SWAT modeling for nutrient loading under BMP and climate scenarios in Lake Erie watersheds

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Ecofor research team

Watershed Team	Affiliation
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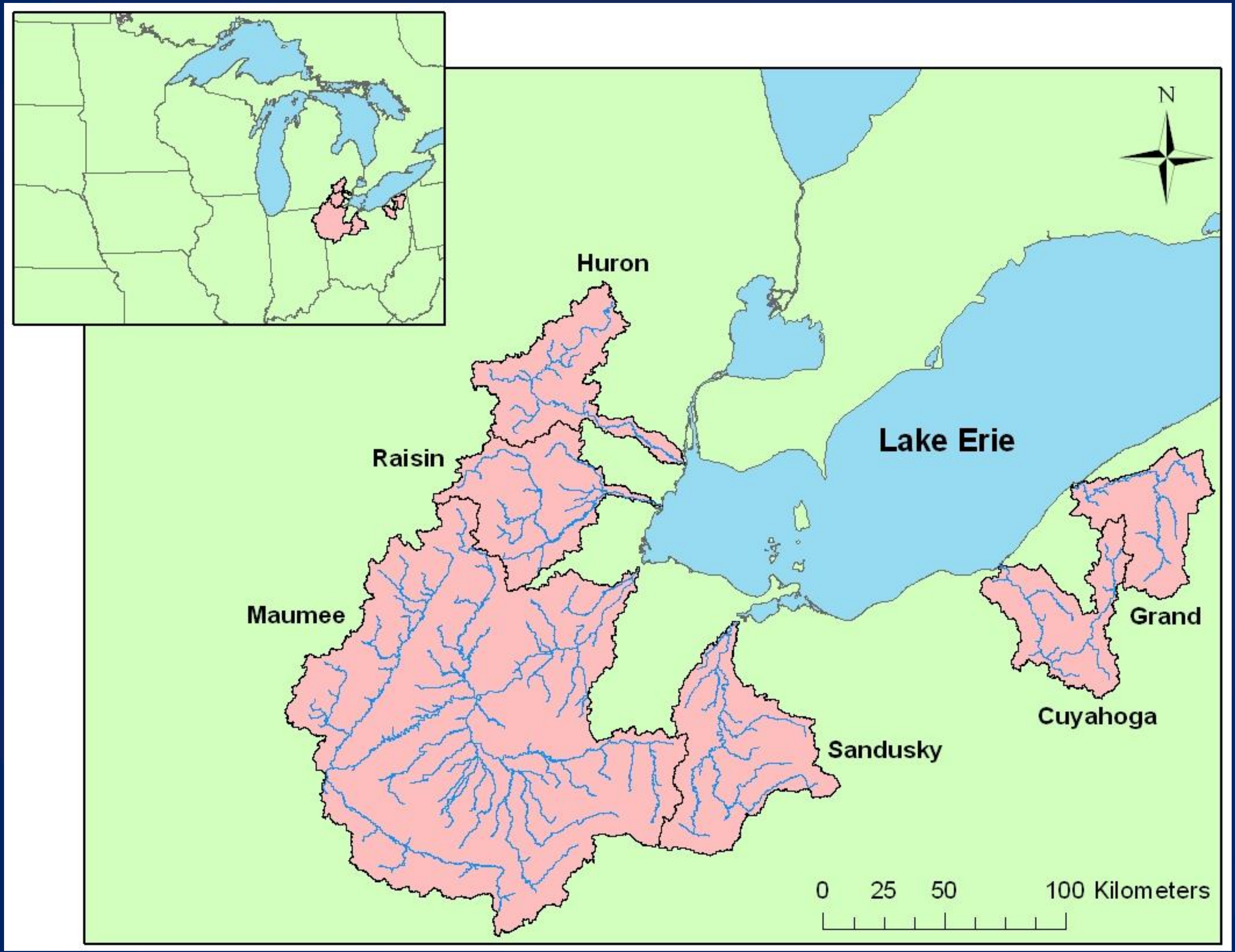
SWAT watersheds



Calibration/validation methods

- Model run: 1995-2005 (3 years spin-up, 4 years calibration, 4 years validation)

- Calibration based on daily USGS flow and near daily WQ data from National Center for Water Quality Research, Heidelberg University (except Huron)

- Calibration at daily time step (time series plots) and monthly time step (evaluation statistics after Moriasi et al. 2007)

Calibration/validation findings

- Agricultural and forested watersheds lend themselves particularly well to SWAT modeling
- Emphasizes the importance of the availability of observed data with high sampling frequency and long duration
- Indications that over-calibration of hydrology can negatively impact subsequent sediment and nutrient calibration

