Development of SWAT Hydrologic Input Parameter Guidelines for Specific Iowa Landform Regions for TMDL Analyses and Other Water Quality Assessments

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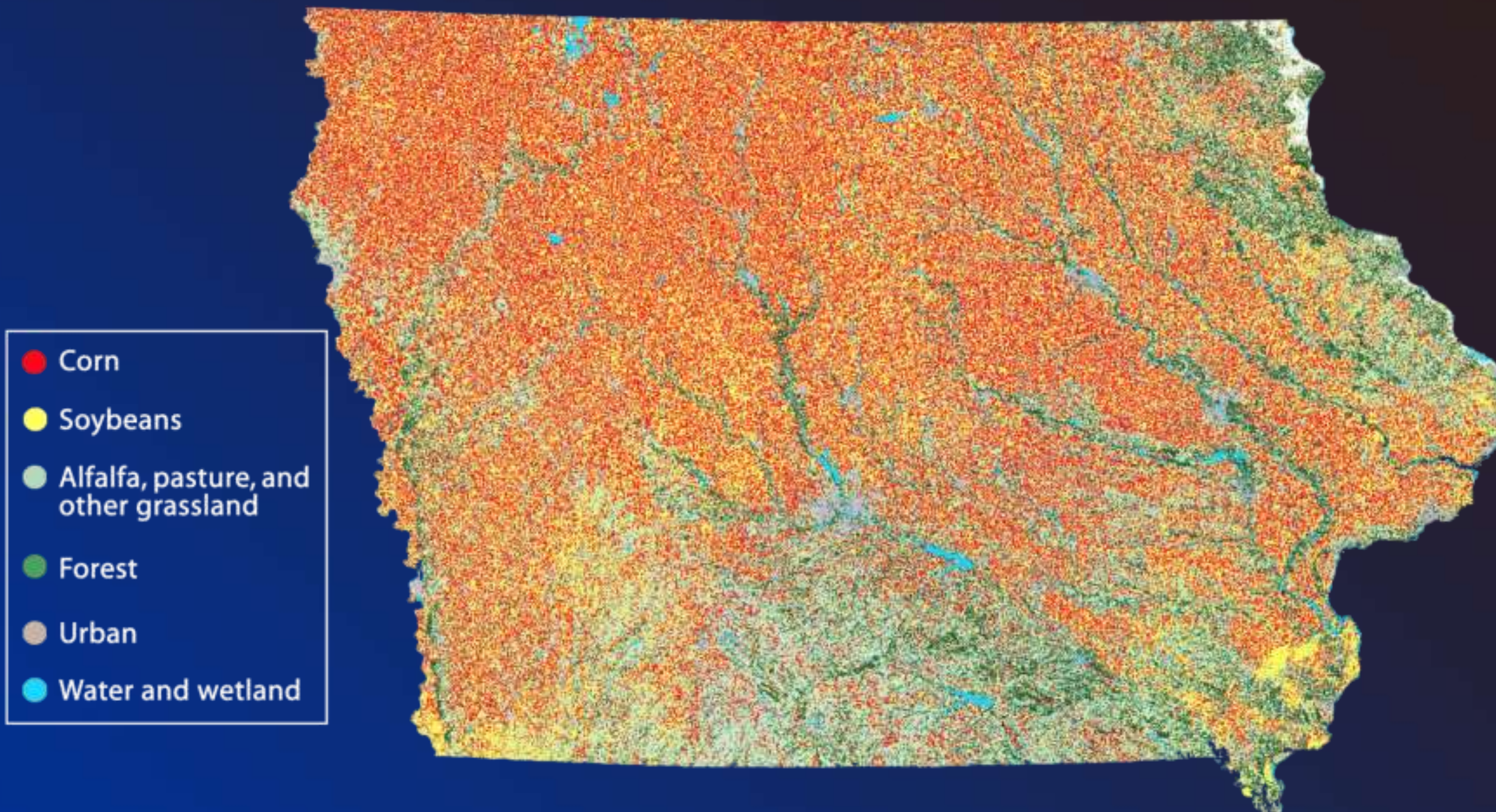
2002 Iowa Landuse Map



