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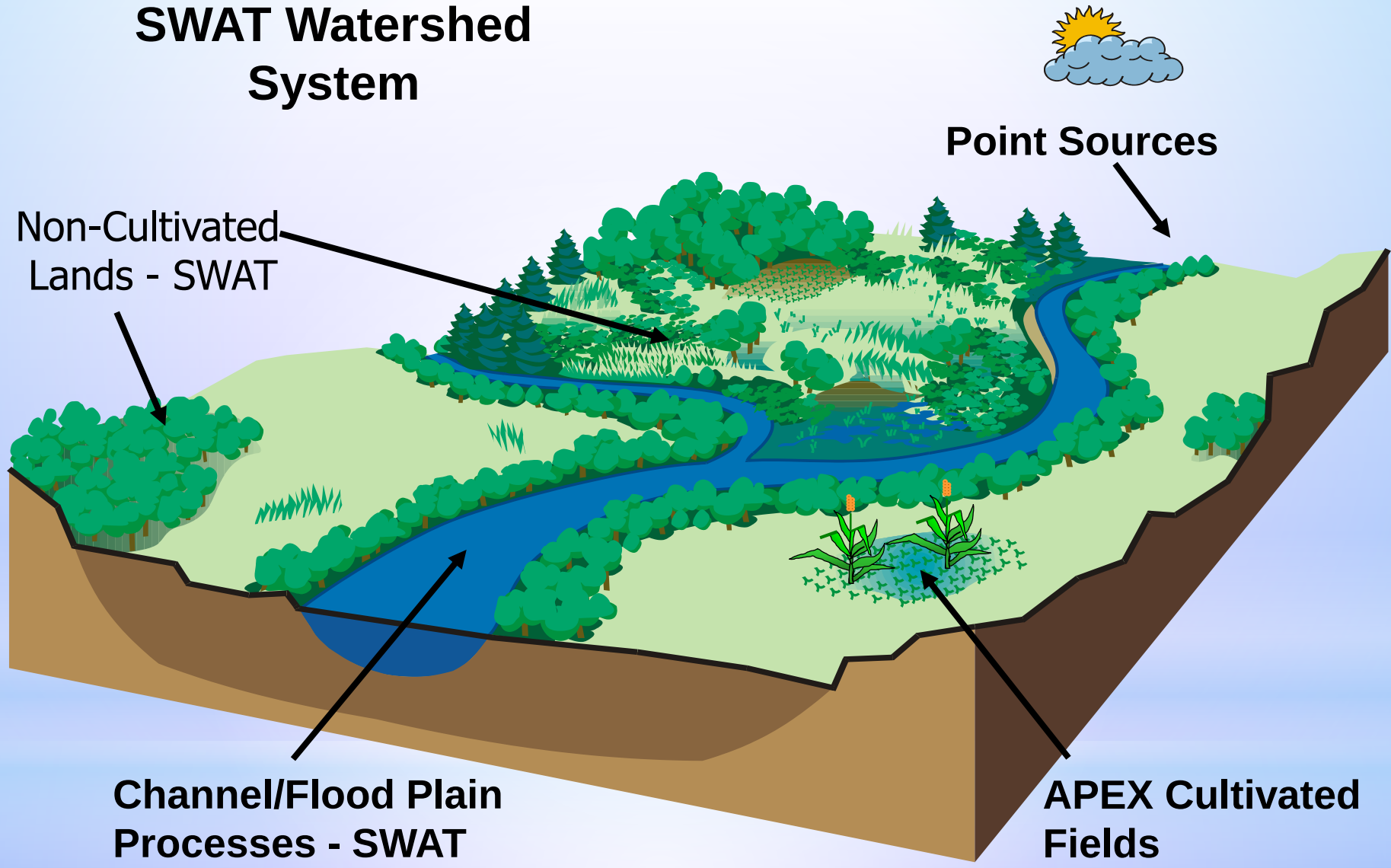
SWAT+
Use of SWAT for Food, Energy and Water Solutions

Presentation Overview

- SWAT Background and History
- Water Solutions
  - Blue-Green Water Assessment
  - Virtual Water Trade
  - US National Conservation Assessment
- Water, Food and Energy Solutions
  - Midwest US – corn for ethanol
  - Hawaii – sugar cane for Navy bioenergy
- Future
  - CEAP downscaling
  - Export Coefficients – Delivery Ratios
  - Global Model
  - Sustainability Indicators

SWAT Watershed System



SWAT Model Capabilities

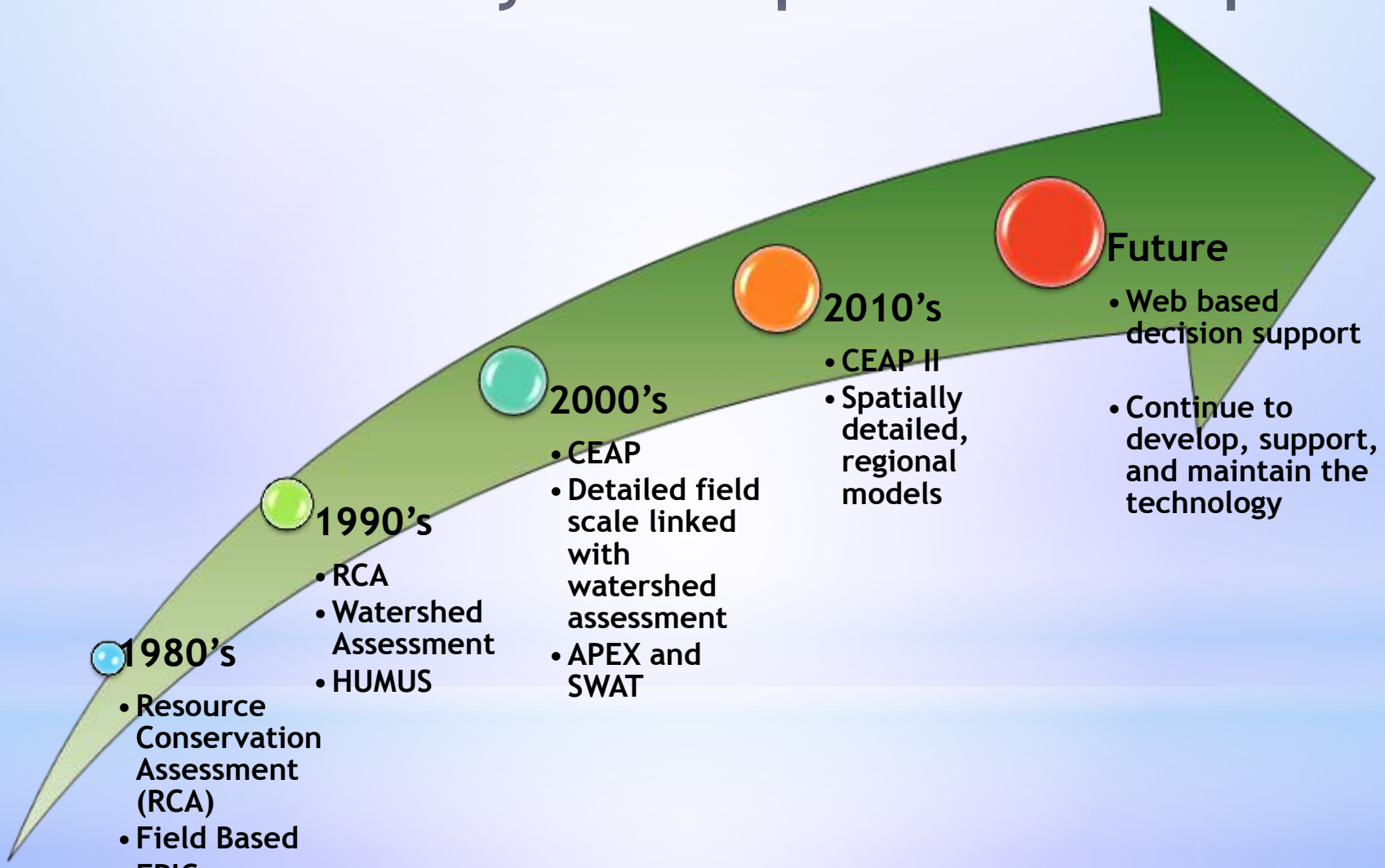
Upland Processes

- Weather
- Hydrology
- Sedimentation
- Plant growth
- Nutrient cycling
- Pesticide dynamics
- Carbon dynamics
- Pathogen fate

Management

- Crop rotations
- Removal of biomass as harvest
  conversion of biomass to residue
- Tillage/biomixing of soil
- Fertilizer applications
- Grazing
- Pesticide applications
- Irrigation
- Subsurface (tile) drainage
- Water impoundment (e.g., rice)
- Urban BMP's – water retention,
  green roof, water garden

History of Conservation Assessment for USDA Policy Development at Temple



SWAT Publications and Support

- 3,000+ journal articles related to SWAT development and application
- 87 journal articles on bioenergy production and economic and environmental impact

Stats - Mendeley | Get Support | Soil and W

swat.tamu.edu/support

SWAT Soil & Water Assessment Tool

SOFTWARE DOCUMENTATION WORKSHOPS CONFERENCES PUBLICATIONS DEVELOPERS

GET SUPPORT

SWAT is a comprehensive watershed management model that encompasses several disciplines. We try to simulate the major components of these processes as simply and realistically as possible.

Not only is the model complex, the inputs and outputs can also seem overwhelming at first. We try to keep all inputs readily available and supply required data for weather, soils, crops, pesticides and nutrients (for the U.S.). We also have developed various interfaces to ease input development. We appreciate any suggestions or bugs you may find in the interfaces.

SWAT User Groups

The SWAT user groups provide a method to exchange your ideas and issues about the use of SWAT model with fellow SWAT model users. The SWAT development team monitors all messages posted to the user groups.

- SWAT User Group
- ArcSWAT Group
- VizSWAT Group
- SWAT-CUP Group
- QSWAT Group
- SWAT-MODFLOW Group

SWAT User Groups Around the World

- Latin American SWAT Users Group
- SWAT-SEA
- SWAT Africa
- Iran SWAT Users

Development Team Support

We will be happy to work with you as problems and questions arise. Please keep in mind (1) it may take several weeks to feel comfortable running the model and (2) we are a research agency. We will do our best to respond to your questions, but if you have tight deadlines, please remember that we are often traveling or have deadlines of our own.

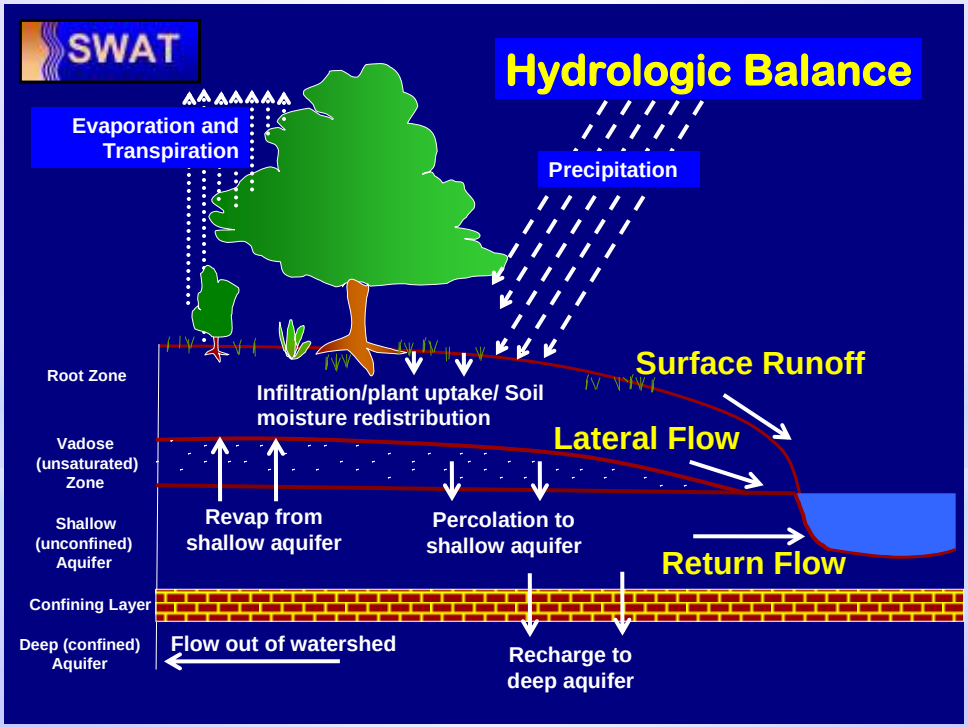
The following list can be used to contact a member of the development team if you do not receive an adequate reply to your question from the user groups.

