Hydrologic and Water Quality of Climate Change in the Ohio-Tennessee River Basin

Yiannis Panagopoulos, Philip W. Gassman, Todd Campbell, Adriana Valcu & Catherine L. Kling

Center for Agricultural and Rural Development, Iowa State Univ., Ames, IA

Ray Arritt & Daryl Herzmann

Agronomy Dept., Iowa State Univ., Ames, IA

Manoj Jha

Civil Engineering Dept., North Carolina A&T State Univ., Greensboro, NC

Jeffrey Arnold & Michael White

USDA-ARS, Grassland, Soil and Water Research Lab., Temple, TX

Raghavan Srinivasan

Spatial Sciences Lab. (SSL), Texas A&M Univ., College Station, TX

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Presentation Overview

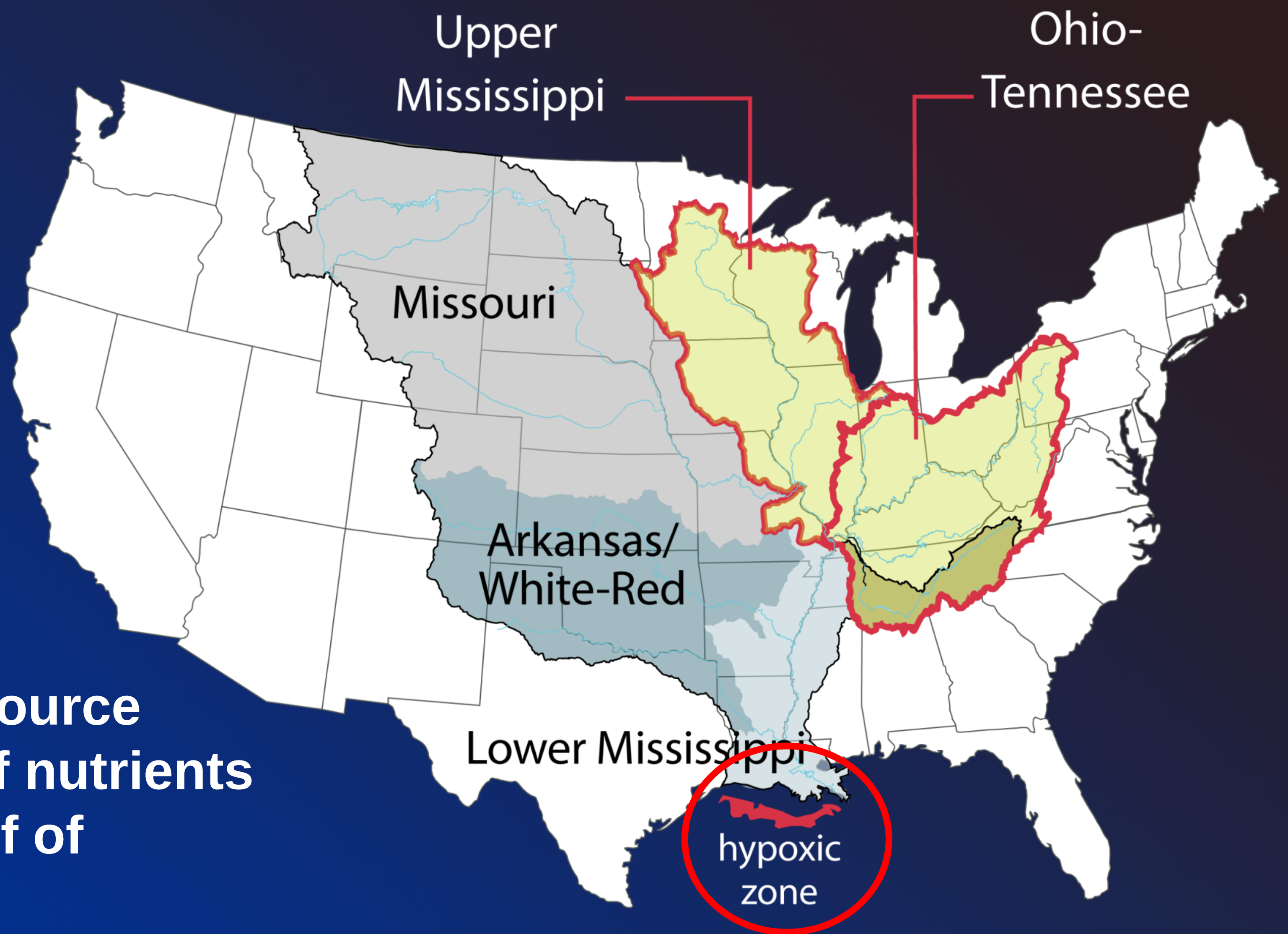
- Background regarding Corn Belt region pollution problems

- Brief review of modeling structure and input data
  - SWAT 2012; Release 610

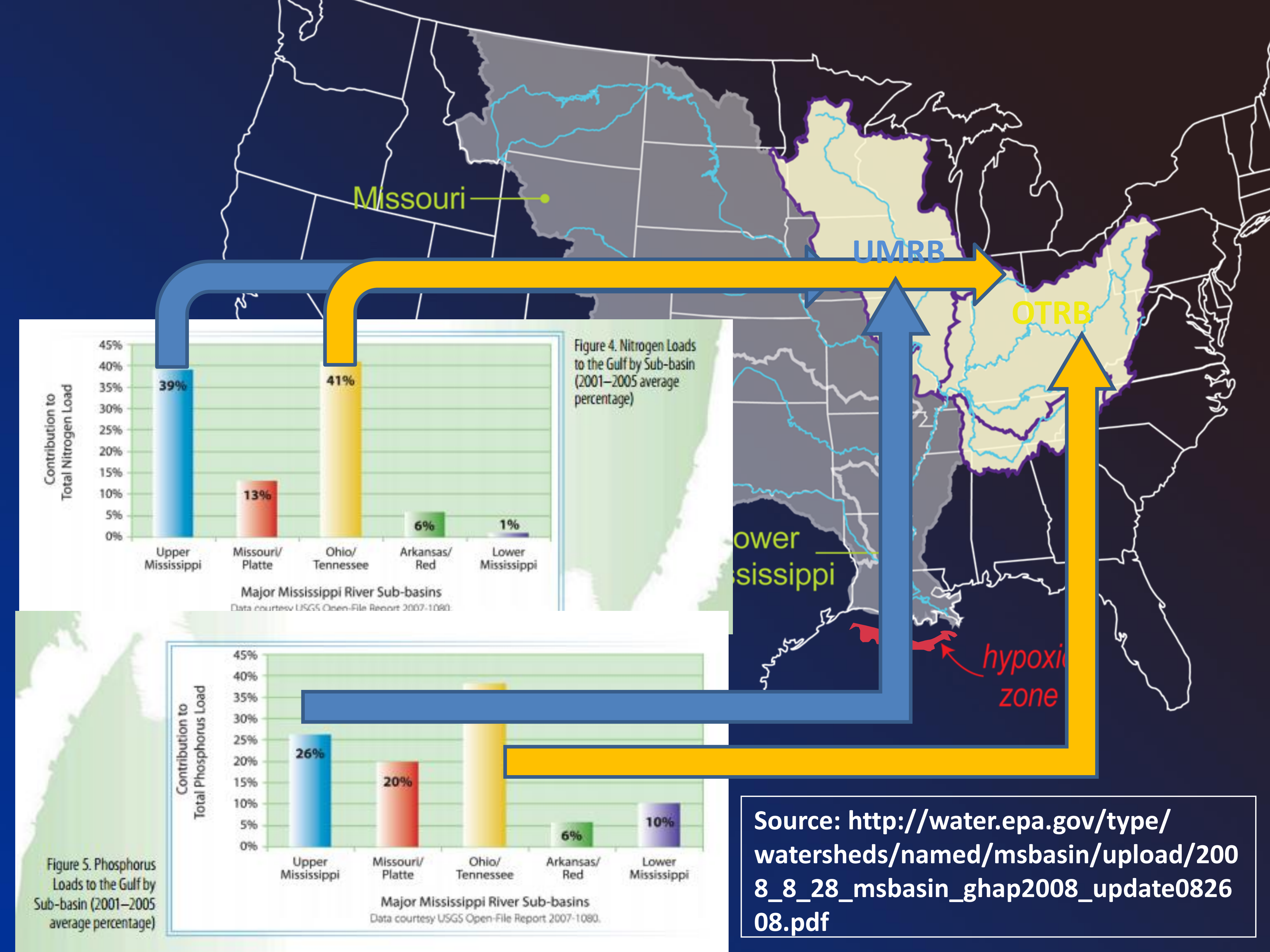
- Description on conservation practice/cropping system scenarios and climate change scenarios

