URBAN GREEN INFRASTRUCTURE FOR A CHANGING CLIMATE

Green Gardening Workshop:
Resilient Landscapes for our Changing Urban Climate
October 21, 2015

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Today's Talk:

Relationship of Urban Green Infrastructure to climate benefit and resilient landscapes:

- **benefit to the climate overall (mitigate or protect climate)**
- **benefit to humans: adaptation to inevitable climate change impacts**

Houtan Park, Shanghai, courtesy Turenscape

Today's Talk:

1. Climate change predictions for and impacts to PNW

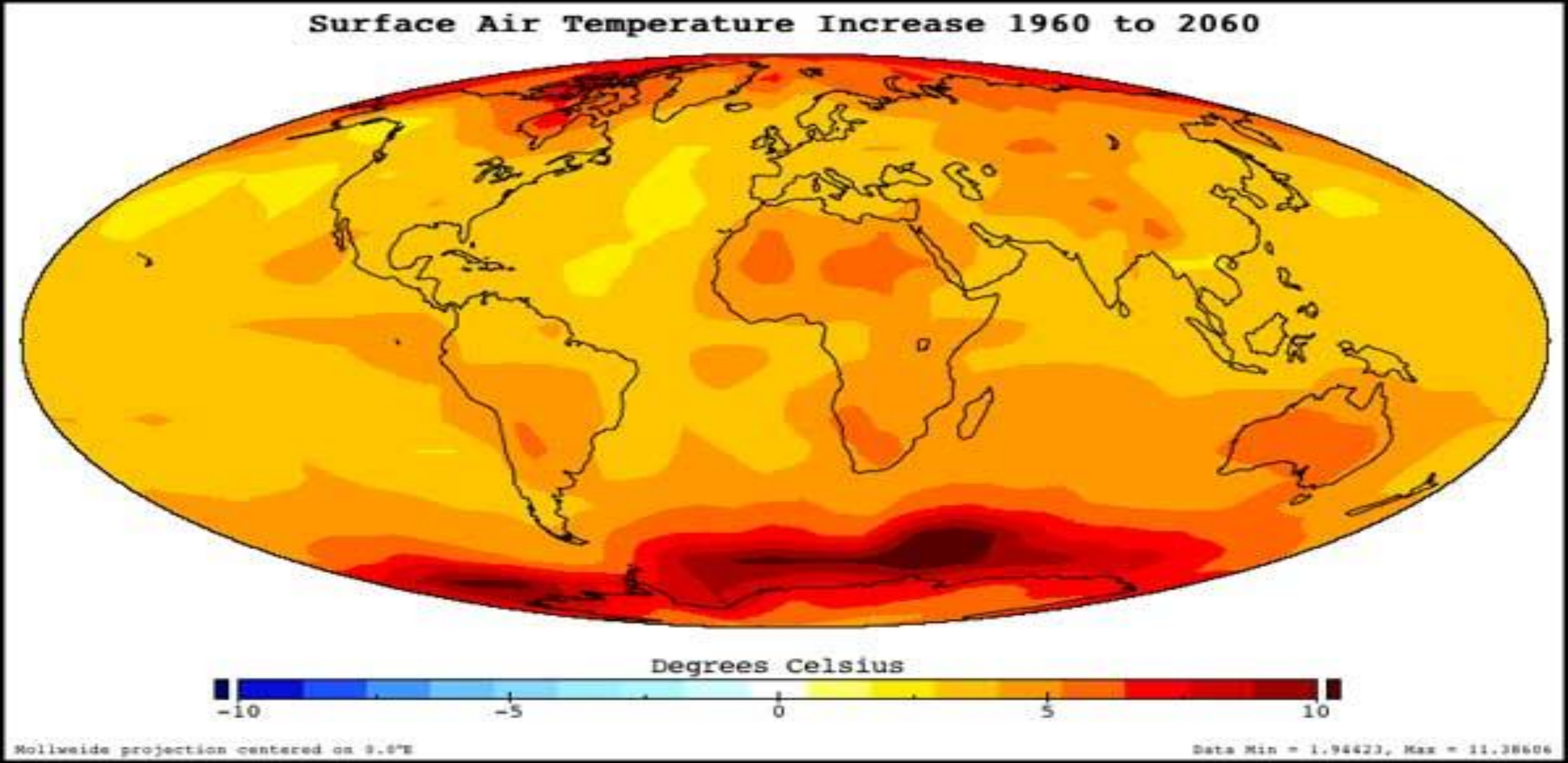
2. Urban Green Infrastructure Systems

3. Green Infrastructure for Climate Mitigation and Adaptation

1. Strategies for using Green Infrastructure for climate and human benefit

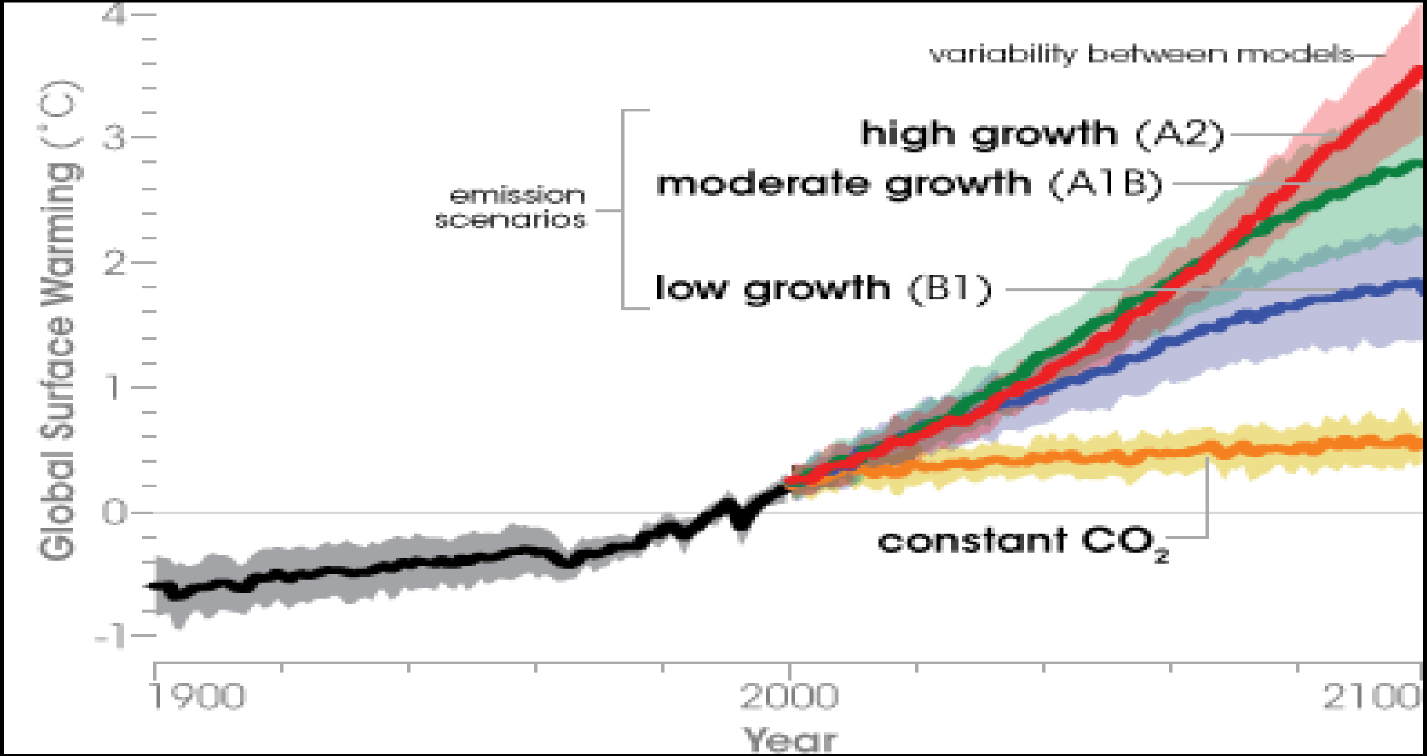
2. Some Principles and Resources

1. A Changing Climate



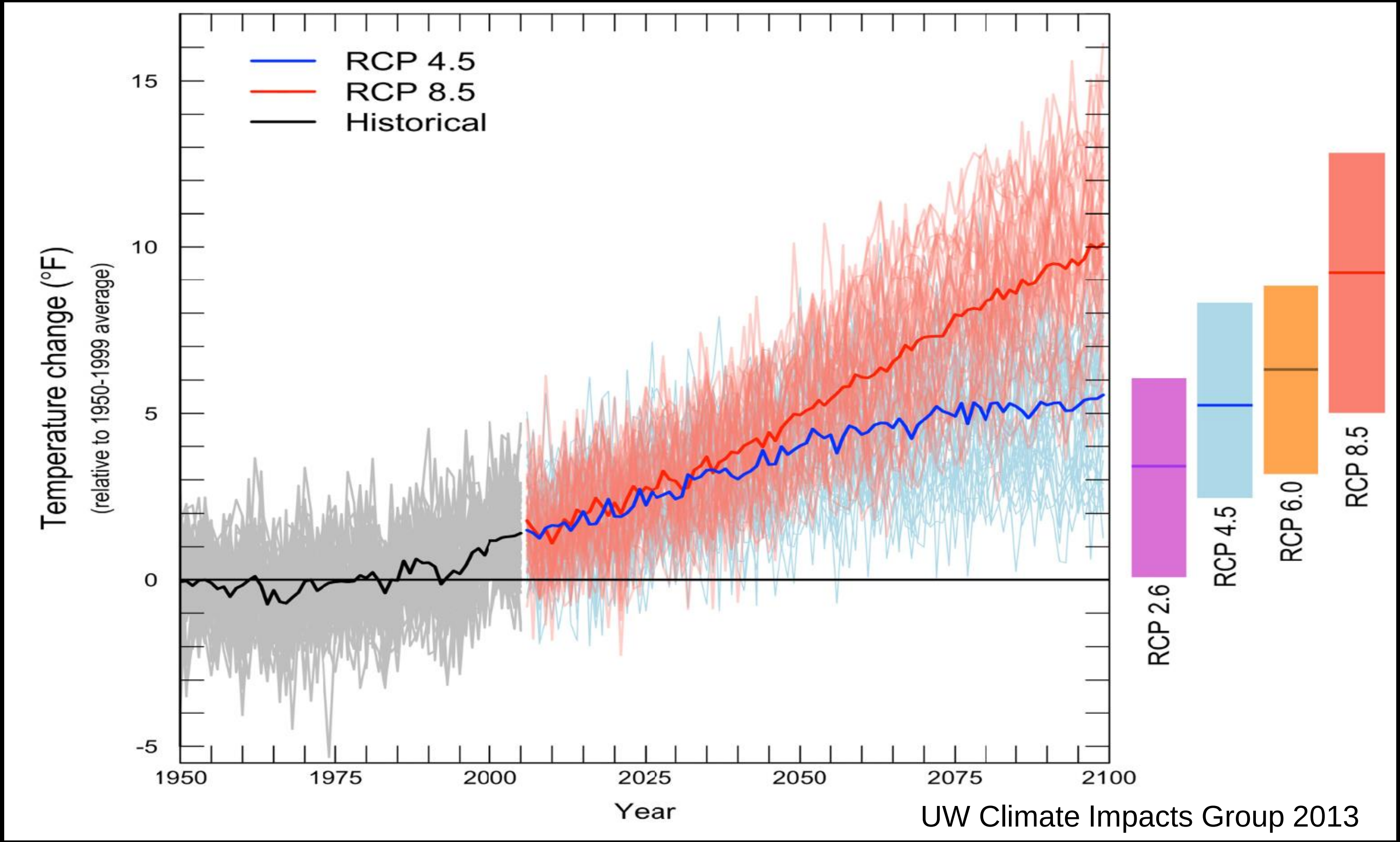
Projected Surface Air Temperature Increase, 1960 to 2060. Courtesy of NASA.