BMP scenarios

Photo from www.oh.nrcs.usda.gov

Grass filter strips: 10 m width, 25% efficiency

Photo from www.leopold.iastate.edu

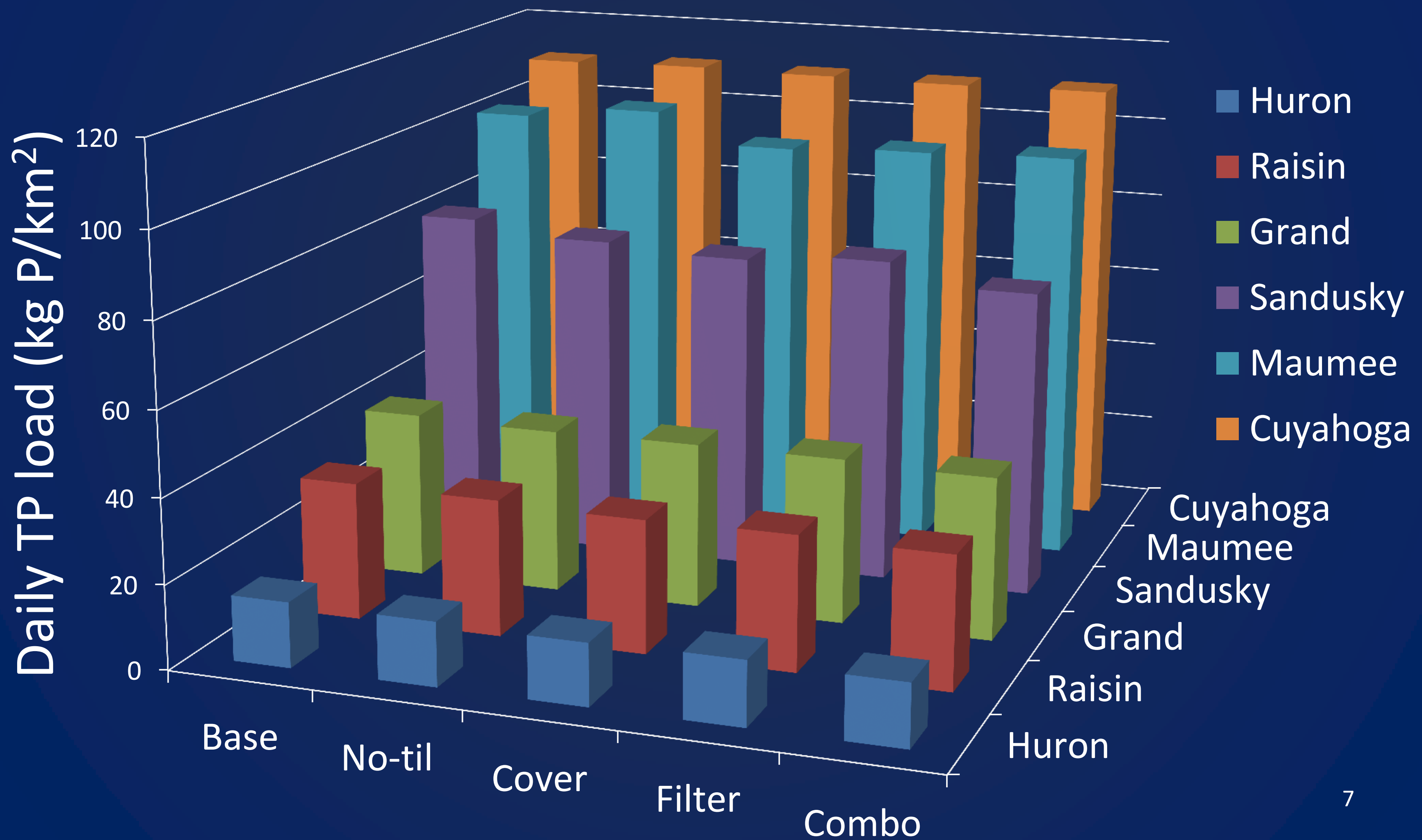
Cover crops: cereal rye planted after soybean harvest

Photo from www.notilltalk.org

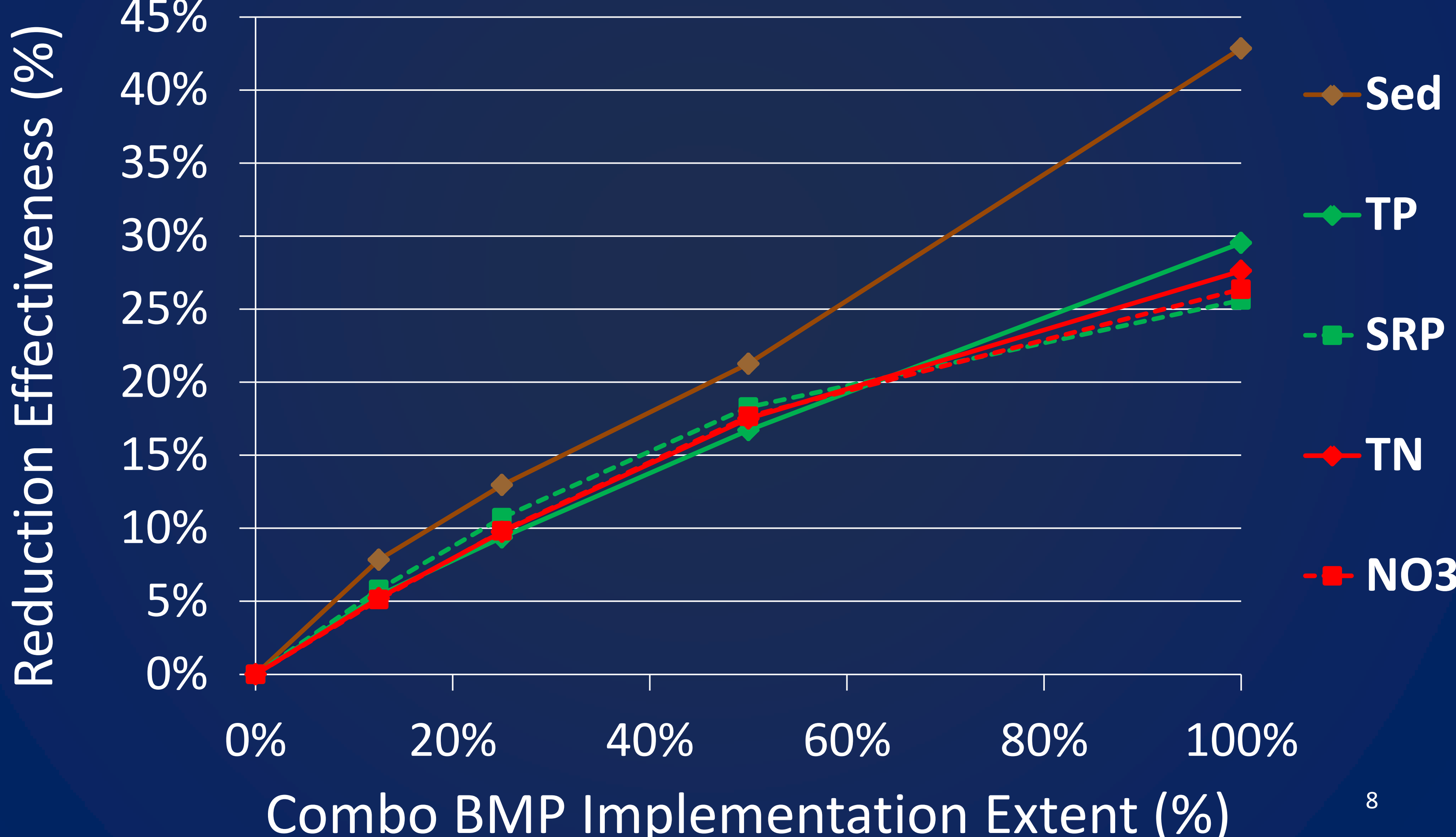
No-till corn and soybean

- Applied randomly to additional row-crop land
- Applied at Moderate (25%) and High (100%) rates