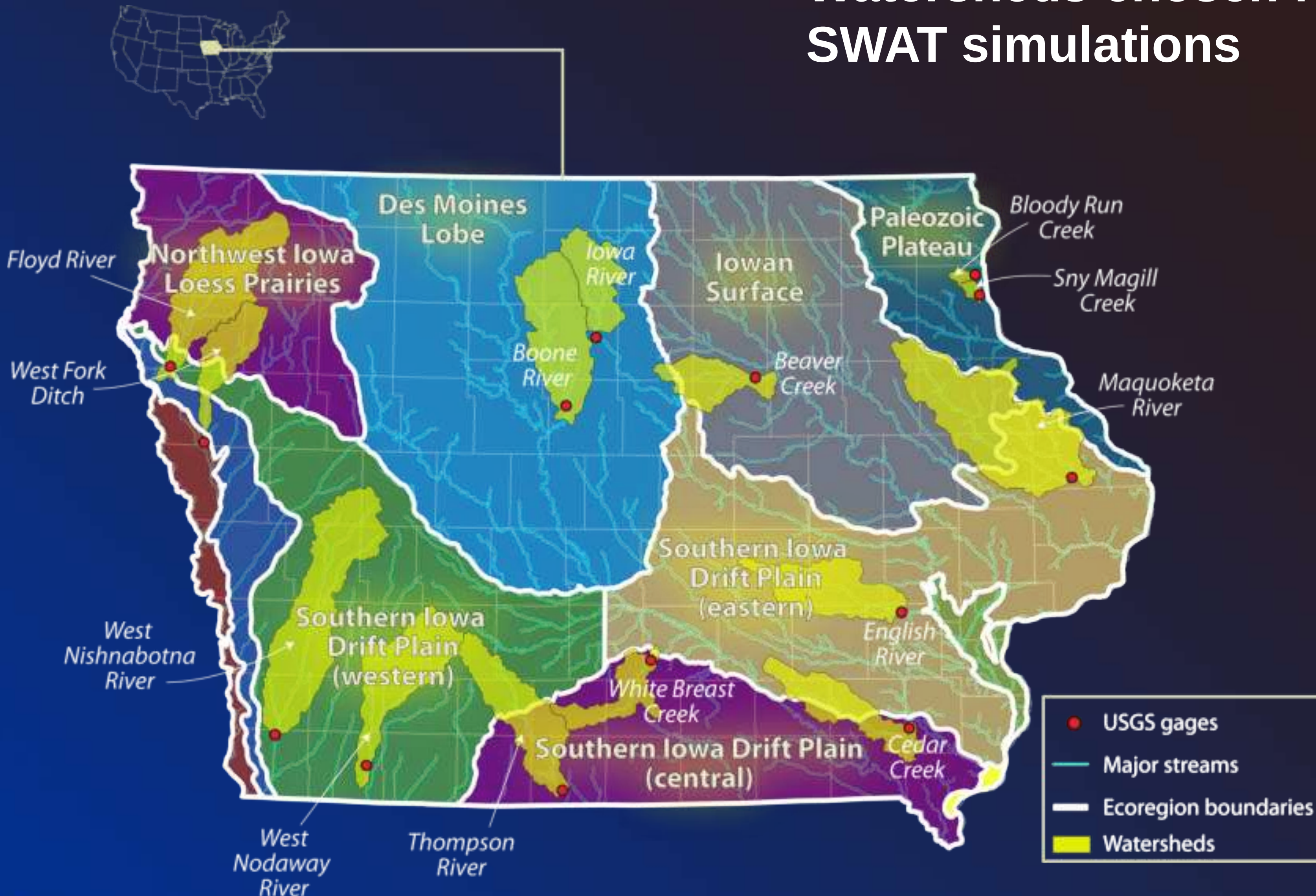
2008 Iowa Rankings

Crop/Livestock	Rank	% of U.S. Total
Corn (grain)	1	16
Soybeans	1	13
Total crop area	1	8
All hogs	1	30
Cattle & calves on feed	7	4
Egg layers	1	16

Background for Study

- Iowa Dept. of Natural Resources (IDNR) are required to perform TMDL assessments for "impaired waters"
- IDNR uses a variety of simulation and other tools for these assessments including SWAT
- IDNR is seeking better guidance regarding the best choice of SWAT hydrologic parameters for different landform regions in the state

Landform Regions and Watersheds chosen for SWAT simulations



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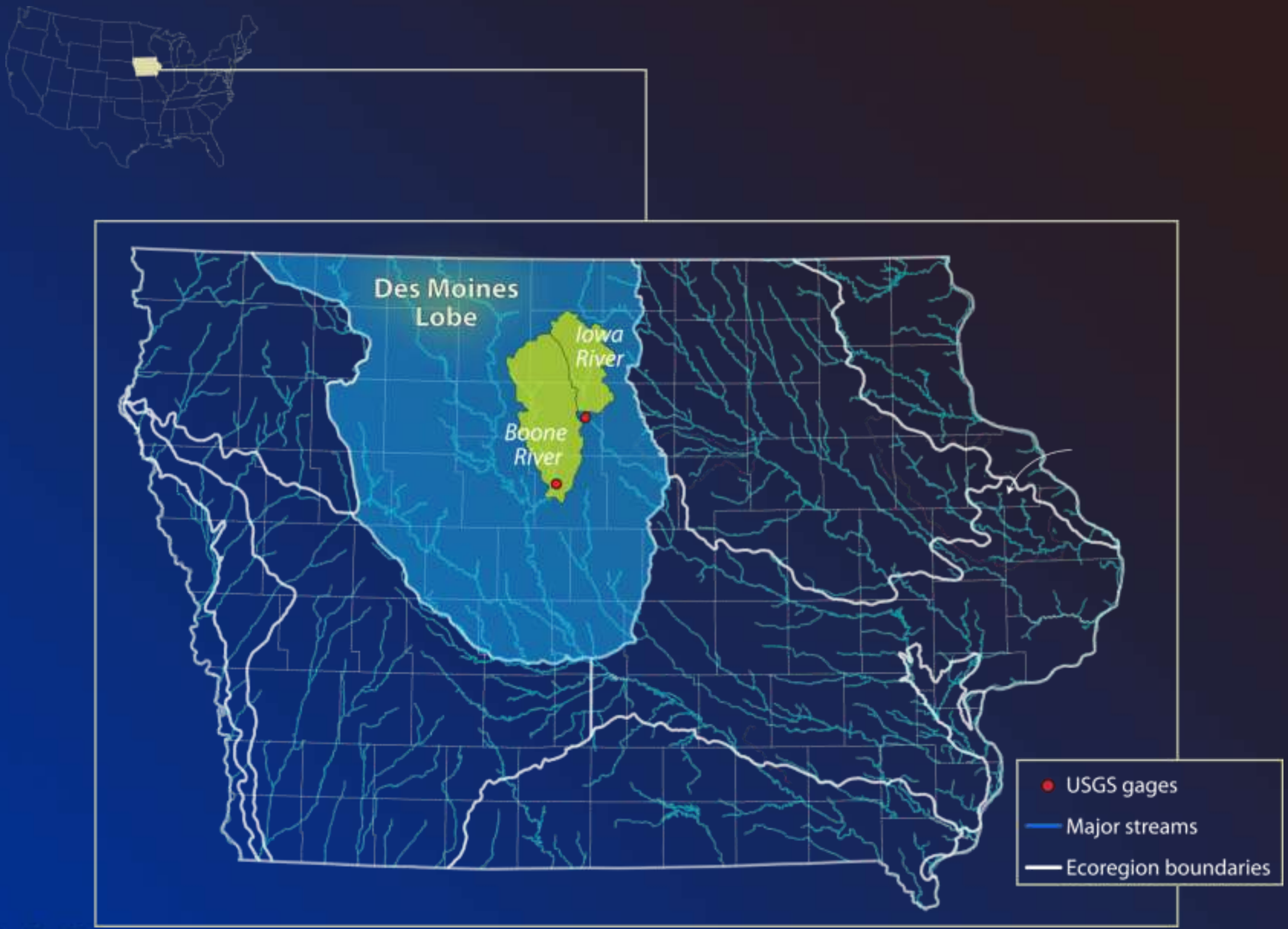
General Modeling Procedures

