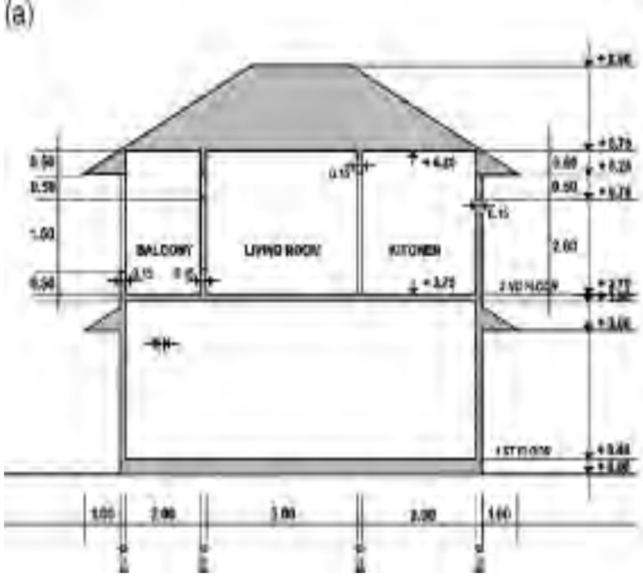
Sistemas de comercialización

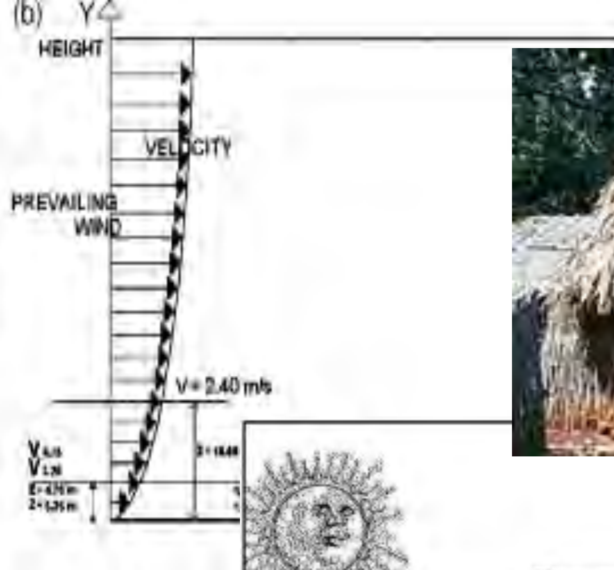
No.	Tipo de comercialización	Toneladas/ mes
1	1032 placitas de ventas normadas	5902
2	72 Mercados Agropecuarios de Oferta y Demanda (MAOD)	9200
3	70 Mercados Agropecuarios Estatales (MAE) hasta llegar a más de 100 para finales de año.	26910
4	1078 Puntos de Venta de la Agricultura Urbana, vendiendo a precios topados por el Consejo de Administración Provincial. (CAP)	20700
5	1375 contratos para la entrega de hortalizas a través de la Resolución 348 del Ministerio de Finanzas y Precios.	1380
	· Círculos Infantiles	173
	· Escuelas Seminternas Primarias	547
	· Escuelas priorizadas	139
	· Salud Pública (Hospitales)	115
	· Gastronomía	155
	· Sectores y Unidades de Organismos	182
	· Restaurantes Vegetarianos	69

