

Soil and Water Resources – Tackling the Last Hydrologic Frontier

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urban forests, schoolyards, open space
parks, urban agriculture
agricultural buffers



lakes, ponds, rivers, creeks, streams
sloughs, marshes, wetlands
stormwater corridors



- green and eco-roofs
- stormwater wetlands
 - bioswales
- phytoremediation of landfill effluent

Source: Rene Kane
for SPROut



utility corridors, sewage/treatment
highways, streets, sidewalks, parking lots

(water stored in **green** and **blue** is available to plants)

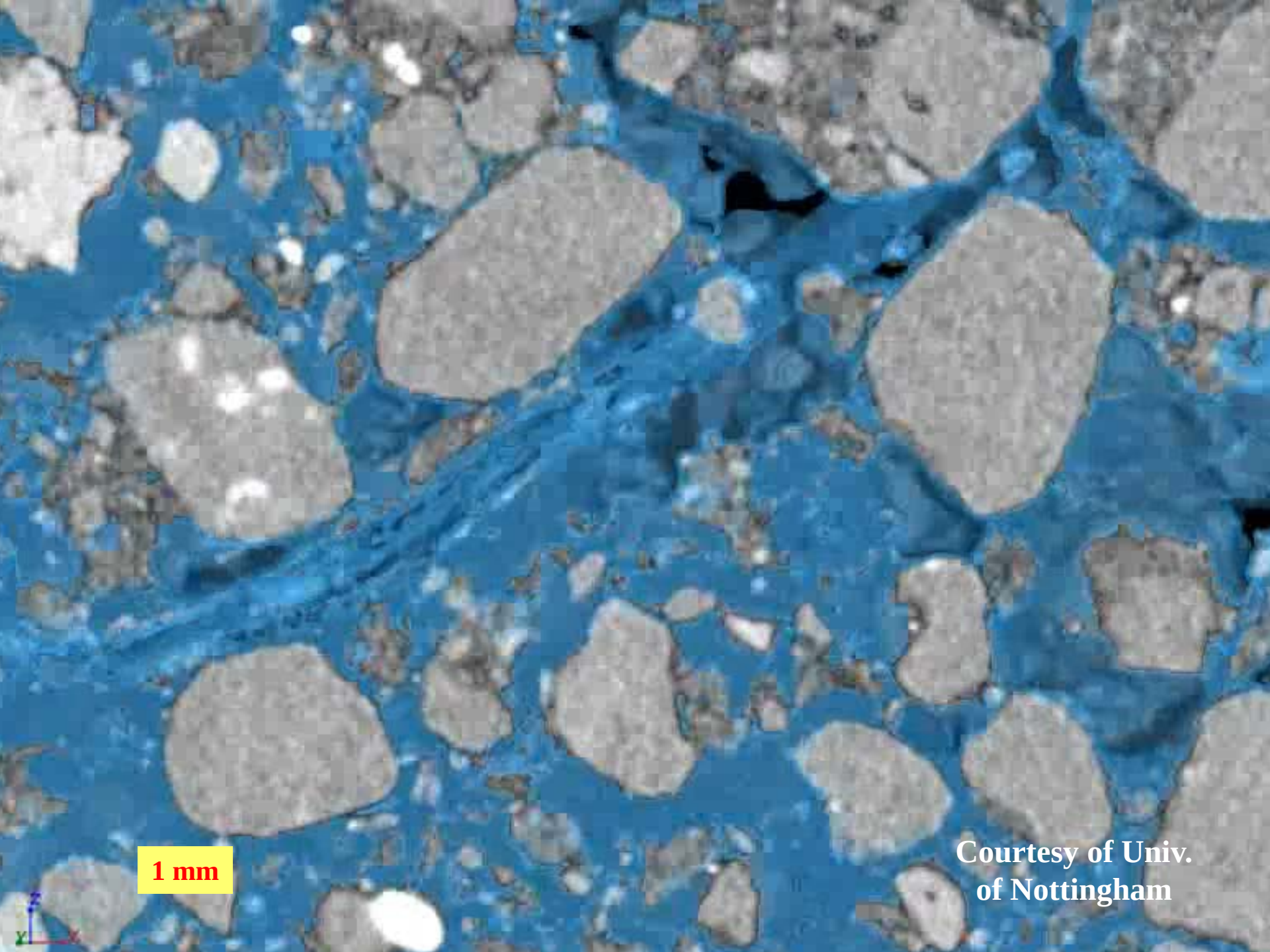
Essential in Combating the Freshwater Crisis

Human Nature: If we don't see it, it doesn't matter?!