Average daily TP loads across watersheds and “feasible” BMP scenarios



Effectiveness vs % Implementation



BMP scenario findings

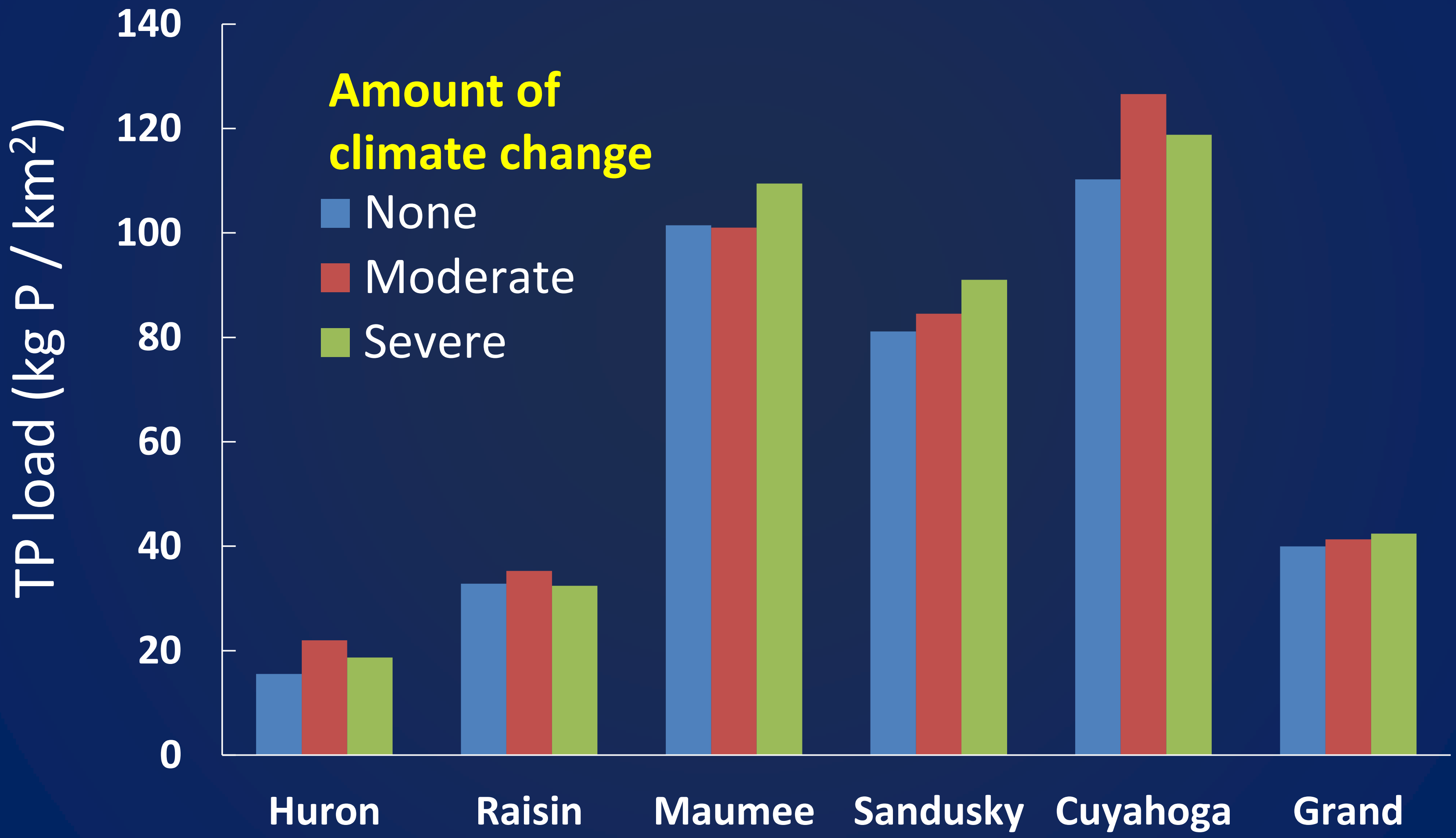
- "Feasible" BMP implementations and source reductions rates are minimally effective
- Implementation of BMPs in specific subwatersheds is much more effective, but may face trade-offs with TP and sediments
- "all-of-above" strategy is needed to substantially reduce nutrient yields and that BMPs should be much more widely implemented