Scenarios predict increased temperatures of between 1.1°C to 4°C by the end of the 21st century, depending upon future greenhouse gas (GHG) emissions.



NASA Earth Observatory

Pacific Northwest average yearly temperature projections (2013) for low (blue) and high (red) emissions scenarios.

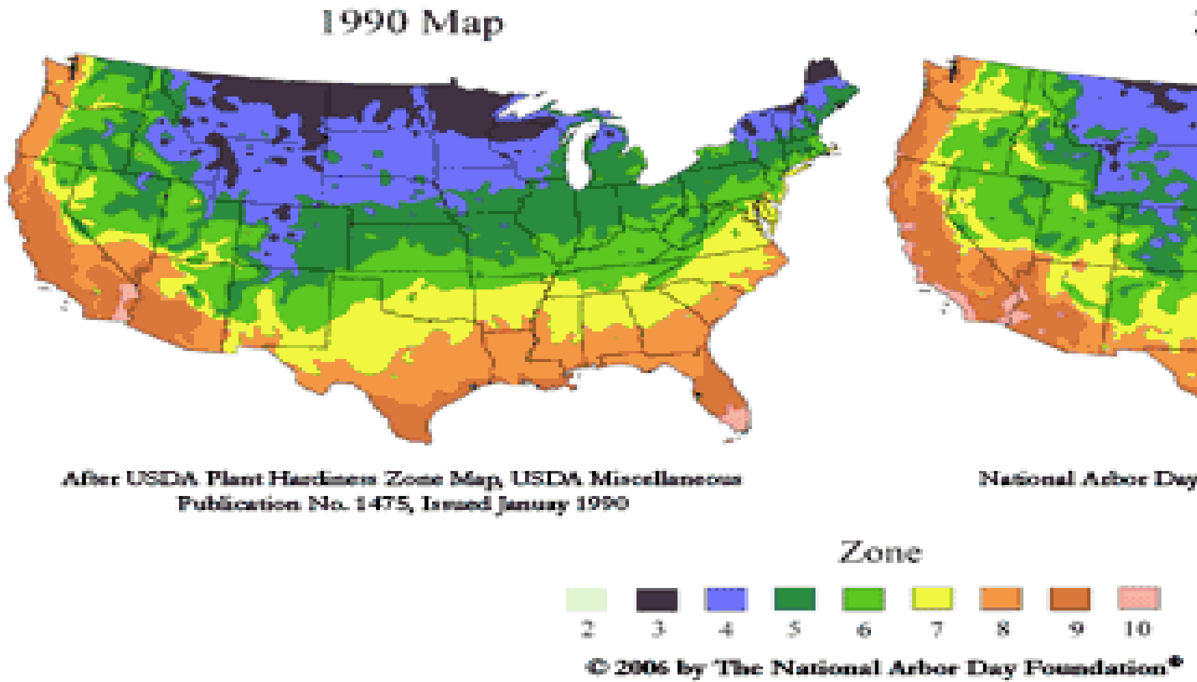


Predicted PNW Climate Change Impacts Related to Urban Landscapes

1. Increased temperatures, summer and winter
   - hotter summers with “heat island” effects and “heat waves”
   - more soil evaporation, higher water demand
   - less snowpack for water supply
   - “climate envelopes” move north / up (150km per 1° C annual temp)
   - Stress on urban plantings
   - Stress on species adapted to native ecotypes and past weather regimes
   - temporal and process changes, e.g. pollination, seed setting, dispersal, match of species to food source, etc.
   - problematic water temperatures for salmon, etc.
   - Reduced biodiversity
   - Regional and traditional culture identity implications, e.g. salmon

Changing Plant Hardiness Zones

2012
USDA



National Arbor Day Foundation

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  - spring flooding, stream erosion, bank undermining
  - windstorm damage

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- Summer droughts
  - less water available for irrigation, hydro and fish; food and urban greening implications

Predicted PNW Climate Change Impacts Related to Urban Forests

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- Stronger winter storms, wetter winters
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  - windstorm damage
- Summer droughts
  - less water available for irrigation, hydro and fish; food and urban greening implications
- Heat Waves and Smog (VOCs)
  - cardiovascular and respiratory deaths