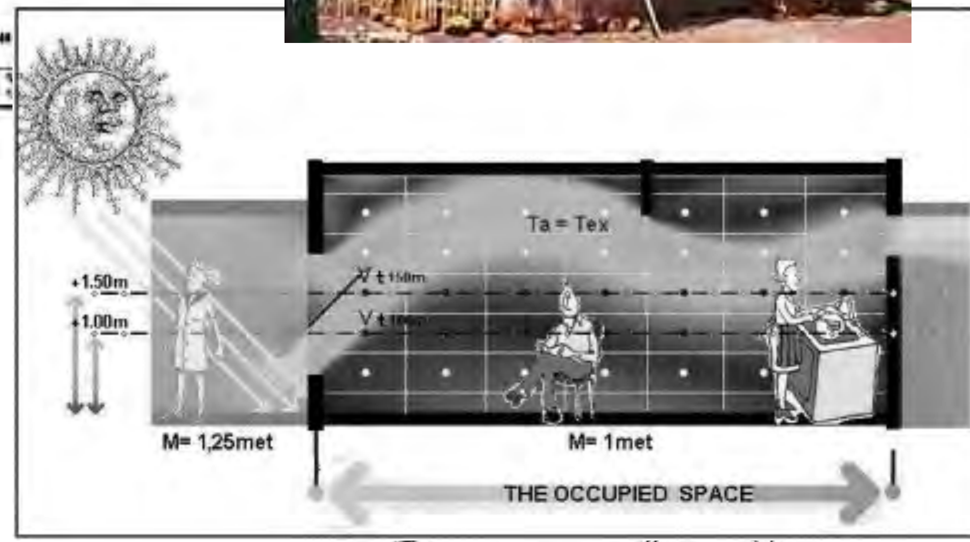
Agricultura Urbana



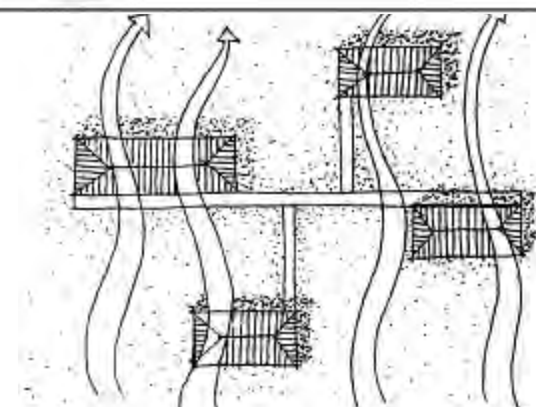
Flow diagram showing the GIS data layers and modeling methods that were used to create the landscape conservation map, determine its relation with current land cover, and compile priorities for a landscape conservation plan.
Source: Wang et.al. 2004





