The power of SWAT+ in conservation policy:

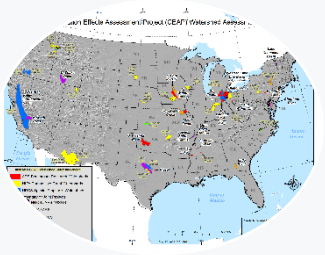
The National Agroecosystems Model for the US

Natalja Čerkasova, Michael White, Jeffrey Arnold, Jungang Gao, Sagarika Rath, Celray James Chawanda, Joon-Hee Lee, Marilyn Gambone, Kelly Thorp, Peter Allen

International SWAT Conference
July 10th, 2024 - Strasbourg, France

CONSERVATION EFFECTS ASSESSMENT PROJECT - CEAP

Short overview of model development



2003

CEAP - CROPLAND NATIONAL ASSESSMENT

Agricultural Policy Environmental eXtender **(APEX)** model, and

Soil and Water Assessment Tool **(SWAT)**

2016

CEAP – SECOND PHASE

Evolved from the original goal of assigning metrics. Dynamic tool informing current and future conservation decision making. More data, better tools.

2021

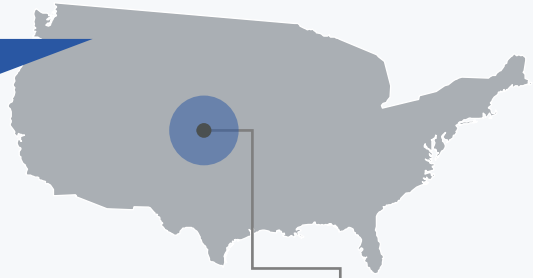
NATIONAL AGROECOSYSTEM MODEL (NAM V 1.0)

SWAT+ - completely revised version of the model

THE NEED

About the Conservation Effects Assessment Project

USDA quantifies and reports on trends in conservation practices, and associated outcomes, over time.



Carried out at national, regional, and watershed scales for conservation efforts related to cropland, grazing land, wetlands, and wildlife.

?

CEAP FINDINGS ARE USED TO:

- guide conservation program development,
- support conservationists,
- support agricultural producers,
- and partners

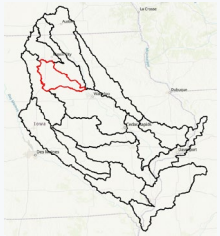
… in choosing the most effective conservation actions and making informed management decisions backed by data and science.

UNIQUE FEATURES OF THE NAM

- ☑ Field-based discretization scheme
- ☑ Manageable modeling framework
- ☑ Open-access data only