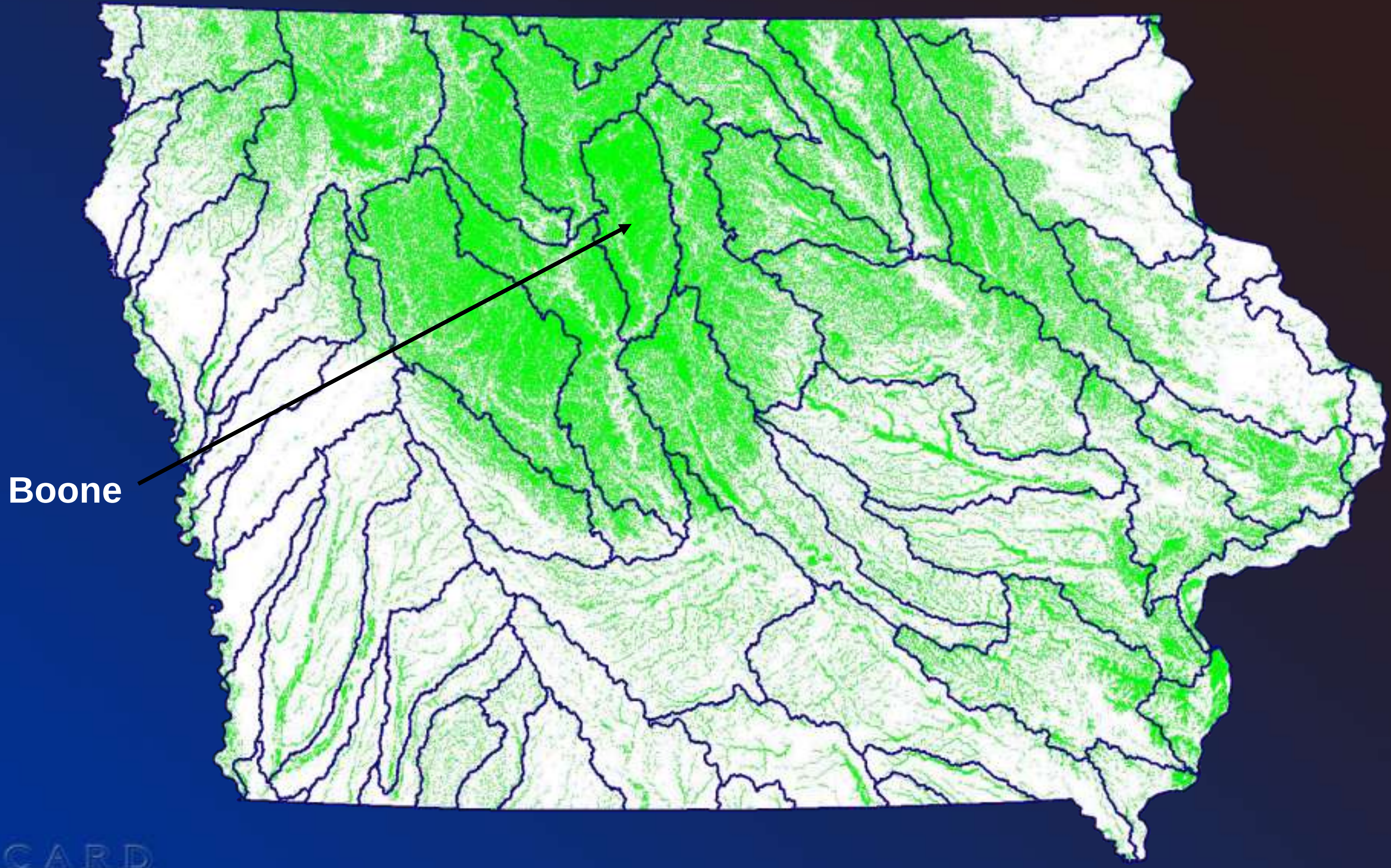
- Selected one watershed for calibration and then perform validation on other watershed
- Used ~SWAT2009 code distributed with ArcSWAT interface (April 2009)
- Initially performed uncalibrated/unvalidated simulations for each watershed
- Then performed manual calibration using limited sets of parameters
- Moriasi et al. (2007) criteria; statistics > 0.5

Initial Modeling Setup: Input Data & SWAT Simulation Options

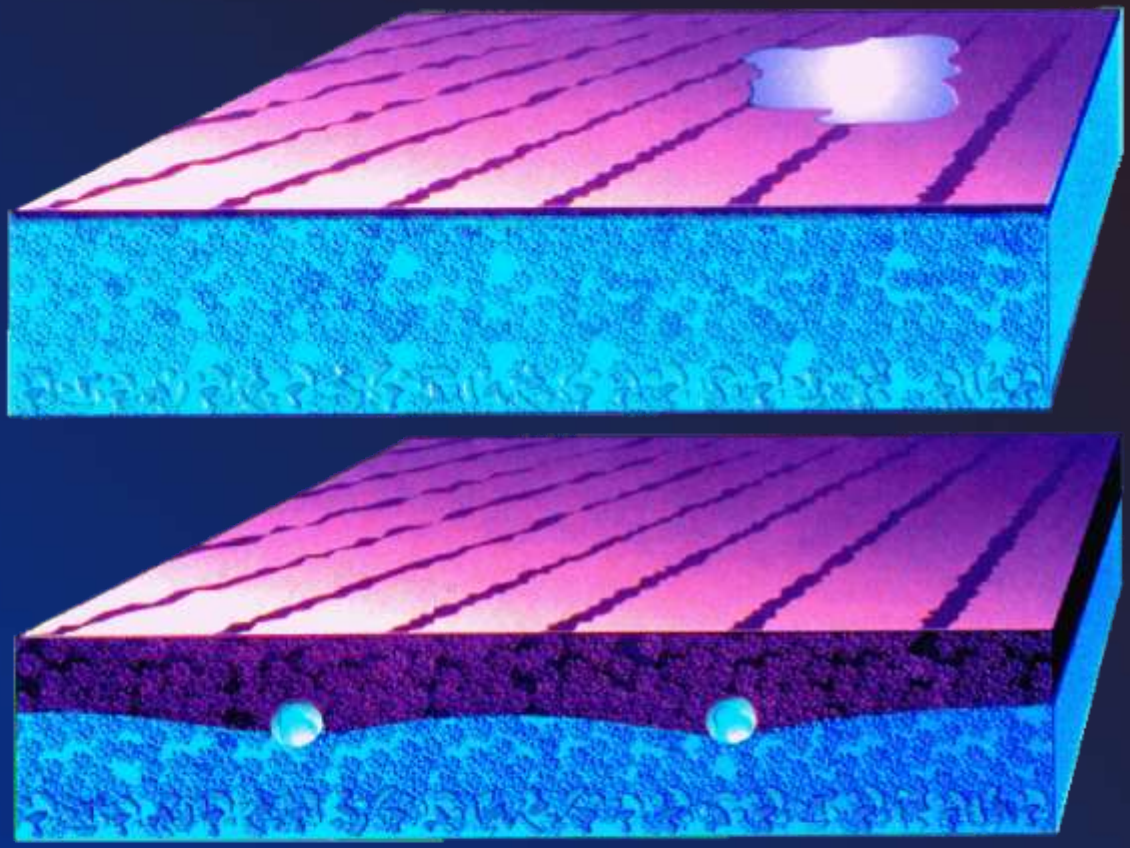
- 2002 IDNR Iowa landuse data
  - row crop converted to corn-soybean rotations
- USDA SSURGO soils (1:12,000 to 1:50,000)
- Standard runoff curve number (RCN) approach
  - alternative RCN approach f(ET) used in calibrations
- Penman-Monteith ET option (ESCO = 0.95)
- Subsurface tile drainage where appropriate
- Mainly used default parameters set by ArcSWAT