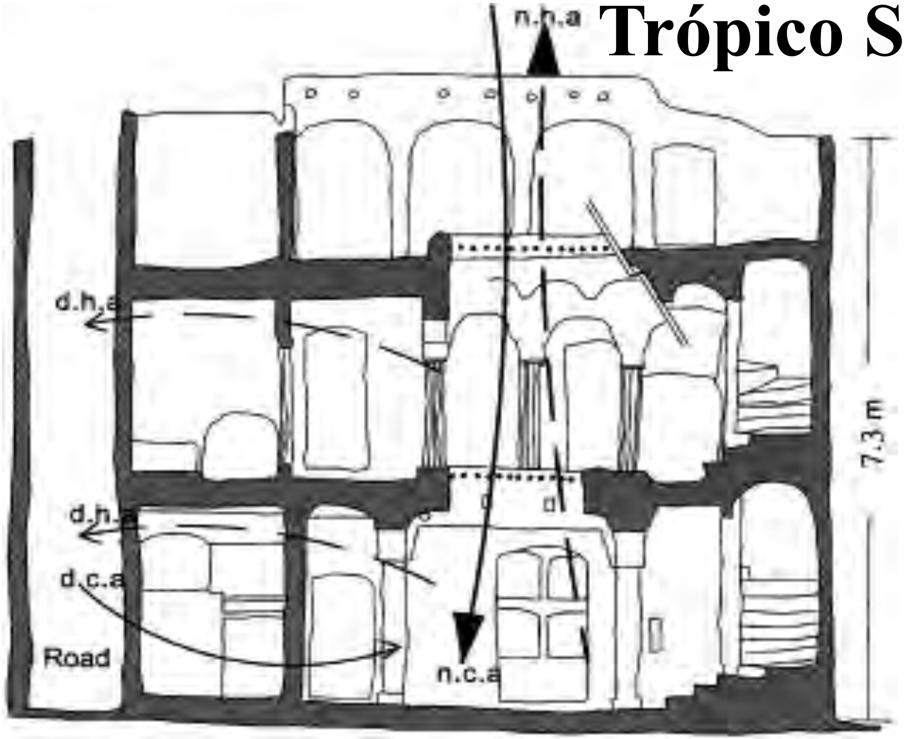


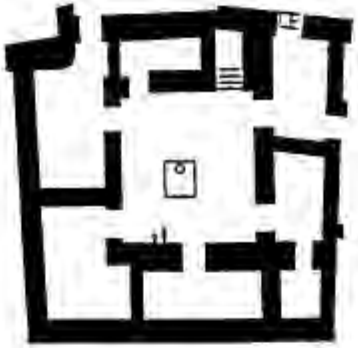
Trópico Humedo

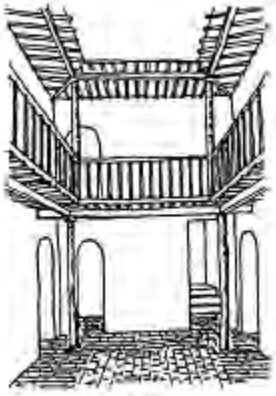


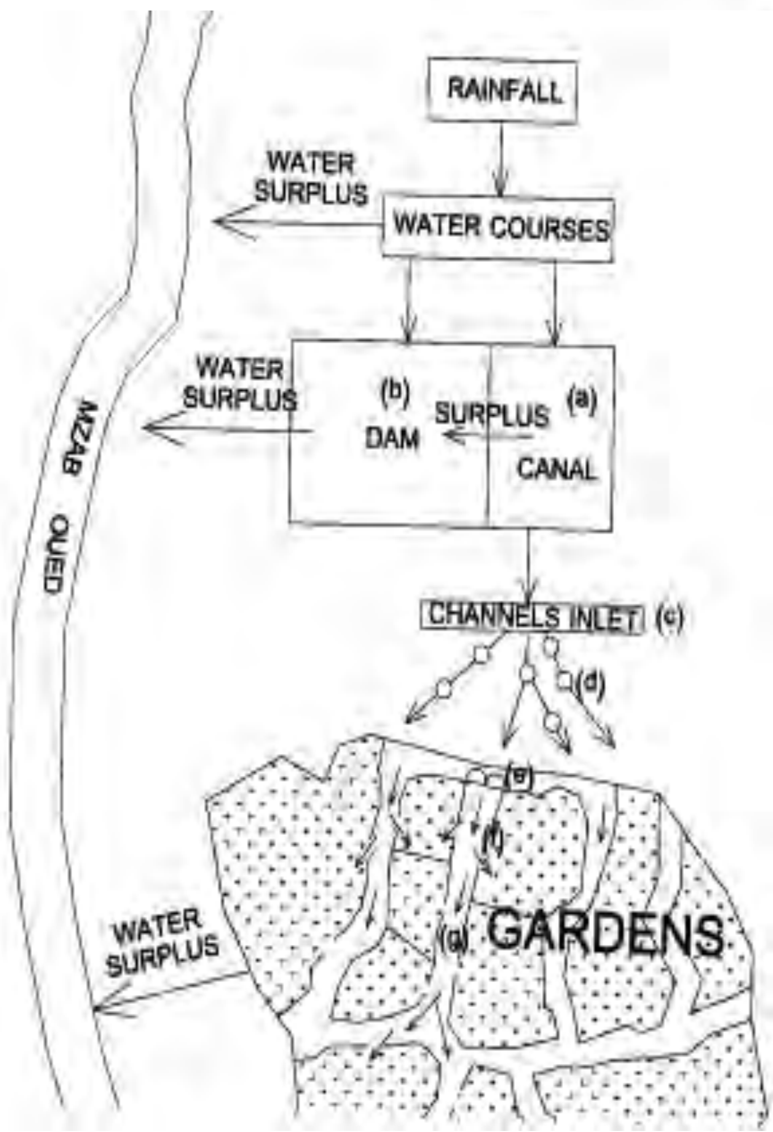

© 1996 by Augusto Areal

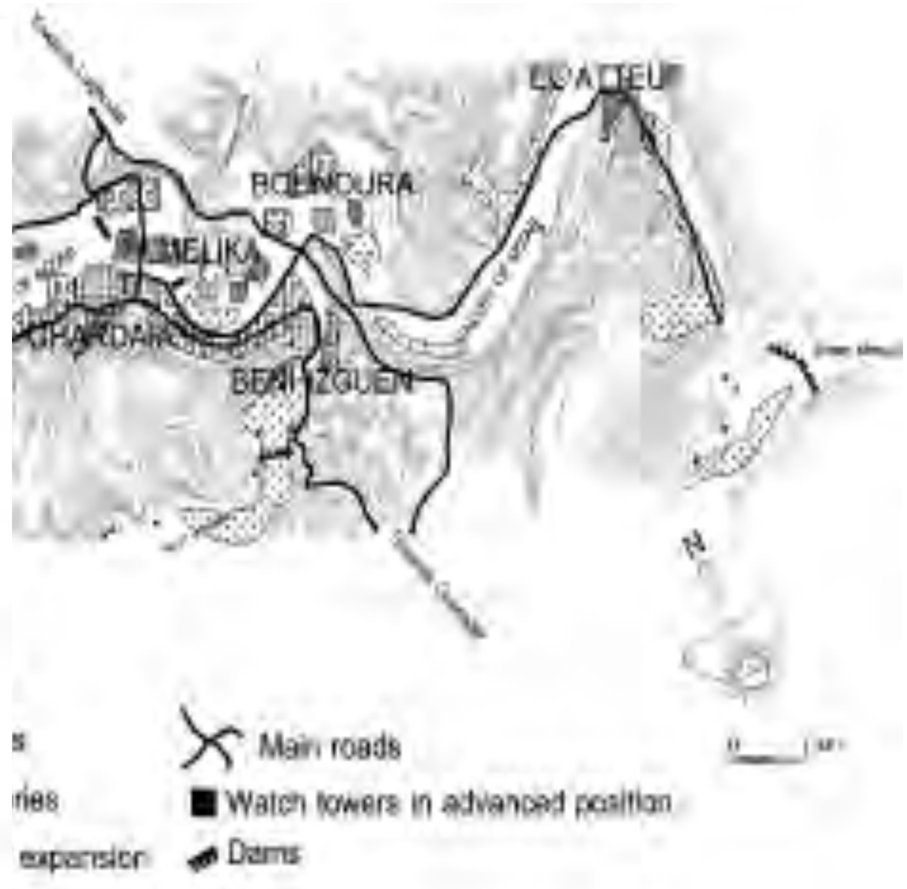
Trópico Seco








RAINFALL
WATER SURPLUS
WATER COURSES
WATER SURPLUS
(b)
DAM
SURPLUS
(a)
CANAL
MZAB OUED
CHANNELS INLET (c)
(d)
(e)
(f)
(g)
GARDENS
WATER SURPLUS