Climate scenarios

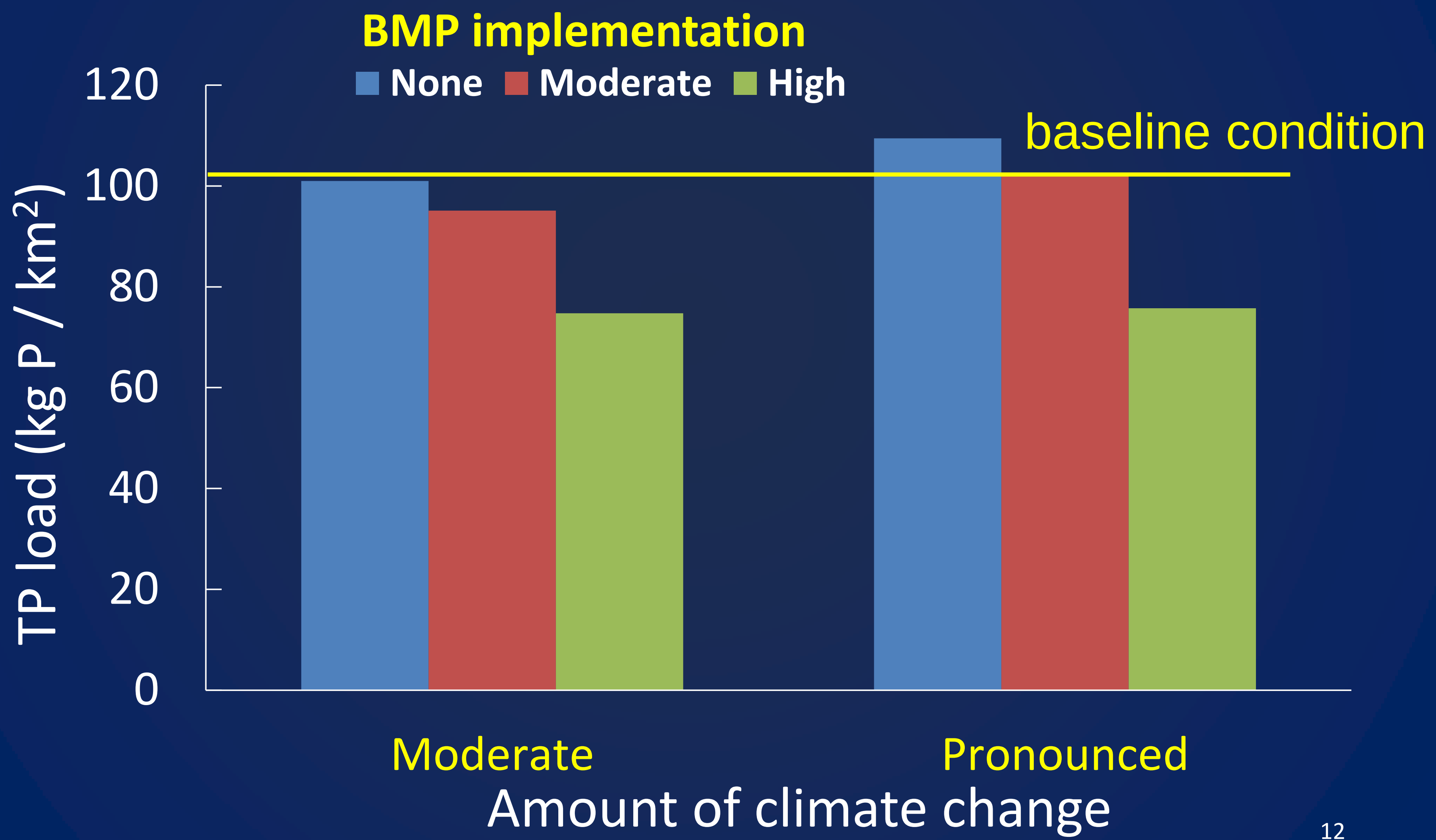
	Moderate		Pronounced	
	Temperature	Precipitation	Temperature	Precipitation
Season	*(˚C)*	*(%)*	*(˚C)*	*(%)*
Winter	+2		+5	
Spring		+11		+29
Summer	+4		+7	
Fall				-7

Hayhoe et al. 2010

Total phosphorus with climate change



Maumee TP: climate and BMPs



Climate scenario findings

- Climate change increases sediment loads more than water flow and nutrient loads
- Individual watershed differ in responsiveness to climate change
- BMPs less effective, but more necessary under climate change conditions
- Stronger BMP implementation and unique management for future watershed load reductions

WSC research team

Climate	Affiliation
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Land Allocation	Affiliation
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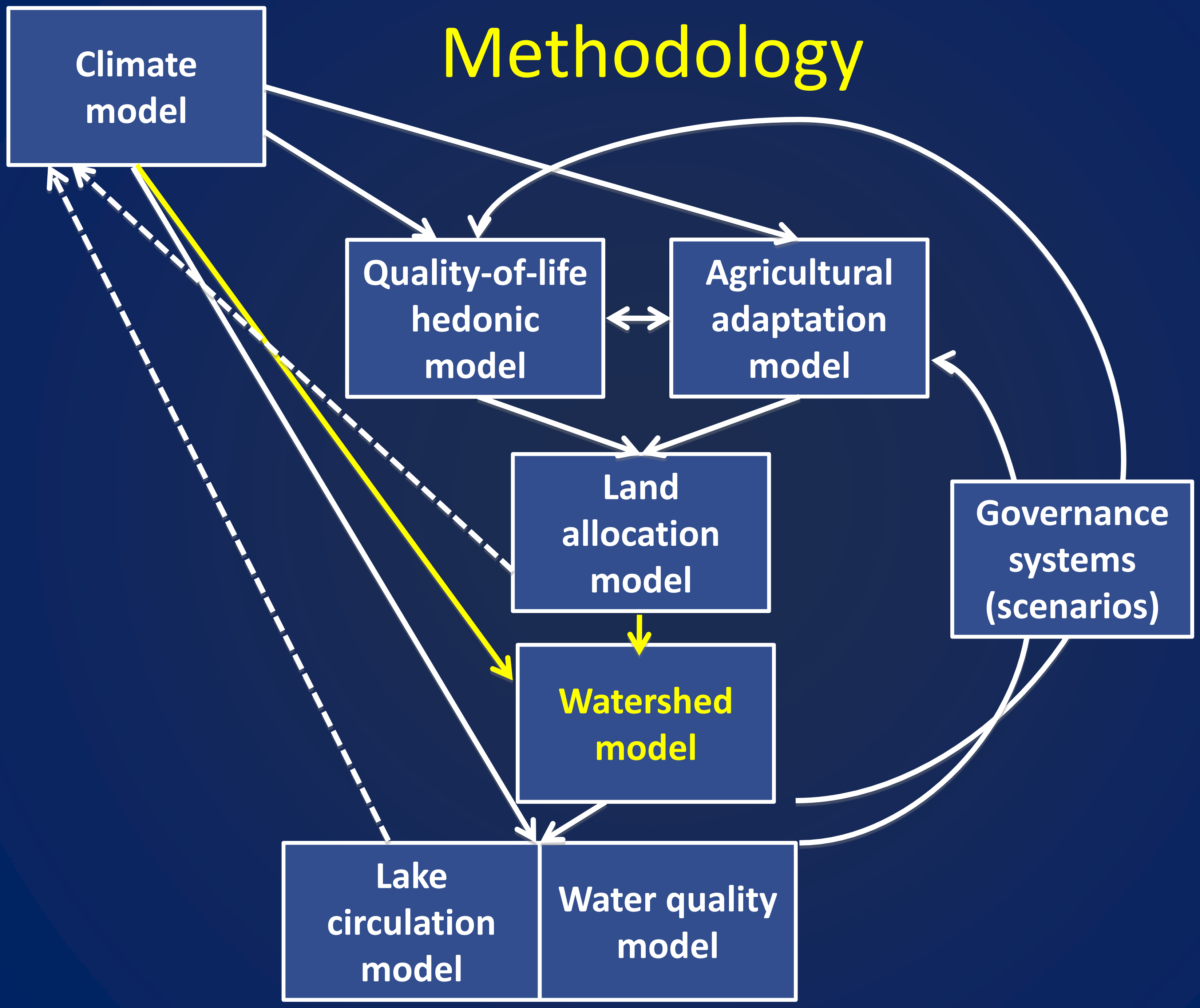
Other Members	Affiliation
Tom Bridgeman	U of Toledo
Jen Read	UM, GLOS
Pete Richards	Heidelberg