Des Moines
Lobe
Iowa
River
Boone
River
USGS gages
Major streams
Ecoregion boundaries

Locations of Hydric (Wet) Soils in Iowa



Effects of Tile Drainage on Soil Water



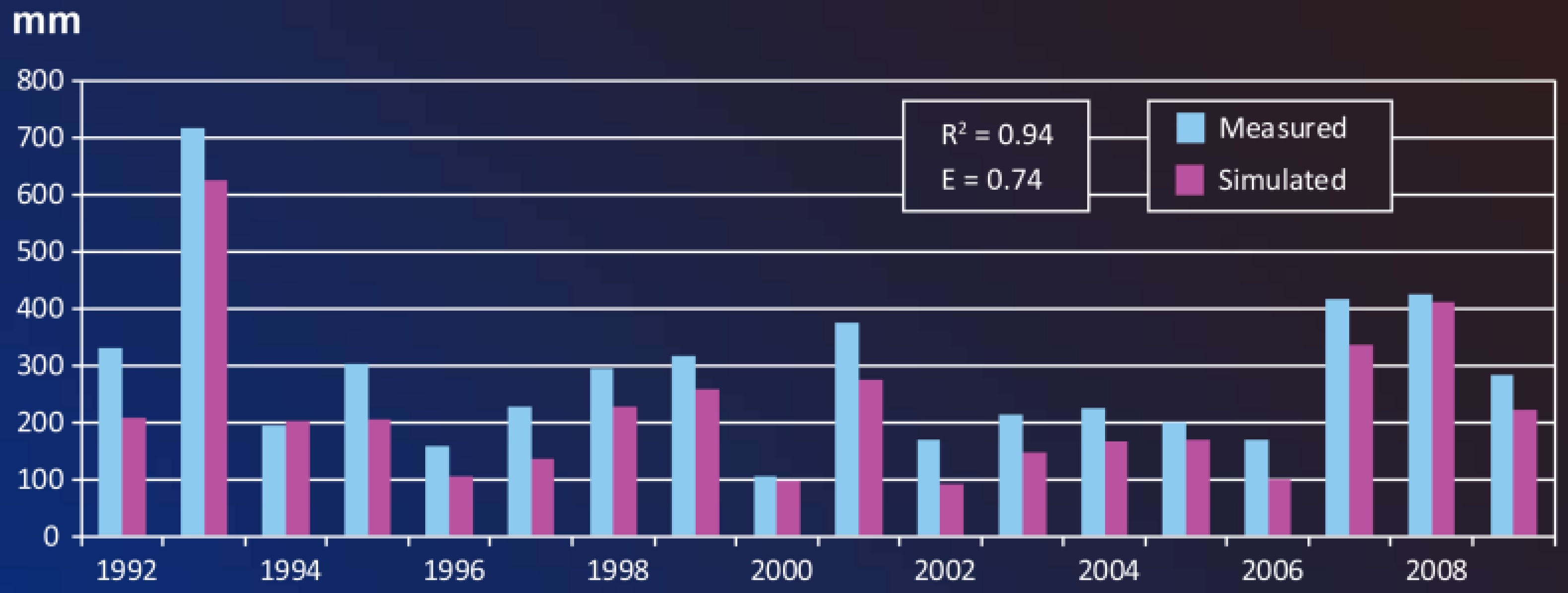
Adapted from: Zucker, L.A. and L.C. Brown (eds.). 1998. Agricultural Drainage: Water Quality Impacts and Subsurface Drainage Studies in the Midwest. Ohio State University Extension Bulletin 871. The Ohio State University.