- Scenario results

Upper Mississippi & Ohio River Basins
(within Mississippi River Basin)

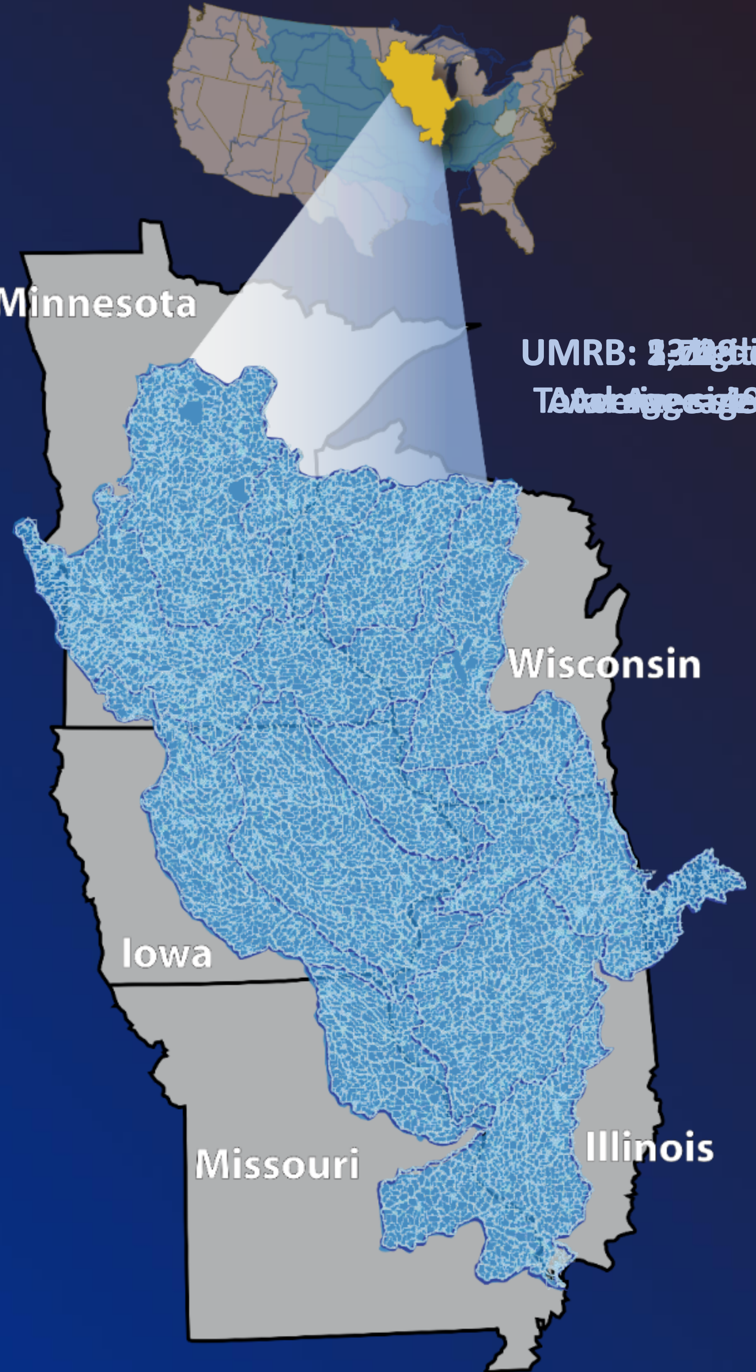


Primary source regions of nutrients to the Gulf of Mexico



Source: http://water.epa.gov/type/watersheds/named/msbasin/upload/2008_8_28_msbasin_ghap2008_update082608.pdf

Standard U.S. watershed classification categories for the UMRB (delineation scheme based on 12-digit watersheds)



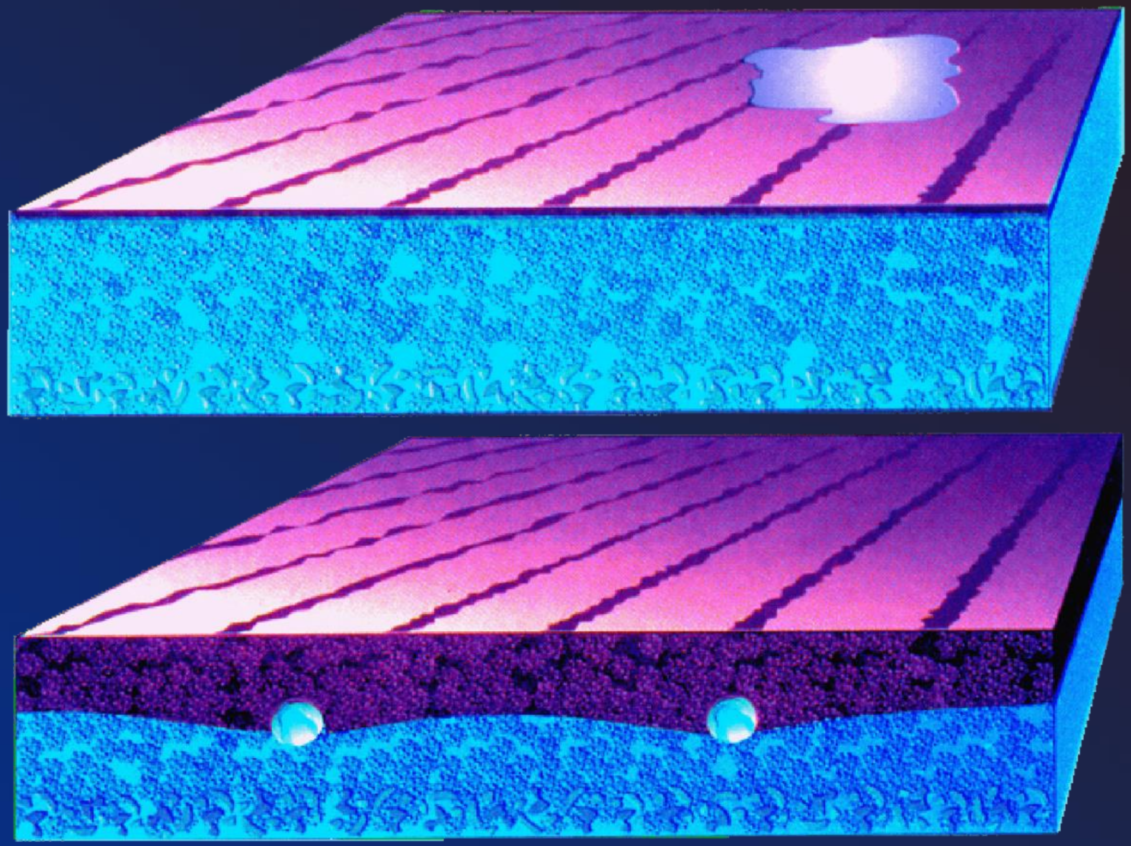
UMRB:

OTRB Watershed Showing 12-digit Subwatersheds & Locations of Monitoring Sites Used for Testing of SWAT

Key Data Inputs for OTRB

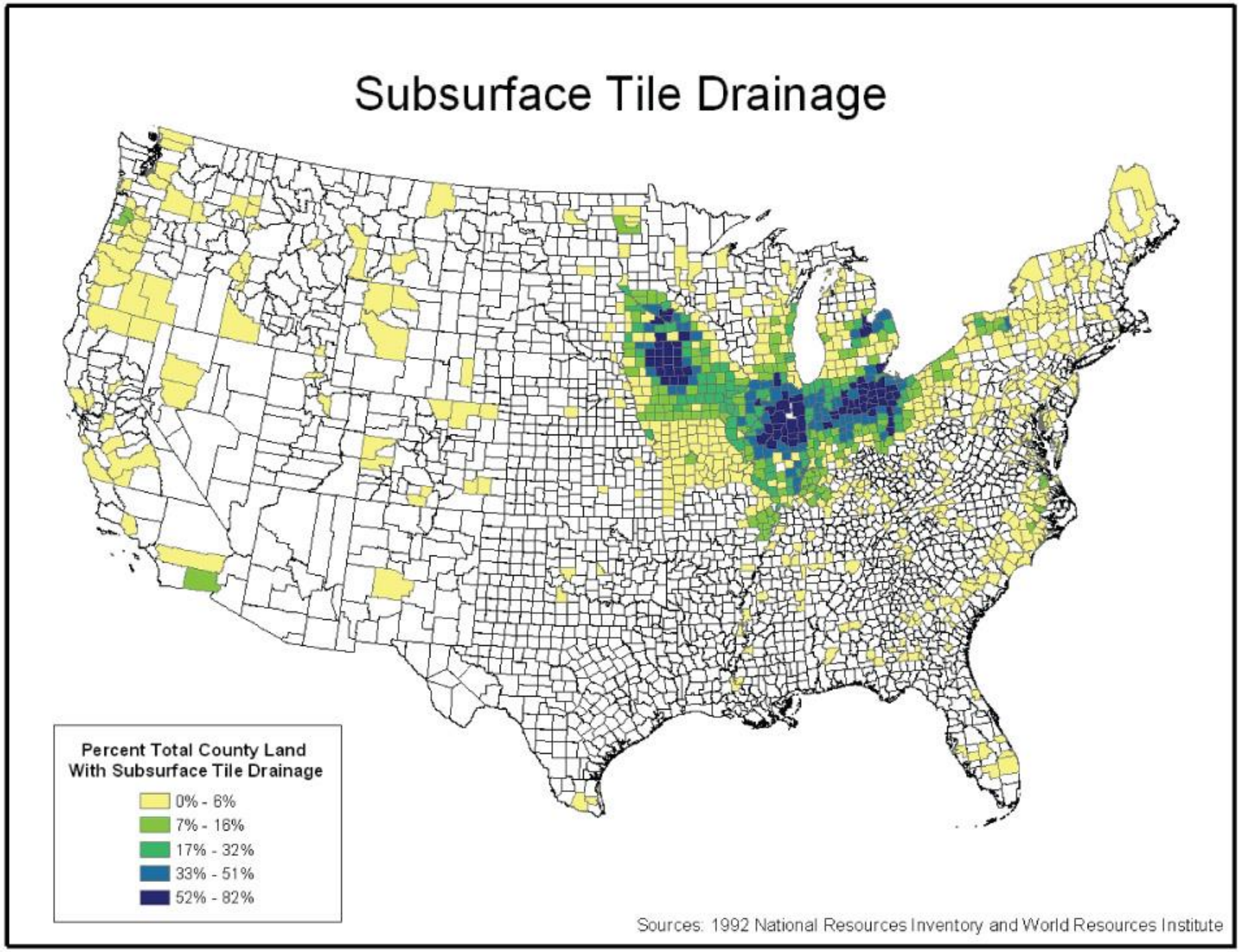
Data category	Data source
Climate data	NCDC daily precip/temp
Soil map/layer	USDA STATSGO (1:250,000)
Topographic	30 m DEM
Land use	USDA NASS CDL (2008-10)
Major reservoirs	U.S. dam/reservoir database
Point sources	Improved USGS data
Subsurface tile drainage	World Resources Inst. county map
Nutrient/manure inputs	Average statewide application rates (NuGIS database)
Tillage systems	Based on CTIC/USGS data
Other cons. practices	Imbedded on proxy basis

Effects of Tile Drainage on Soil Water



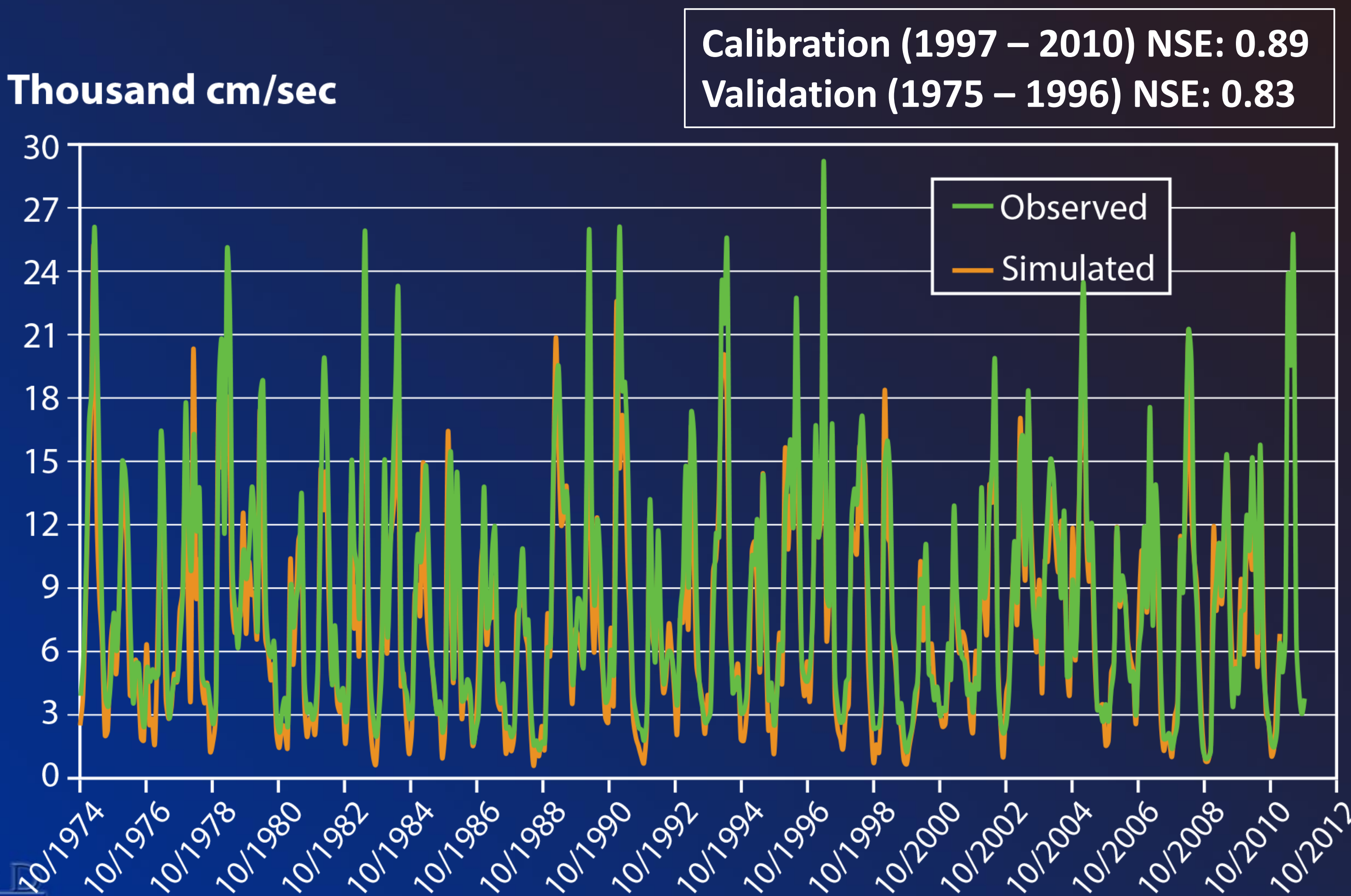
Adapted from: Zucker, L.A. and L.C. Brown (eds.). 1998. Agricultural Drainage: Water Quality Impacts and Subsurface Drainage Studies in the Midwest. Ohio State University Extension Bulletin 871. The Ohio State University.