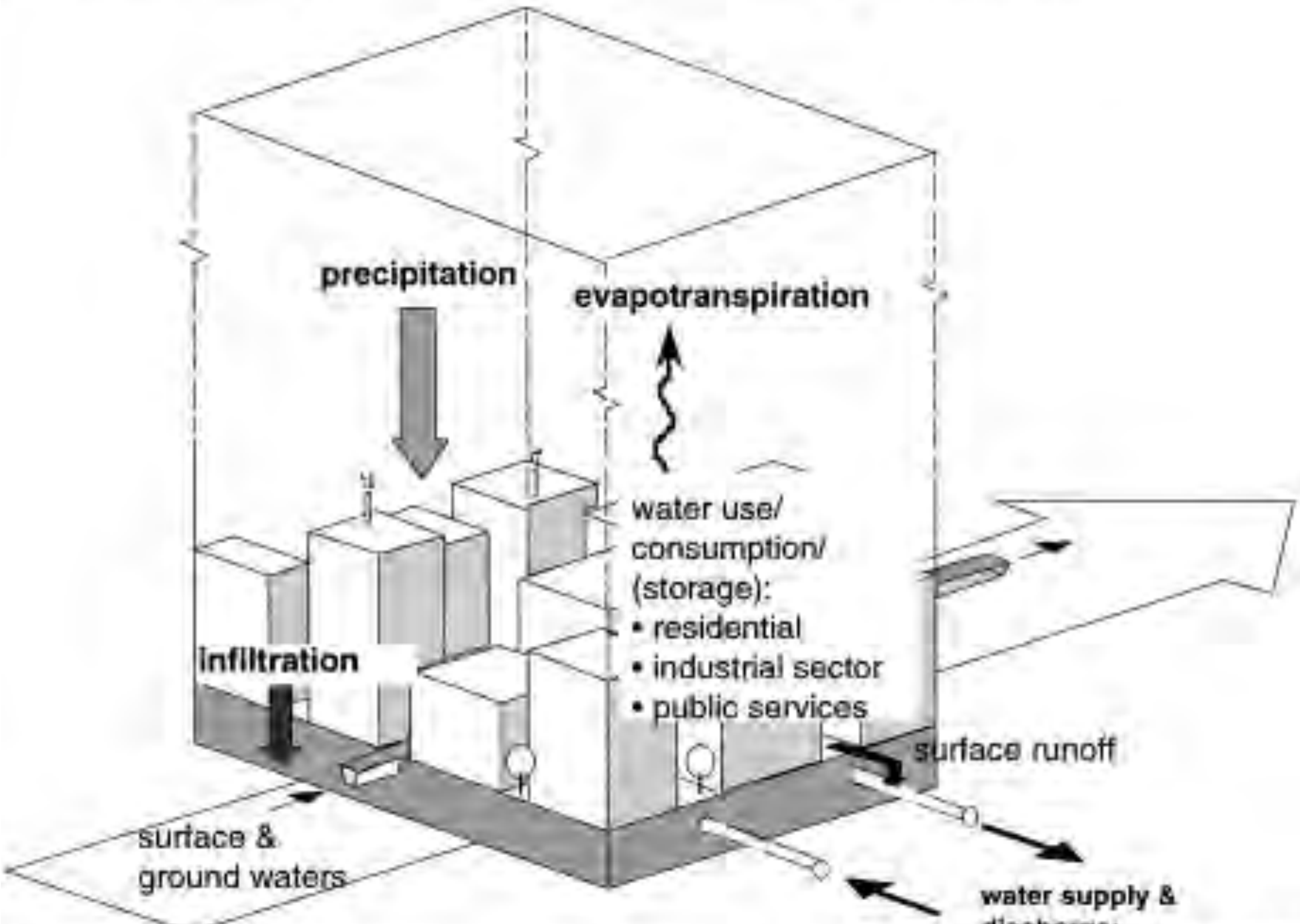

BOUNOURA
MELIKA
GHARDAIA
BENI ISGUEN
N
Main roads
Watch towers in advanced position
Dams
expansion