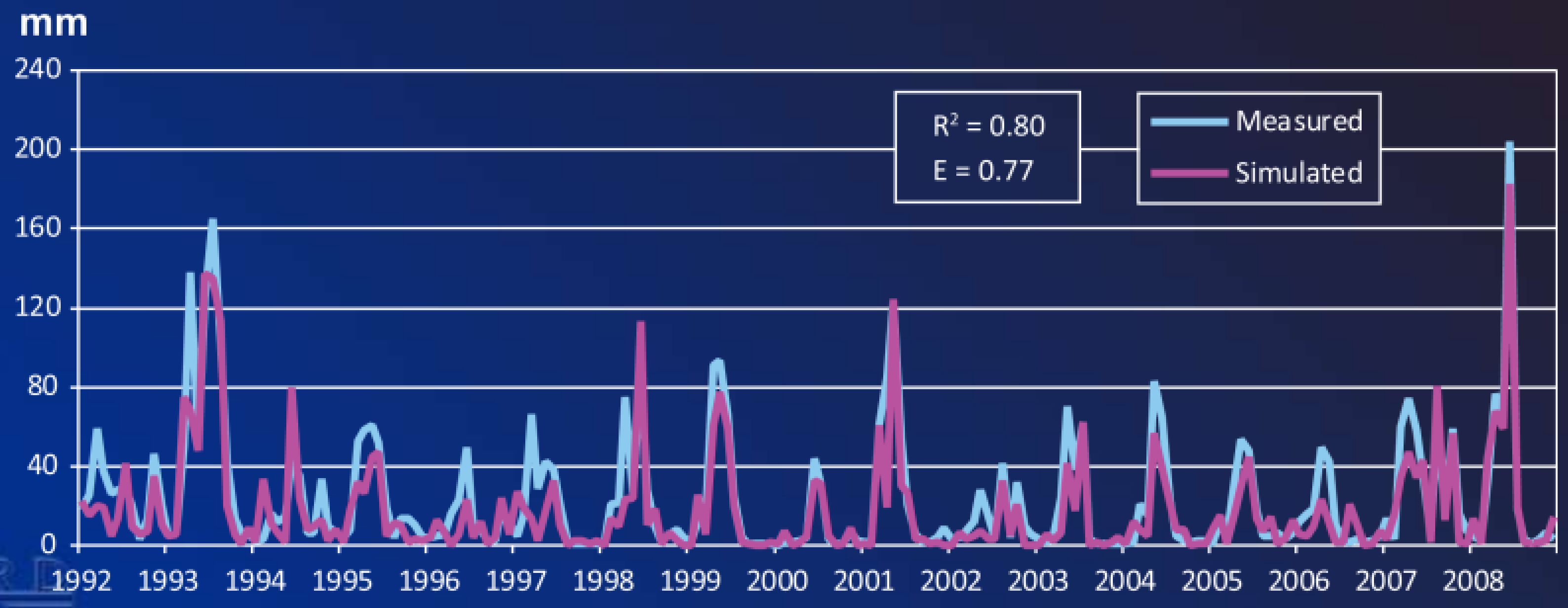
Boone and Iowa Characteristics

Watershed	Calib. or valid?	Area (km^2)	Sub-watersheds	Total HRUs	Tile drained (%)
Boone	Calibration	2170.8	28	1863	82.6
Iowa	Validation	1085.4	11	817	64.2

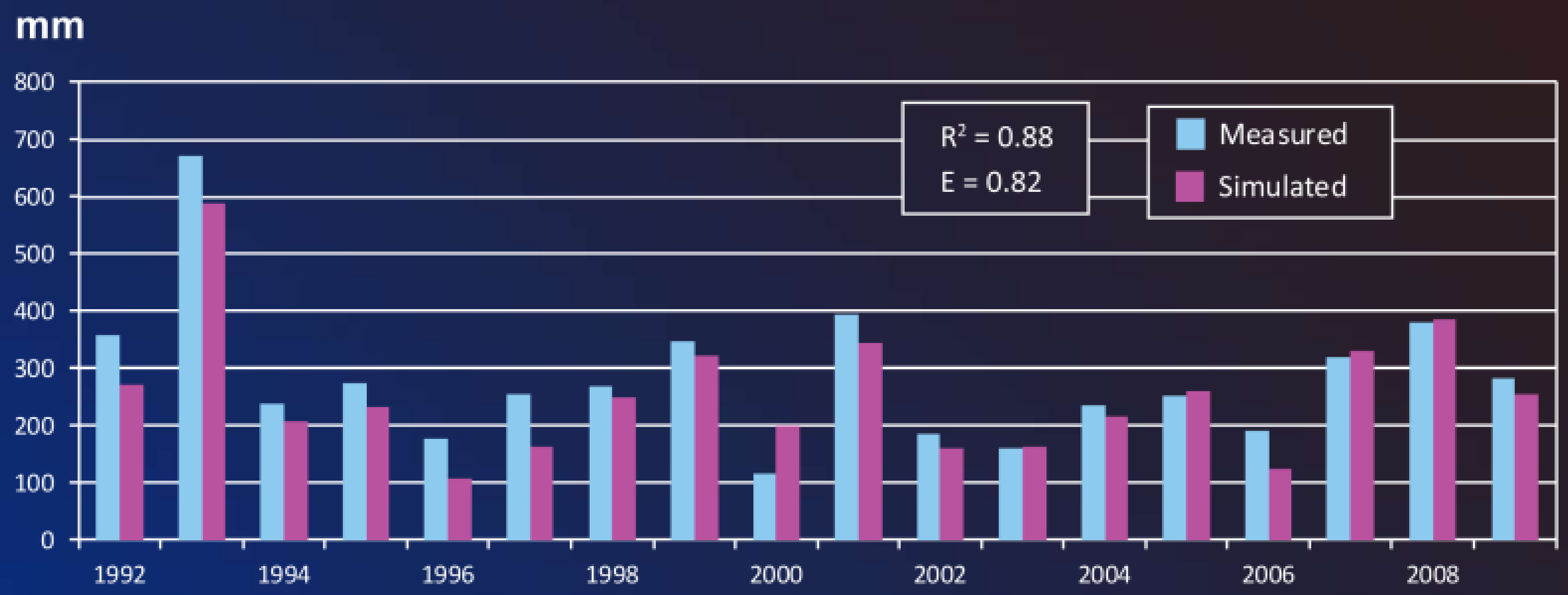
Watershed	Row crop (%)	Grass / pasture (%)	Slope (0-2 %)	Slope (2-5 %)	Slope (5-9%)
Boone	88.7	11	88	12	0.5
Iowa	86.2	13.8	73	23.7	2.9

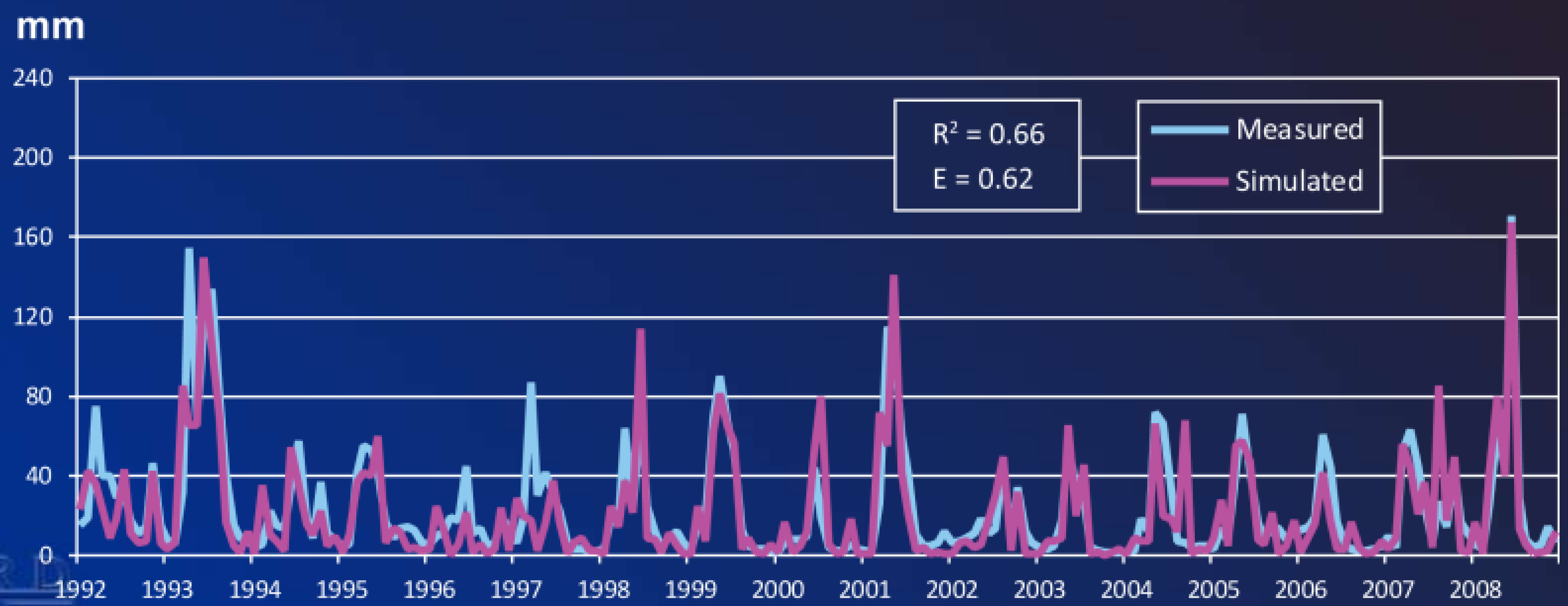
Boone River SWAT Simulation (uncalibrated)