Subsurface Tile Drains by County for the Conterminous U.S.

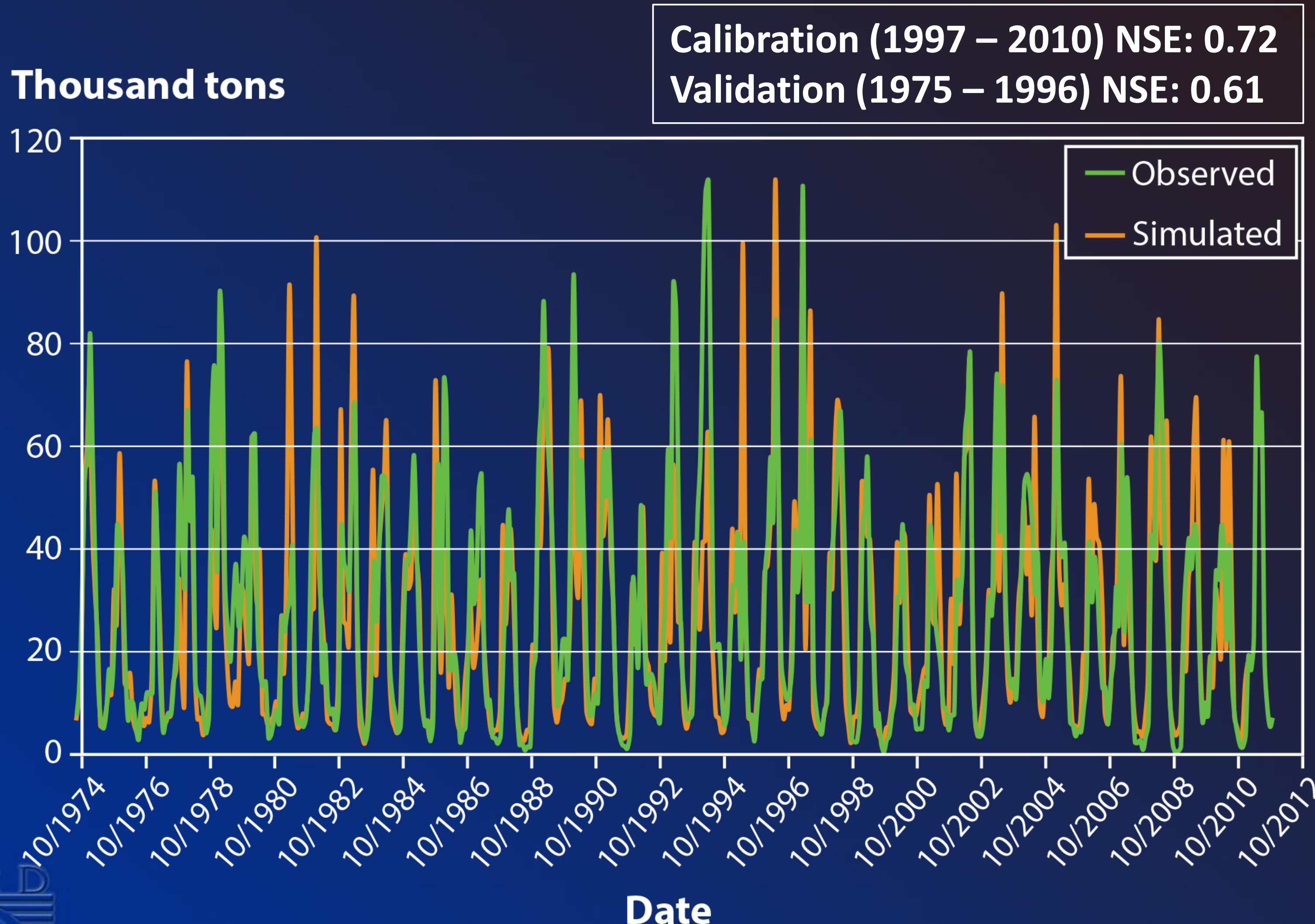


Source: Sugg, Z. 2007. Assessing U.S. Farm Drainage: Can GIS Lead to Better Estimates of Subsurface Drainage Extent? World Resources Institute, Washington, D.C. http://pdf.wri.org/assessing_farm_drainage.pdf.