2. What is Urban Green Infrastructure?

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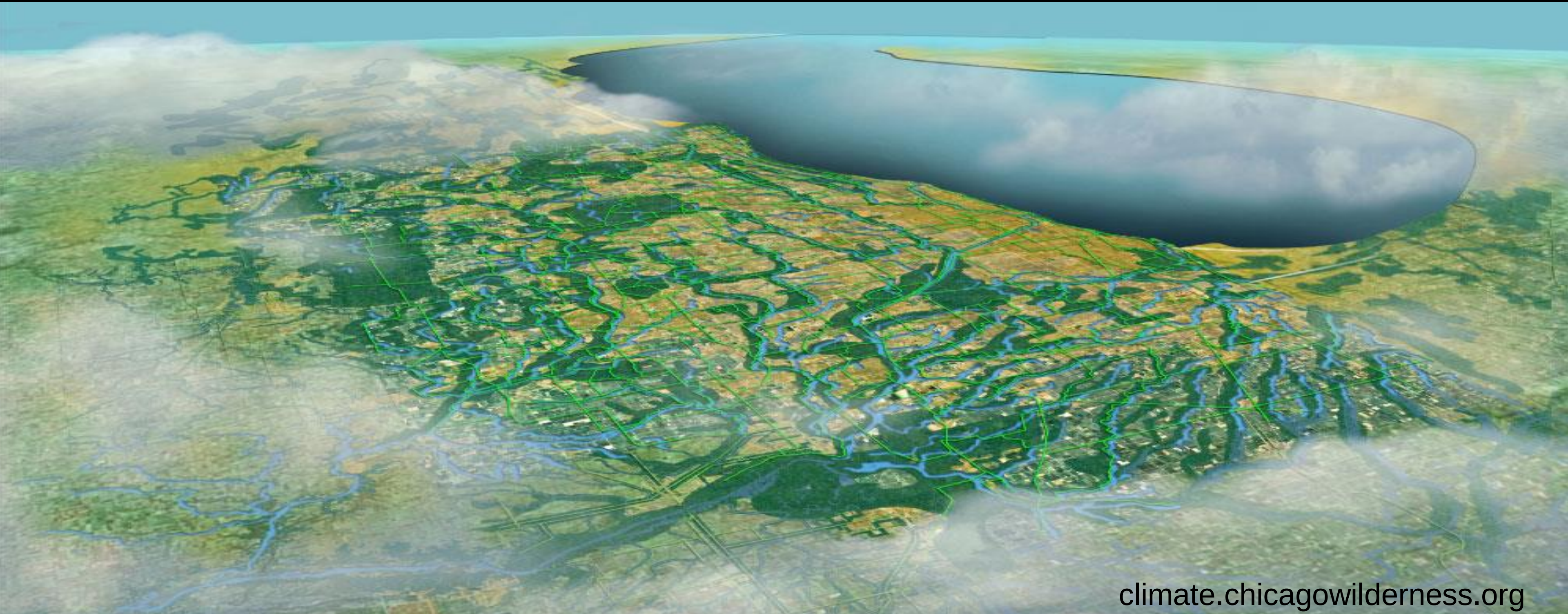
Green Spaces that perform environmental and human services in cities



climate.chicagowilderness.org

What is Urban Green Infrastructure?

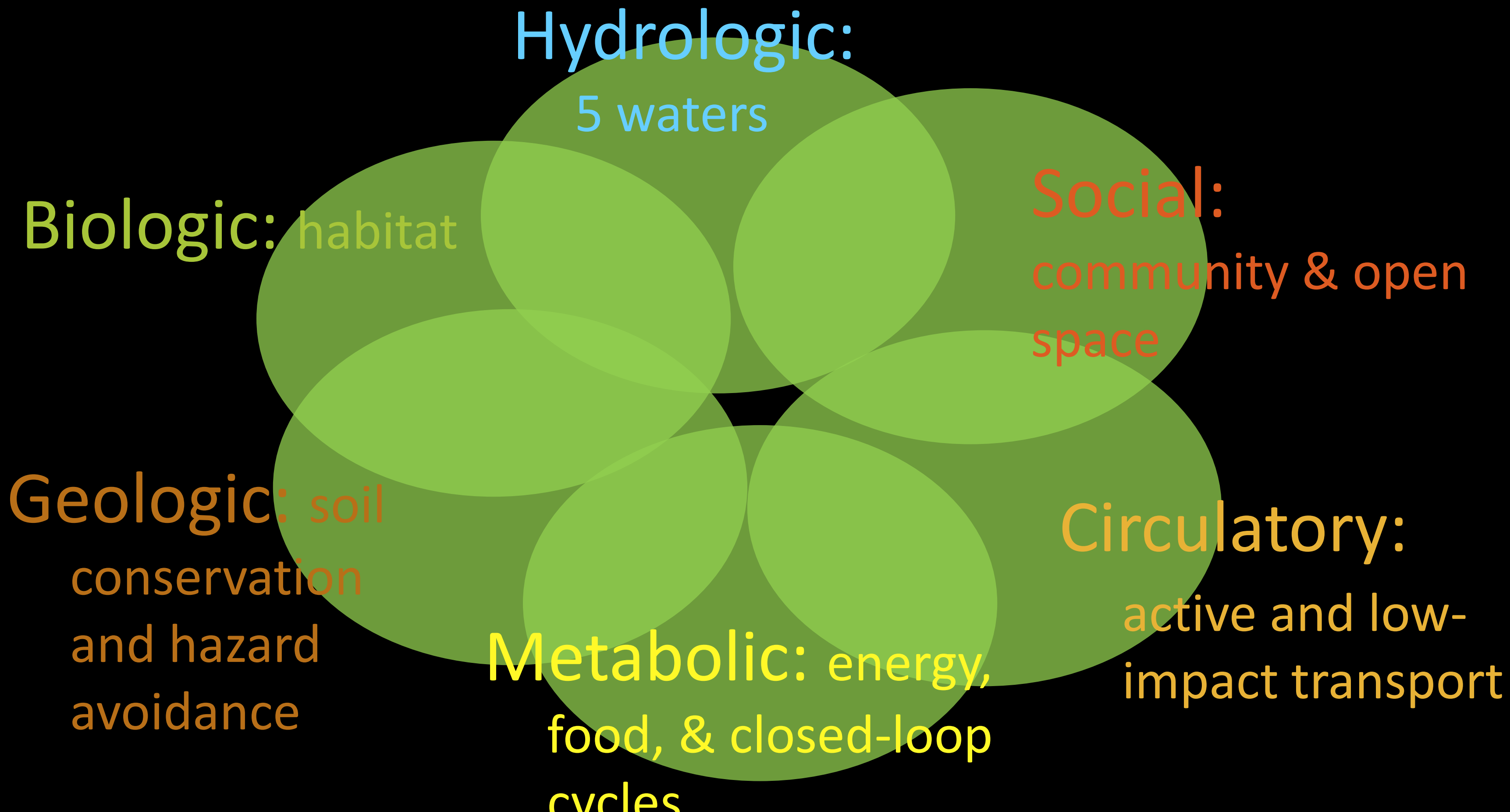
Utilities that use natural forms and processes

www.uswateralliance.org

Urban Green Infrastructure:

It’s both: green spaces and green utilities, at all scales.