Iowa River SWAT Simulation (non-validated)





Boone and Iowa Initial Hydrologic Balance Results

Watershed	Baseflow partition estimate	SWAT baseflow percentage	SWAT streamflow (mm)	Measured streamflow	SWAT ET Estimate (% of rainfall)
Boone	0.64	0.21	218.1	281.2	74
Iowa	0.69	0.18	254.4	283.9	70

Runoff Curve Number (RCN) Eq.

$$Q = \frac{(P - 0 \cdot 2S)^2}{(P + 0 \cdot 8S)}$$

$$S = \frac{1000}{CN} - 10$$

Alternative Retention Parameter (S) Calculations

Standard

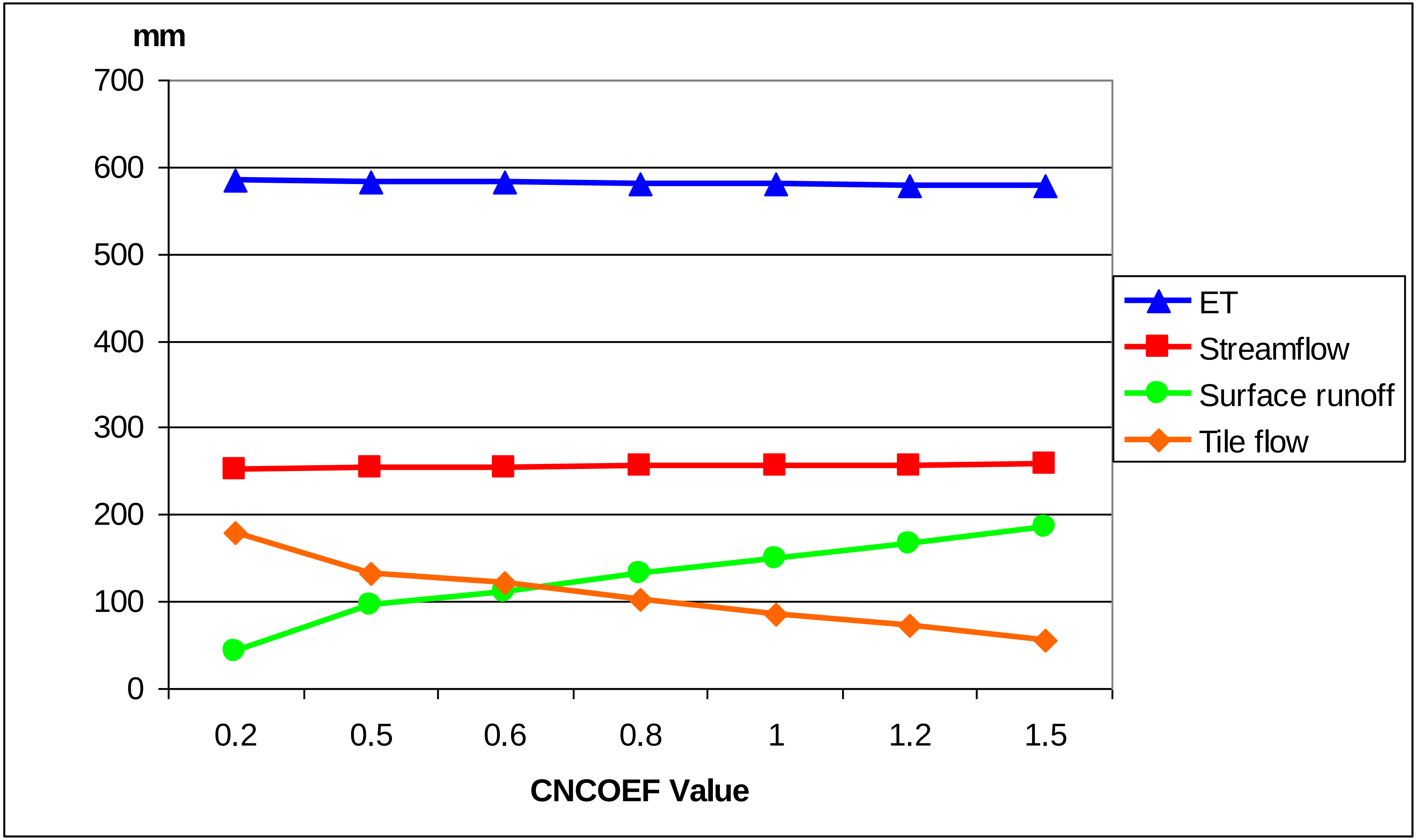
$$S = S_{\max} \cdot \left(1 - \frac{SW}{\left[SW + \exp\left(w_1 - w_2 \cdot SW \right) \right]} \right)$$

Alternative

$$S = S_{prev} + E_o * \exp\left(\frac{-CNCOEF - S_{prev}}{S_{\max}} \right) - R_{day} - Q_{surf}$$

Kannan et al. 2008. Development of a continuous soil moisture accounting procedure for curve number methodology and its behavior with different evapotranspiration method. *Hydrological Processes*. 22(13): 2114-2121.