Questions on model input/output	Nancy Sammons Jeff Arnold Georgie Mitchell
Windows interface support	Nancy Sammons
GRASS interface	R. Srinivasan
Model support	

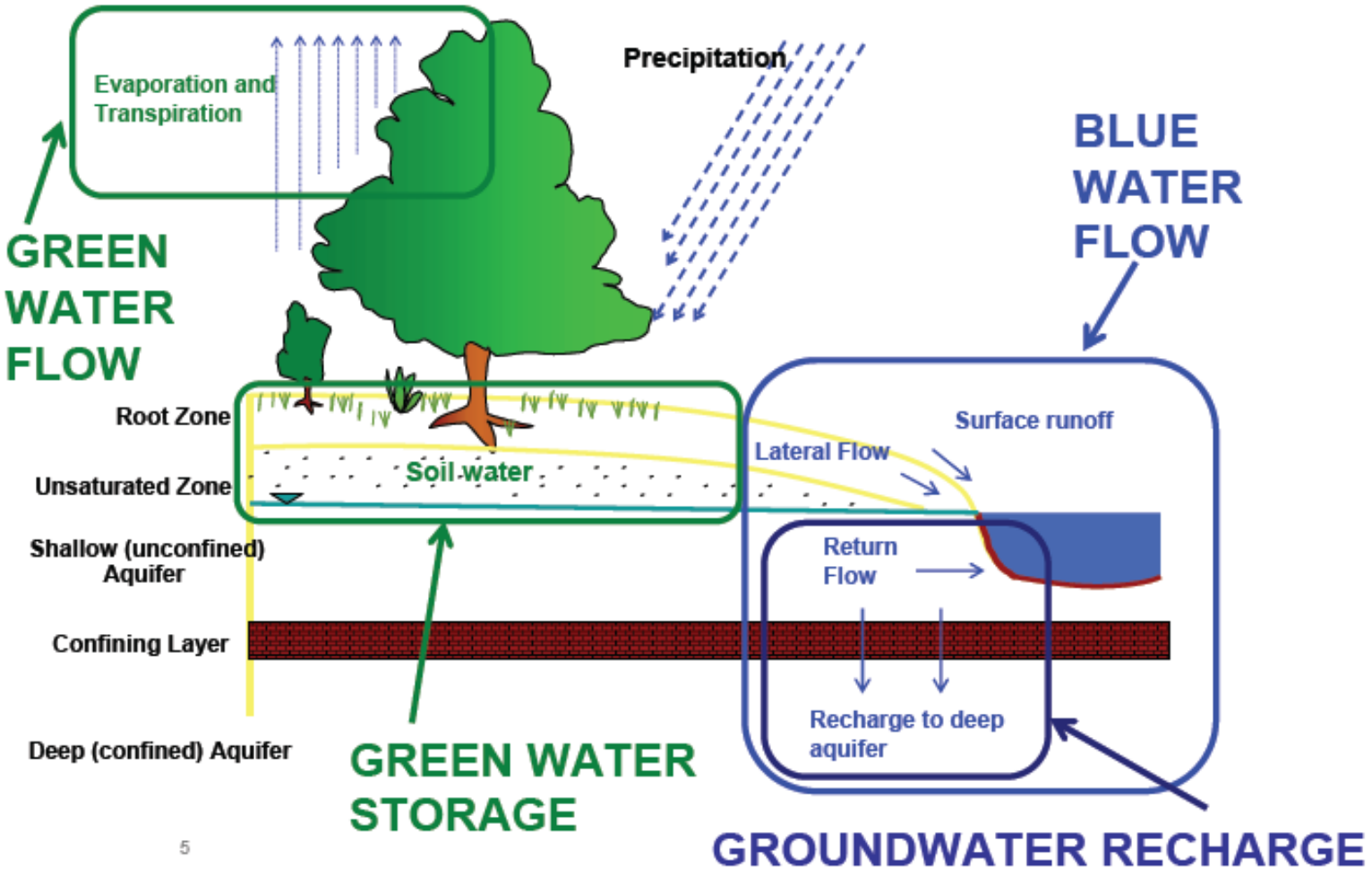
Wednesday, November 22, 2017

Water Solutions

- SWAT applied to solve water problems related to sustainability (blue/green water), regional irrigation planning, reservoir management, ground water recharge, climate change and storm water detention



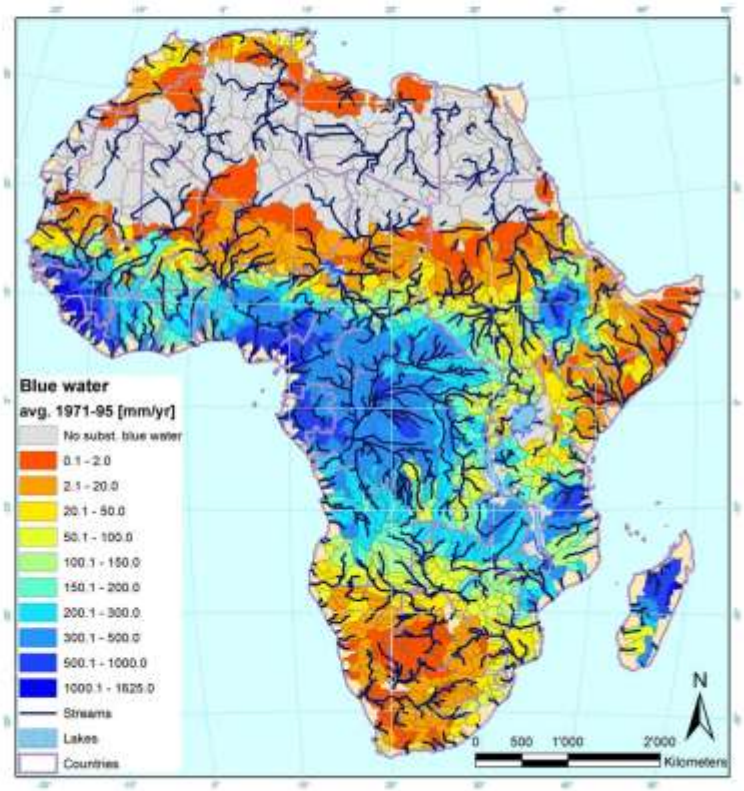
Blue and green water



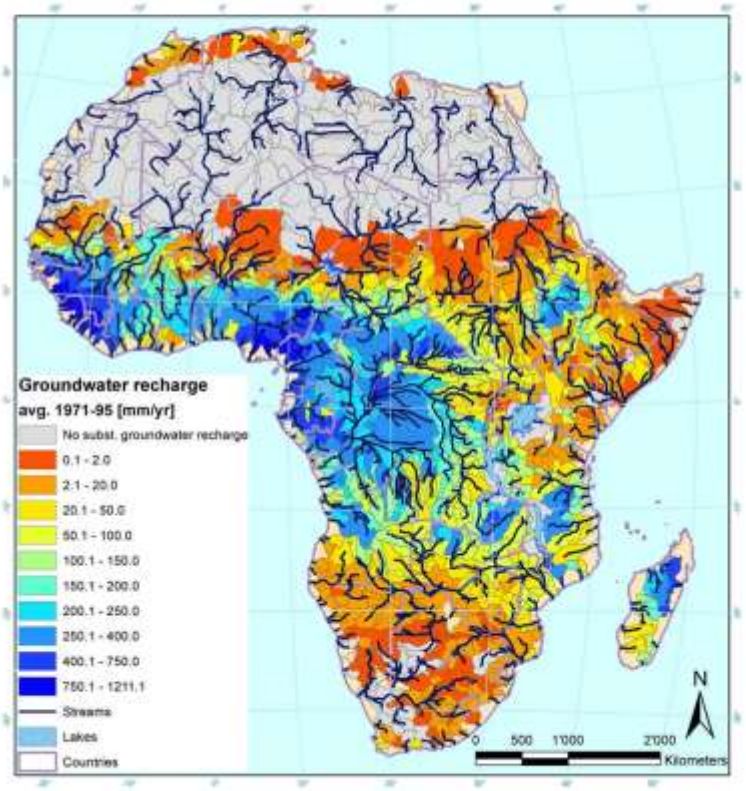
Karim Abbaspour & others; EAWAG, Dubendorf, Switzerland