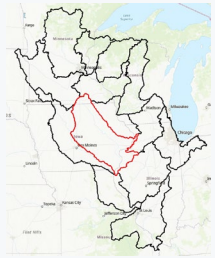
SCOPE AND SCALE

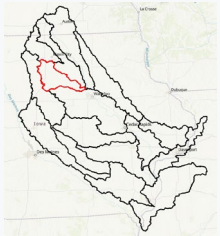
HUC2 – 18 Units

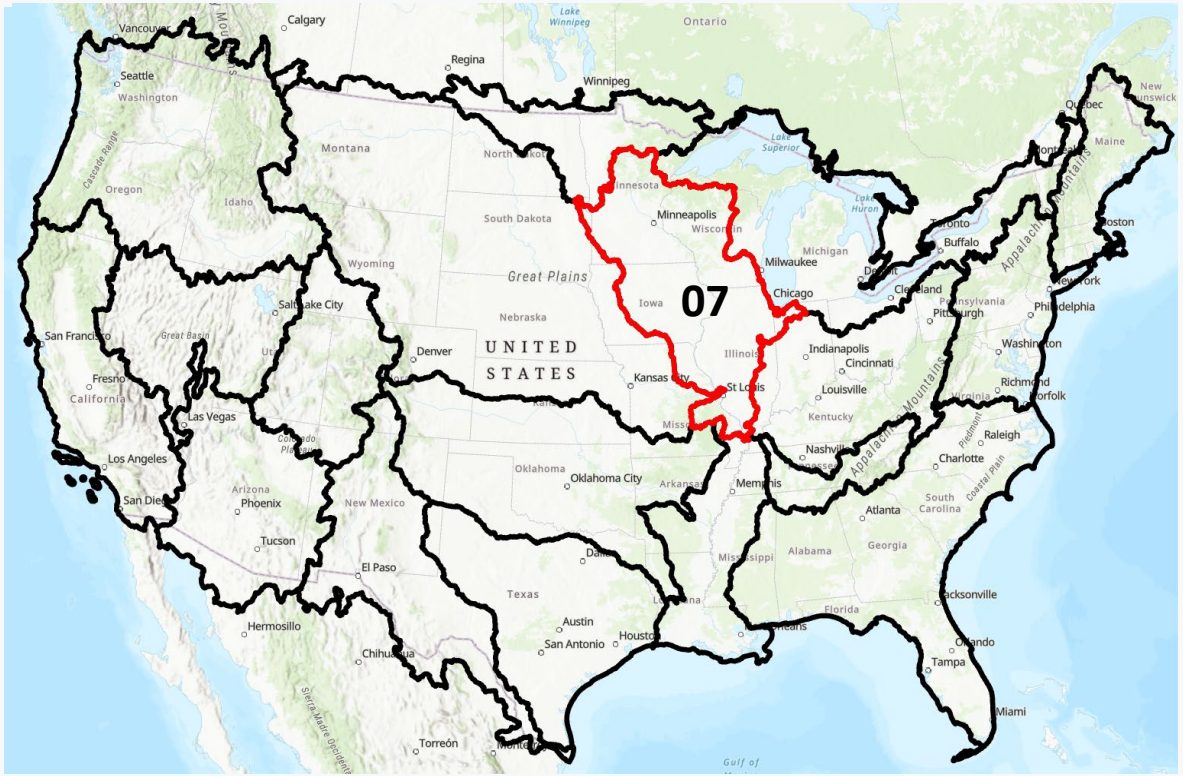


SCOPE AND SCALE

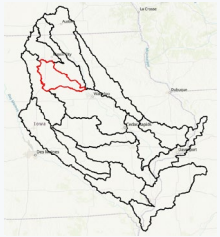
HUC2 – 18 Units



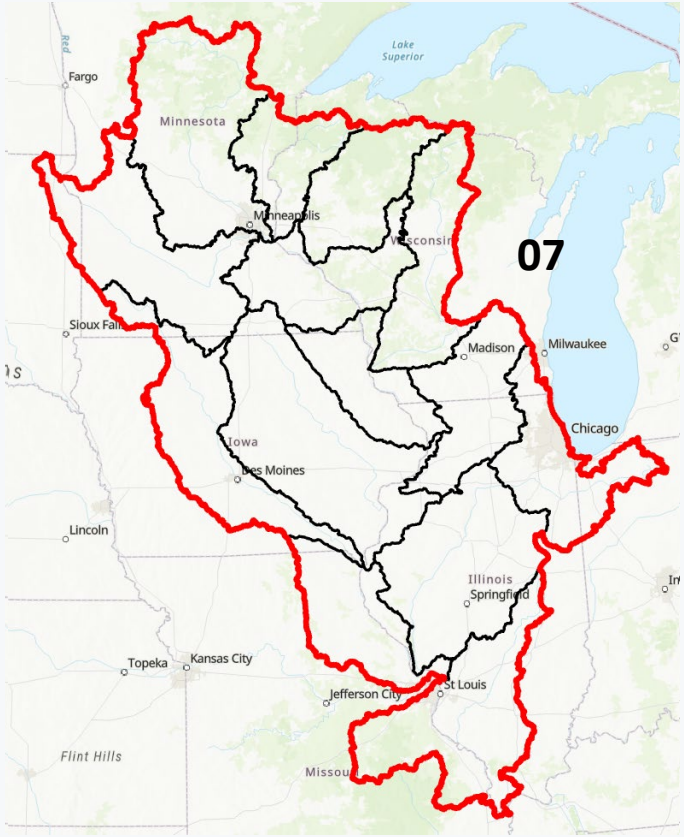




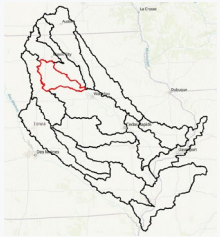
SCOPE AND SCALE



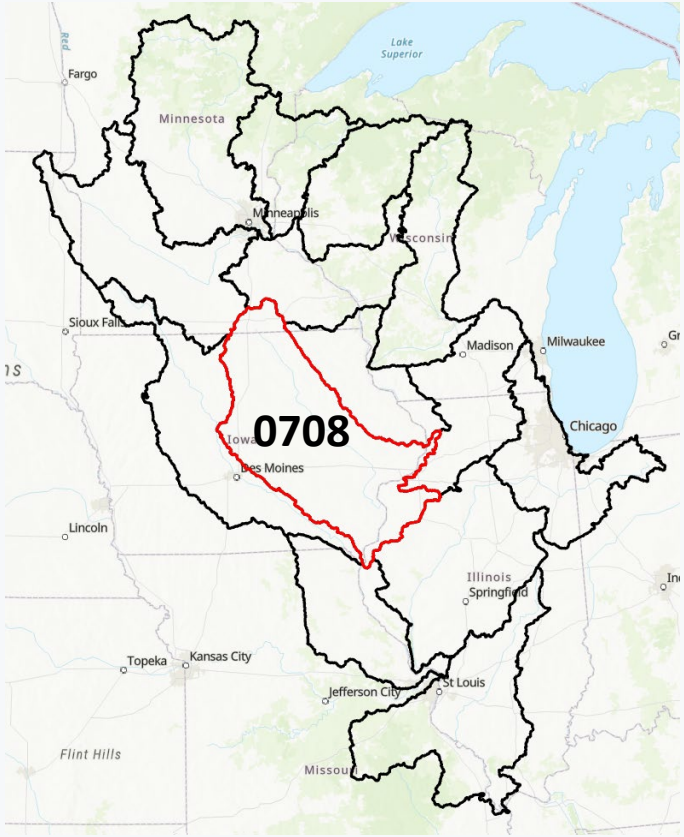
HUC4 – 202 Units in US



SCOPE AND SCALE

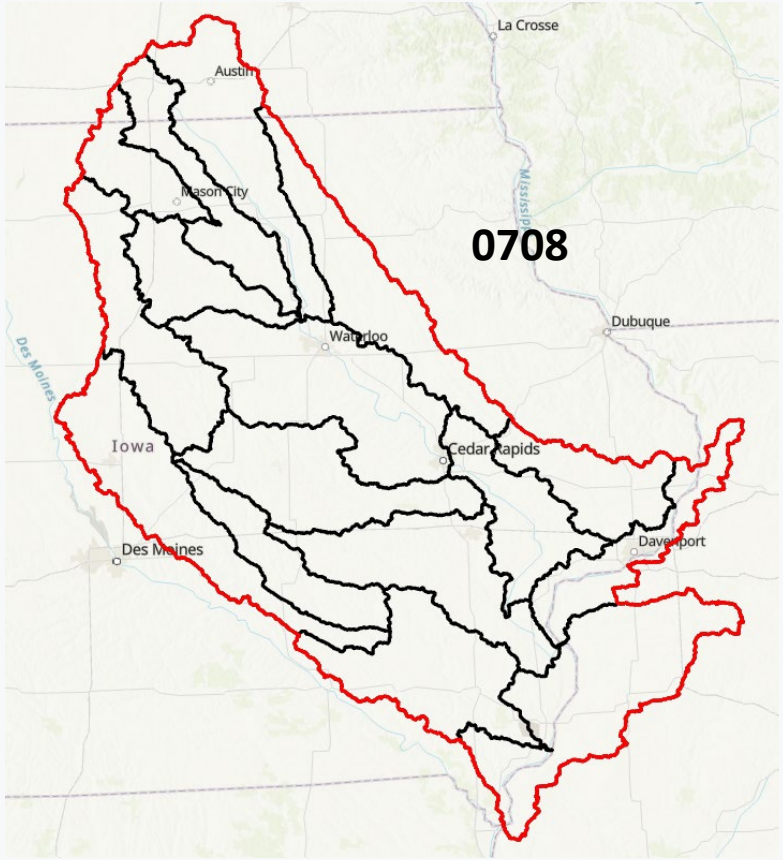


HUC4 – 202 Units in US



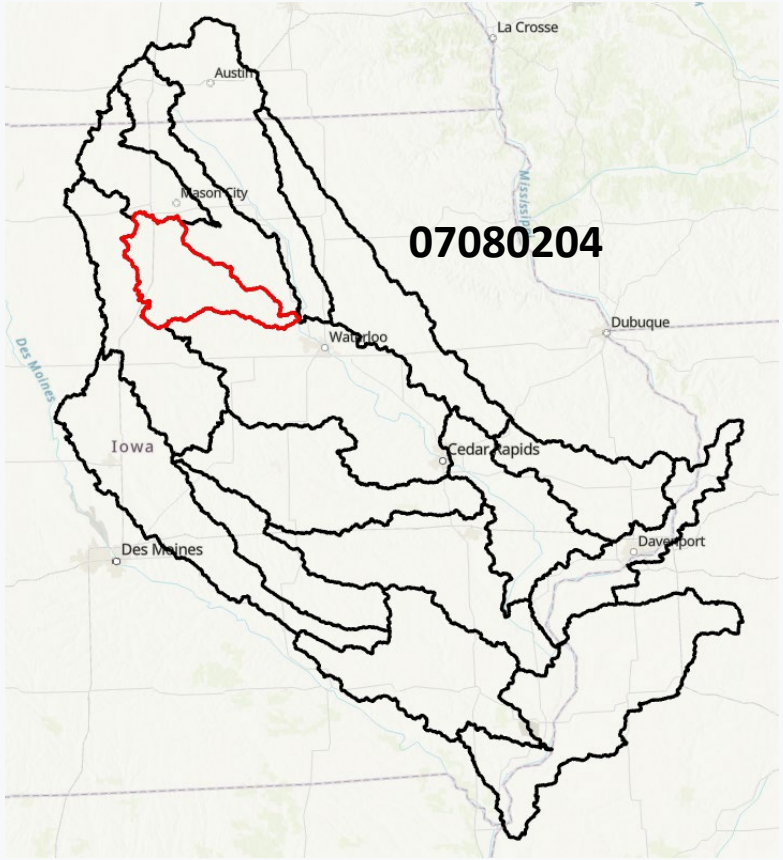
SCOPE AND SCALE

HUC8 – 2,121 Units in US

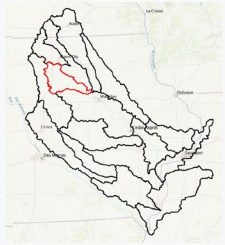


SCOPE AND SCALE