6 Green Infrastructure Systems



Social: Community and Open Space

Circulatory: Active Transport

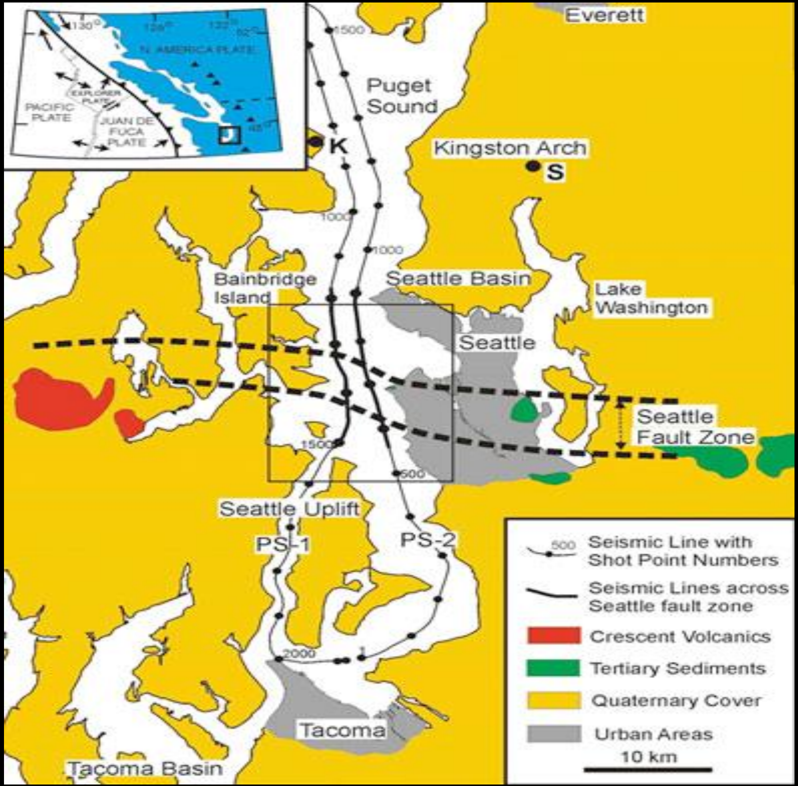
Biologic: Habitat

Hydrologic: 5 Waters

- Clean Water source
- Stormwater quantity and quality (rain run-off)
- Gray Water (washing)
- Black Water (sewage)
- Aquatic environments

Metabolic: Energy, Food Systems and Materials

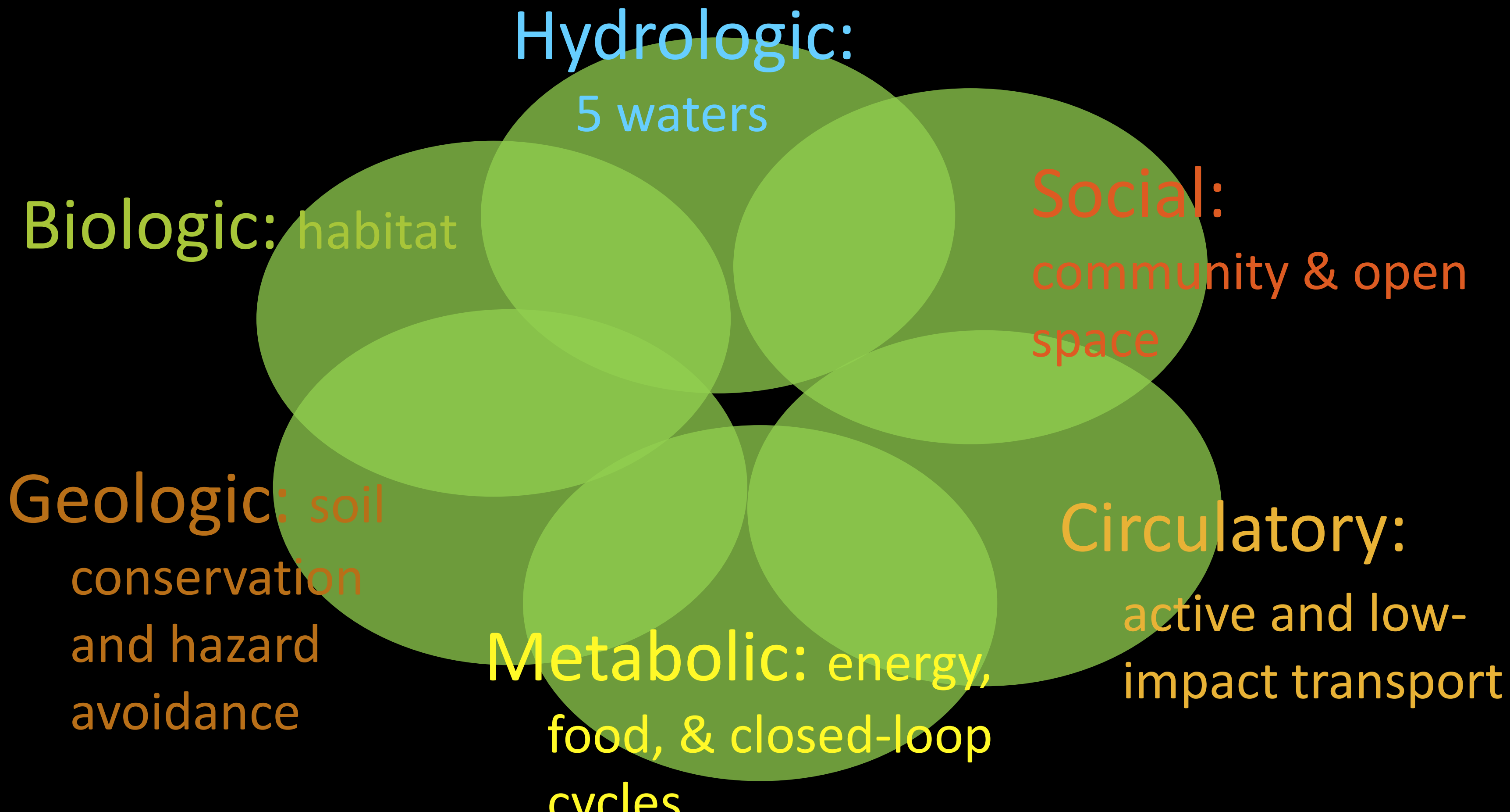
Geologic: Soils, Slope, Underlying forces