The continental picture: Blue water

Blue water flow



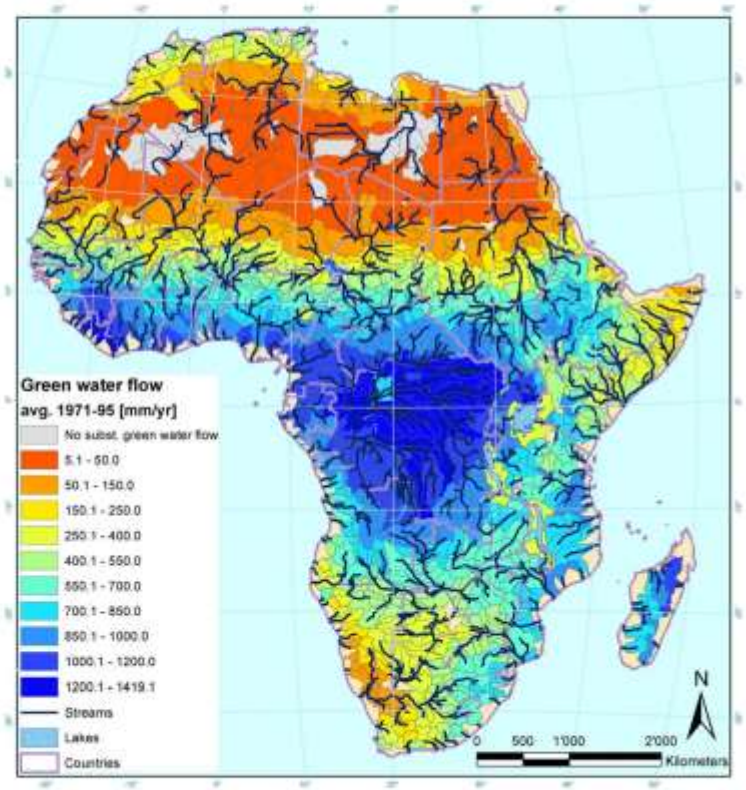
Groundwater recharge



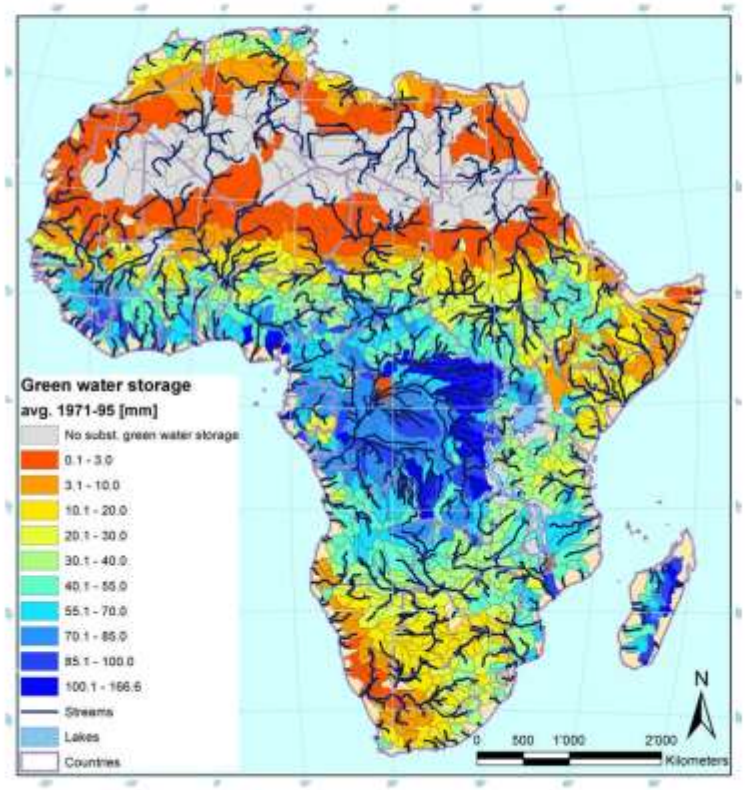
Schuol et al. 2008. Modeling blue and green water availability in Africa. *Water Resources Research.* 10.1029/2007WR006609.

The continental picture: Green water

Green water flow



Green water storage

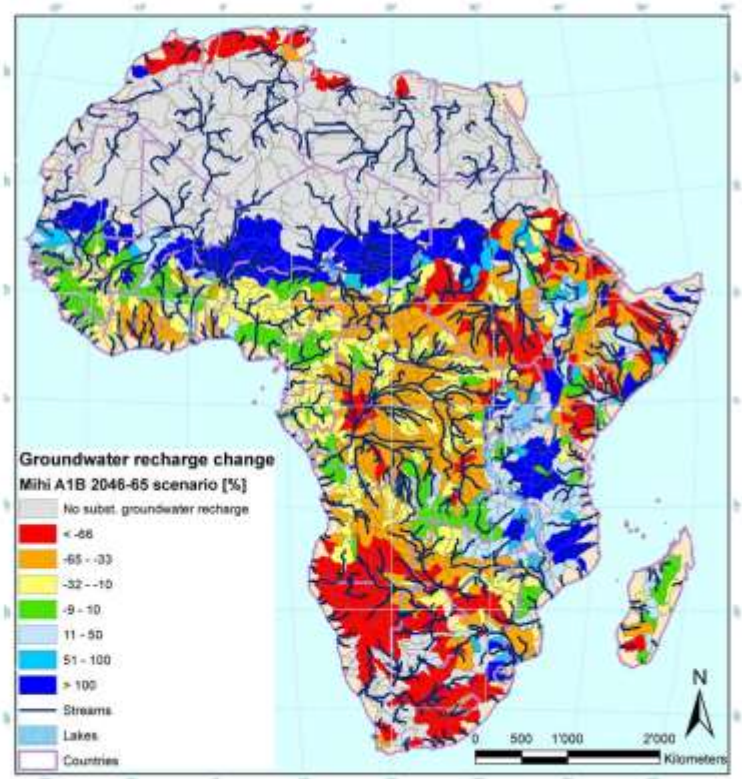


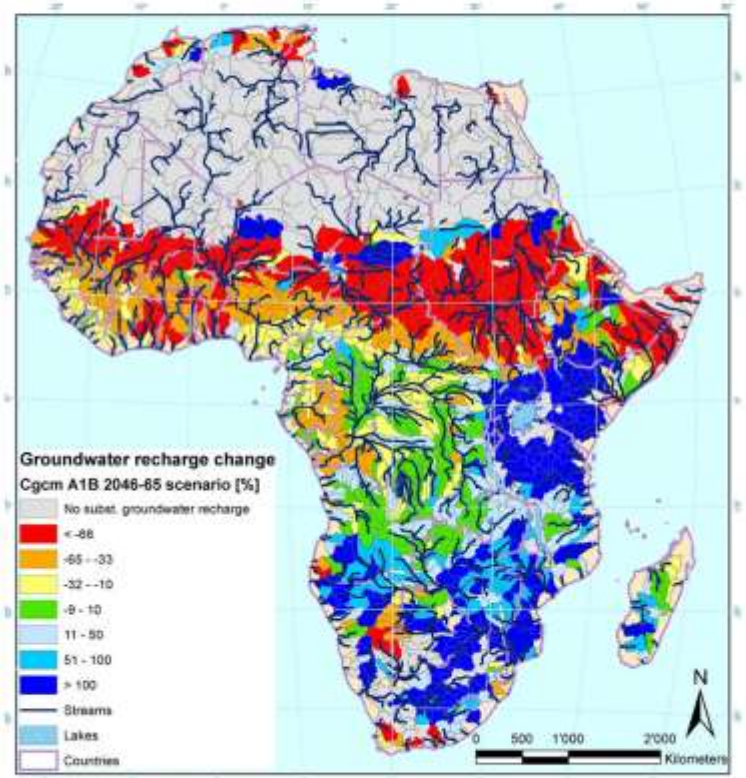
Schuol et al. 2008. Modeling blue and green water availability in Africa. *Water Resources Research.* 10.1029/2007WR006609

Changes in groundwater recharge

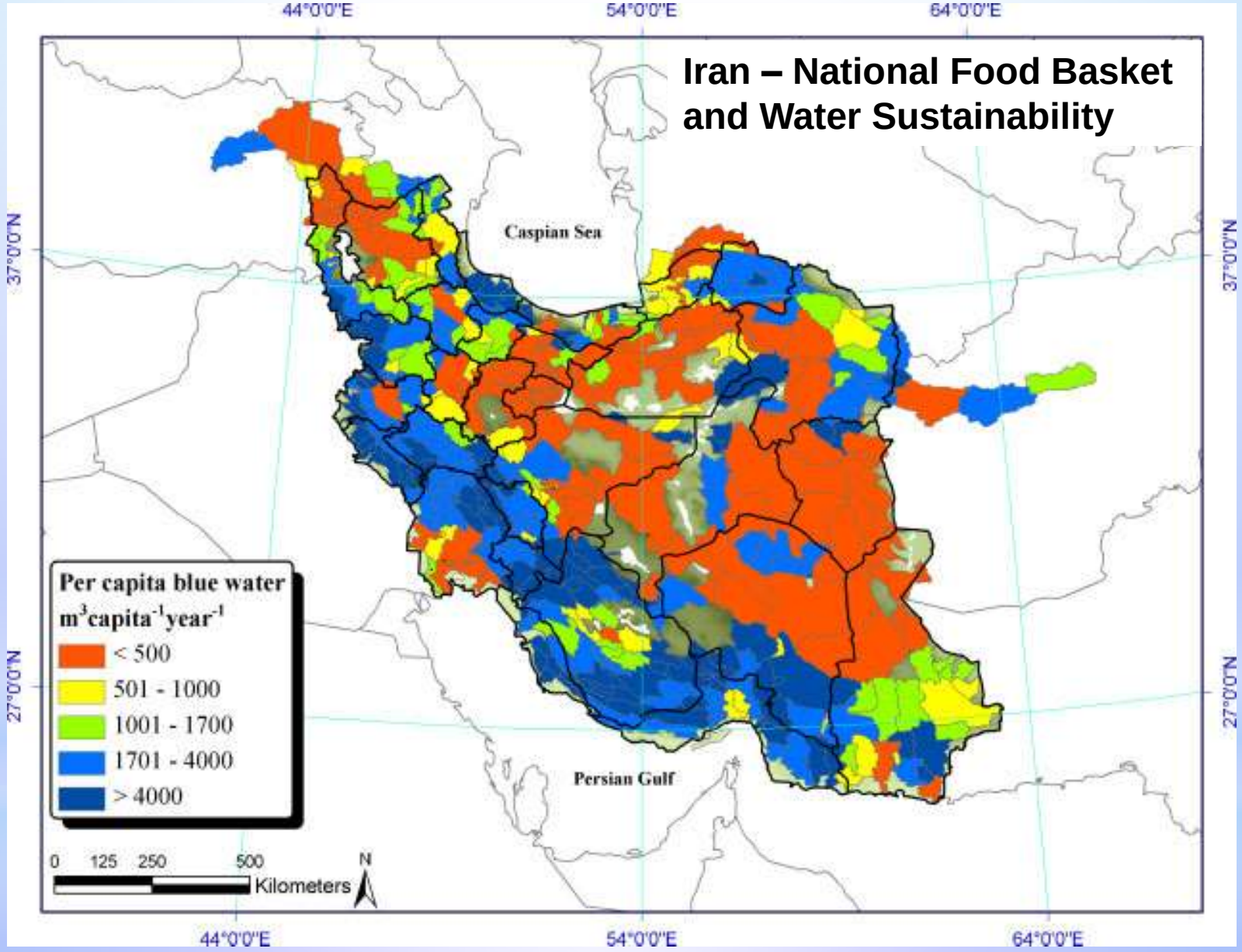
A1B emission scenario

MIROC3.2(hires) **2046-2065** **CGCM3.1(T63)**





Schuol et al. 2008. Modeling blue and green water availability in Africa. *Water Resources Research.* 10.1029/2007WR006609.