We have many other collaborators as well.

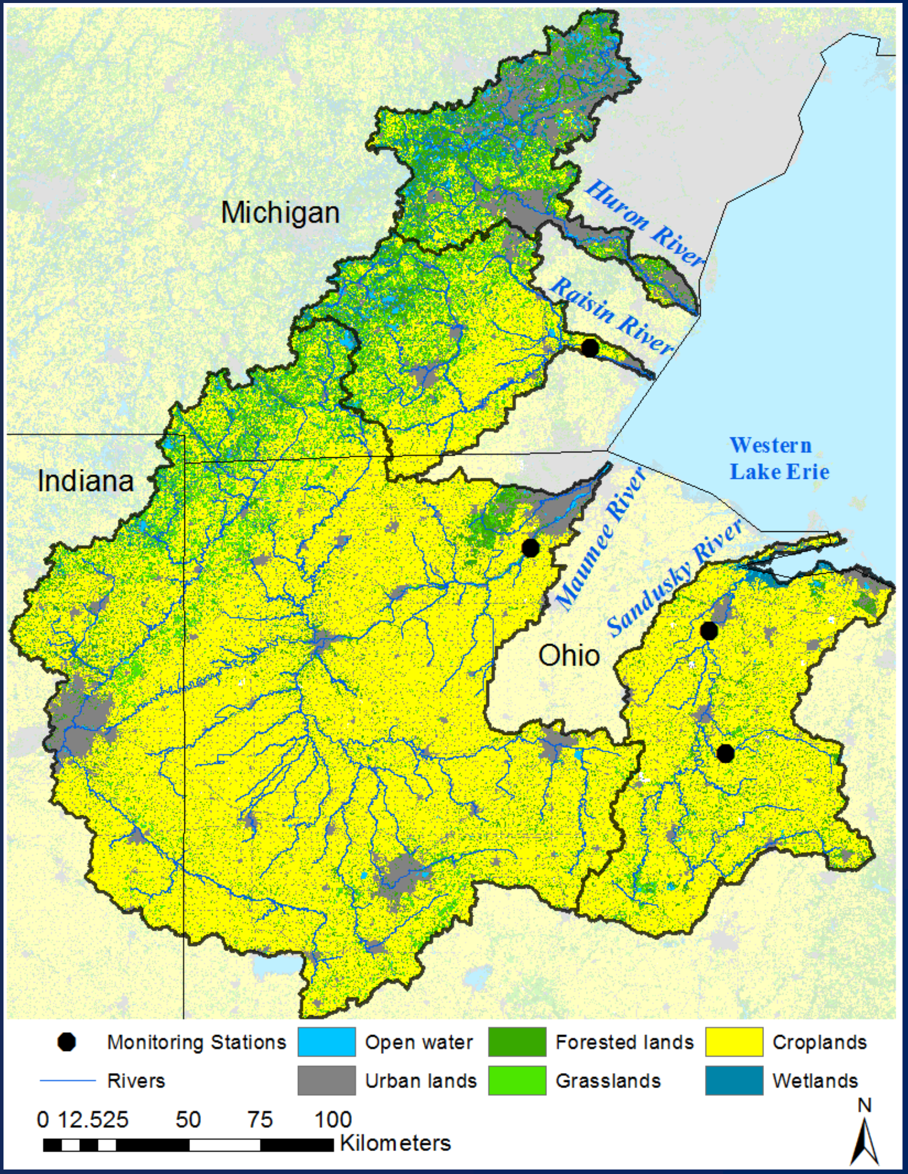
Methodology



Model setup and calibration

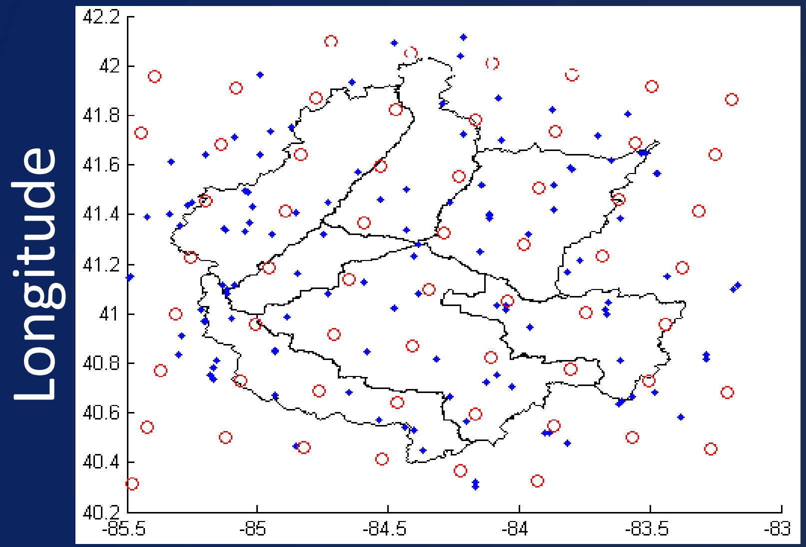
Changes from Ecofor:

- 2006 National Land Cover Dataset (NLCD)
- Soil Survey Geographic (SSURGO) soils
- Setup with HUC-12 subbasins
- HRUs: no threshold so all are represented
- Newer version of SWAT (2012) and newer tile drainage routine
- Model run: 1998-2010 (3 years spin-up, 5 years calibration, 5 years validation)
- Climate and land use change



Integrating future climate change

Maumee HUC-8



Climate variables (daily, 25 years ~2050):

Precipitation Temperature (min/max) Solar radiation

Relative humidity Windspeed

Integrating future climate change

Spatial location of climate data:

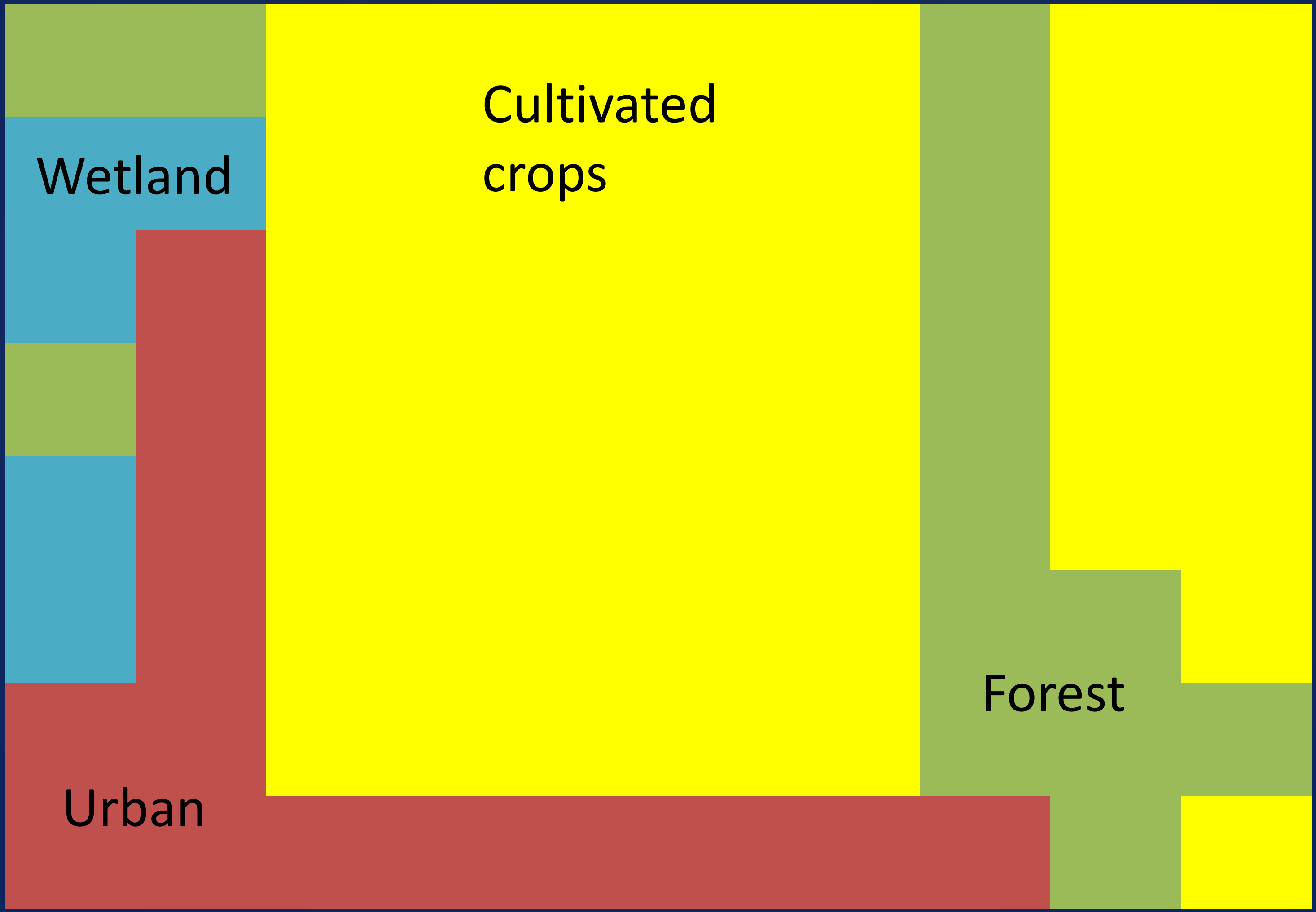
- Weather stations or grid?

Correct use of climate projections:

- Run Global Climate Model (GCM) pair (present-day and future) and compare the difference?
  - Pro: uses the projected climate data and compares apples to apples.
  - Con: spatial heterogeneity somewhat lacking.
- Use statistical downscaling or bias correction to create more accurate spatial heterogeneity.
  - Pro: more realistic spatial heterogeneity.
  - Con: assumes present-day statistics apply to future.