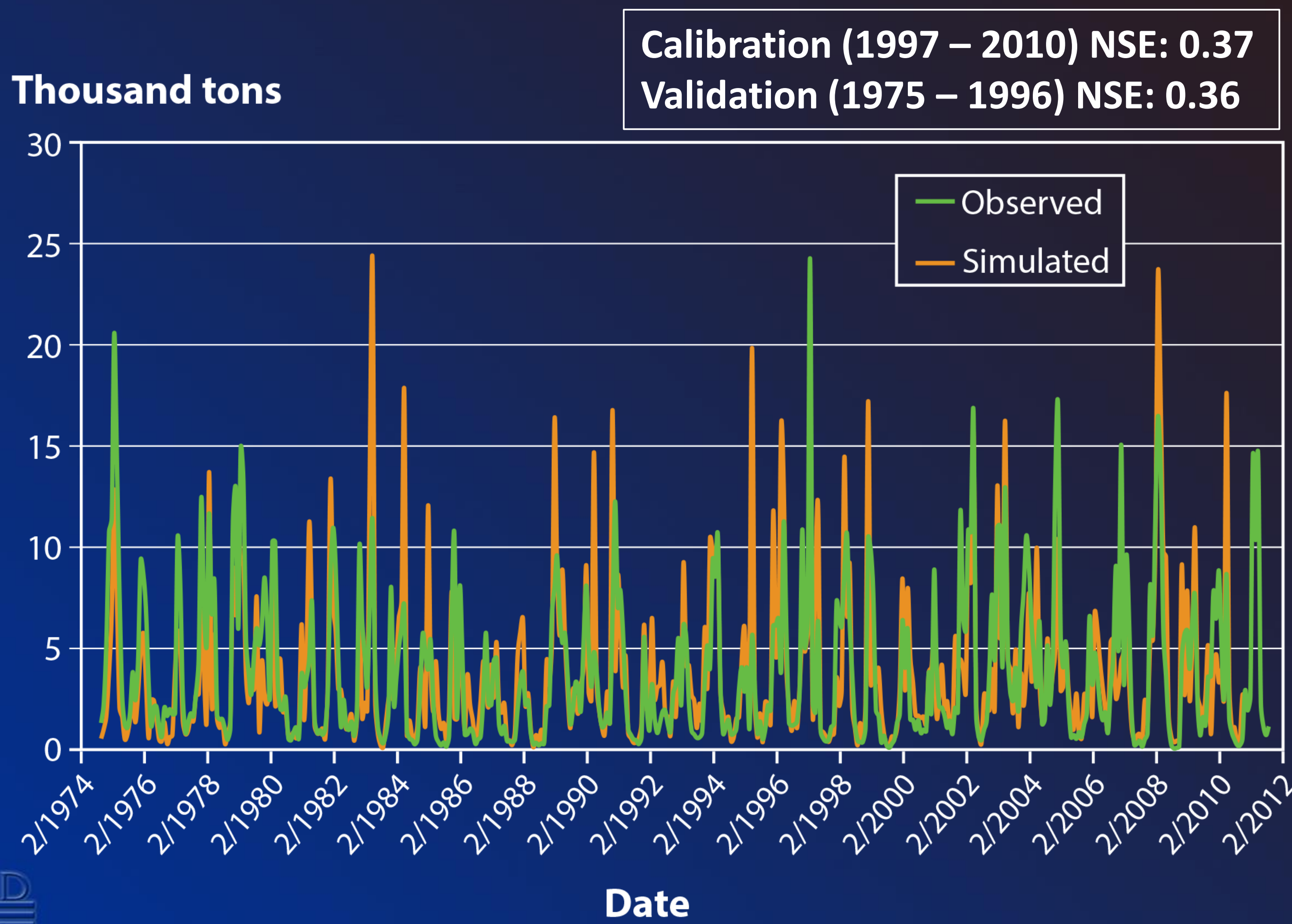
Comparison of Simulated vs. Observed Streamflows at Metropolis



Comparison of Simulated vs. Observed NO_3-N & NO_2-N at Metropolis



Comparison of Simulated vs. Observed Total Phosphorus at Metropolis



OTRB Agricultural Management Scenarios

Baseline: row crop dominated corn-soybean (C-S)

Scenarios:

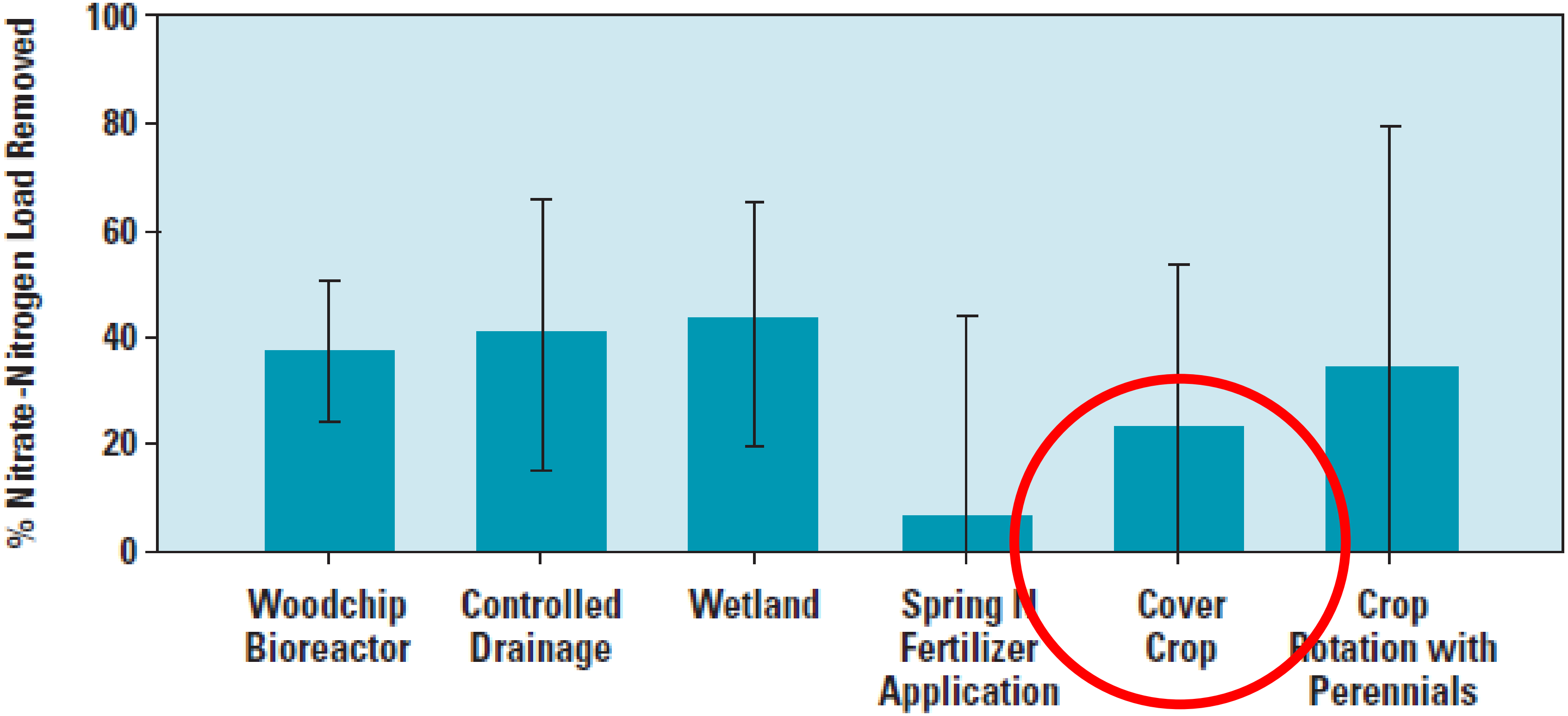
1) Convert corn-soybean (C-S) to continuous corn (C-C)

2) Apply no-till (NT) to all cropland (baseline row crops)

3) Rye winter cover crop (Ccrops) between corn and soybean (baseline row crops)

Conservation practices

Comparison of Nitrate Removal Effectiveness between Practices



Source: Christianson, L. and M. Helmers. 2011. Woodchip bioreactors for Nitrate in Agricultural Drainage. PMR 1008. Iowa State Univ. Extension & Outreach. Available at: http://www.sare.org/Learning-Center/Project-Products/North-Central-SARE-Project-Products/Woodchip-Bioreactors-for-Nitrate-in-Agricultural-Drainage

Climate Change Scenarios

- World Climate Research Programme Coupled Model Intercomparison Project phase 3 (CMIP3)
  - temperature & precipitation patterns similar to more recent CMIP5