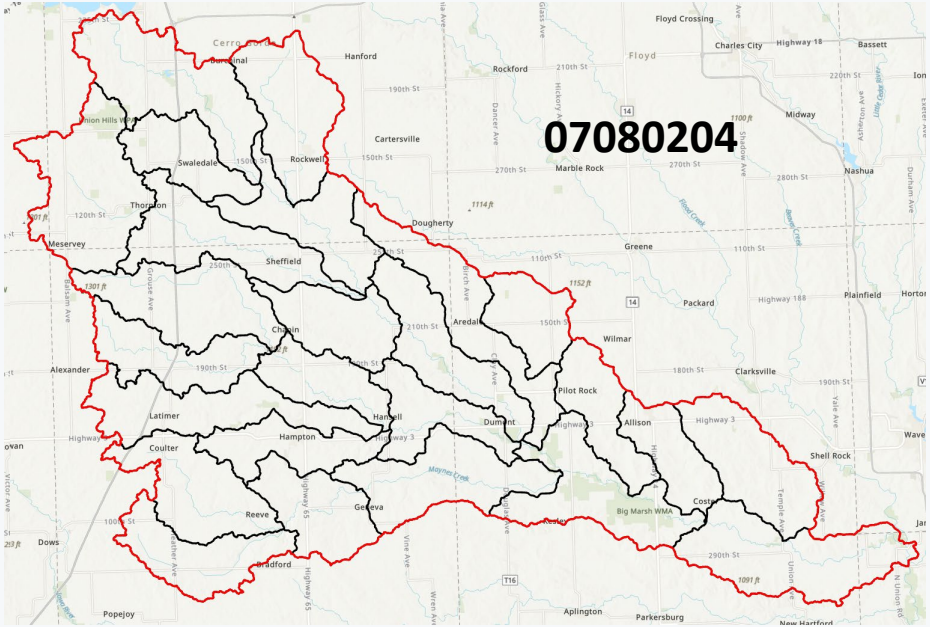
HUC8 – 2,121 Units in US



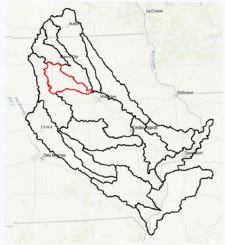
SCOPE AND SCALE



HUC12 – 65,000 Units in US



SCOPE AND SCALE



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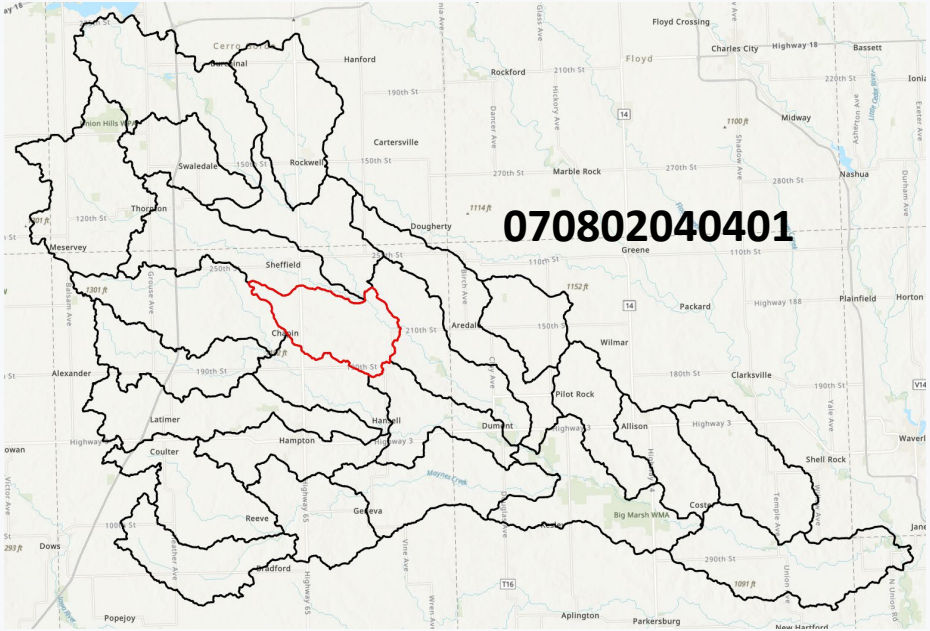
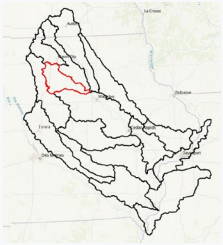
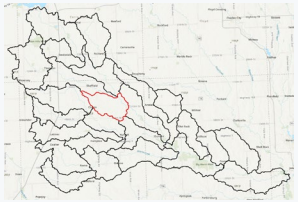


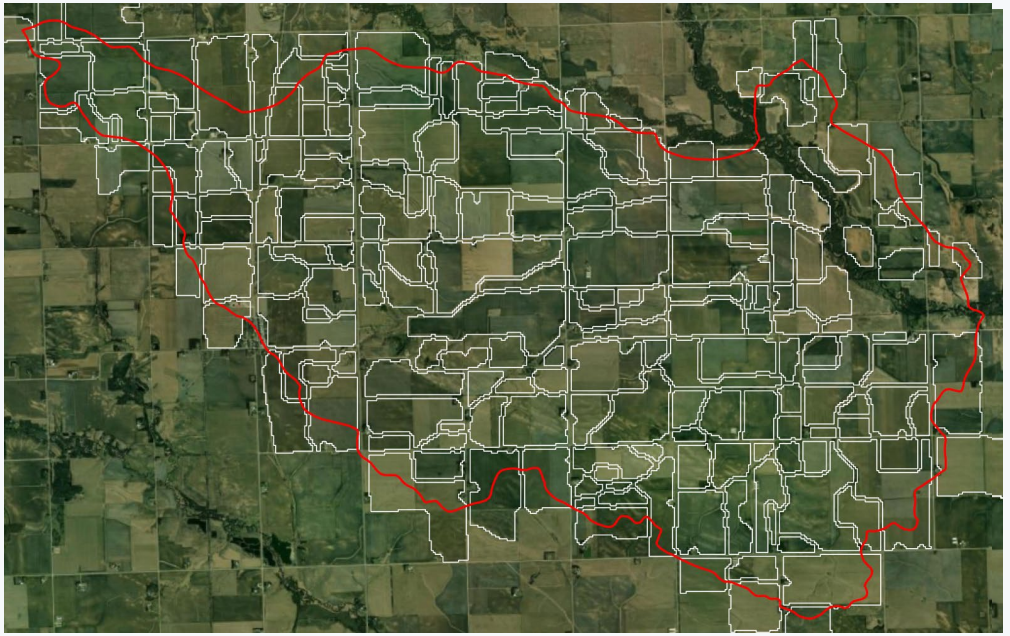
SCOPE AND SCALE



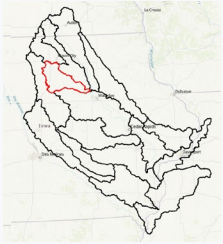


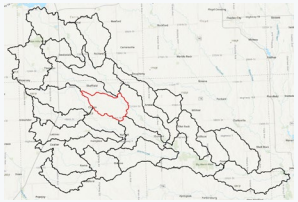
HUC12 – 65,000 Units in US

070802040401



SCOPE AND SCALE





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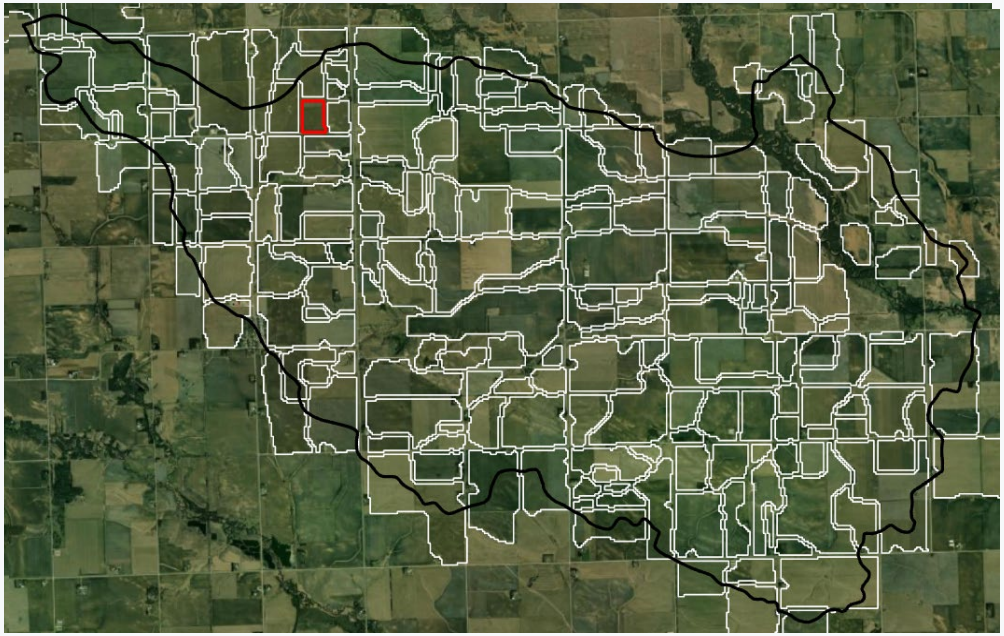