**How water moves
through soils?**

**How plants tap
into soil water?**





1 mm

Courtesy of Univ.
of Nottingham

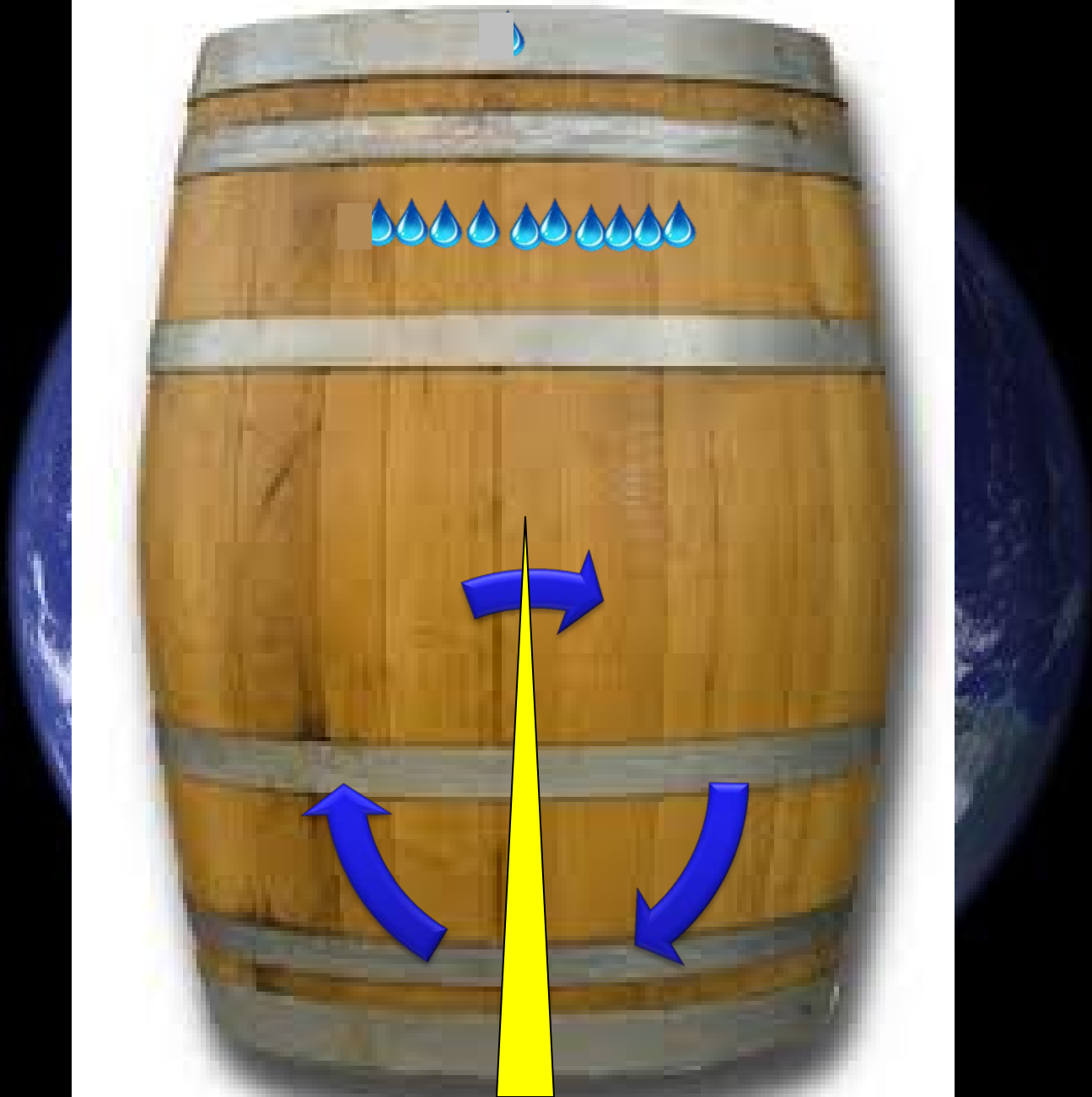


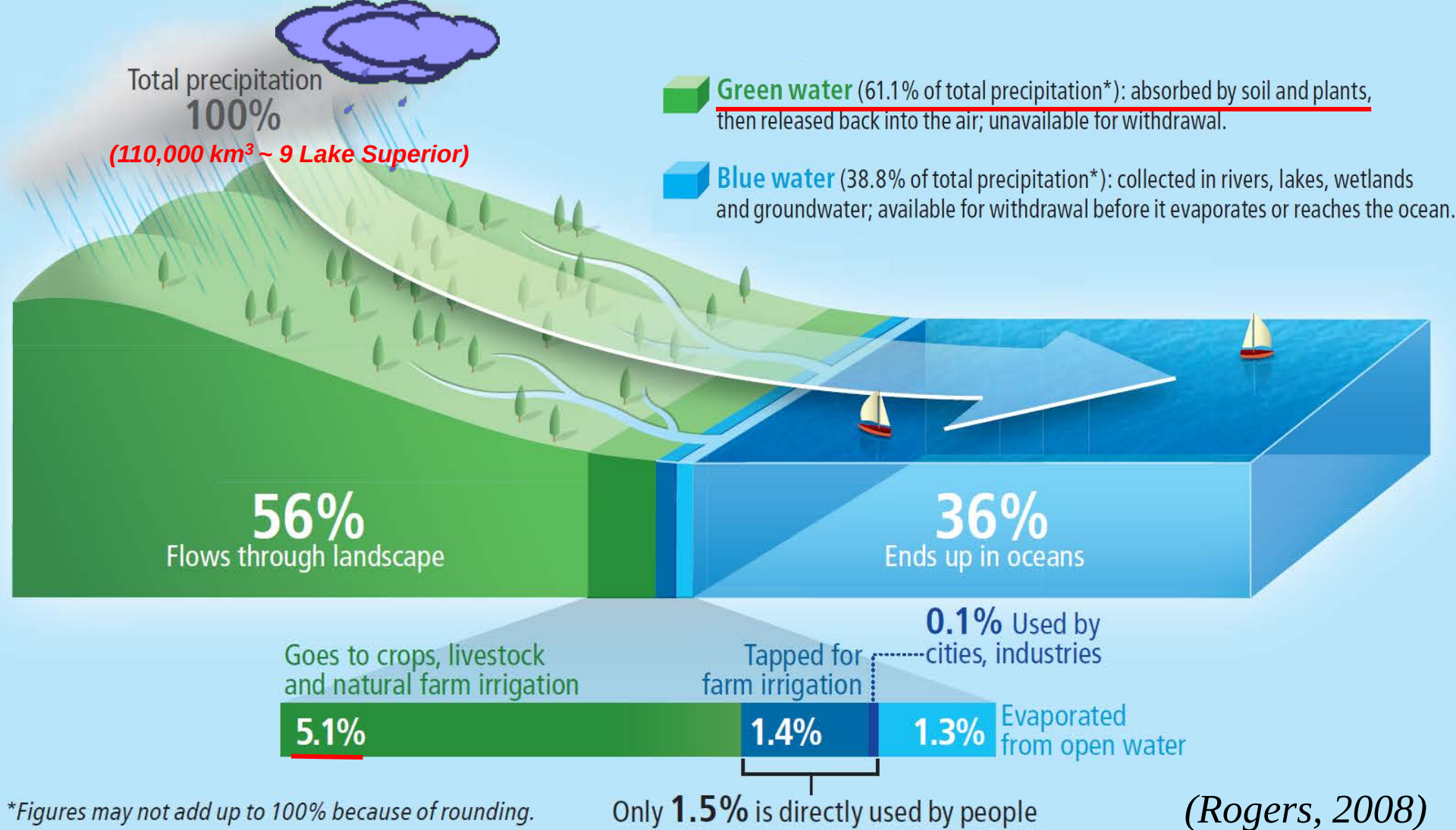
My Dream

- ***The Brown Evolution:*** Caring, maintaining, and creating healthy soils – the backbone of agriculture, ecosystem services, and environmental quality – through cultivating **land ethic**, implementing comprehensive **soil conservation policy**, adopting **precision management**, and **recycling wastes** to generate new soils.
- ***The Blue Evolution:*** Combating looming global **freshwater crisis** and preventing **water pollution** to achieve water sustainability (including water quantity, quality, distribution, and related socioeconomics), and to do so in ways that are **environmentally sound** and **economically feasible**, thus requiring a combined global coordination, regional planning, and local actions.