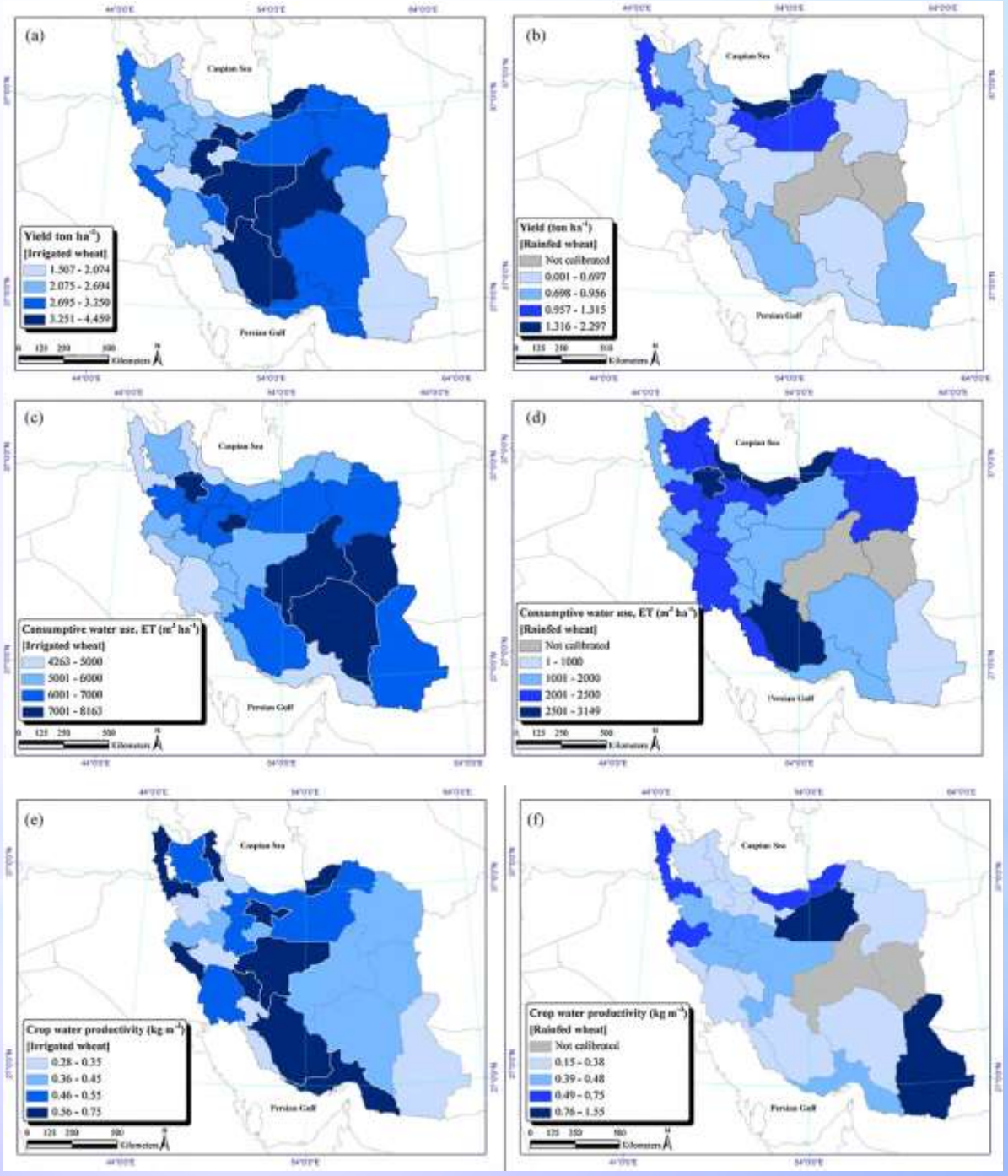
Faramarzi et al. 2008. Modelling blue and green water resources availability in Iran. *Hydrological Processes* 23(3): 486-501.

Food and Water - Iran

Yield (t/ha)

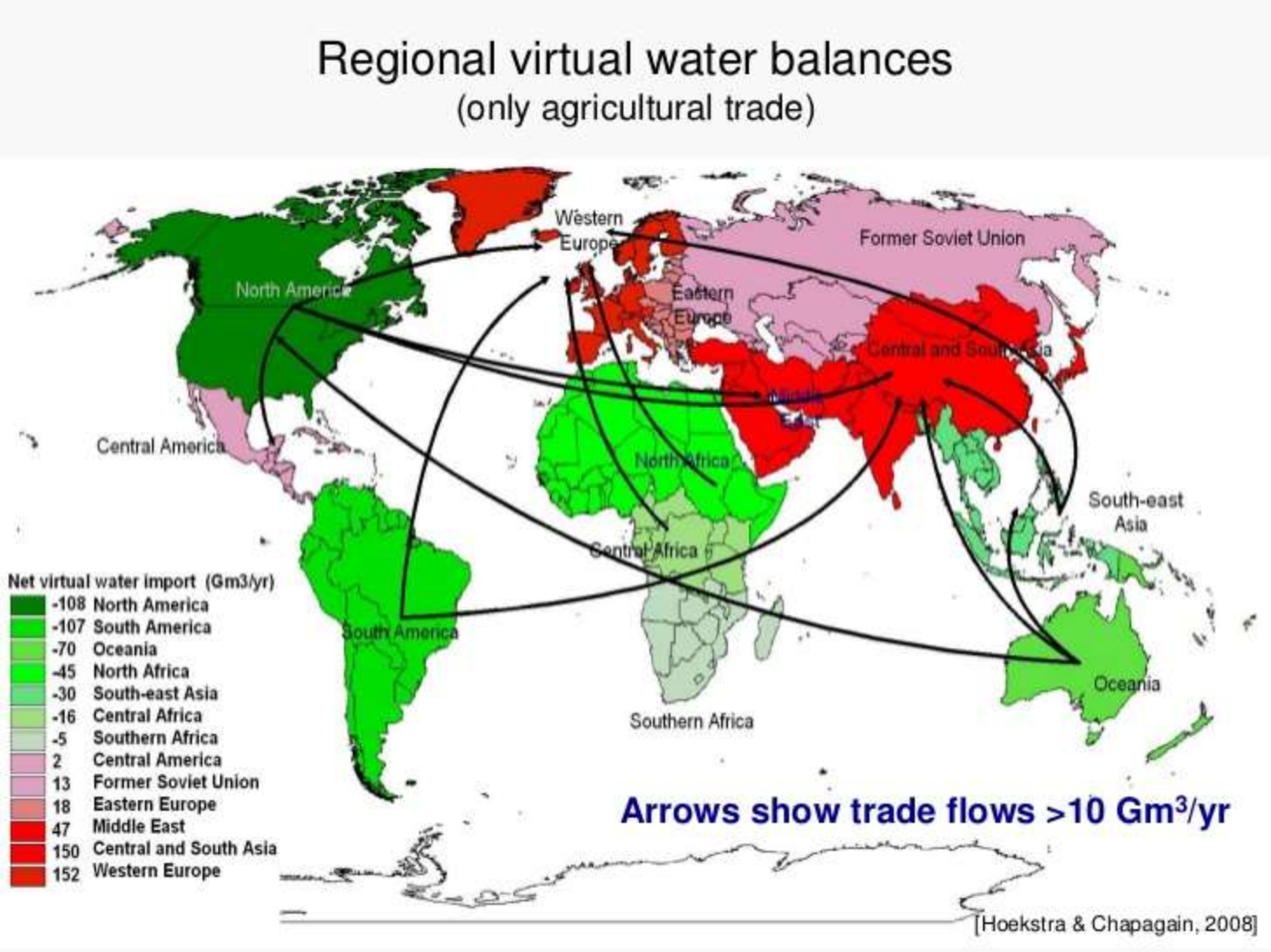
Water Use (m^3/ha)

Crop Water Productivity (kg/m^3)



Faramarzi et al. 2008. Modelling blue and green water resources availability in Iran. *Hydrological Processes* 23(3): 486-501.

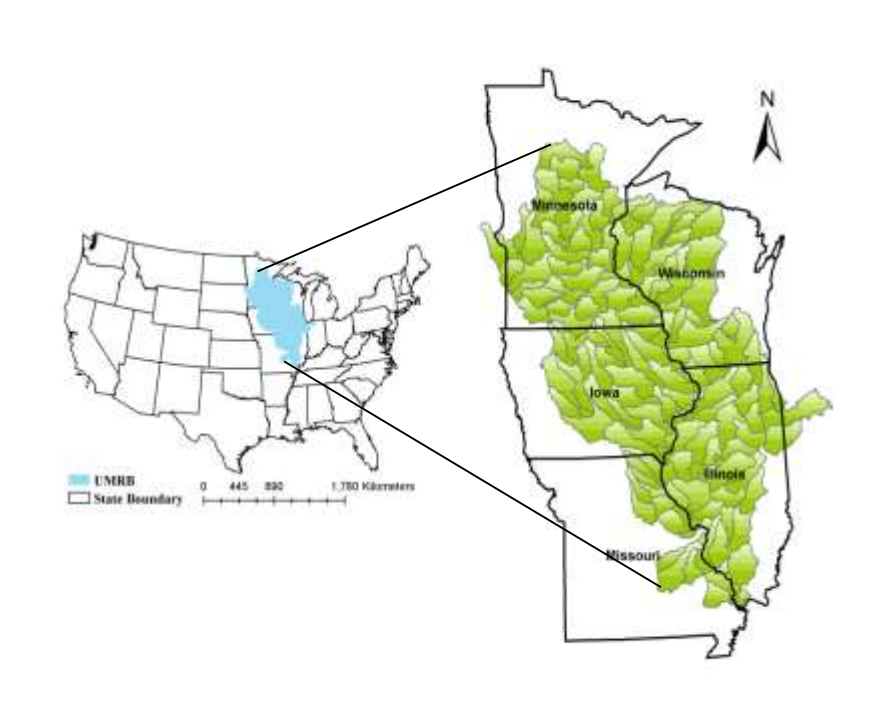
Virtual Water Trade - EPIC



Water, Food and Energy

Upper Mississippi – Ethanol Production

- Corn based ethanol production is projected to increase to meet growing demand for alternative fuels
- Rivers are subject to increased sediment, nutrient and pesticide loadings
- SWAT used to estimate effects of increased corn production in the Upper Mississippi River Basin



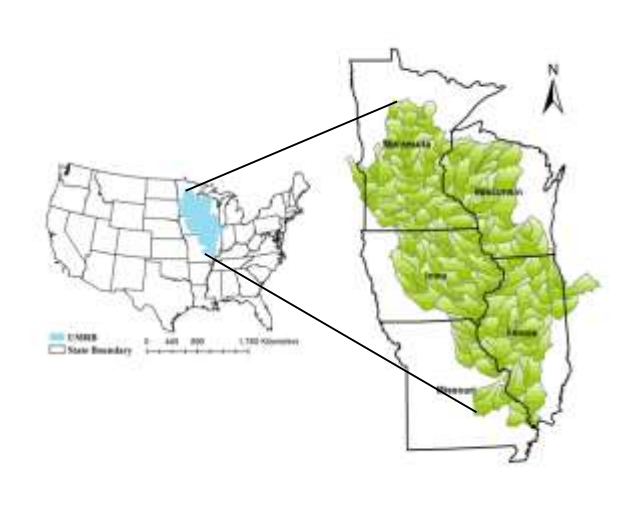
Water, Food and Energy

Ethanol Production

	Scenario Average Yield (bu/ac)	(t/ha)	Corn Area (Million Ha)	Ethanol Produced (Billion Liters)
Baseline	140.7	8.2	9.6	-
2010	149.6	8.7	13.5	19.6
2015	159.0	9.3	14.4	24.2
2020	169.0	9.9	14.0	24.2
2022	173.2	10.1	13.9	24.2

Nitrogen Loads in Mississippi River

	Unit Load (kg/ha)	Total Load (Million Kg)	Outflow in River (Million Kg)
Baseline	17.5	860.46	650.22
2010	18.4	904.33	686.19
2015	18.2	896.43	680.52
2020	17.9	879.29	666.55
2022	17.8	873.80	662.06



2012 ASABE Annual International Meeting
Dallas, Texas, July 29th- August 1st, 2012

Production and Environmental Sustainability of Bioenergy for a Hawaiian Sugarcane Plantation

J. Jeong, J. G. Arnold, C. A. Jones,
R. Srinivasan, M. Nakahata

Bioenergy Feedstock Trials

Blackland Research Center, Temple, Texas USA

Maui Sugarcane Plantation

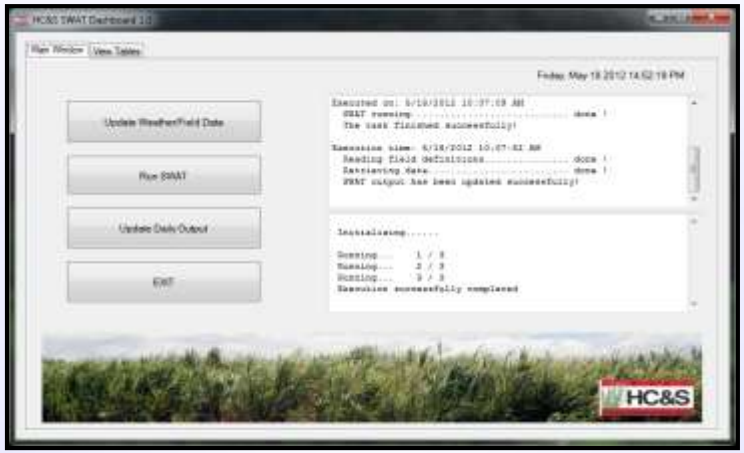
Bioenergy Production for US Navy

Area: 141 km^2
Production: 200,000 tons/yr
Water Use: 1 Mil m^3/day (70% rainforest water and 30% groundwater)
Water storage capacity: 1 day