Where traditional infrastructure is a single system addressing a single function, green infrastructure typically provides ecological services that serve multiple functions.

e. g. Urban forests =
stormwater control
habitat
community space
climate control

Overlapping Green Infrastructure Systems are Multifunctional and therefore Efficient



Green Infrastructure Supports Livable, Ecological Cities

Intensity

+

Ecological Amenity

=

Sustainability

Vancouver, Canada

"In livable cities lies the preservation of the world"

-Mike Houck, Urban Greenspaces Institute

3. Green Infrastructure addresses both Climate Mitigation (Protection) and Adaptation to Climate Change Impacts

Mitigation:

"anthropogenic intervention to reduce the sources or enhance the sink of greenhouse gases"

Adaptation:

"adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" **(cope with increased heat, floods, drought, extremes)**

- IPCC 2007 p 869

Urban Green Infrastructure Landscapes Mitigate (protect) climate:

- Store Carbon
- Sequester Carbon
- Reduce burning of fossil fuels by tempering weather (e.g. heat, wind), reducing energy use for heating and cooling
- Create better biking and walking environments, fewer emissions
- Inspire environmental protection

Urban Green Infrastructure Landscapes Help Communities Adapt to Climate Change Impacts through:

- Summer cooling
- Stormwater interception and infiltration
- Air Quality Improvement
- Social cohesion and Aesthetics
- Habitat provision, stress reduction for sensitive species

Green Infrastructure:
Simultaneously Mitigating and Adapting to Climate Change

	Mitigate (reduce energy usage, store carbon)	**Adapt** (community resilience, reduce stresses of extreme weather & resource shortages)
Social: Community Space		
Urban Amenities support Compact Form	x	x
Urban Green Space, Nearby Nature	x	x
Circulatory: Active Transport		
Pedestrian Environments, + connections to transit	x	x
Bicycling for All	x	x
Hydrological: 5 Waters		
Water Supply: Harvest and Re-use (rain, greywater, blackwater)	x	x
Green Stormwater Treatment - Biofiltration, Green Roofs, Tree Canopy	x	x
Aquatic and Coastal Environments	x	x
Biological: Habitat		
Urban Forests, Connected Habitats	x	x
Habitat Restoration (patches)	x	x
Metabolism: Energy and Materials		
Community Gardens	x	x
Small-scale Energy	x	x
Green Roofs, Walls and Trees (lower energy use)	x	x
Recycled, Low-energy Materials	x	

Rottle, N. "Green Infrastructure for Climate Benefit, Global to Local" *Nordic Journal of Architectural Research*

“Adaptive Mitigation”

“the question is not whether the climate has to be protected from humans or humans from climate, but how both mitigation and adaptation can be pursued in tandem.”

- Swart and Raes (2007 p. 301)

4a. Strategies for Climate Change Mitigation

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- Increase the number of healthy trees and woody vegetation in cities

Urban Forests and Soil Store and Sequester Carbon

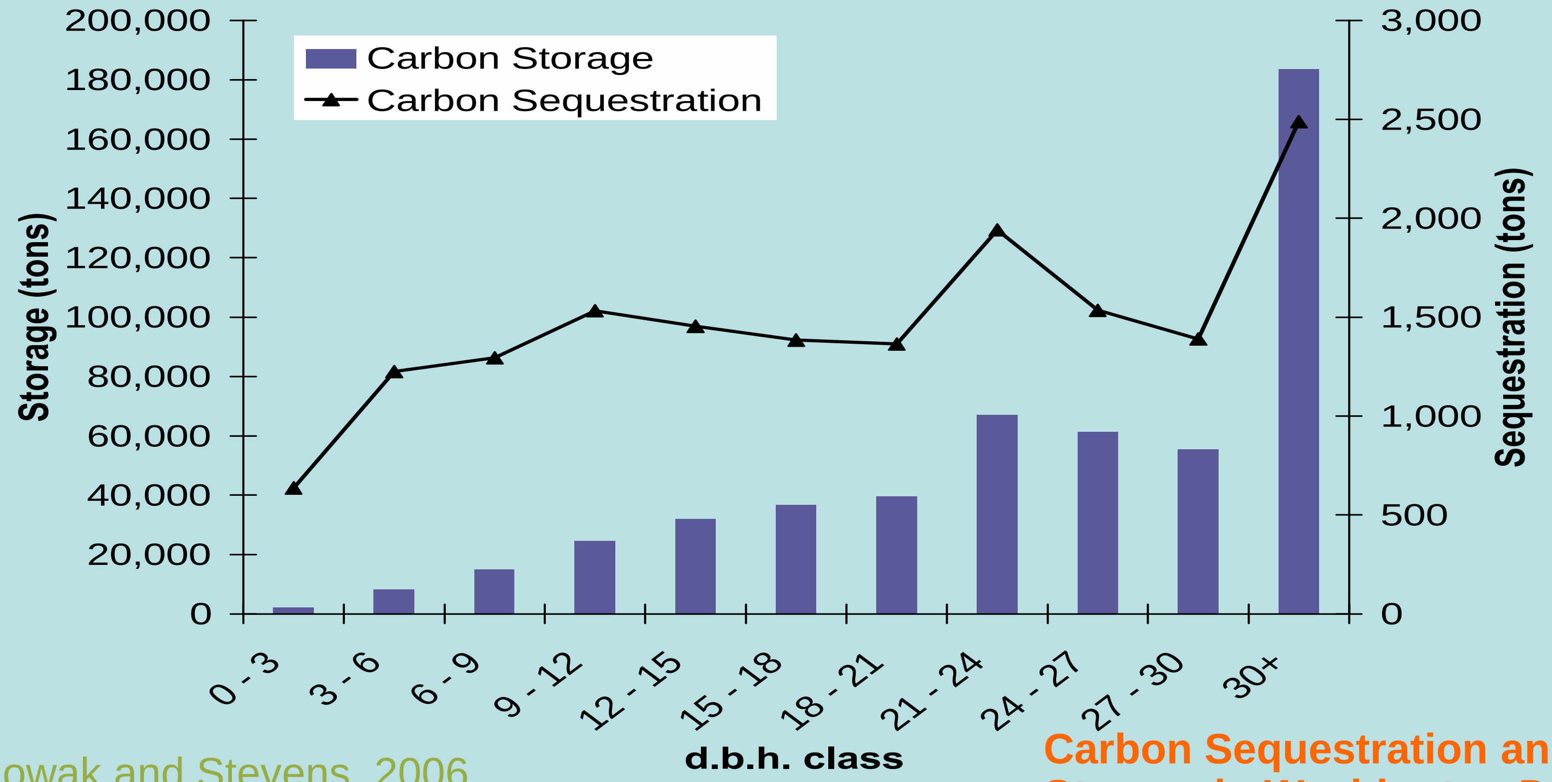
- One 12” tree = 17 lbs/yr = 63 miles (passenger car)