BLUE BEAUTY

Photos by Astronaut Sunita Williams

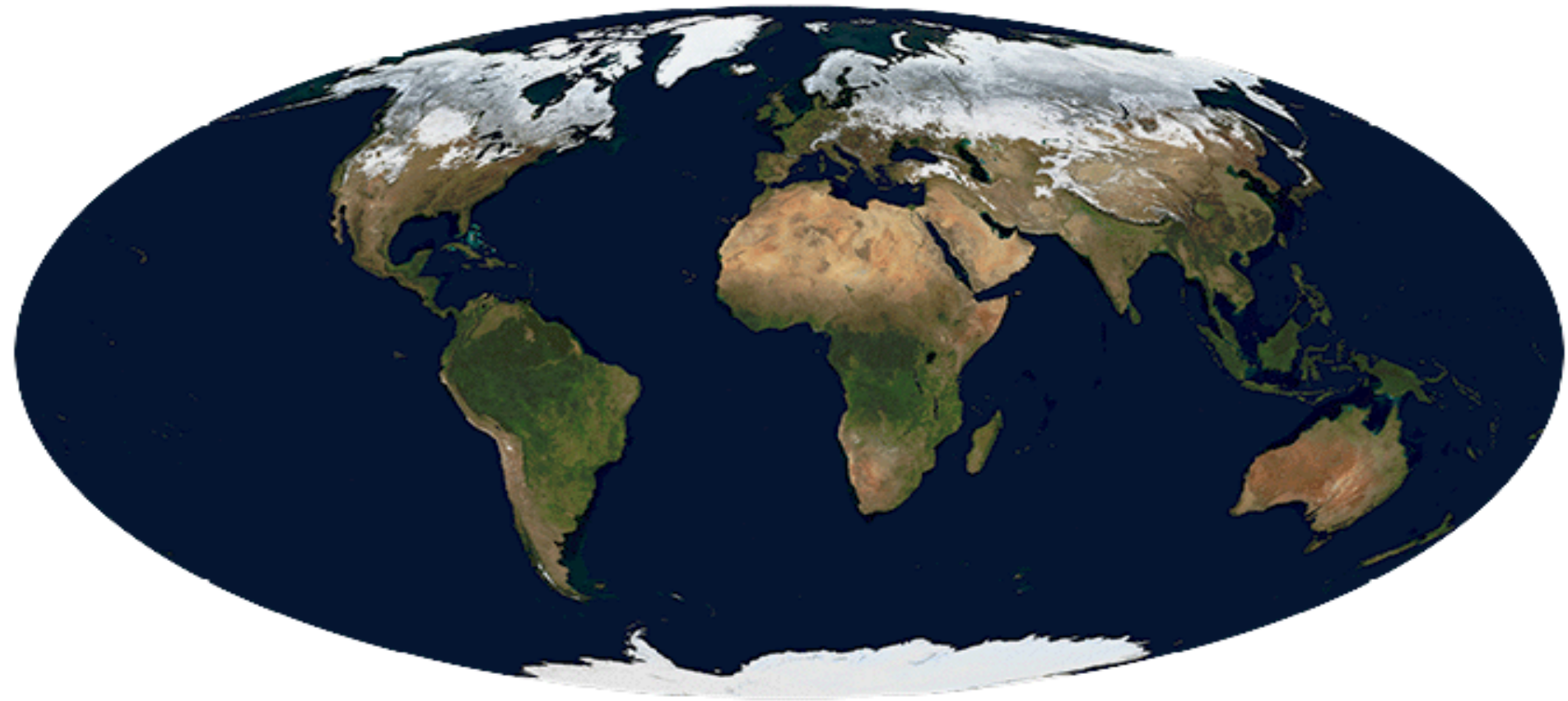




Green water: Often overlooked, whose annual global flow (~5.5 Lake Superior) matches that of all the rivers in the world flowing to the sea, and ~90% of water consumed by croplands worldwide is green water (Sposito, 2013).

Critical Importance of Green Water:

“Greened” lands advance & retreat across a year (NASA's Blue Marble data)



Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec



When there is too little water in soils:
Modern dust bowl?



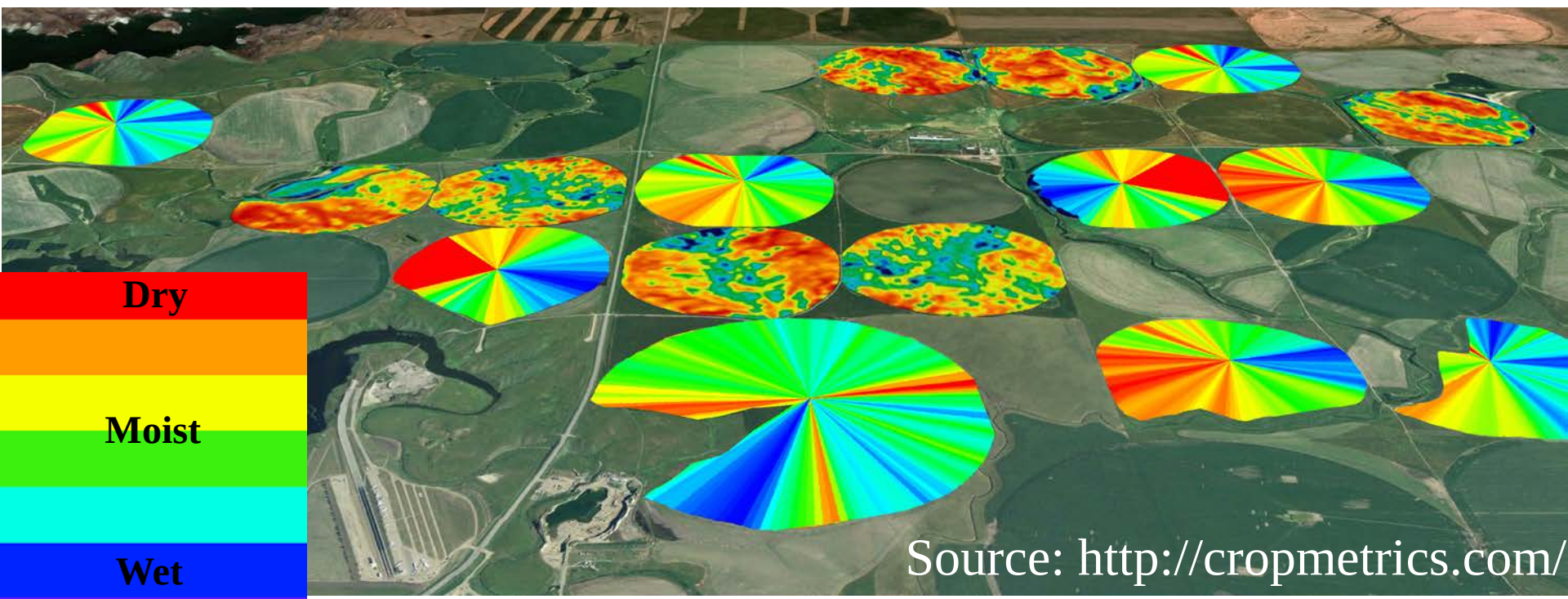
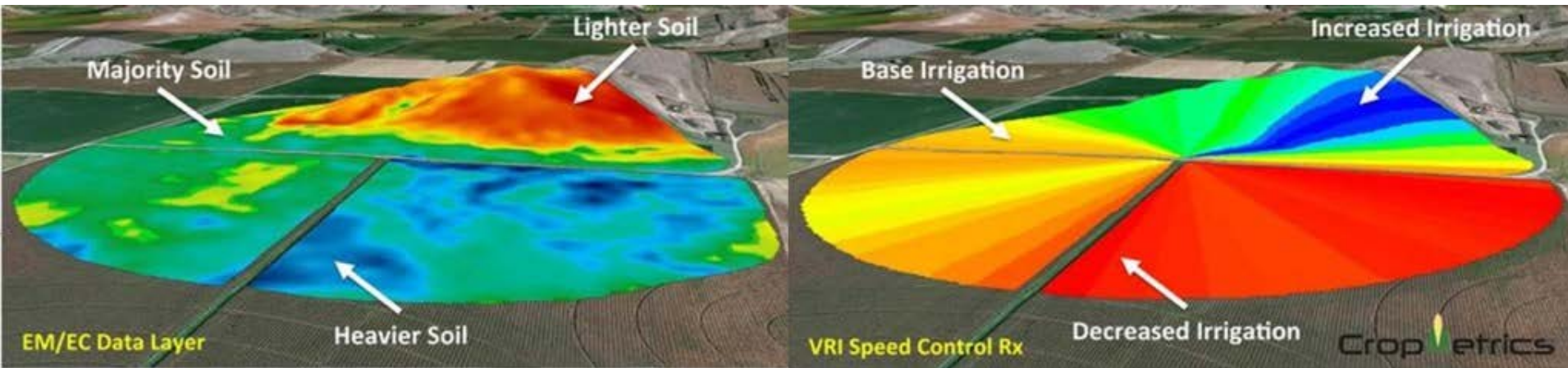