Real-Time Decision Support Tool

SQL Database

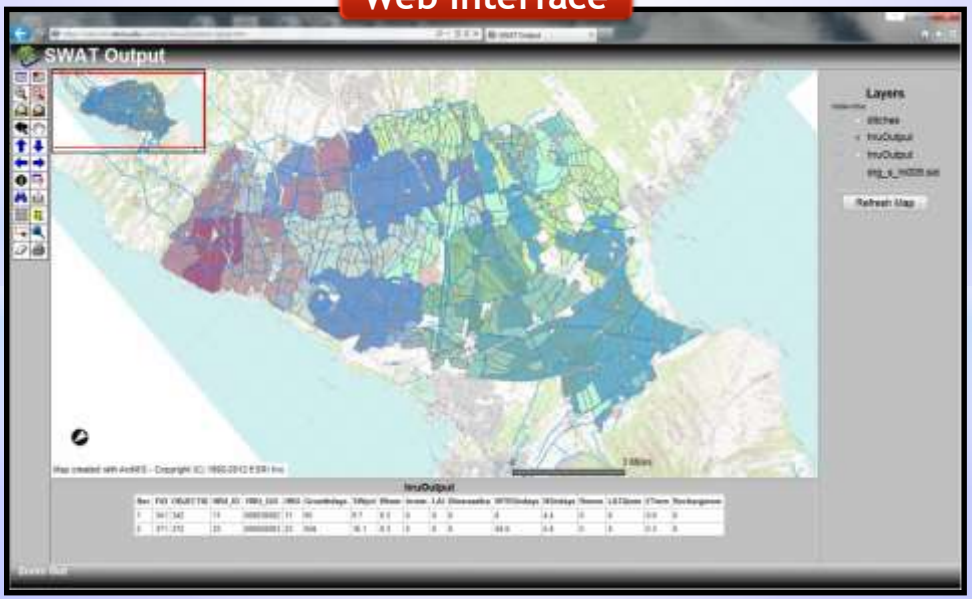
- Rainfall/Irrigation
- Temp/Humidity
- Wind/Solar
- Fertilizer/Pest
- MGT Operations
- Crop Age



SWAT

- ET/PET
- Soil Water
- GW Recharge
- Crop Growth
- MGT Operations
- Erosion/Transport

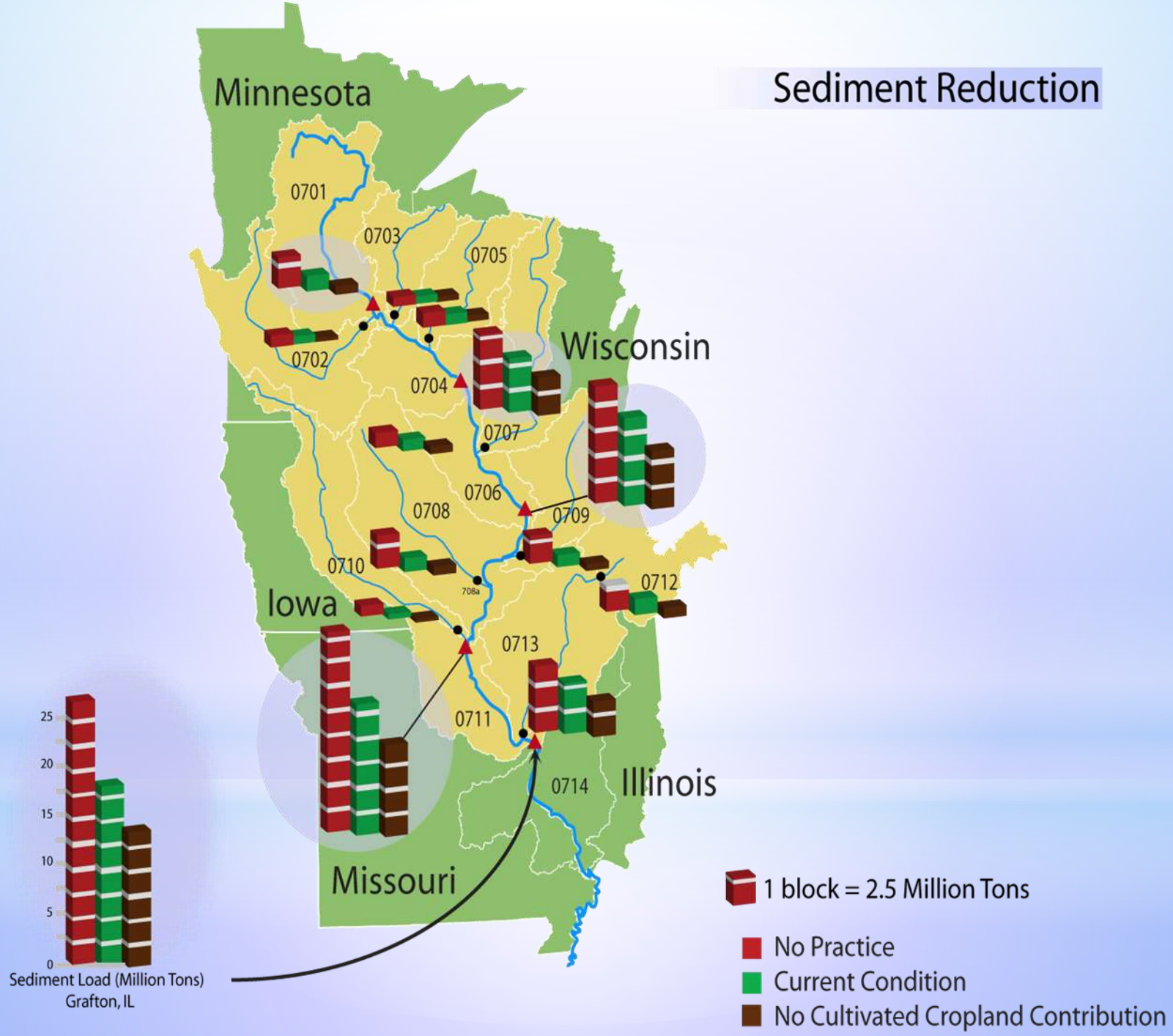
Web Interface

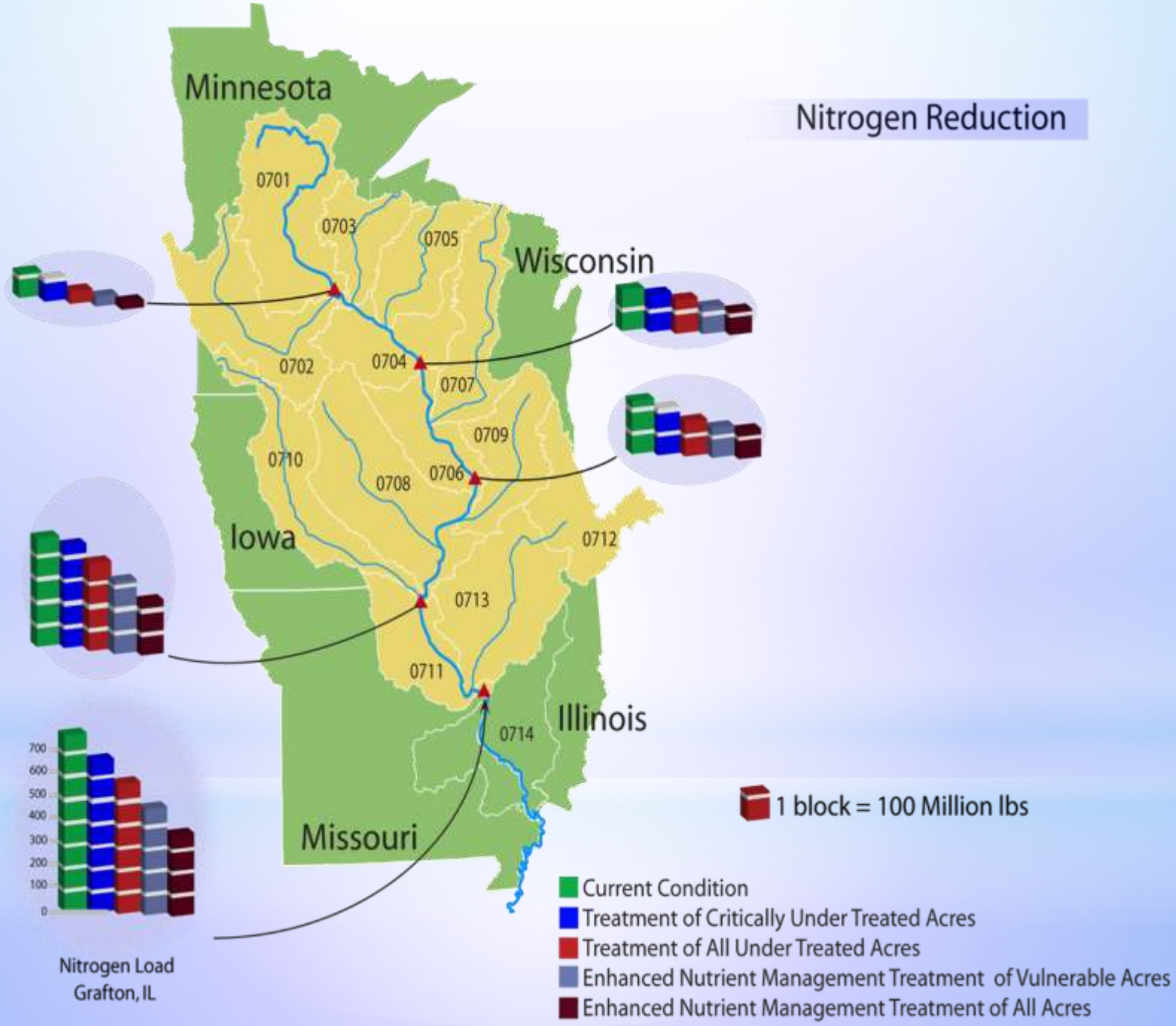


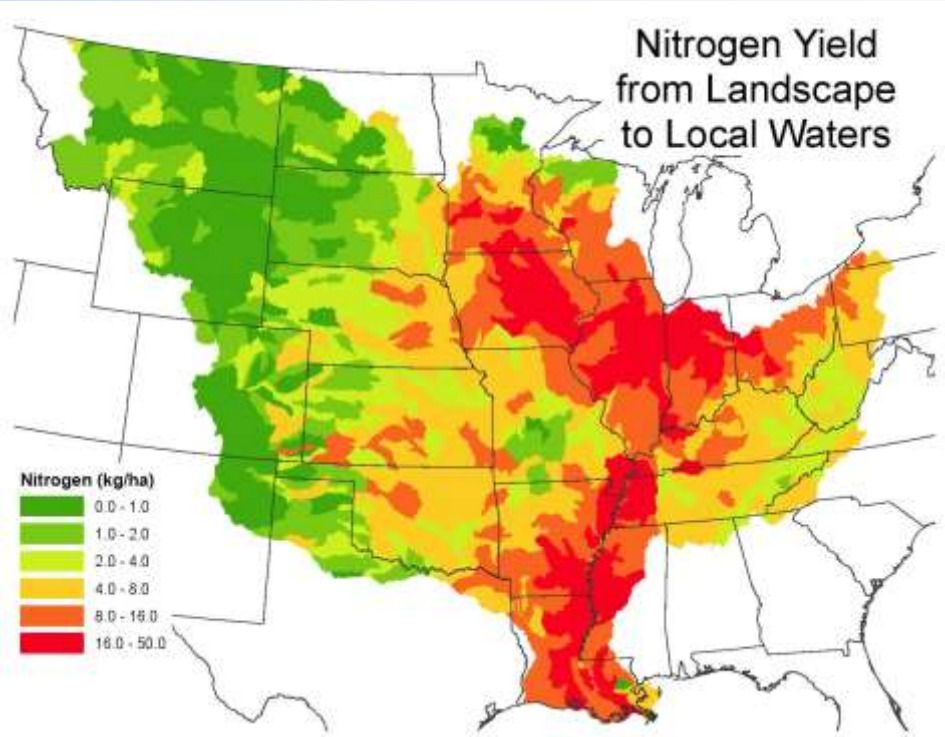
CEAP
Conservation Effects Assessment Program