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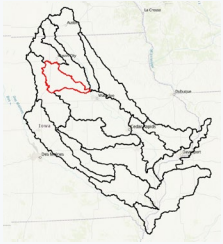
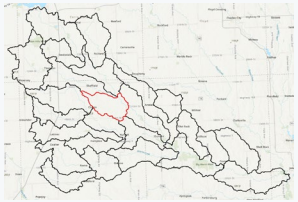
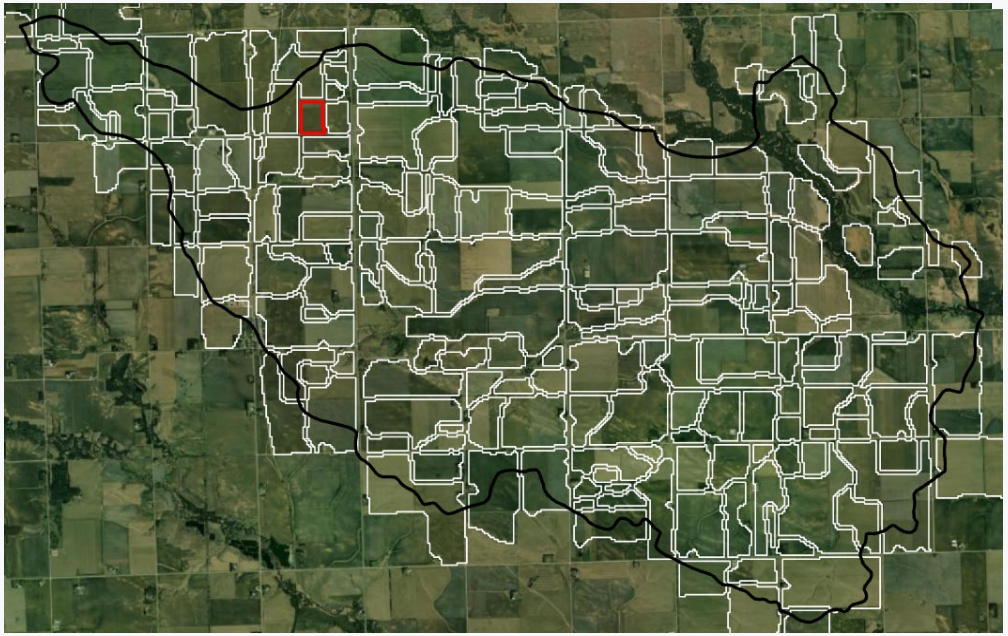


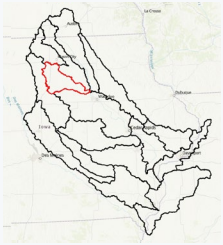


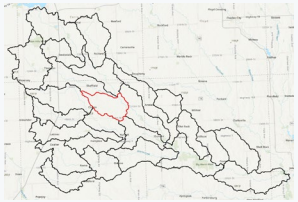
Fields – 4.5 Million Units in US

FUID = 1277645001



SCOPE AND SCALE





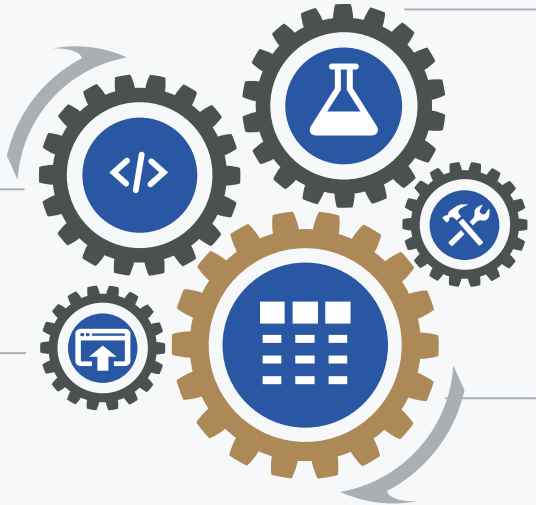
Fields – 4.5 Million Units in US

FUID = 1277645001

HRU_ID = 1484863
FUID = 1277645001
1% Slope
Soil = Dinsdale
Corn-Soybean rotation
Tiled
Conservation Tillage

SWAT+ MODEL SETUP

Data: Open Source



BASE DATA
Topography, land use, soil properties, stream network, forest, etc.

MANAGEMENT
Irrigation, tile drainage, tillage, etc.

POLLUTION
Diffused pollution, point sources, etc.

CALIBRATION DATA
Reported crop yields at state-level for the 2015-2020

WB from US-based studies

MODEL OUTPUT
Water balance components, crop yields, nutrient load, etc.

AGRICULTURAL CONSERVATION PRACTICES

DATA SOURCES

- ☑ US Agricultural Census: cover crops
- ☑ Survey (CTIC): tillage intensity
- ☑ Google Earth:
  - 13,500 fields surveyed
  - Multi-year imagery
  - Field boundaries
  - Details Published in JAWRA

Terraces

Roughly parallel lines, running cross slope, sometimes accompanied by shadows. Terraces follow contour lines and are usually accompanied by contour planting. The distance between terraces is related to field slope. Terraces are permanent and are generally visible in multiple past images.

Waterways

- Strips of grass following field drainage. usually they have a strong color contrast as compared to the crop area. Waterways generally appear green, but may vary depending on season. Waterways are generally visible in past images.

Filter Strip/Field Borders

A strip of grass that borders one or more sides of a field, a stream. The strip or border is generally uniform in thickness and much wider than a waterway. The filter stips are almost always a shade of green in one or more past images.

Contour Planting

The implement marks follow contour lines and share the same patterns as seen on topographical maps. Practice is most often associated with terraces, but may be found singularly.

Center Pivot Irrigation

Very clear and distinct lines that form a circular pattern. Most fields with a center pivot are fully circular, but half and quarter coverages are common. The center pivot itself is often visible.

Strip Crops

Crops grown in alternating strips, which can be easily distinguished from aerial photography due to the contrast may not be present in past images, so the most recent image is used to make the final determination.

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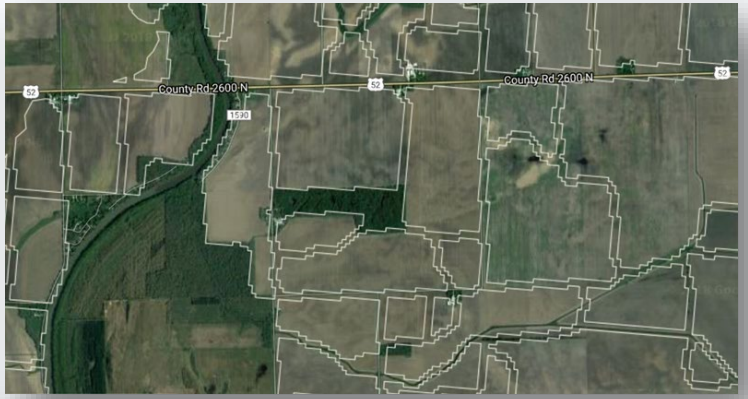
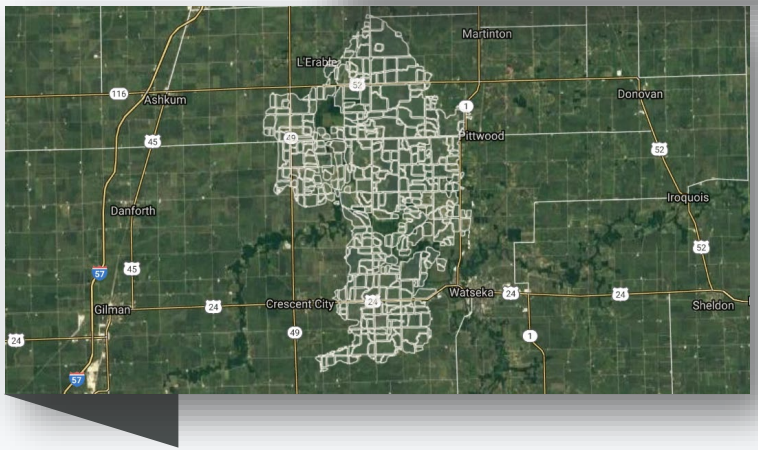
CROPLAND FIELD BOUNDARIES