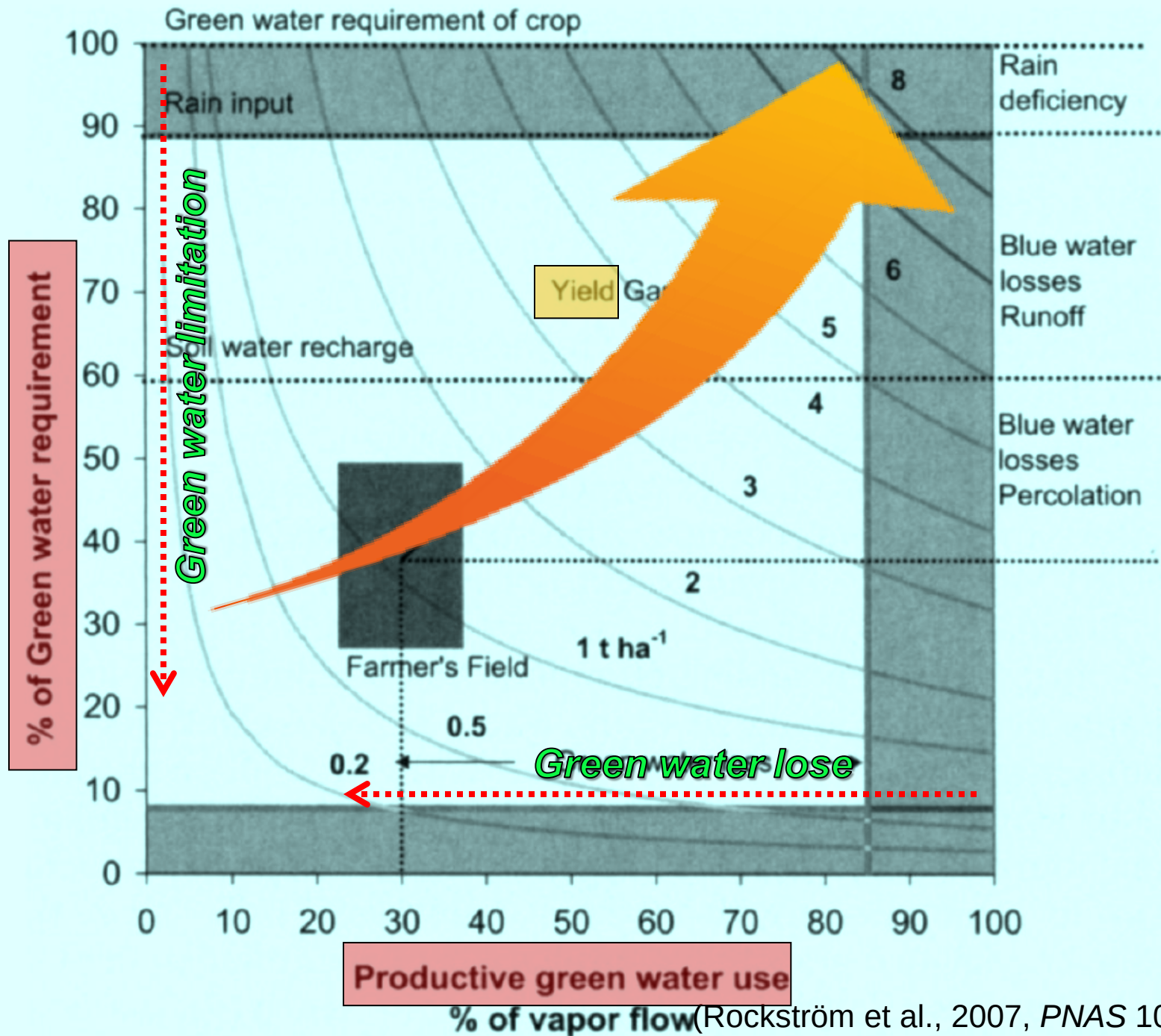
When there is too much water in soils:
Massive landslides around the world