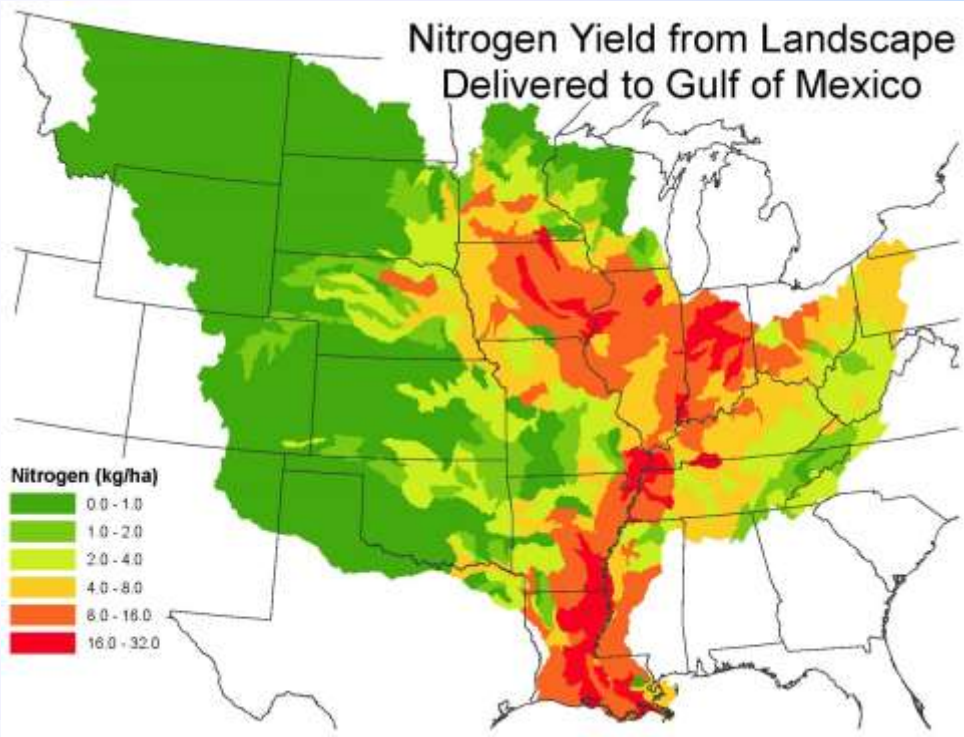
- OMB requests for outcome-based reporting
- 2002 Farm Bill
- *40-fold increase* in authorization for conservation programs call for better accountability
- Assessment to guide design and implementation of conservation programs
- Tier I – full biogeochemistry, detailed agricultural management, routing
- USGS 8-digit subbasins – 3,000 km^2

Sediment Reduction



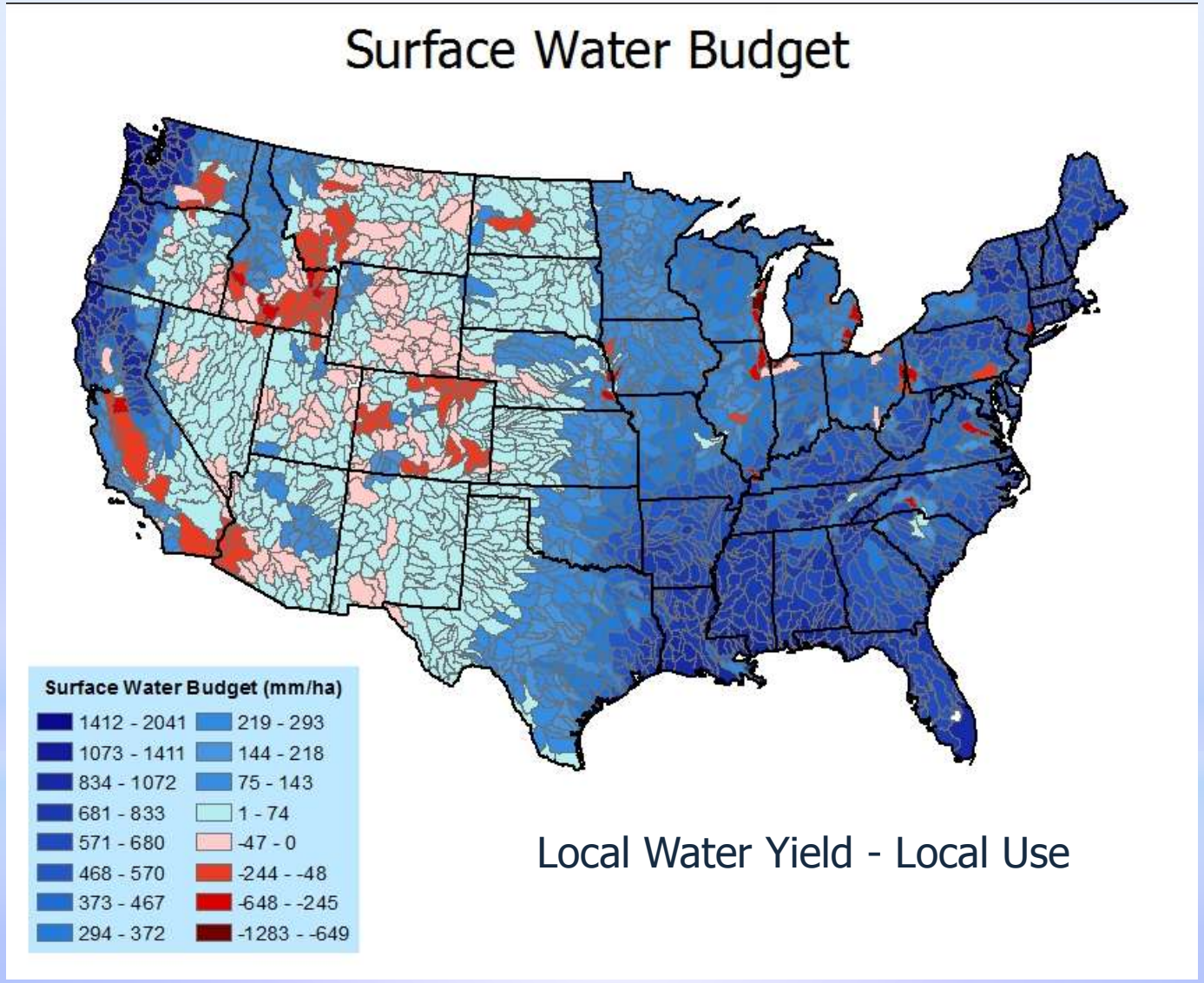

Nitrogen Reduction
Minnesota
Wisconsin
Iowa
Illinois
Missouri
0701
0702
0703
0704
0705
0706
0707
0708
0709
0710
0711
0712
0713
0714
700
600
500
400
300
200
100
0
Nitrogen Load
Grafton, IL
1 block = 100 Million lbs
Current Condition
Treatment of Critically Under Treated Acres
Treatment of All Under Treated Acres
Enhanced Nutrient Management Treatment of Vulnerable Acres
Enhanced Nutrient Management Treatment of All Acres