Low-income Housing in desert settlements

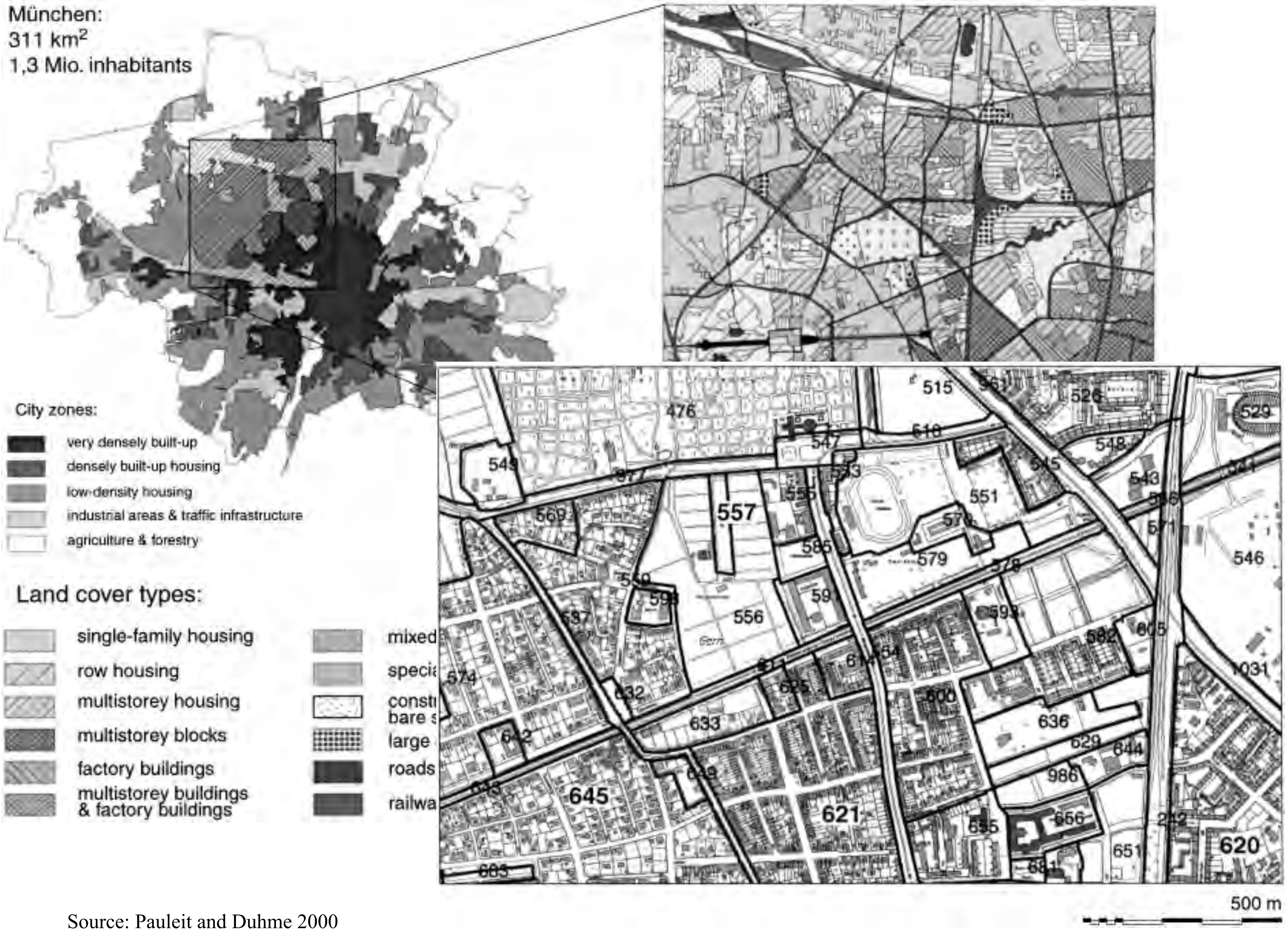
(a)

(b)