  5000 miles/yr = (79) 12” trees

- One 30” tree = 92 lbs = 337 miles (passenger car)

  5000 miles/yr = (15) 30” trees

Urban Forests Store and Sequester Carbon



Nowak and Stevens, 2006

Carbon Sequestration and Storage in Washington DC Urban Forests by DBH

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  - reduce overall city temperatures;
  - on properties plant trees on west side to block hot west sun, "solar friendly" trees on SE and SW; smaller deciduous to south; shade AC units

Lowering Energy Consumption through Urban Greening

OR

A large tree shading a western wall saves 268kWh / year electricity in US Midwest, and 3,430 kBtu annually for heating and cooling (McPherson 2006);

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Strategies for Mitigation

Encourage Active Transport on Green Ways

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- Contribute carbon storage and sequestration in stormwater management features

Green Stormwater Infrastructure – cleaning and detaining at the source

OR

carbon emissions

carbon storage?

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- Retain biomass, reduce amount of fossil fuels used in management

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- STORE CARBON + REDUCE GREENHOUSE GAS EMISSIONS

3b. Strategies for Climate Change Adaptation

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A. Urban Greening for Cooling and Shading
B. Urban Design to cope with more/less precipitation, stronger storms and drought
C. Landscapes for Human Health, Air Quality and Social Cohesion
D. Preserving Identity, Biodiversity, Resiliency
E. Species Selection for Our Future Climate

Strategies for Adaptation

A. Urban Greening for Cooling and Shading

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- **Ensure access to cool shaded places for all citizens to provide refuge in heat events, shield from UV radiation**
  - **Parks and green spaces**
  - **large trees and groves over sidewalks**
  - **green roofs and walls.**

Strategies for Adaptation

Urban Greening for cooler air temperatures.

Trees can reduce outside temperatures 5-9° F;

Variation between green /non-green city centers 9° F (McPherson, 2006, Akbari 1992)

Huazhong University, China

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Cascade Land Conservancy

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- Trees, walls and roofs to shade buildings (as in mitigation)

Urban Greening - Roofs, Walls

Musée du Quai Branly, Paris

UW Green Futures Lab

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- Shade streams and riparian zones to reduce water temperatures

B. Urban Design to cope with more / less precipitation, stronger storms and drought

http://www.komonews.com/

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- **Rain gardens + water harvesting**

http://www.komonews.com/

Strategies for Adaptation

Urban Design for Stormwater Control

Siskyou Street, rain gardens, Portland, Oregon

292 -2162 gallons are intercepted annually by a single large tree (McPherson et al 2006)

Strategies for Adaptation

Water Harvest and Re-use: Closing the Loop

Water harvesting and re-use will become more important as we experience drought, to maintain full climate-mitigation function of vegetation. …

Center for Urban Waters, Tacoma, Washington

Strategies for Adaptation:

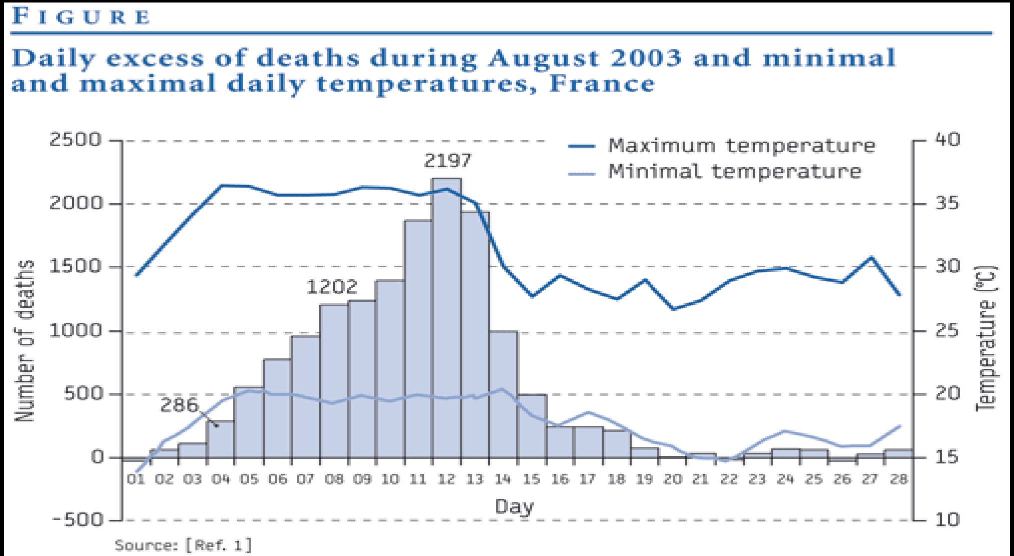
C. Landscapes for Human Health, Air Quality & Social Cohesion