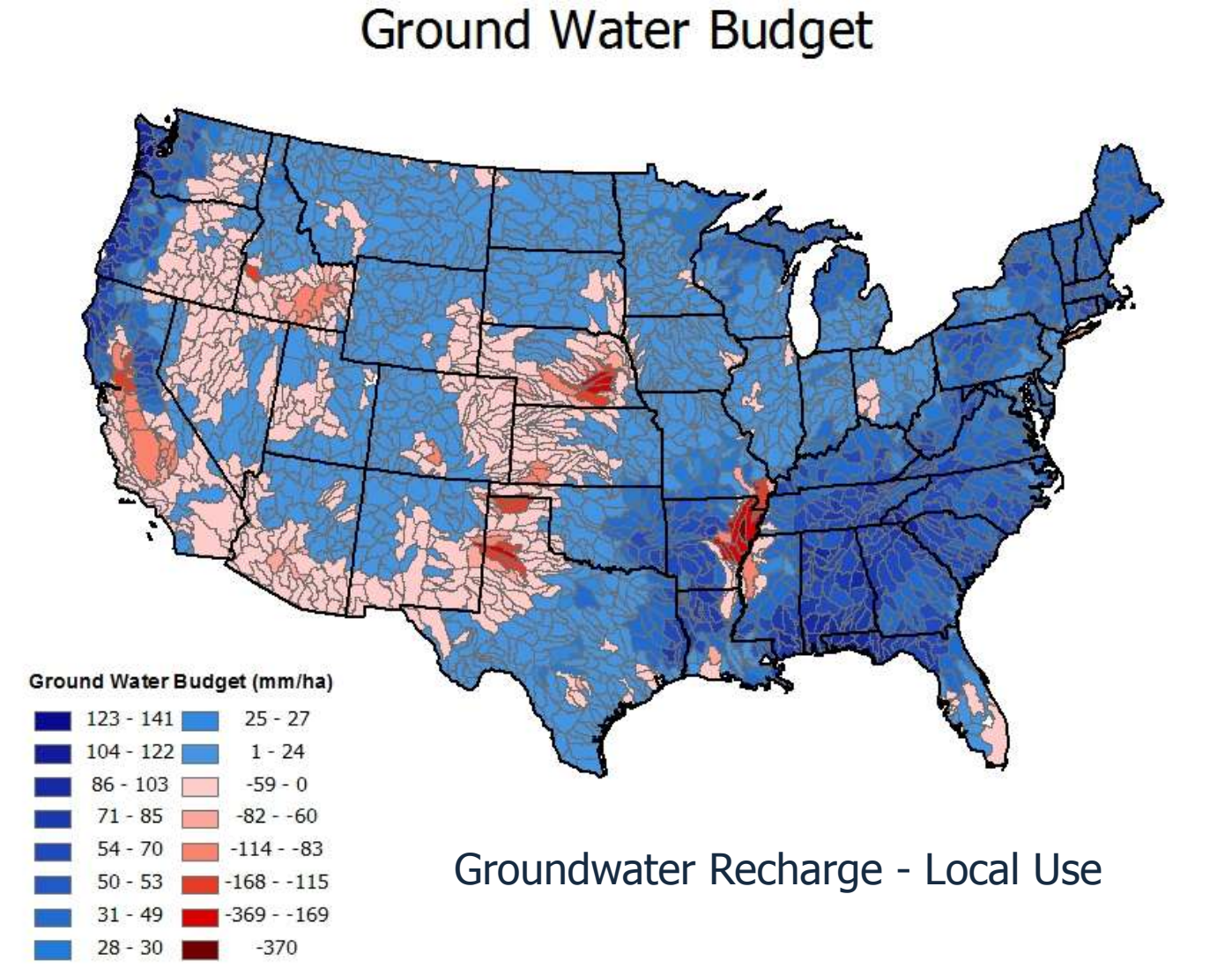
Nitrogen - Local and Delivered

Surface Water Sustainability



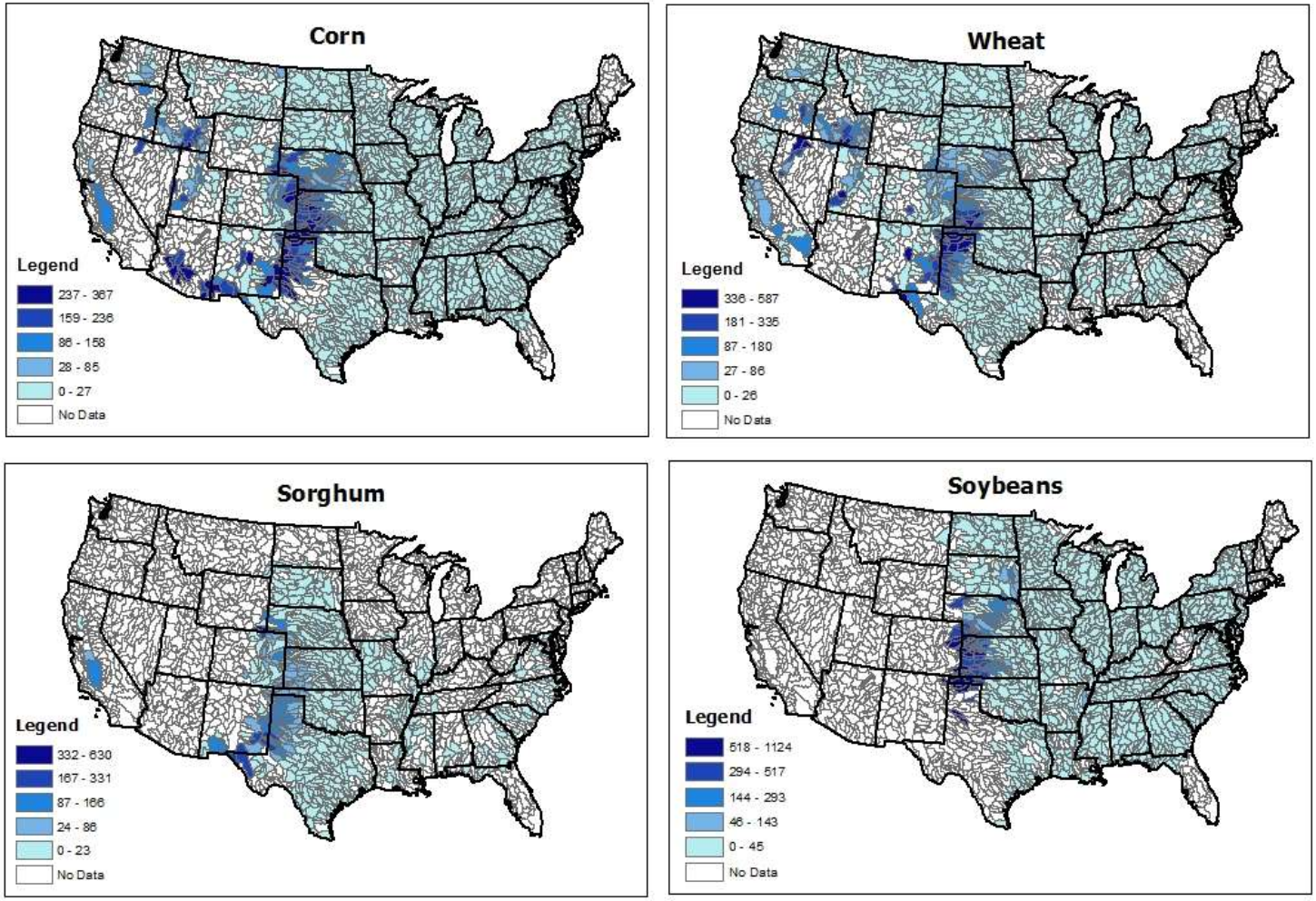
Local Water Yield - Local Use

Groundwater Depletion



Groundwater Recharge - Local Use

Non-Sustainable Production



Crop water content sourced from groundwater depletion in m^3/ton.

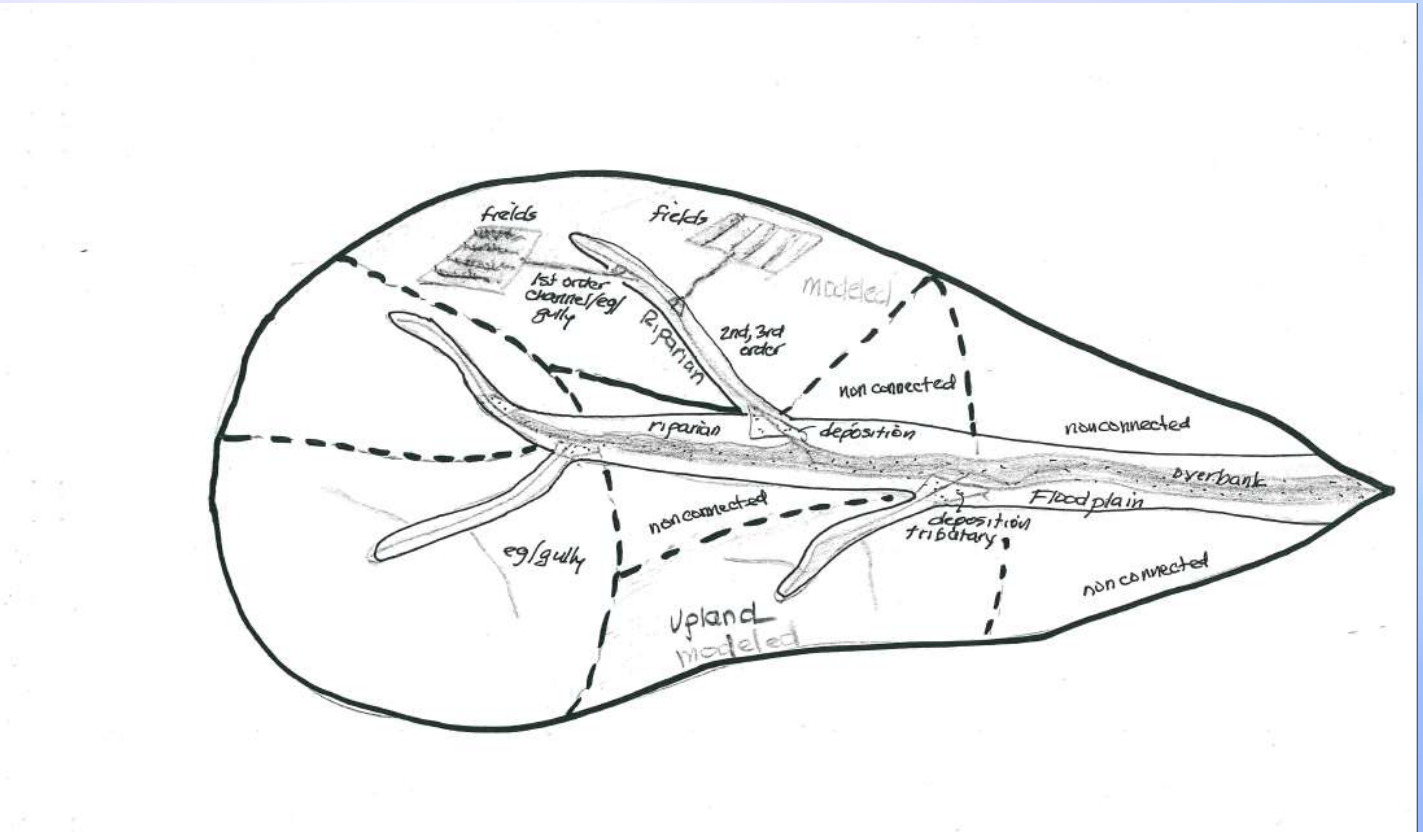
CEAP II National Cropland Assessment

Downscaling from 8-digit subwatersheds (3,000 km^2) to 12-digits (75 km^2)

Example: 8-digit vs. 12-digit Subwatershed Configurations for the Raccoon River Watershed in West Central Iowa

Subbasin (12-digit) Configuration

- Gully/First order channels.
- Delineation of main channel flood plain and tributary riparian zones.
- HRU overlay within upland and valley bottom.
- Wetlands within the valley bottom.
- Updated point sources, reservoirs, atmospheric deposition, etc.



Hydrologic and Water Quality System (HAWQS) Project

Sponsored by the US Environmental Protection Agency
Office of Water

David Wells, EPA
Raghavan Srinivasan, Texas A&M University
Jeff Arnold, USDA-ARS

EPA United States Environmental Protection Agency Office of Water

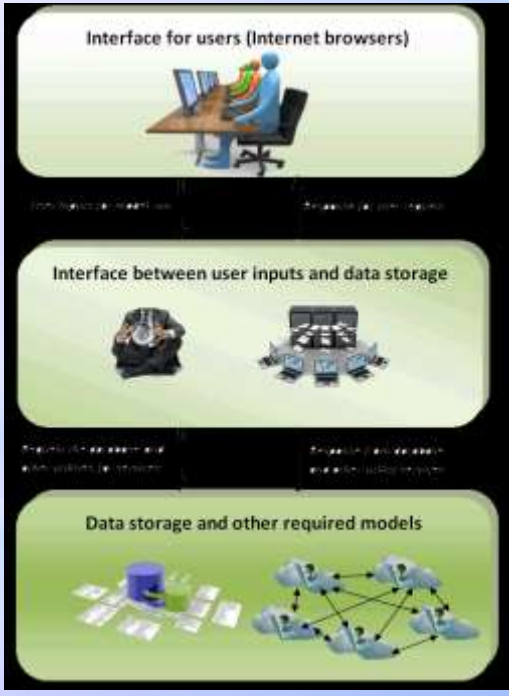
USDA

AgriLIFE RESEARCH Texas A&M System

Hydrologic and Water Quality System **(HAWQS)**

HAWQS is an advanced, state-of-the-art total water quantity and quality modeling system with databases, interfaces and models that is being developed for the U.S. Environmental Protection Agency's Office of Water to evaluate the impacts of management alternatives, pollution control scenarios, and climate change scenarios on the quantity and quality of water at a national scale.