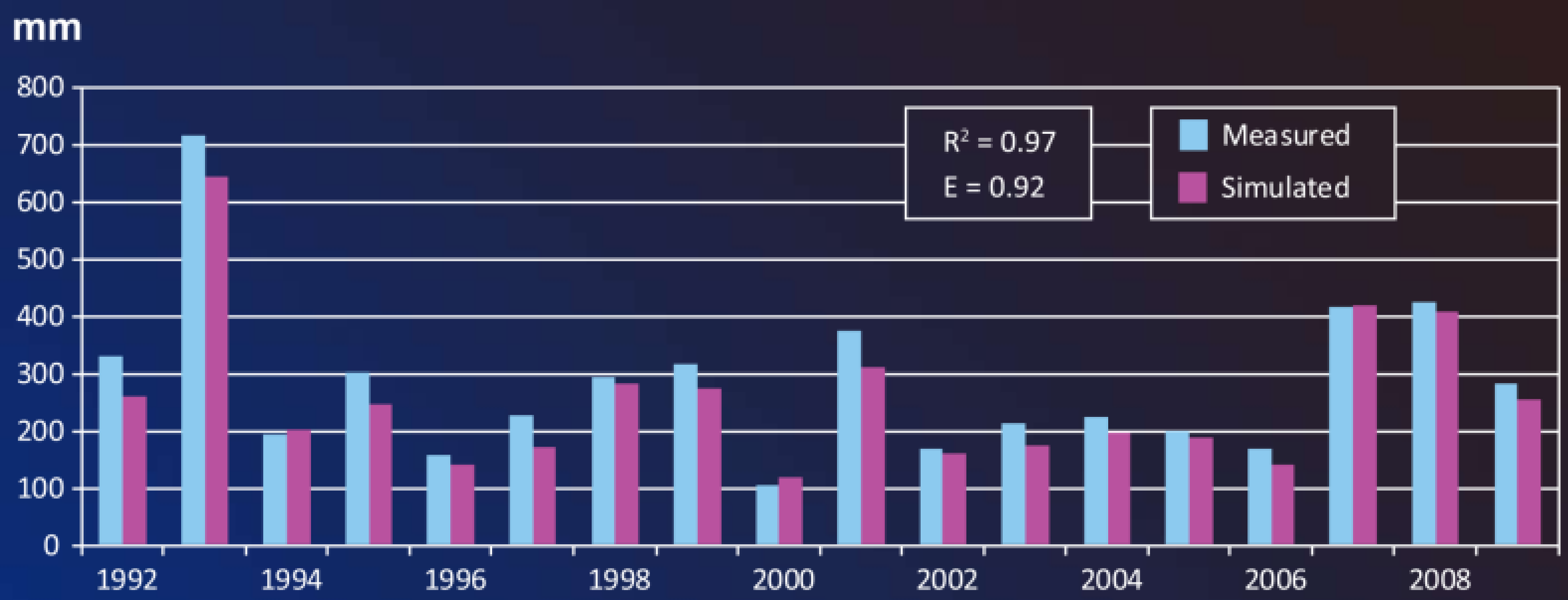
Effects of Varying CNCOEF on Water Balance Components