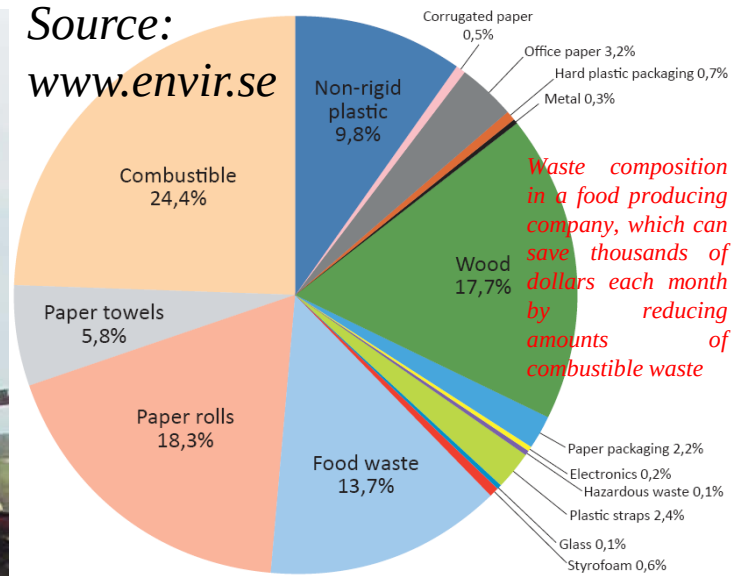
Precision Irrigation in Agriculture

Right amount, at the Right time, in the Right place, with the Right quality (4R)



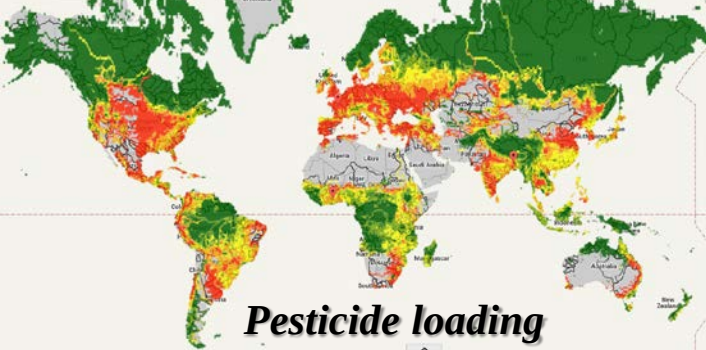


Source:
www.envir.se

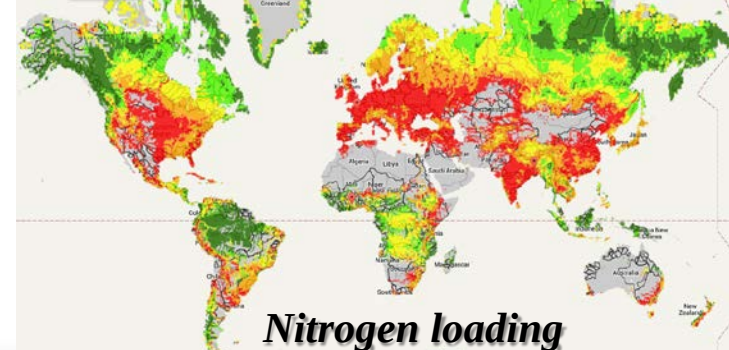
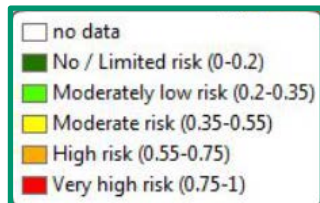


Waste composition in a food producing company, which can save thousands of dollars each month by reducing amounts of combustible waste