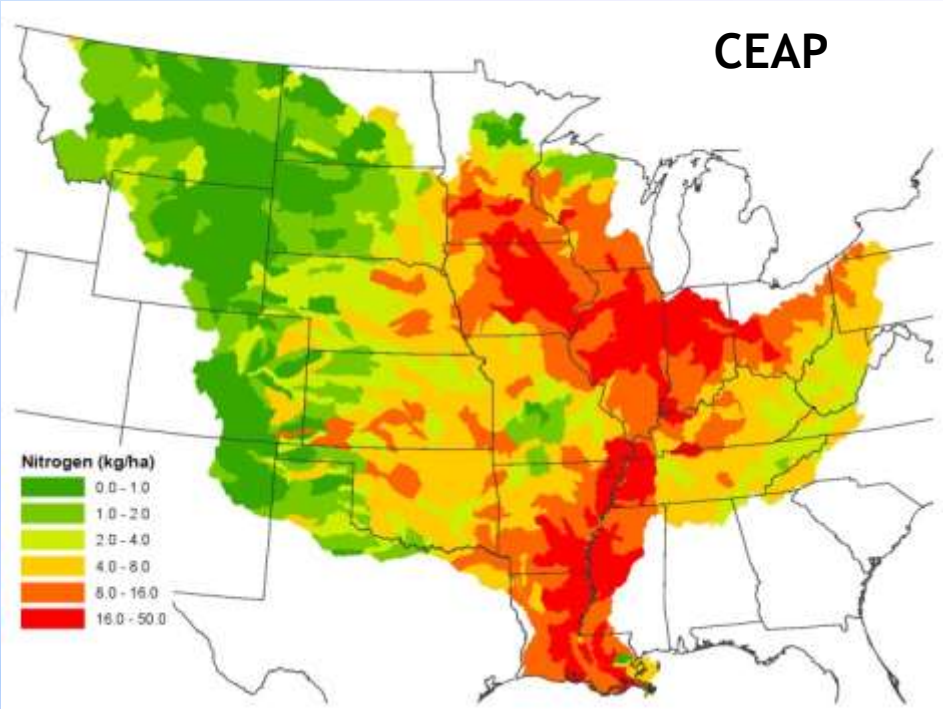
- Is a server/client modeling system that uses a web-based interface to access datasets for modeling at the three spatial scales for any watershed over the contiguous lower 48 states.
- Uses latest nationally available • federal government databases at three spatial resolutions (NHD+, 10-digit and 8-digit watershed levels)
- Uses the latest SWAT model
- Uses National Hydrography Dataset (NHD+) stream network

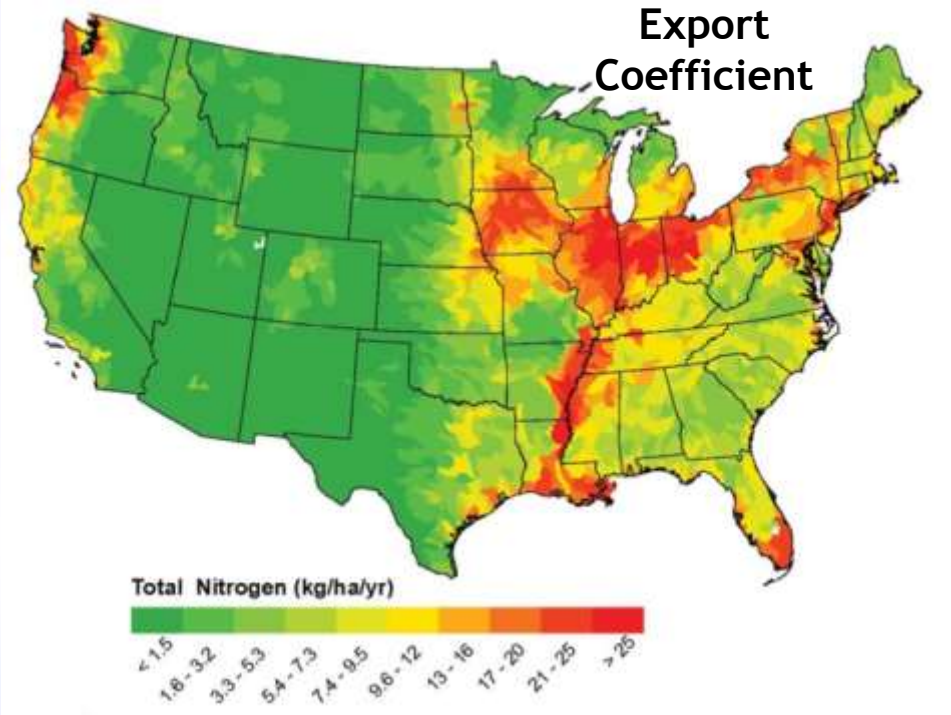


Export Coefficients – Tier I

- Export Coefficient – average annual loading from uplands
- Delivery Ratio – delivery through channels and reservoirs
- SWAT+ has exco/dr as objects. Use the same connect files as subbasins, channel, and reservoirs
- Advantage – simple, fast and easily linked to economic models
- Disadvantages – need to pre-run all scenarios, doesn't simulate seasonal variability
- Full library of SWAT simulations for US – 40,000,000 simulations
- Potential for linking with economic models and developing simple interfaces. Link with other Risk Indicators and Loss Index.

Export Coefficients Compared with CEAP





Global Model– Tier II

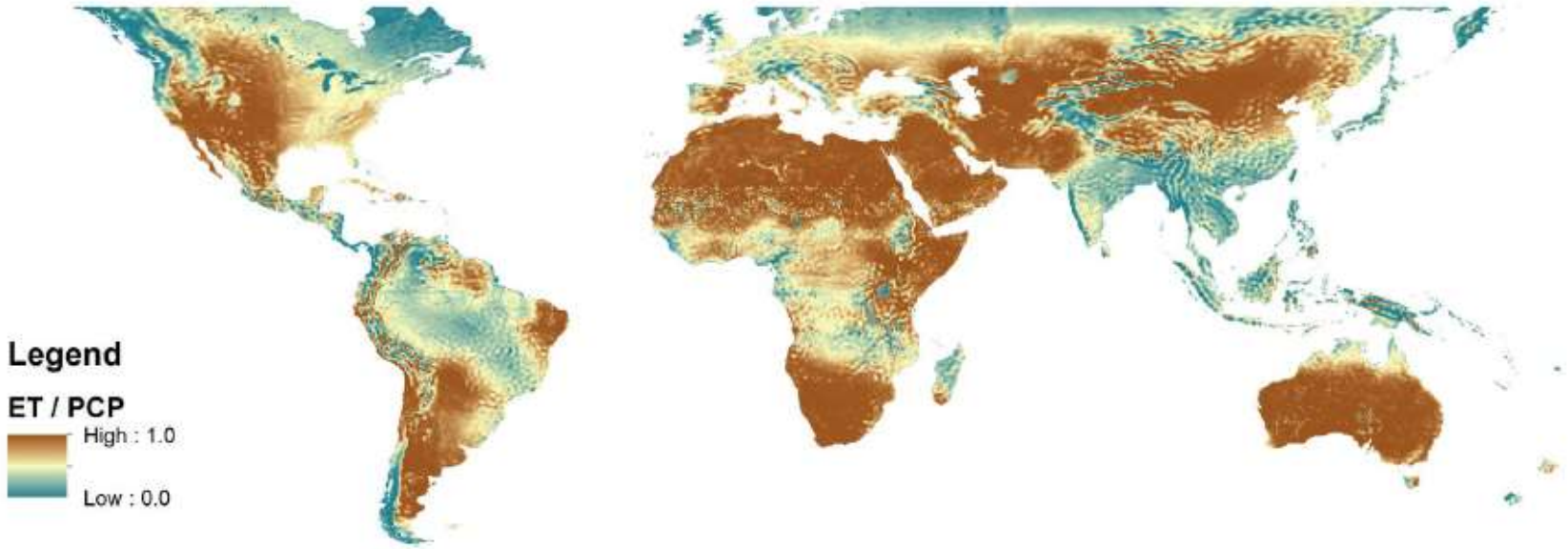
- 10 km x 10 km cells – 4-6 soil land use overlays
- hru-lte – water balance and plant growth, erosion
- 20 years of generated weather
- No channel or reservoir routing
- Each continent is a SWAT simulation - North America takes 5 minutes per year (748,833 hru-lte)

- Link with Risk Indicators and Loss Index

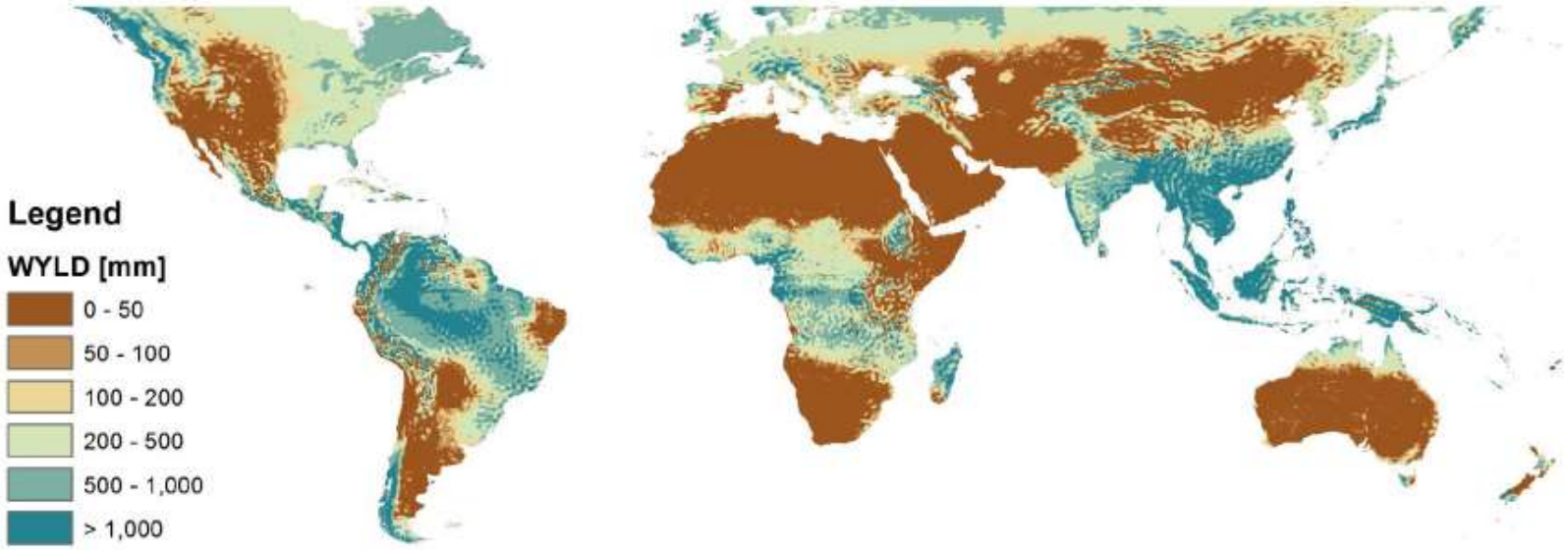
Global Model Subbasins (10km vs 1km)

Continent	Number of grid cells (10 km resolution) [*1,000]	Number of grid cells (1 km resolution) [*1,000,000]
Africa	367	37
Asia	463	46
Australia	103	10
Central America	33	3
Europe	233	23
North America	238	24
South America	223	22
Total	**1,661**	**166**

Ratio of ET/Precipitation



Water Yield (Blue Water)



Indicators SWAT Could Provide

- Environmental Pillar
  - Loss of Organic Matter – DAYCENT integration – carbon balance
  - GHG Emissions – EPIC simulates emissions from landscape
  - Erosion productivity impact calculator
  - Loss of nutrients – total N and P balance
  - Link SWAT to harmful algal blooms in Gulf of Mexico and W. Lake Erie
  - Link SWAT to fish habitat and populations in Western Lake Erie
- Social Pillar
  - Supply of national food basket
  - Changes in production due to weather conditions
- Economic Pillar
  - Productivity – amount of bioenergy by mass, volume of energy

Thank You