important components of the urban hydrologic balance

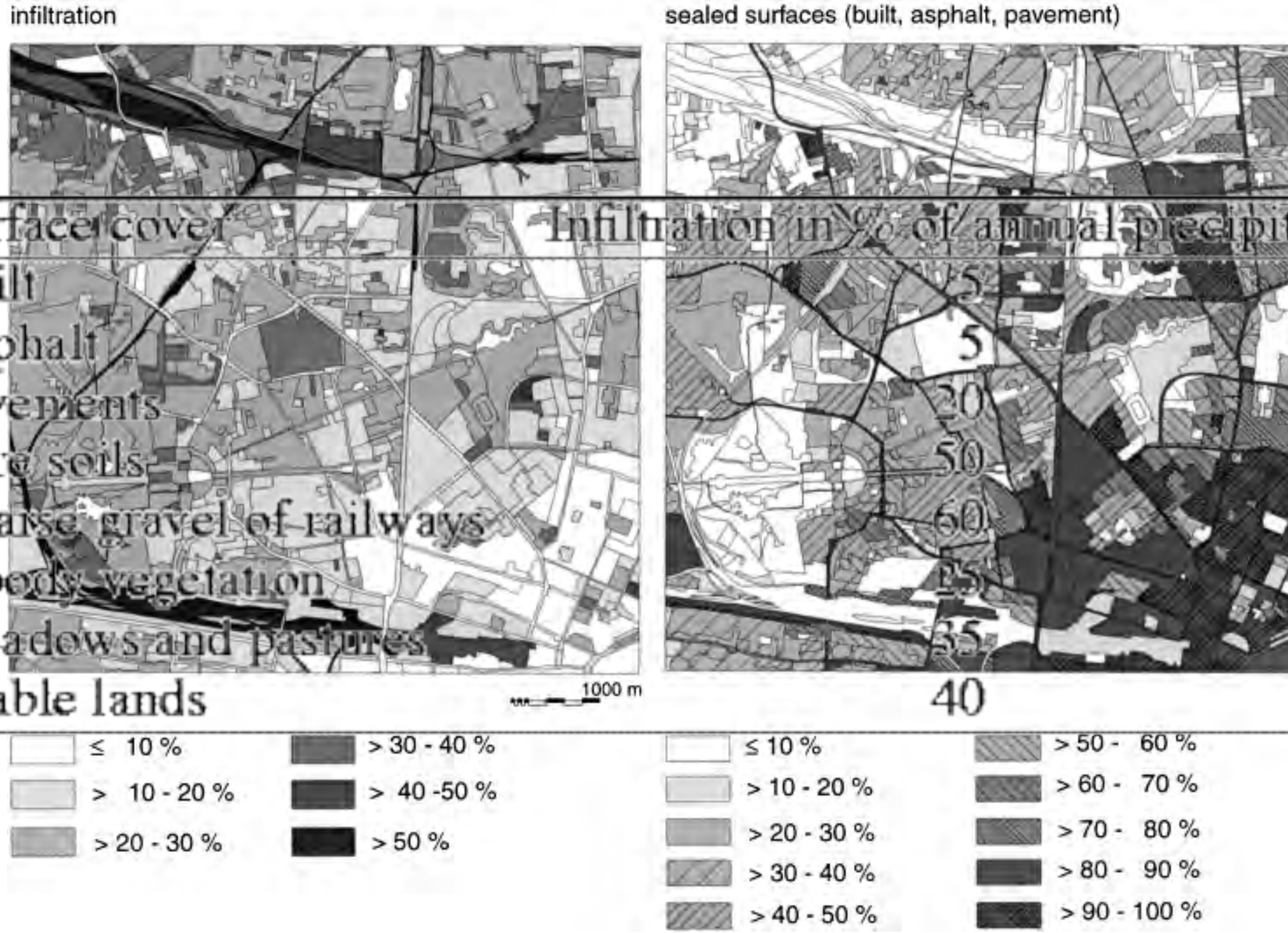


based on a figure in Oke (1987)