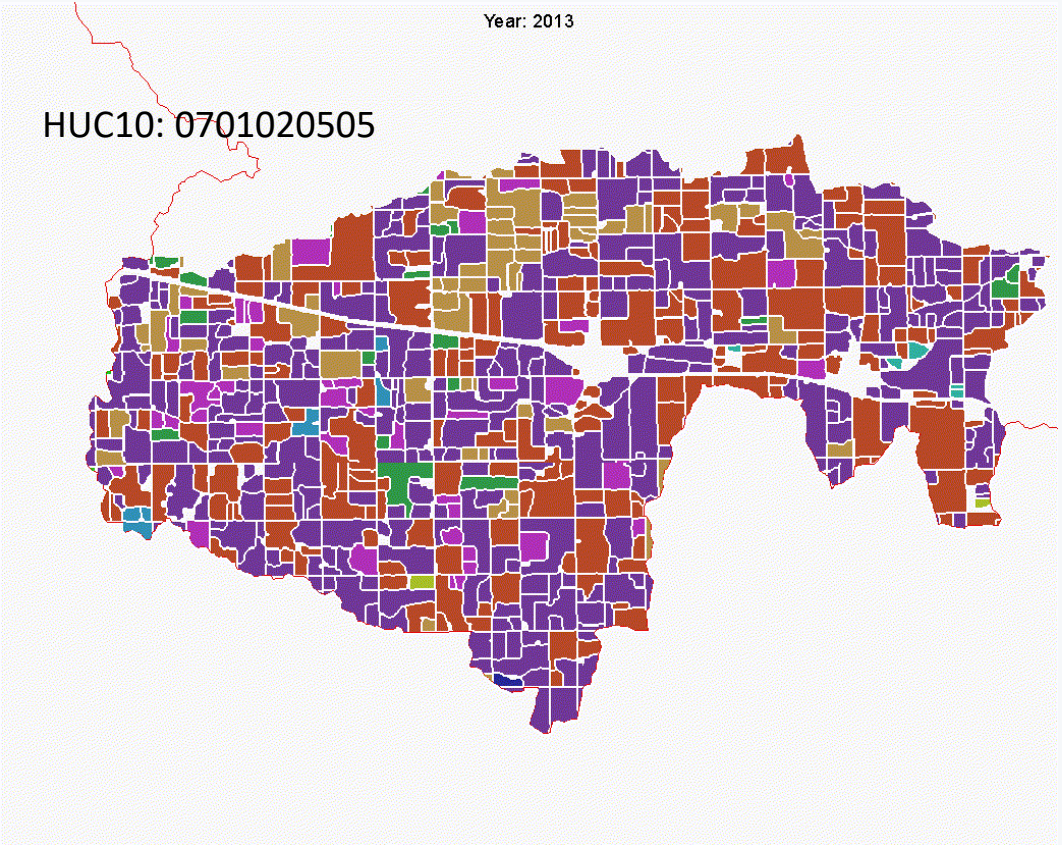


DATA SOURCES

- ☑ Field map of U.S. derived from satellite data
- ☑ 4.2 million fields in U.S.
- ☑ Average size 20-30 ha

Session G1: Friday, 12 July
09:20 - 09:40
US and European Field Boundary Extraction Tools for SWAT Modeling Using ArcGIS Pro with Image Analyst
By Marilyn Gambone

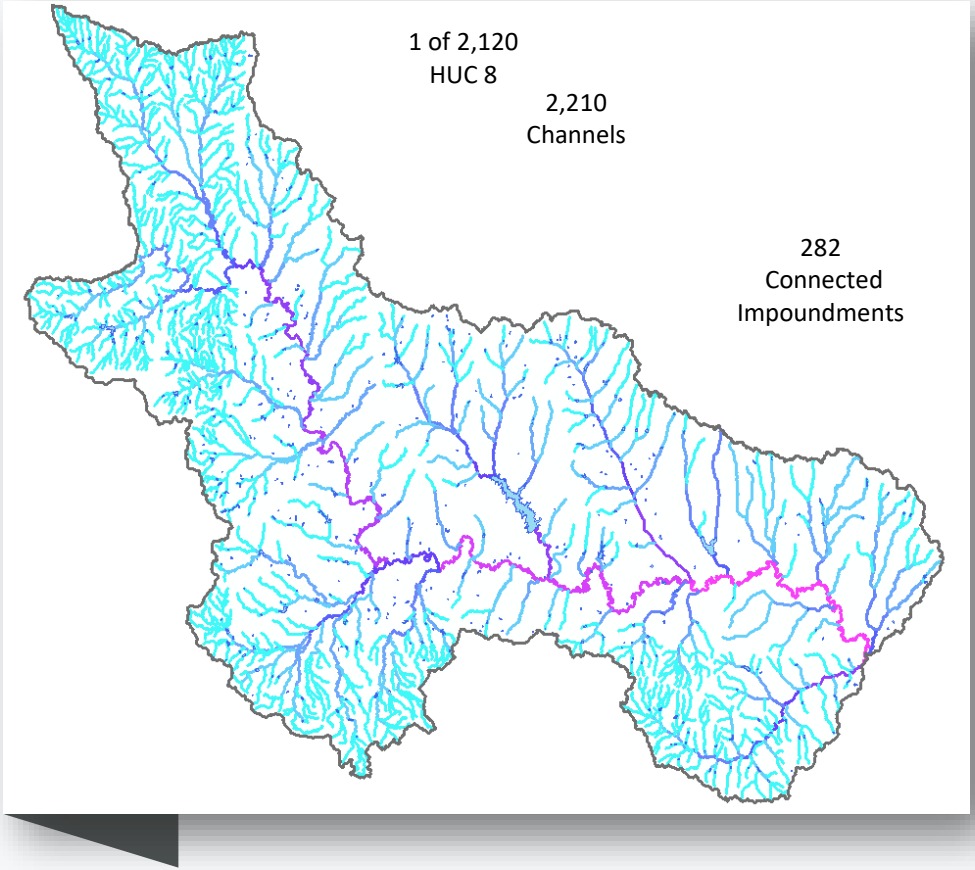
MULTI-YEAR LAND USE: 2013-2017 CDL



STREAM REACHES AND WATER BODIES

DATA SOURCES

- ☑ National Hydrography Dataset V2
- ☑ 3 million digitized reaches
- ☑ Waterbodies
  - Lakes/Reservoirs
  - PL-566
  - Farm Ponds



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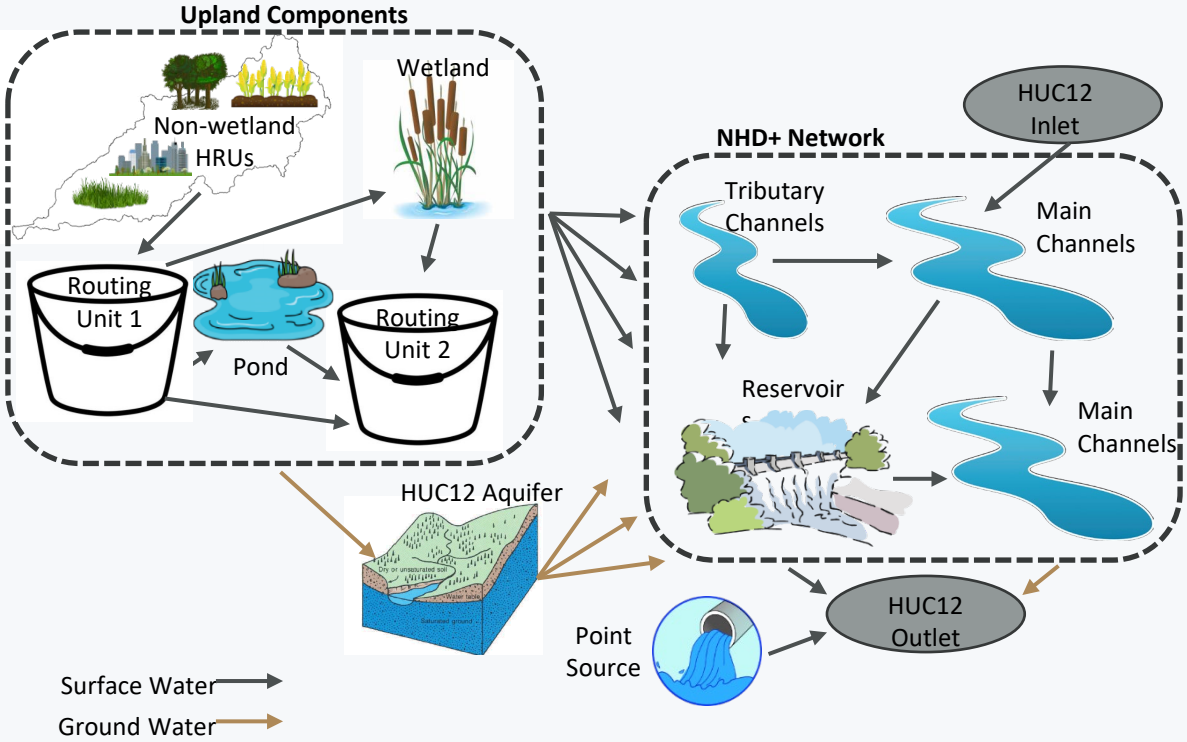
OBJECT CONNECTIONS