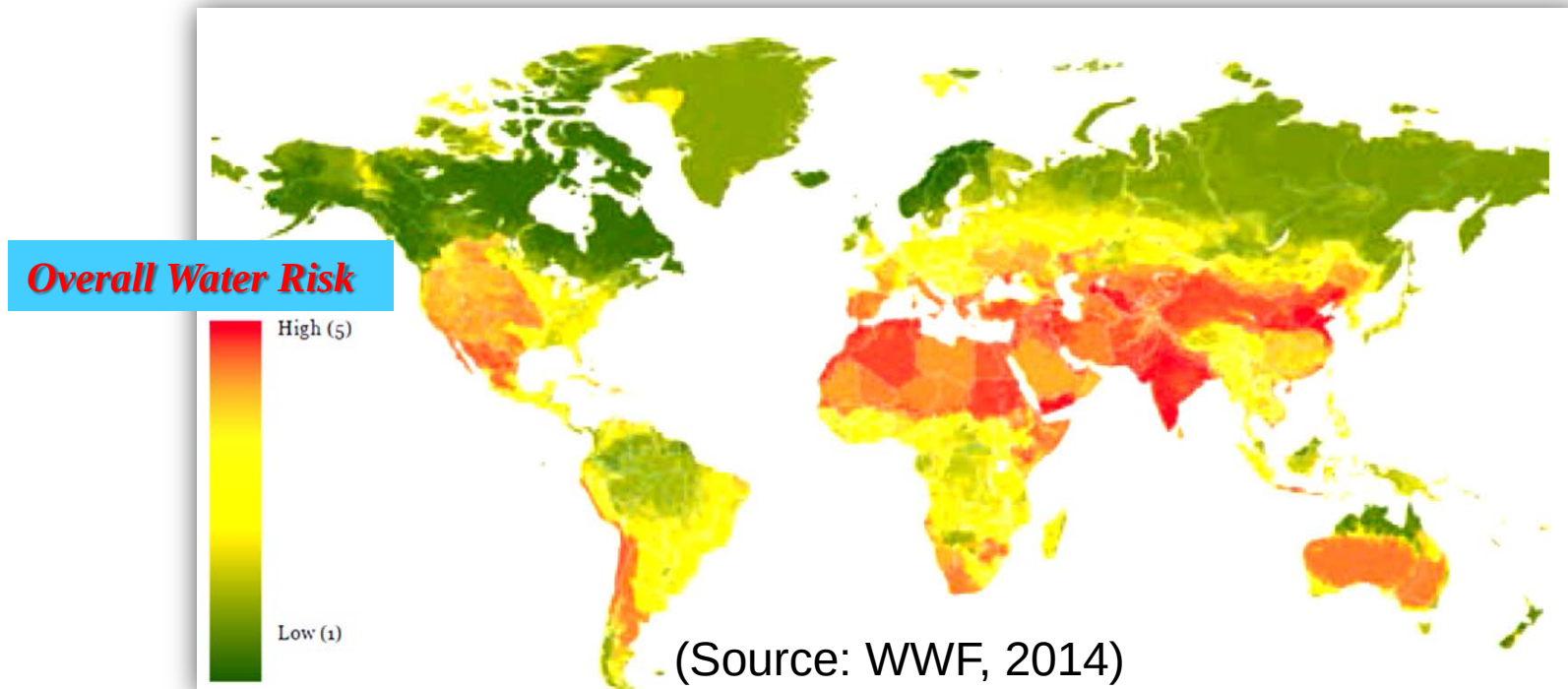




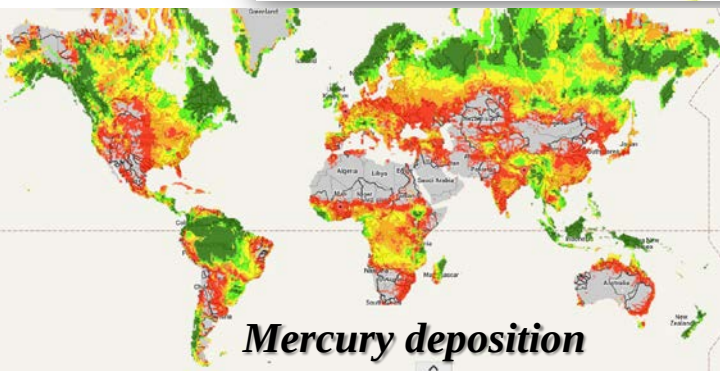
Pesticide loading



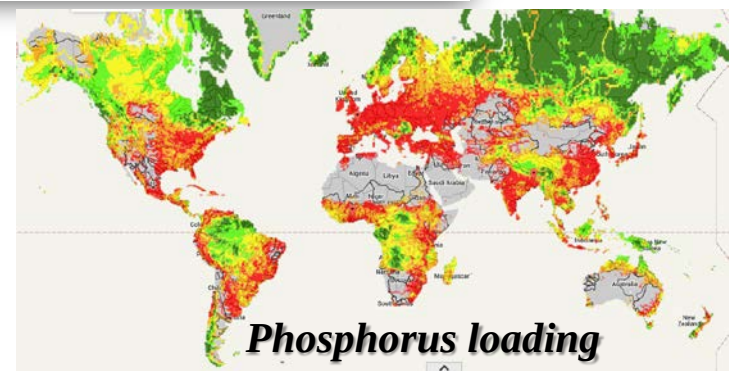
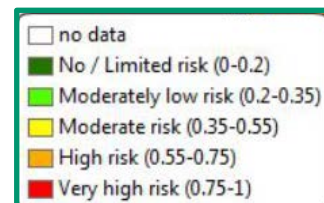
Nitrogen loading



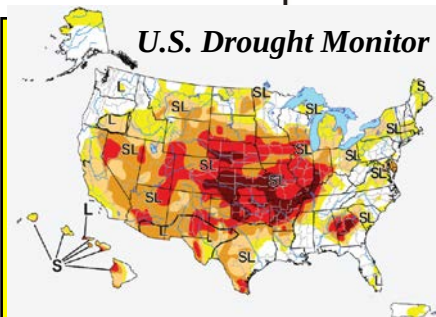
(Source: WWF, 2014)



Mercury deposition



Phosphorus loading



Agricultural Drought



Hydrological Drought



Socioeconomic Drought



Time (duration)

Climate Variability/Change

4 types of drought

Precipitation deficiency
(amount, intensity, timing)

High temperature, high winds, low
relative humidity, greater
sunshine, less cloud cover

Reduced infiltration, runoff,
deep percolation, and
ground water recharge

Increased evaporation
and transpiration

Soil water deficiency

Plant water stress, reduced
biomass and yield

Reduced streamflow, inflow to
reservoirs, lakes, and ponds;
reduced wetlands,
wildlife habitat

Economic Impacts

Social Impacts

Environmental Impacts

**Meteorological
Drought**

**Agricultural
Drought**

**Hydrological
Drought**

**Socioeconomic
Drought**

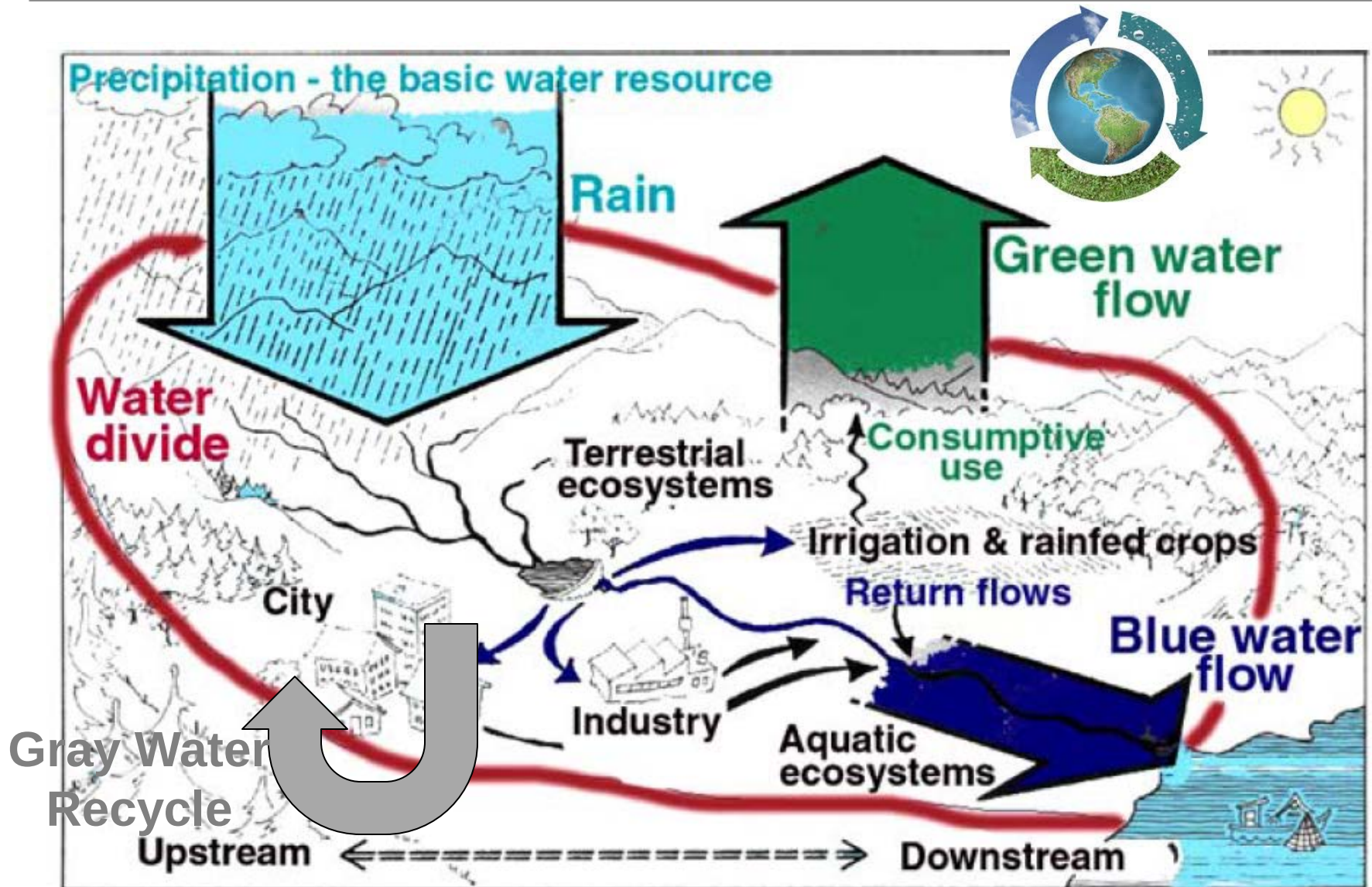
(Source: National Drought Mitigation Center)

**Facing the Earth's Wounding Fragile Skin
& the Need to Secure the Foundation for Sustainability**

So what can we do?