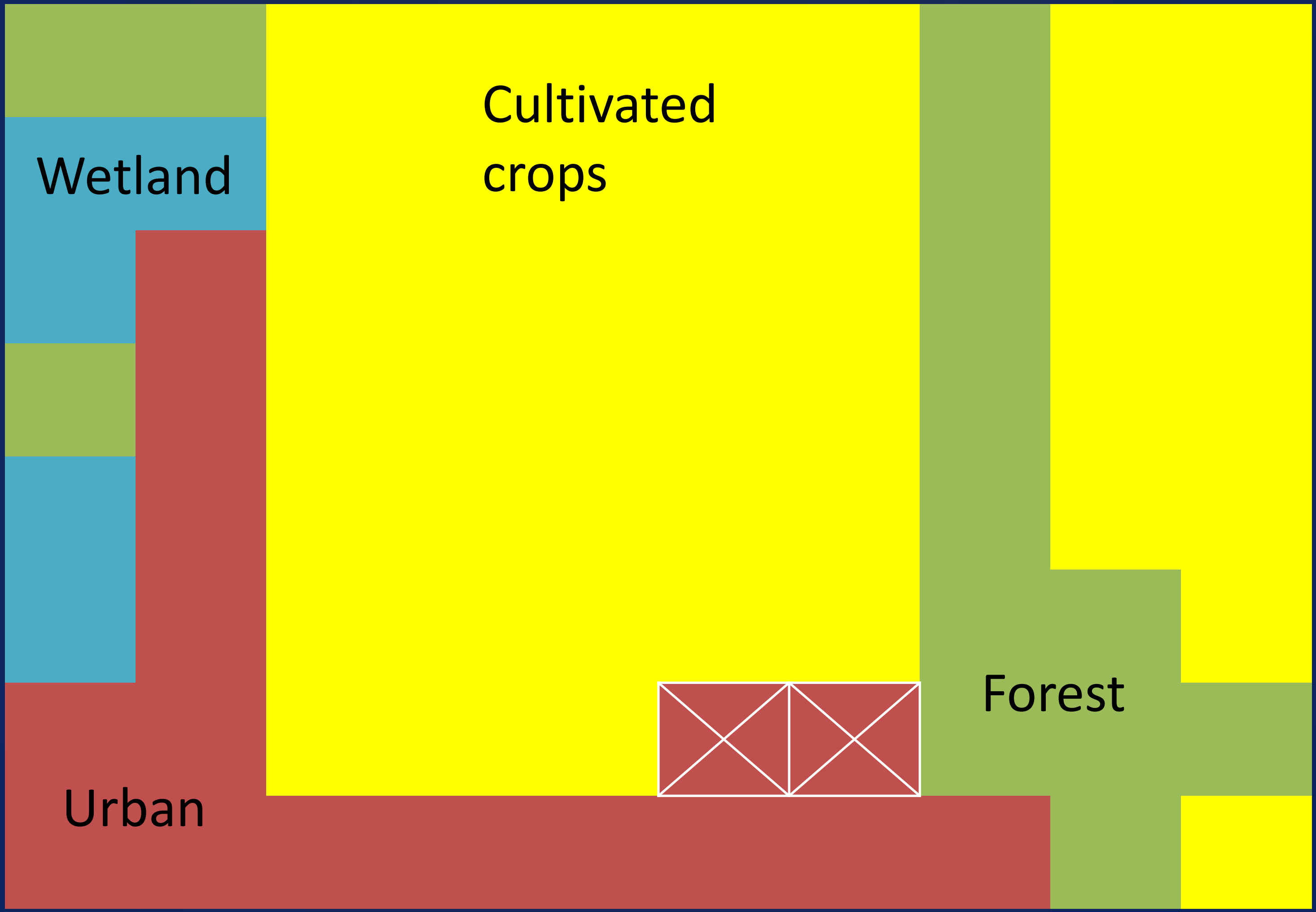
Integrating land allocation

Schematic of land use pixels (30 m x 30 m)