22

HOW TO DEAL WITH COMPLEXITY: RUNNING

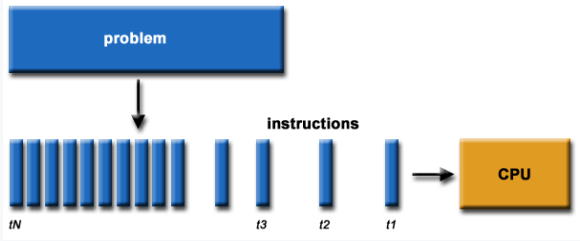
NATIONAL AGROECOSYSTEMS MODEL: RUNNING

7.5 million HRUs
4 million streams
150,000 impoundments

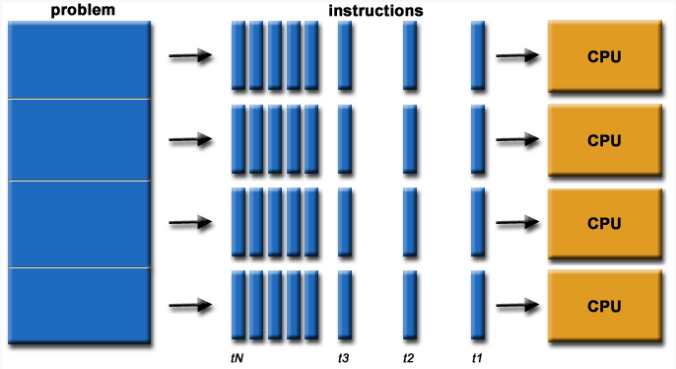
Solutions?

- ☐ Parallelize SWAT+ Code
- ☑ Parallelize NAM Model

Serial Processing



Parallel Processing

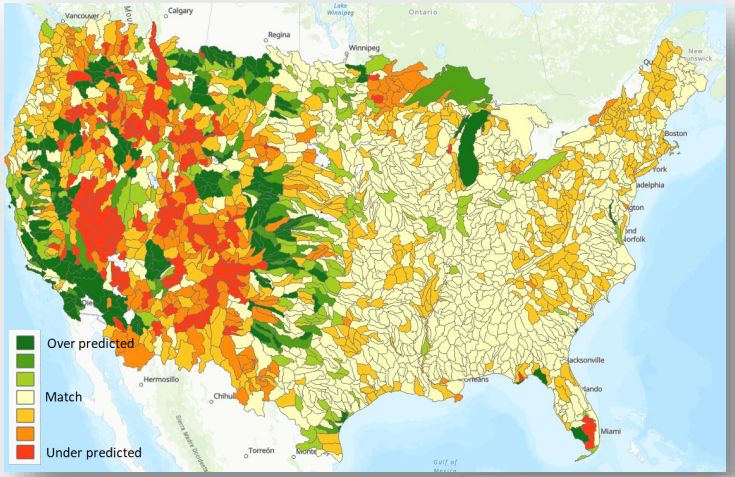


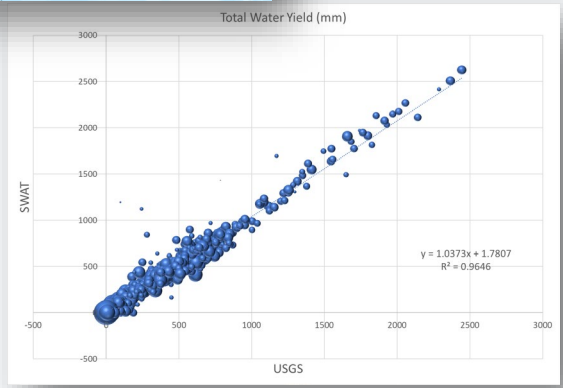
HOW TO DEAL WITH COMPLEXITY: CALIBRATION

NATIONAL AGROECOSYSTEMS MODEL: CALIBRATING

Solutions?

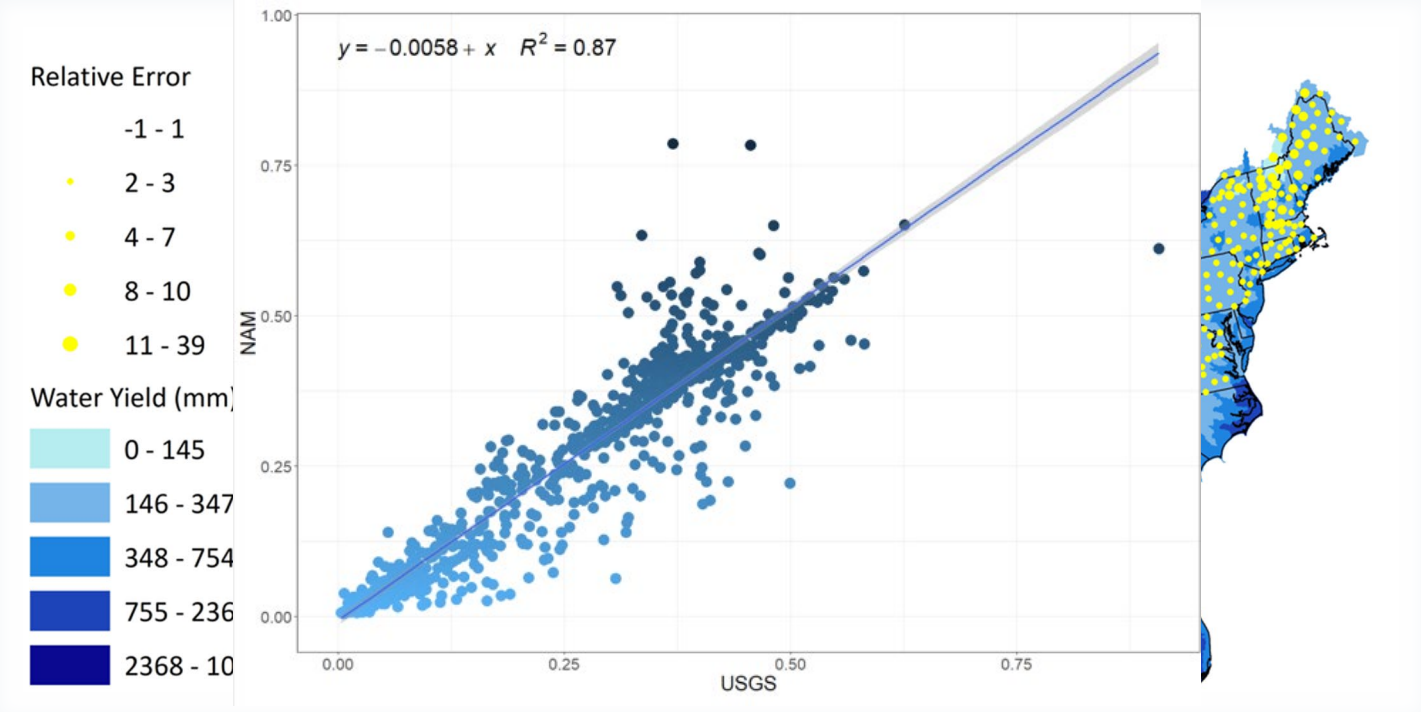
- ☑ SWAT+ Internal code for calibration:
  - Upland water balance
  - Crop yields
- ☑ Strengths:
  - No routing is needed
  - Each Model is independent
  - Executed on Servers
  - Takes about 10-12 cycles