- Future monthly projections from 7 general circulation models (GCMs)
  - subset with complete set of required climate data available
  - span complete range of CMIP3 projections (lowest to highest)
  - downscaled to 1/8 degree grid; bias-corrected spatial aggregation
  - CMIP3 A1B scenario: doubling of CO_2 (720 ppm)
  - representative of mid-century projections: 2046-2065

- 1981-2000 served as scenario baseline; future climate effects simulated as adjustments to measured climate data
  - percentage changes in precipitation and absolute changes in maximum and minimum temperatures

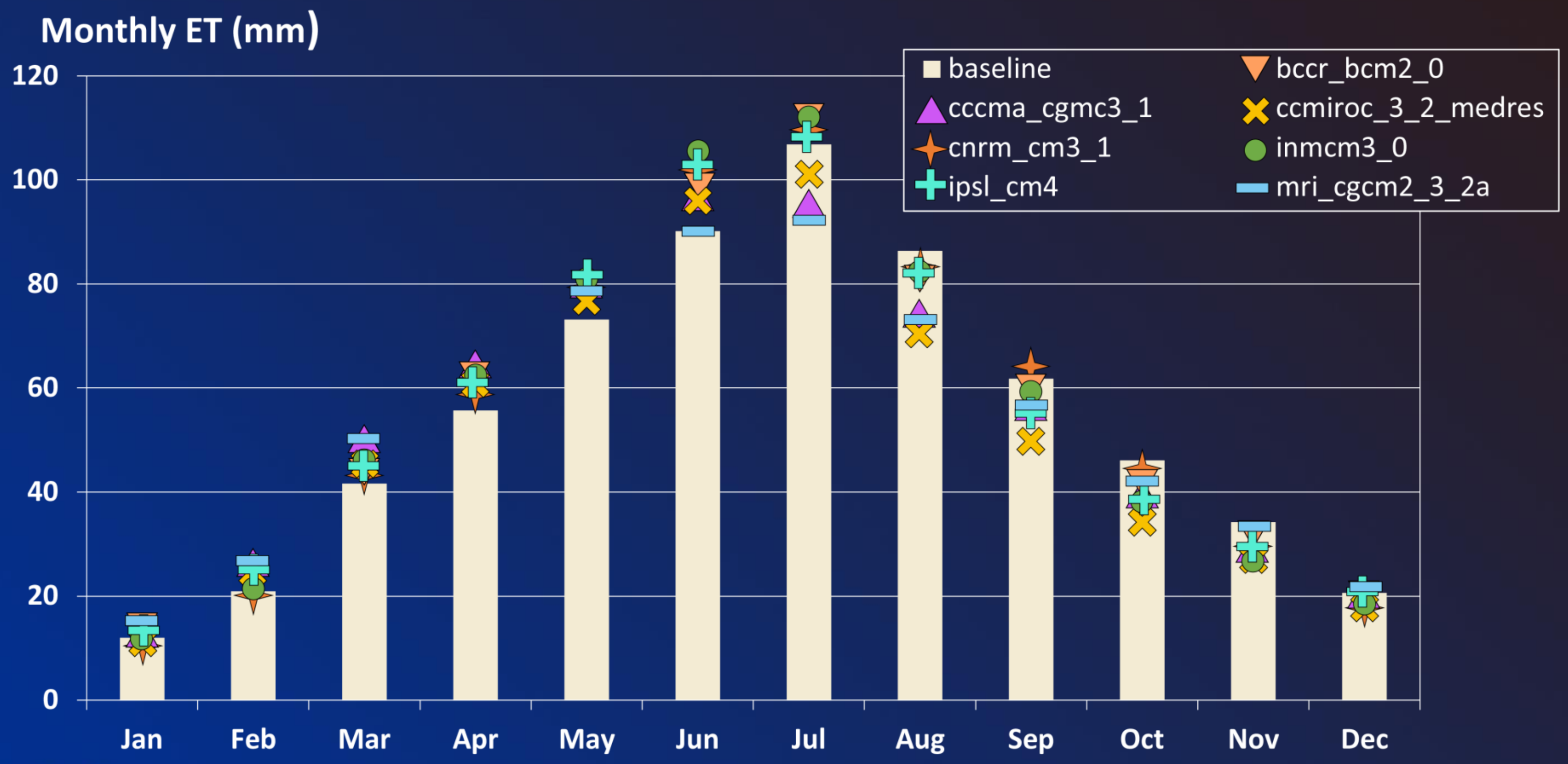
GCM Models Used in Analysis

GCM Model	Model Name 2	Institution	Country	Grid spacing
BCCR-BCM2.0	bccr_ bcm2 -0	Bjerknes Centre for Climate Research	Norway	$1.9^{o} \times 1.9^{o}$
CGCM3.1	cccma_ cgm3_1	Canadian Centre for Climate Model. & Analysis	Canada	$2.5^{o} \times 2.5^{o}$
INM-CM3.0	inmcm3_0	Institute for Numerical Mathematics	Russia	$4^{o} \times 5^{o}$
CNRM-CM3	cnrm_ cm3_1	Météo-France / Centre National de Recherches Météorologiques	France	$1.9^{o} \times 1.9^{o}$
IPSL-CM4	ipsl_cm4	Institute Pierre Simon Laplace	France	$2.5^{o} \times 3.75^{o}$
MIROC3.2 (medres)	ccmiroc_3 _2_medres	Univ. of Tokyo, National Inst. for Environ. Studies, & Frontier Res. Center for Global Change	Japan	$2.8^{o} \times 2.8^{o}$
MRI-CGCM2.3.2	mri_cgcm2 _3_2a	Meteorological Research Institute	Japan	$2.8^{o} \times 2.8^{o}$