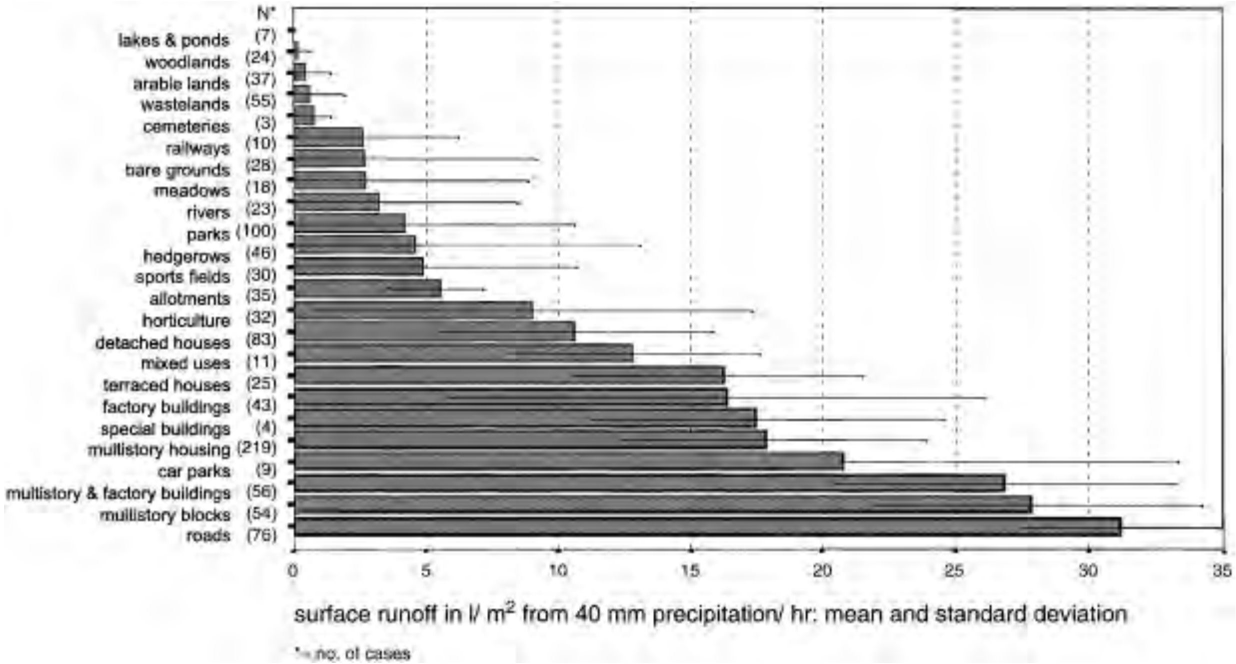


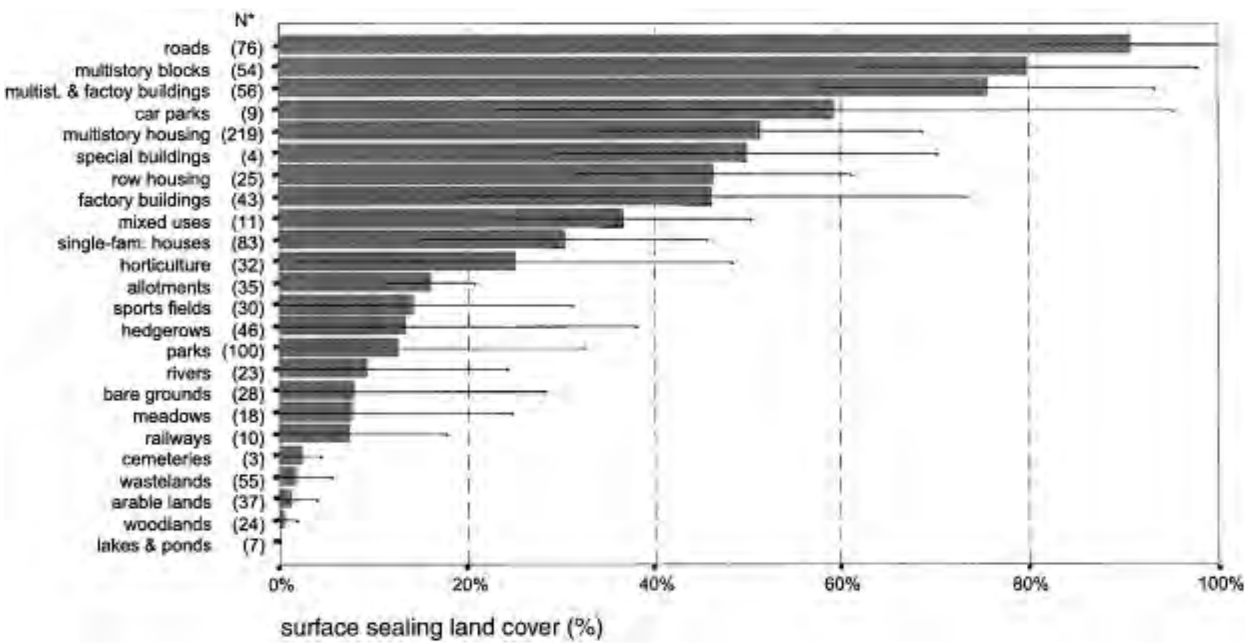
Source: Pauleit and Duhme 2000

Surface cover	Infiltration in % of annual precipitation[a]
Built	5
Asphalt	5
Pavements	20
Bare soils	50
Coarse gravel of railways	60
Woody vegetation	25
Meadows and pastures	35
Arable lands	40