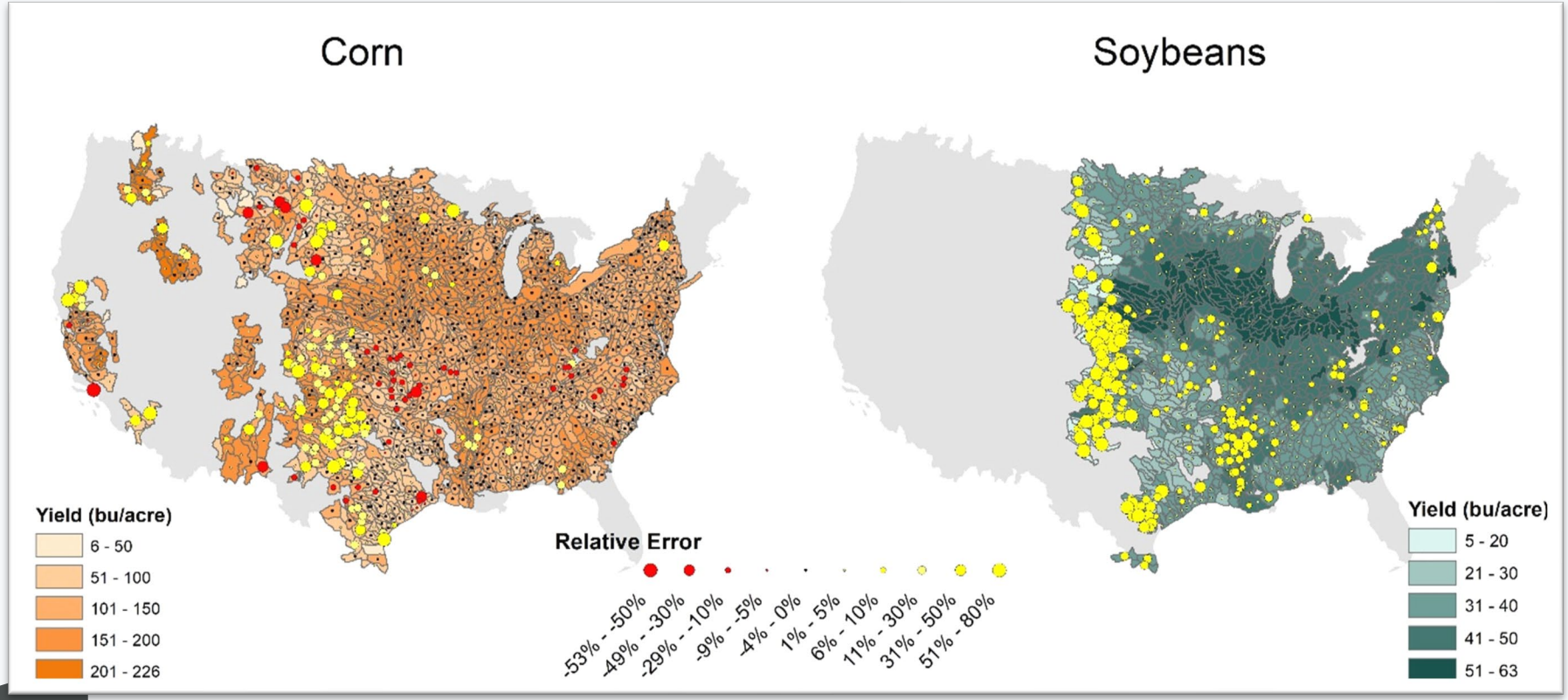
MODEL PERFORMANCE ACROSS THE US

Water Balance



MODEL PERFORMANCE ACROSS THE US

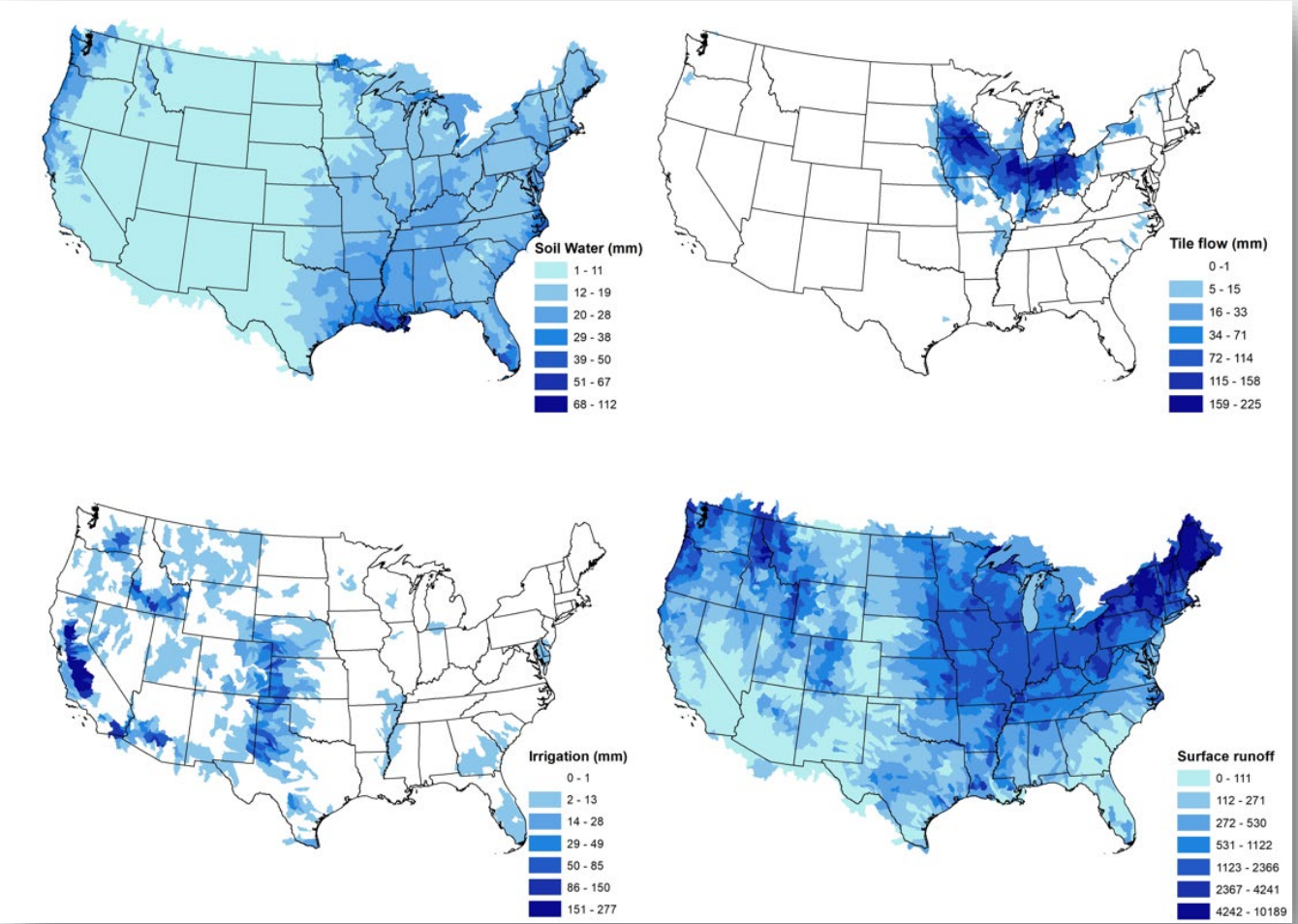
Simulated vs Observed average annual production Relative Error (RE)