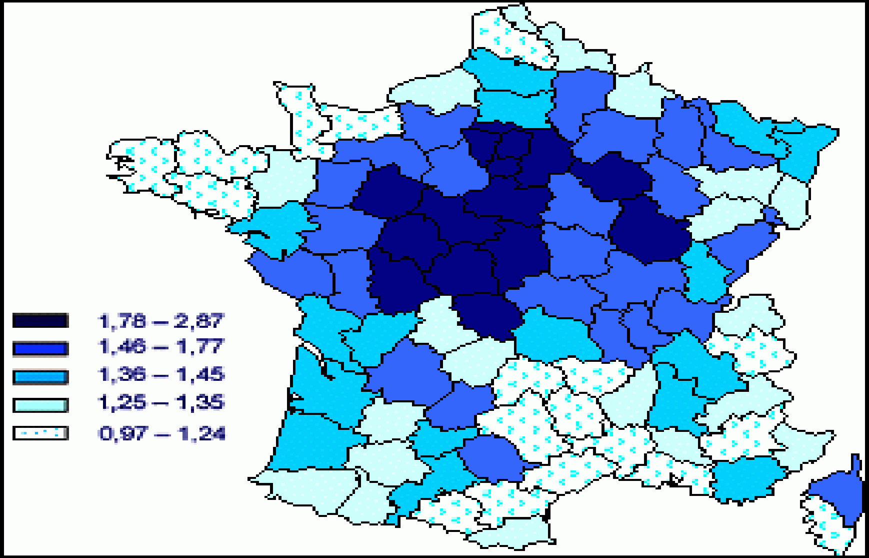
Portland, Oregon USA

Strategies for Adaptation

Urban Greening for human health

15,000 excess deaths in France’s 2-week heat wave in 2003 (“Canicule”)





http://www.eurosurveillance.org/

http://www.ined.fr/

Strategies for Adaptation:

Landscapes for Human Health, Air Quality & Social Cohesion

- **Provide parks for social cohesion and for “green lungs” in every neighborhood, especially in dense residential areas.**

Portland, Oregon USA

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- **Food: plant fruit and nut trees; provide community gardens**

Portland, Oregon USA

Strategies for Adaptation

D. Preserving Identity, Biodiversity and Ecological Resiliency

Strategies for Adaptation

Urban Greening to support biodiversity

Riparian vegetation cools water, to help salmon and other cold-water species to survive.

Connected habitat may increase resilience for species survival

Preserving Identity, Biodiversity and Ecological Resiliency

- **Connected, diverse vegetative habitat for species' resilience to habitat changes, exotics and pests. Prioritize native species.**

Strategies for Adaptation

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- **"Ecological redundancy" - provide a diverse palette of plants whose functions and tolerances overlap for resiliency**

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- **Identify and replicate qualities of signature plants that maintain "sense of place" (e.g. I-5 Deodar cedars somewhat resemble Western Hemlock)**

Strategies for Adaptation

Species Selection for Our Future Climate

Strategies for Adaptation

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- **Consider current and future stressors; Identify and select:**
  - **- Species for dry, hot and less nutrient-poor conditions;**
  - **- Anaerobically tolerant trees for wet places;**
  - **- Wind-firm species for unprotected locations;**
  - **- Pollution-resistant species for ultra-urban contexts.**

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- Consider climate mitigation and adaptation benefits, e.g.
  - winter stormwater interception
  - summer shading
  - air purification

Strategies for Adaptation

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  - - winter stormwater interception
  - - summer shading
  - - air purification

- Beware of exotic (and native) invasives

Species Selection for Our Future Climate

- Some possible trees and shrubs for the future? From adjacent zones (mostly)

Quercus garryana	Oregon White Oak
Arbutus menziesii	Pacific Madrone
Calocedrus decurrens	Incense Cedar
Chamaecyparis lawsoniana	Lawson's Falsecypress
Prunus emarginata	Bittercherry
Castanopsis chrysophylla	Chinkapin
Lithocarpus densiflora	Tanoak
Quercus ilex	Holly oak (Mediterranean)
Sequoia sempervirons	Coast Redwood
Sequoiadendron giganteum	Giant Sequoia
Umbellularia californica?	California Bay Laurel (but hosts pathogen)
Arctostaphylos columbiana	Hairy Manzanita
Holodiscus discolor	Ocean Spray
Sambucus racemosa	Red Elderberry

5. Some Principles

Think both mitigation and adaptation:
“adaptive mitigation”

5. Some Principles

Think multifunctional

5. Some Principles

Think downstream and up-hill

5. Some Principles

Consider both ecological and social

5. Some Principles

Go beyond “resilient” to be “regenerative”

5. Some Principles

Be an intrinsic educator

Places to Learn More

- UW Botanic Gardens Workshops
- Washington Stormwater Center / WSU Extension
- Washington Association of Landscape Professionals
- Washington ASLA (American Society of Landscape Architects
- Edmonds Community College
- South Seattle Community College
- University of Washington Landscape Architecture
- UW Climate Impacts Group

[Tree planting] will come to be viewed as a down payment on the massive program of climate management soon to be undertaken by cities -- the beginnings of an inland seawall to guard against the rising tide of heat.

- Brian Stone, *The City and the Coming Climate* 2012 p. 102