- 1) A move from a **blue-only** to a **green-blue-gray** approach in land-water management
- 2) Use of **water footprint** (water embedded in food, products, and services) to inform responsible consumption and land use planning
- 3) Advancing **scientific frontiers** of hydrogeology (integrated soil and water sciences)
- 4) Promoting global interdisciplinary science of the Earth's **Critical Zone** (soil & water are critical)
- 5) Cultivating **land-water ethic** and realizing the dream of the **Brown and Blue evolutions**

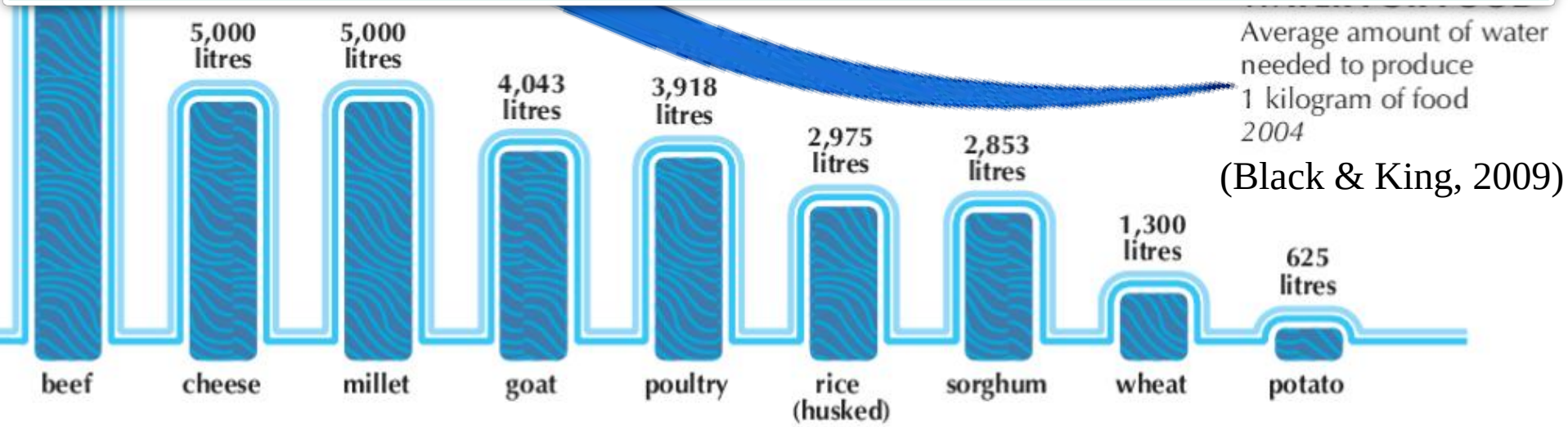
Watershed Approach to Integrated Green-Blue-Gray



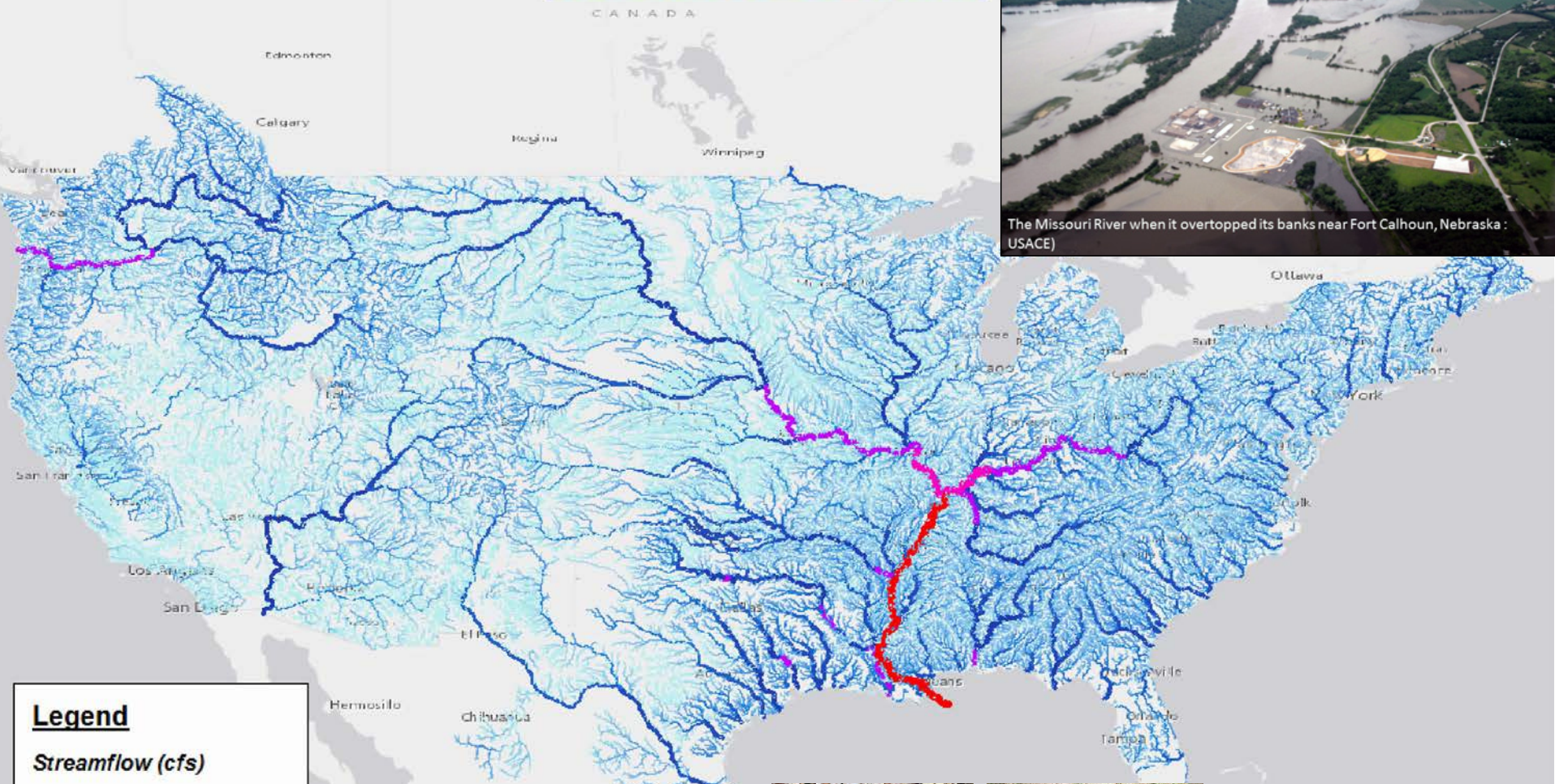
(Falkenmark, 2007; Falkenmark and Rockström, 2010)