NAM OUTPUT: HYDROLOGY

EVERY SWAT+ OUTPUT IS POSSIBLE

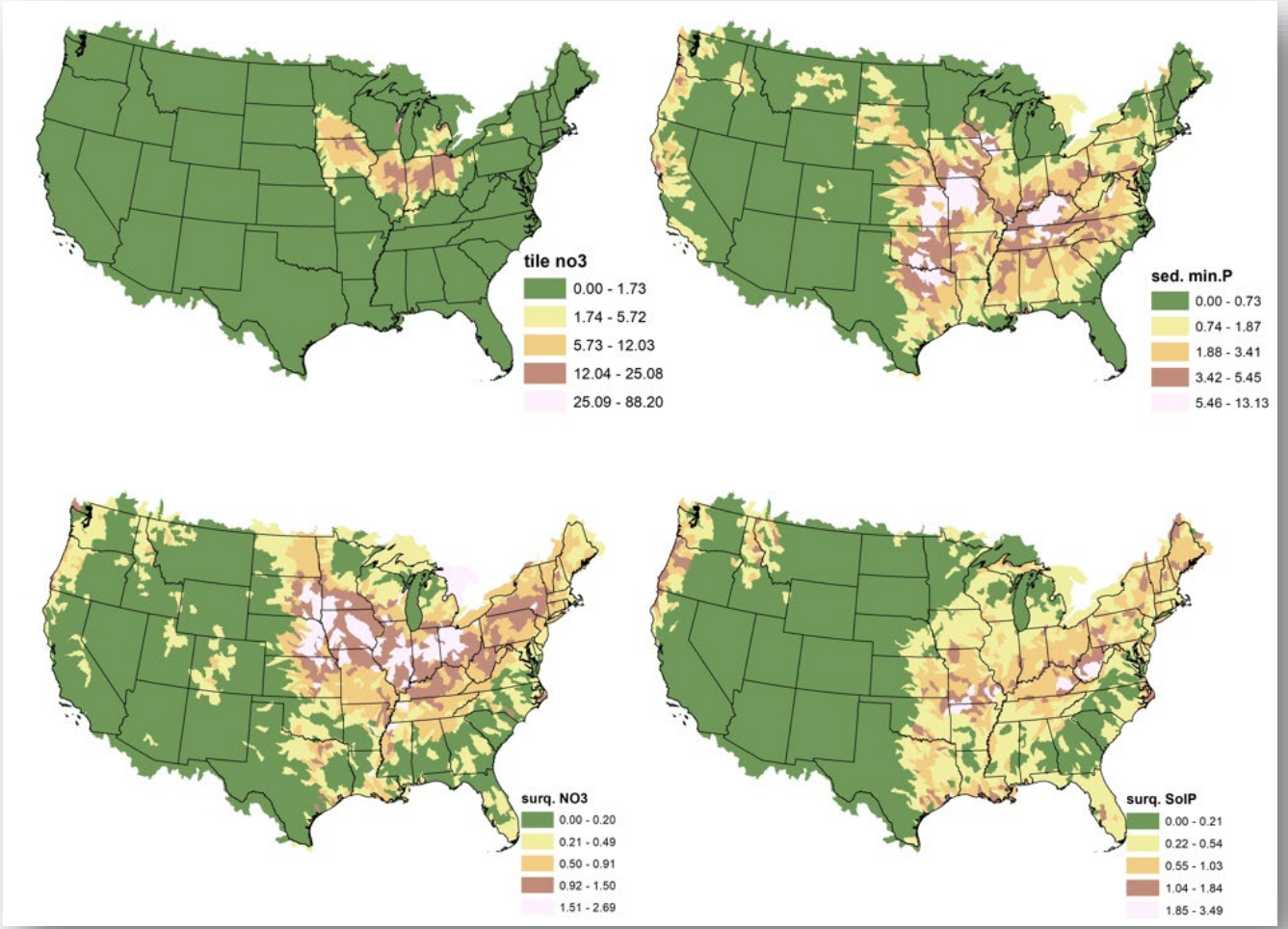
- ☑ Soil water
- ☑ Tile flow
- ☑ Irrigation
- ☑ Surface Runoff
- ☑ ….



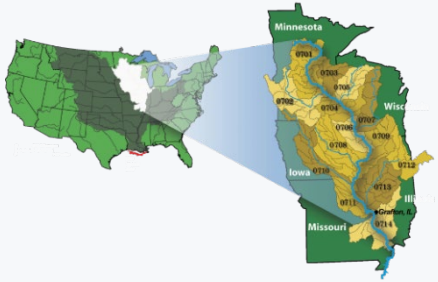
NAM OUTPUT: UPLAND LOAD

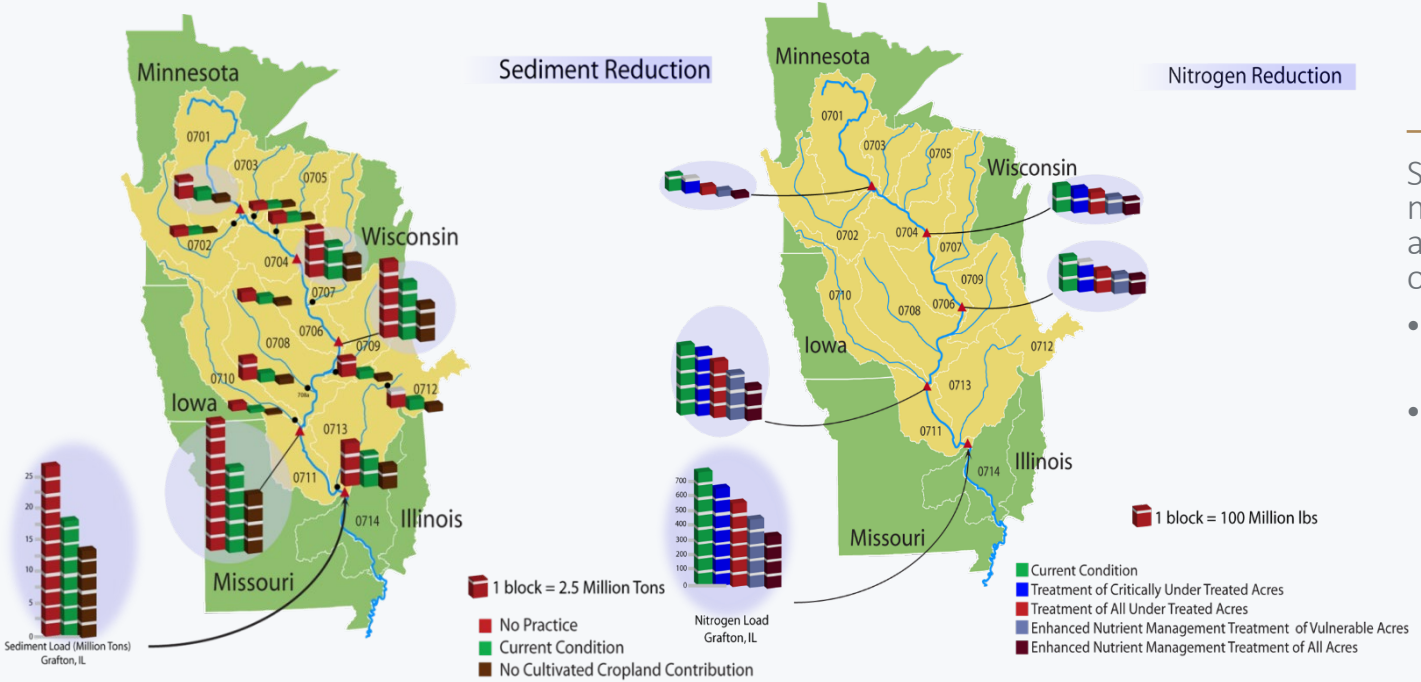
EVERY SWAT+ OUTPUT IS POSSIBLE

- ☑ Tile NO3
- ☑ Mineral P (sed)
- ☑ Surface NO_3
- ☑ Surface Soluble P
- ☑ ….



POTENTIAL SCENARIO ANALYSIS





Scenarios possible on most any calibrated and validated SWAT+ output

- Runoff - Sediment – Nutrients
- Edge-of-field or instream

NAM CURRENT APPLICATIONS

CEAP and related projects

CEAP - CROPLAND

Link NAM and APEX to evaluate current and future conservation policy

NRCS/Texas A&M/Iowa State

CEAP – WILDLIFE

Link NAM with fish habitat model in UMRB

NRCS/TNC/U. Kansas/U. Missouri/Texas A&M

LEGACY P PROJECT

Goal of improving SWAT+ P routines and develop regional P models

NRCS/Many ARS/Univ partners

NATURAL INFRASTRUCTURE PROJECT

Mitigate Flood and Nitrate Risks in the Mississippi-Atchafalaya River Basin using NAM

Iowa State/Environmental Defense Fund

INTEGRATED ASSESSMENT MODEL

Link NAM with socioeconomic model identify disproportionally pollutant impacted communities and possible solutions

Univ Mass/Cornell

MODEL EVOLUTION AND NEXT STEPS

Work is ongoing

SWAT+: A POWERFUL TOOL FOR INTEGRATED ASSESSMENTS

Provides the flexibility of setup, and reliable process representation at any scale: from field to the entire county

Calibration to Flow Duration Curves: Session C3, Today at 15:20 - 15:40. *By Jungang Gao.*

Improvements and analysis: improving the in-stream processes and new data assimilation

Update 1: Transition to DT

Update 2: Calibration of other constituents and crops

THANK YOU

For your attention!

Looking forward for your questions!

E-mail: natalja.cerkasova@brc.tamus.edu

SWAT+ is a product of joint effort of scientists from USDA-ARS and Texas A&M AgriLife Research Blackland Research and Extension Center.