Source: Pauleit and Duhme 2000





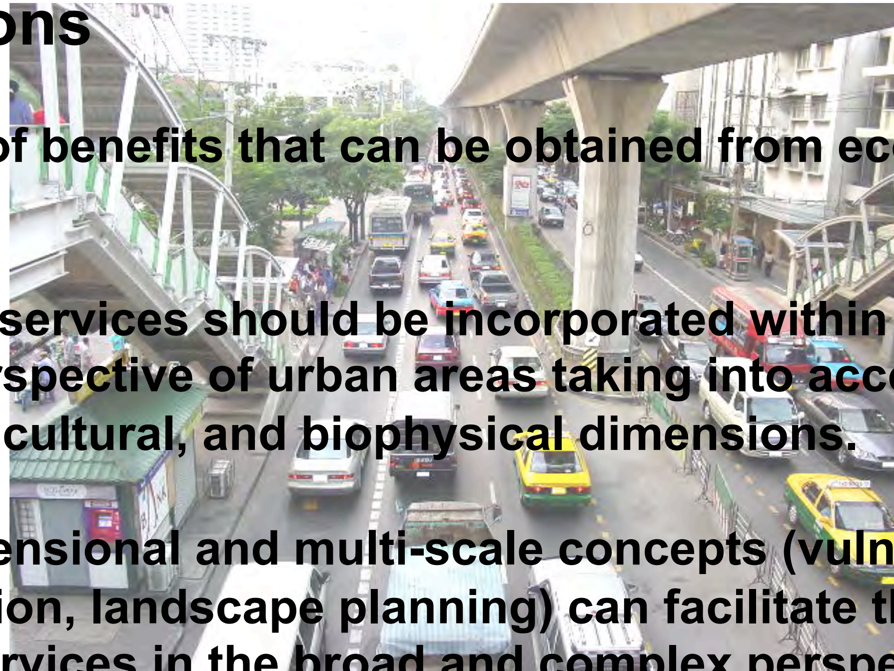
Source: Pauleit and Duhme 2000

Annual Rainwater Infiltration

S. No.	Land cover types	No. of units	Area (ha)	Percentage of study area (%)	Sealed surfaces (%)[a]		Built-up (%)[a]		Vegetation (%)[a]		Precipitation infiltration rate[b]		Surface runoff ($l/m^2/h$)[c]	
					Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	Detached houses	83	724.99	14.78	30.5	15.3	15.3	6.9	66.8	14.8	24.5	4.4	10.6	5.3
2	Terraced houses	25	107.42	2.19	46.4	14.9	29.0	11.5	52.5	15.4	19.6	3.7	16.3	5.3
3	Multistory houses	219	836.27	17.04	51.5	17.3	29.5	11.0	43.8	17.5	19.5	5.0	17.9	6.0
4	Multistory blocks	54	513.39	10.46	79.9	18.1	44.3	10.5	19.1	16.9	12.0	5.0	27.8	6.4
5	Factory buildings	43	129.13	2.63	46.3	27.2	23.9	16.1	31.8	23.2	23.9	10.5	16.4	9.7
6	Multistory/factory buildings	56	432.90	8.82	75.7	17.7	35.2	14.6	12.8	14.0	13.9	6.2	26.9	6.4
7	Mixed use	11	38.36	0.78	36.7	13.8	22.0	9.7	59.1	11.1	22.4	4.0	12.8	4.8
8	Special buildings	4	24.96	0.51	50.0	20.4	22.5	6.5	41.3	21.4	20.9	4.9	17.5	7.1
9	Construction sites	28	122.07	2.49	8.0	20.4	3.9	8.6	16.0	17.4	43.9	7.8	2.7	6.5
10	Large car parks	9	31.90	0.65	59.3	36.1	5.8	11.3	15.9	10.2	20.9	14.5	20.8	12.6
11	Roads	76	299.62	6.11	90.8	10.4	0.2	1.0	6.9	8.8	10.4	3.3	31.2	3.7
12	Railways	10	261.32	5.33	7.4	10.4	1.2	2.3	8.1	8.1	53.7	5.3	2.6	3.6
13	Lakes and ponds	7	35.82	0.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	Streams	23	29.99	0.61	9.3	14.9	0.3	1.2	52.8	28.5	18.9	9.0	3.2	5.3
15	Woodlands	24	226.30	4.61	0.5	1.4	0.0	0.2	96.7	3.1	21.4	0.7	0.2	0.5
16	Hedgerows/woodlots	46	47.02	0.96	13.3	24.8	0.7	2.0	83.4	24.3	21.5	4.7	4.6	8.5
17	Parks and green spaces	100	357.72	7.29	12.7	19.8	0.9	3.7	77.6	21.4	30.4	5.7	4.2	6.4
18	Cemeteries	3	55.85	1.14	2.3	2.1	1.3	1.5	88.0	9.8	34.1	5.6	0.8	0.7
19	Allotment gardens	35	108.19	2.20	16.1	4.7	11.0	3.8	77.2	7.6	30.2	1.6	5.5	1.6
20	Sports fields	30	162.64	3.31	14.1	17.1	3.7	6.4	73.6	18.2	31.4	5.2	4.8	5.9
21	Meadows and pastures	18	78.93	1.61	7.7	17.1	4.1	16.5	88.1	20.8	33.3	5.1	2.7	6.1
22	Extensive grasslands	55	88.33	1.80	1.8	3.7	0.3	1.1	80.1	20.0	34.3	4.2	0.6	1.3
23	Arable fields	37	134.21	2.74	1.2	2.8	0.2	0.8	96.7	4.0	39.0	1.3	0.4	1.0
24	Horticulture/nurseries	32	59.19	1.21	25.1	23.4	19.9	20.7	68.8	24.6	29.5	7.8	9.0	8.4
	Totals/average[d]	1028	4906.52	100.00	42.3	–	18.2	–	45.0	–	23.3	–	14.7	–

Source: Pauleit and Duhme 2000

Some Conclusions



- There is a diversity of benefits that can be obtained from ecological services in urban areas.

- The design of these services should be incorporated within the integrated and interdisciplinary perspective of urban areas taking into account their social, economic, political, cultural, and biophysical dimensions.

- The use of multidimensional and multi-scale concepts (vulnerability, livelihoods, adaptation, landscape planning) can facilitate the sound use of ecological services in the broad and complex perspective of urban systems and their interactions with global environmental change.