Hope: Discouraging production & export of heavily water-embedded crops and goods from water-short areas, and encouraging water-dependent economic activities to be situated in water-rich areas.

Challenge: Most products, exports, and trades are driven by socioeconomic and political factors.



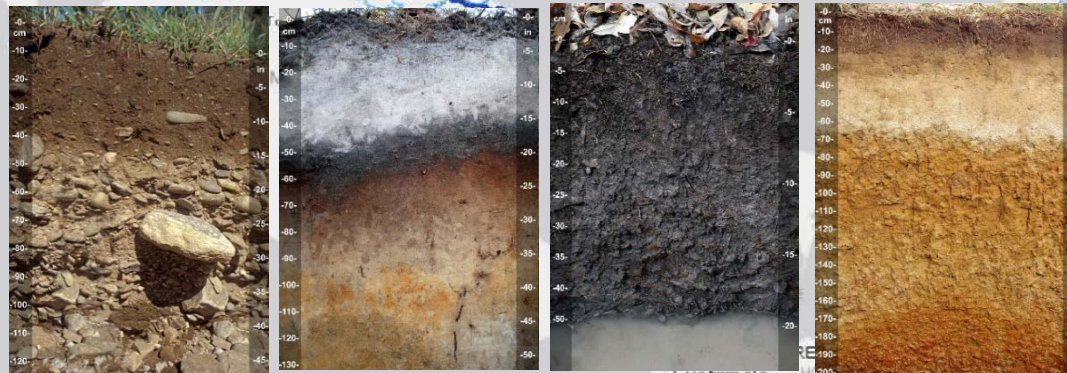
National Water Model



Legend

Streamflow (cfs)

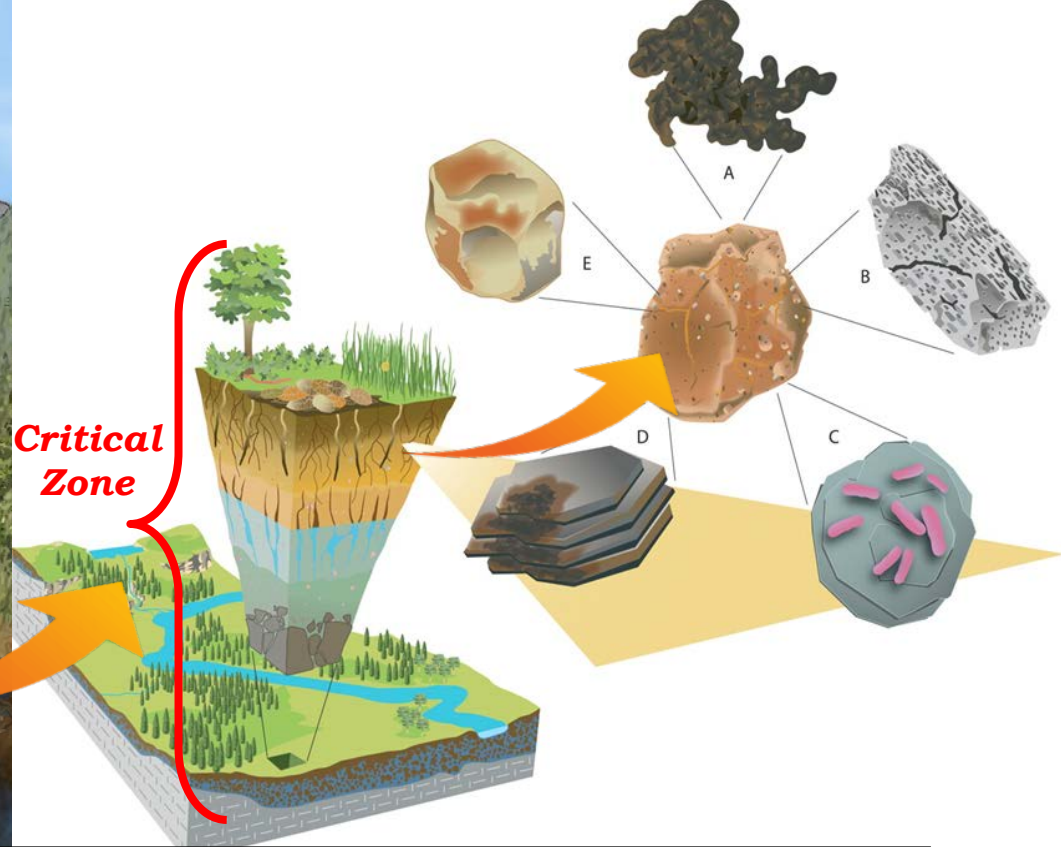
- 0 - 119
- 119 - 7,520
- 7,521 - 88,700
- 88,701 - 201,900
- 201,901 - 460,000
- 460,001 - 1,200,000



(Courtesy of
David Maidment
UT-Austin)

5/01/2015 00:00

StreetMap contributors, and the GIS user community



A Global Network of Critical Zone Observatories (CZO)



*(Guo and Lin, 2016;
Chorover et al., 2011)*

Food quantity & quality

Realizing the Dream

*The Blue
Water
Evolution*

*The Brown
Soil
Evolution*

Quality & climate

Health &

Infrastructure

Soil Ethic: At the core of
the nexus of food, water,
air, health, and energy

Take-home Messages

- 1) From **blue-only** to an integrated **green-blue-gray** in managing soil and water
- 2) Use **water footprint** to inform responsible consumption and land use planning
- 3) Advance **hydropedology frontiers**
- 4) Advance global **Critical Zone science**
- 5) Cultivate **land-water ethic** to realize the dream of the **Brown and Blue evolutions**

Look beneath the surface for sustainability!



THANK YOU

Nature's Story

My Soils!

My Water!