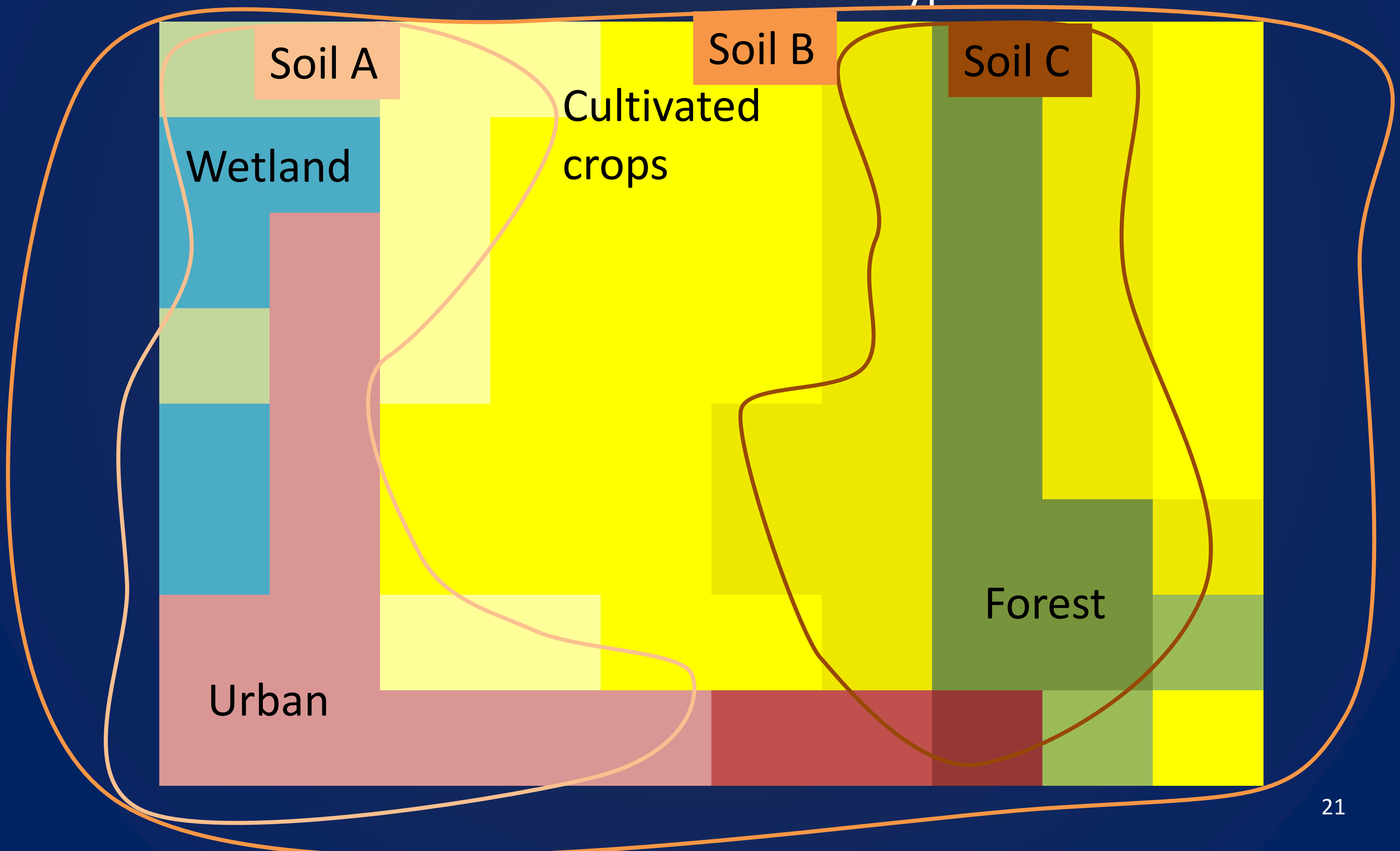
Integrating land allocation

If two agricultural pixels changed to urban



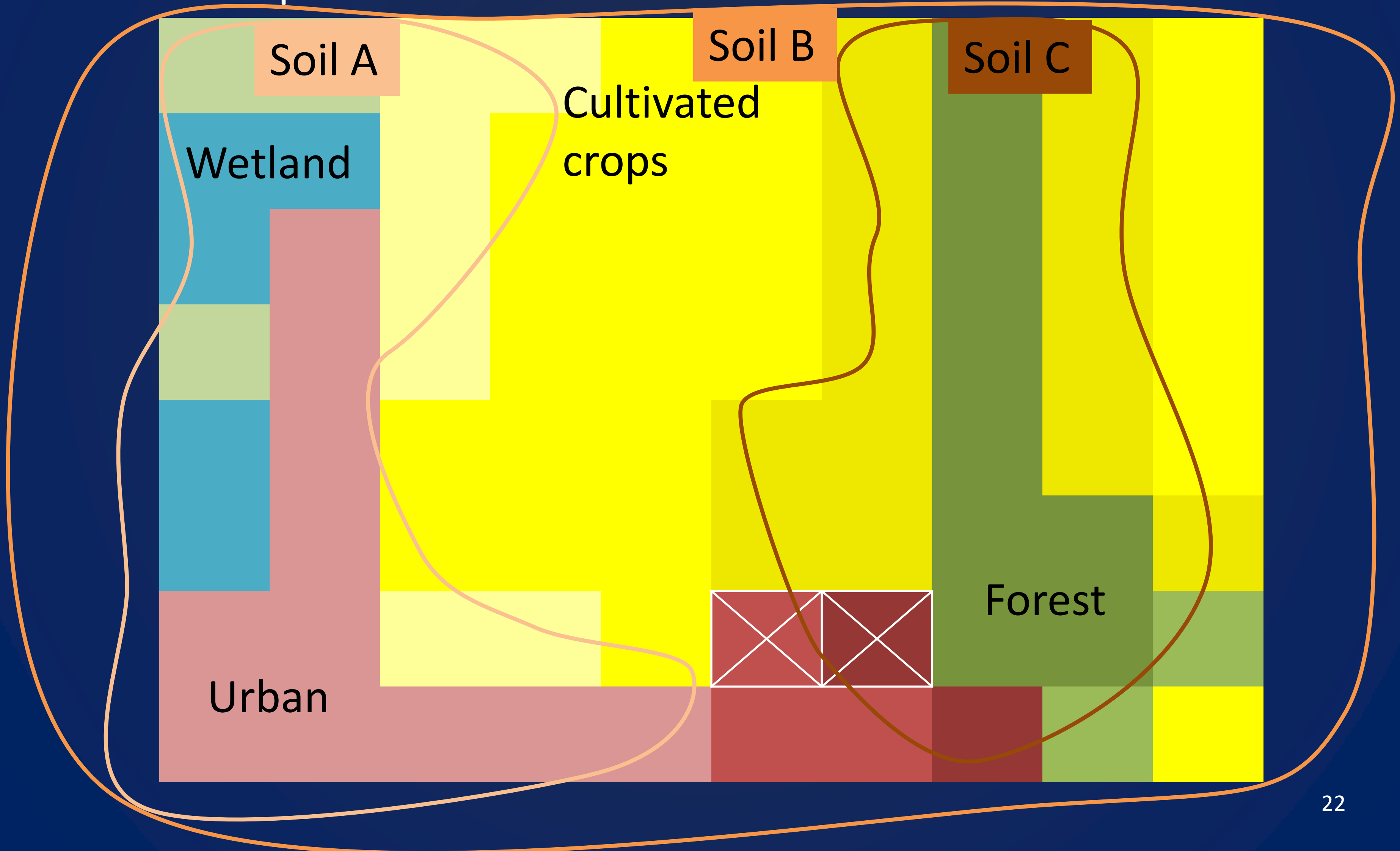
Integrating land allocation

HRUs = land use + soil type



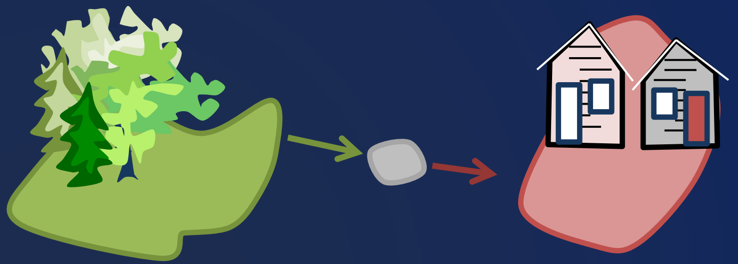
Integrating land allocation

Each pixel moves to HRU with correct land use and soil



Integrating land allocation

SWAT contains a land use change tool (LUP.dat) where HRUs can shrink and grow



SWAT setup decisions:

- Limitation of LUP.dat approach: need to have all possible soil and land use combinations present in each subbasin at setup stage. Alternatively, create new HRUs after setup stage (Looking at a tool that could create new HRUs called LUPSA (Koch et al., 2012, International Congress on Environmental Modelling and Software))
- Need to have 0% land use and soil lumping threshold (no lumping) to ensure every pixel is in an HRU (e.g. Chiang et al., 2010, *Transactions of the ASABE,* 53(5):1569-1584)

Challenges

Data gaps:

- Lack of long-duration, high-frequency sediment and nutrient data for evaluation
- Lack of quantitative BMP implementation data for model parameterization

Methodology:

- Incorporating future climate projections that are most believable in aggregate at small spatial and temporal scales
- Setting up SWAT for land use change experiments