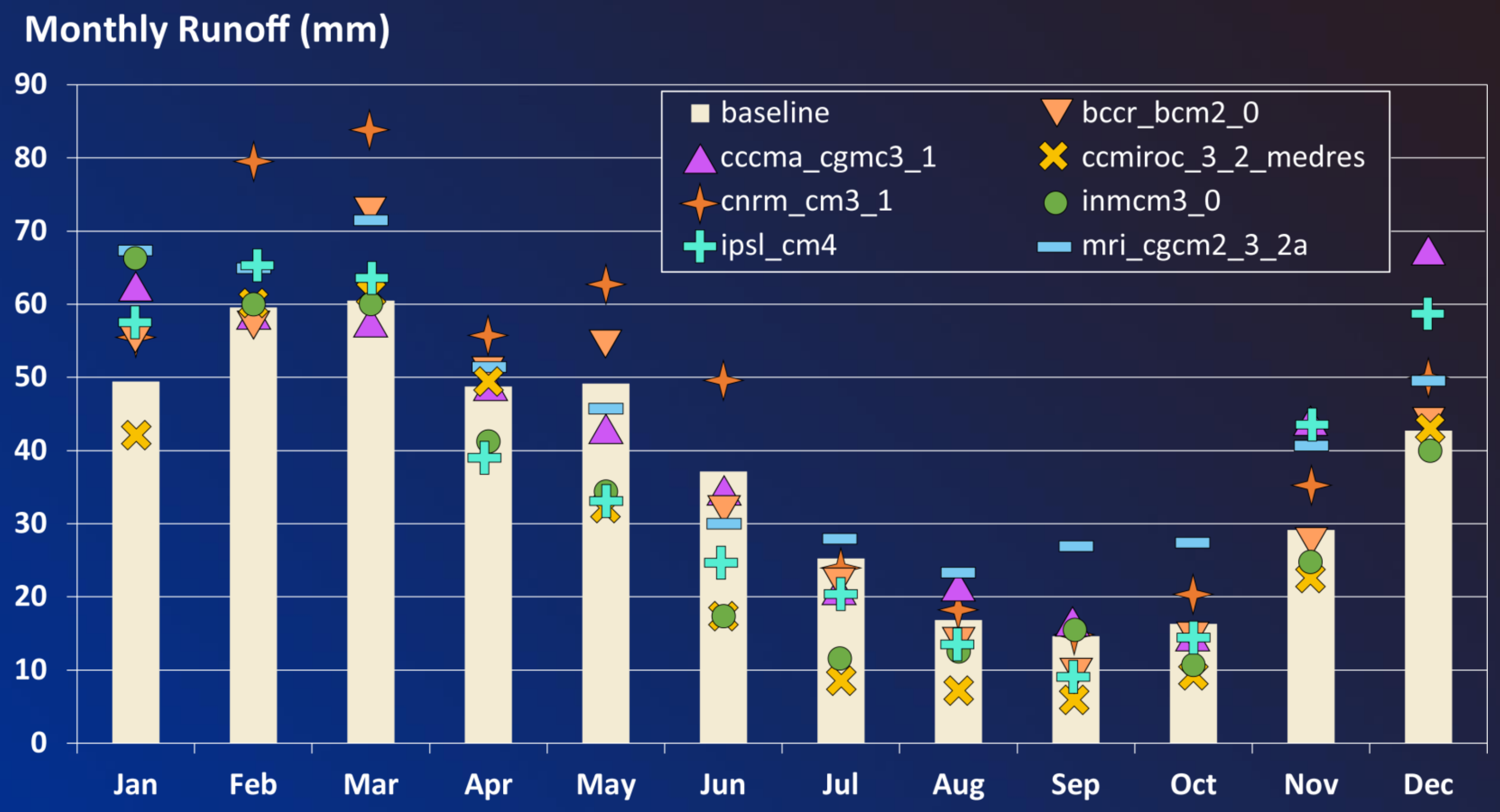
Average Annual GCM Results for Selected Water Balance Indicators (mm/year)

Scenario	Precipitation	Snowfall	ET	Surface Runoff
Baseline	1175	78	649	151
BCCR-BCM2.0	1189	45	663	141
CGCM3.1	1228	50	656	157
CNRM-CM3	1296	62	663	185
INM-CM3.0	1136	60	663	132
IPSL-CM4	1195	29	668	137
MIROC3.2 (medres)	1046	38	617	106
MRI-CGCM2.3.2	1248	49	642	163

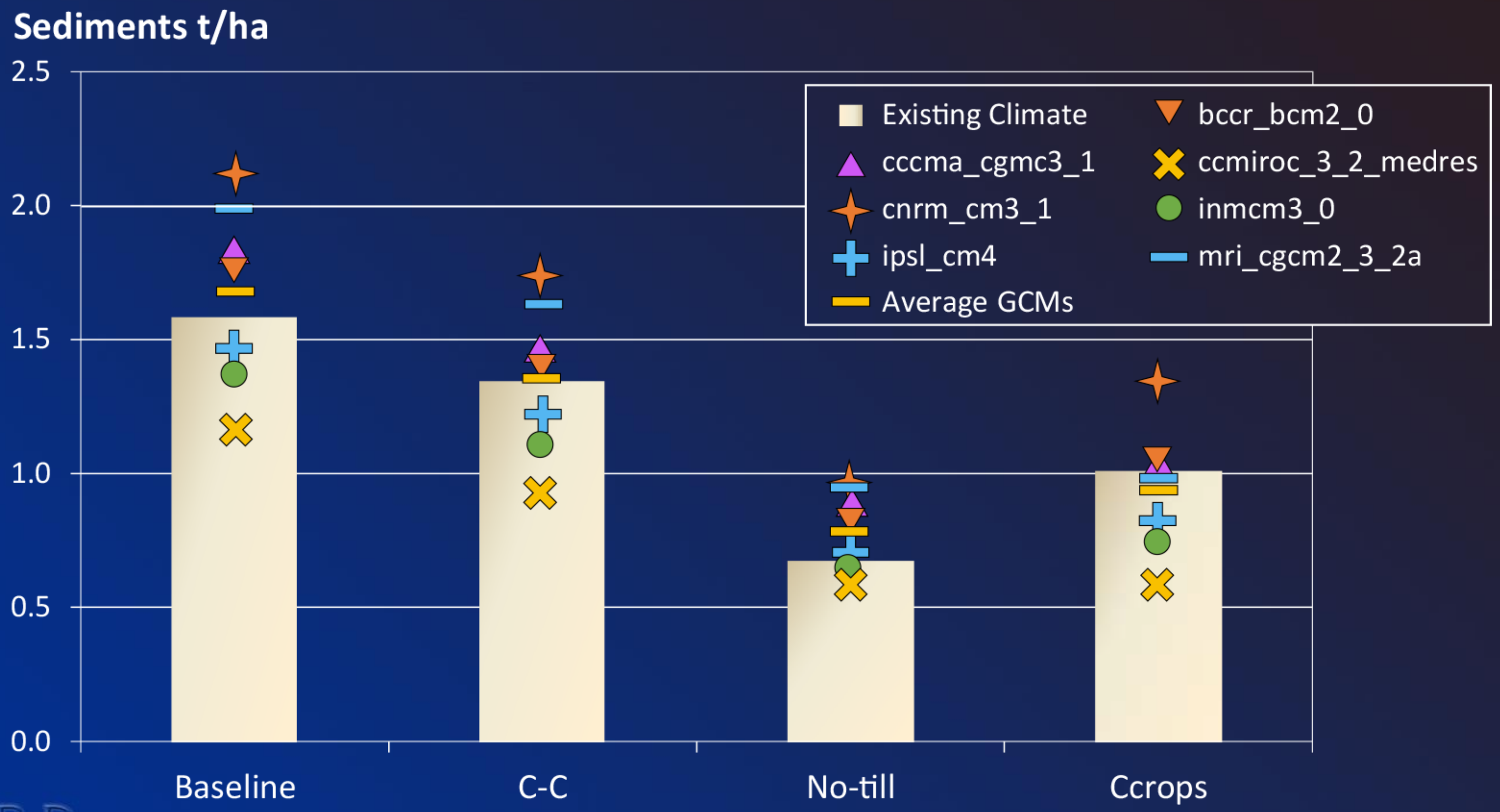
Baseline vs. Future GCM Scenarios Evapotranspiration Comparisons



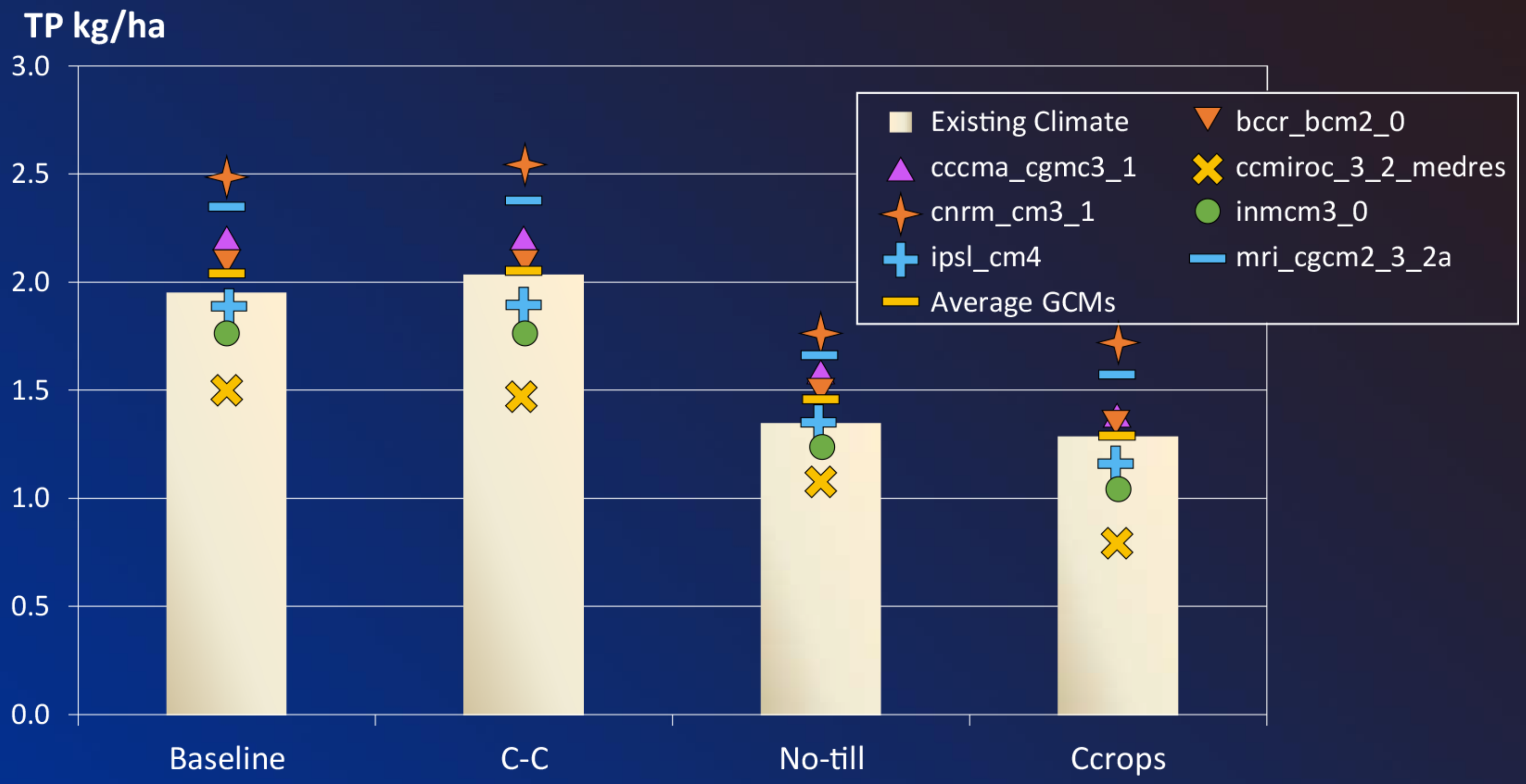
Baseline vs. Future GCM Scenarios Surface Runoff Comparisons



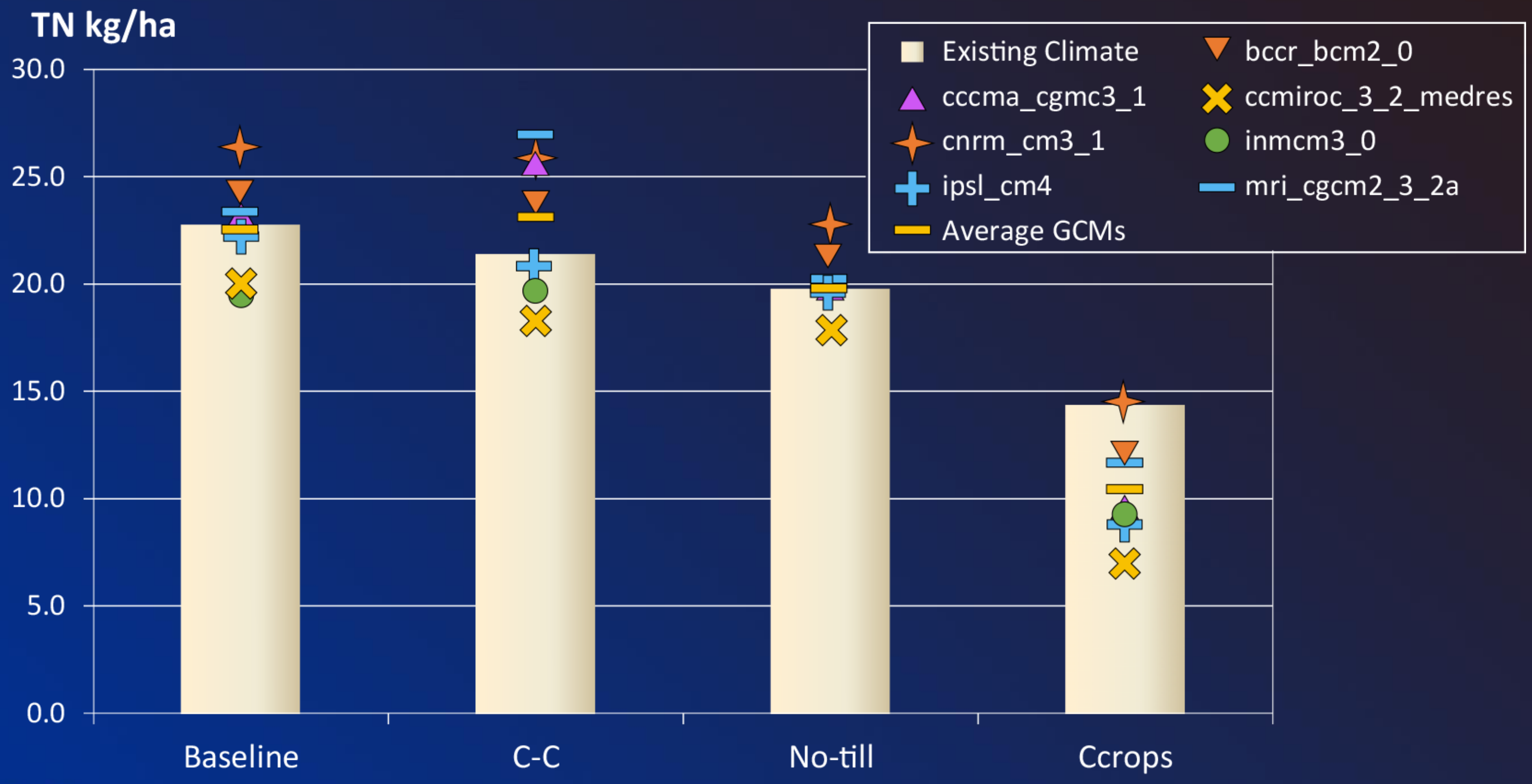
Baseline vs. Future GCM Scenarios
Sediment Loss Comparisons



Baseline vs. Future GCM Scenarios Total Phosphorus Loss Comparisons



Baseline vs. Future GCM Scenarios Total Nitrogen Loss Comparisons



Some Conclusions

- Future mid-century temperature increases result in less snowfall and greater runoff during winter
- Average of future climate projections resulted in very similar sediment and total P losses for the four scenarios using baseline climate data
- The use of cover crops was predicted to be the most effective deterrent for reducing total N losses under possible mid-century climate change