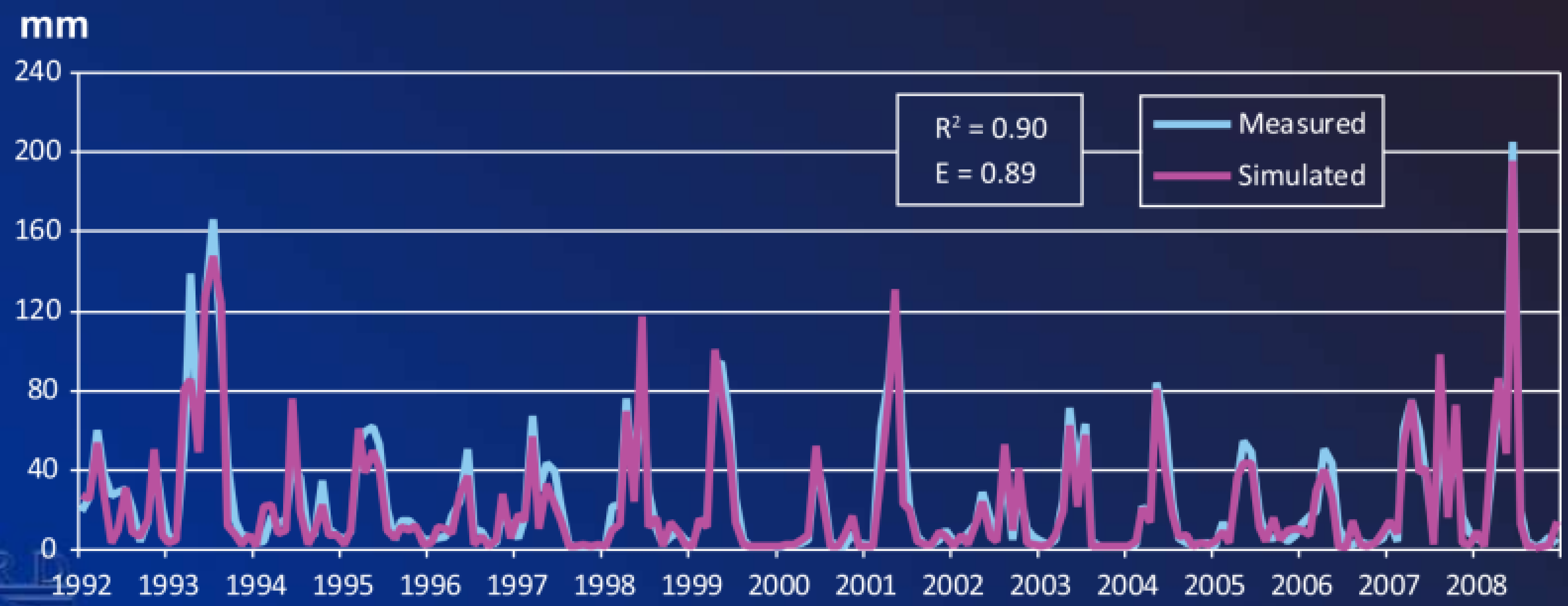


Boone Calibration Steps

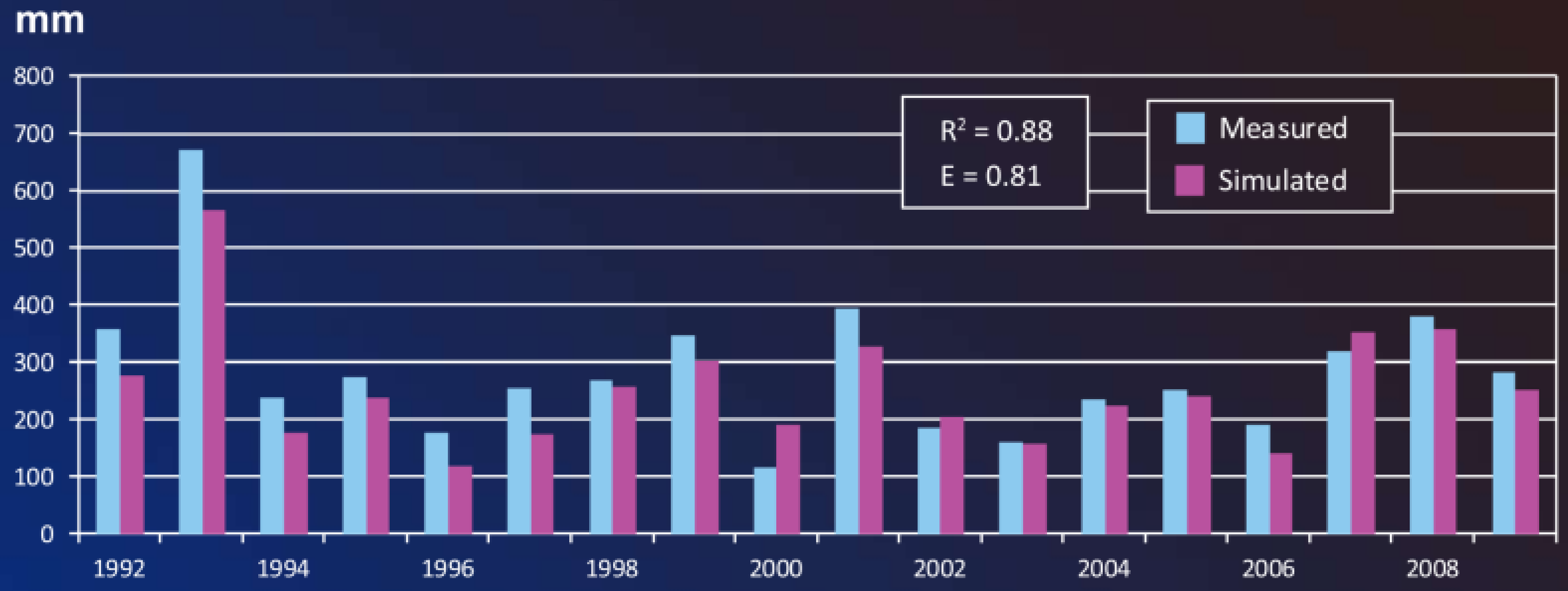
- Reduced CNs by 10%;
- Switched to alternative ET-based RCN method
  - CN COEFF = 0.5
- Hargreaves ET method (ESCO = 1.0)
- Adjusted subsurface tile drainage and groundwater related parameters
  - very minor effects

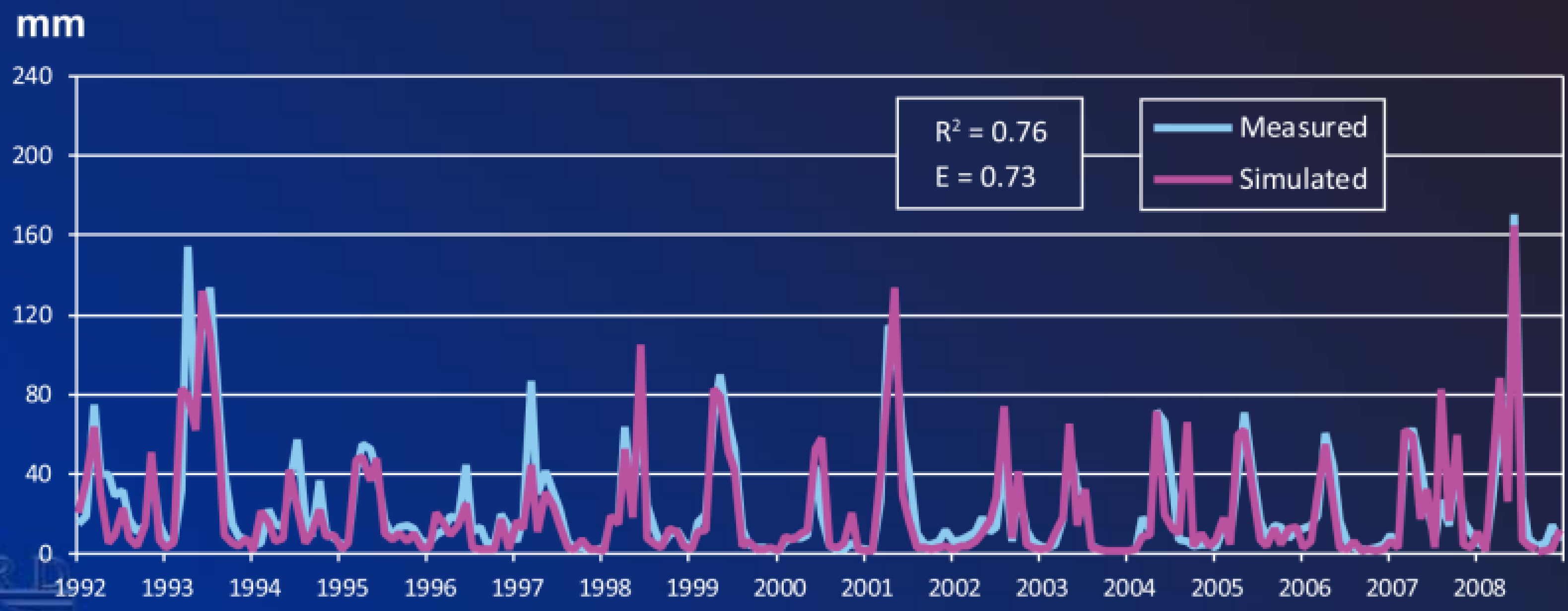
Boone River SWAT Simulation (calibrated)





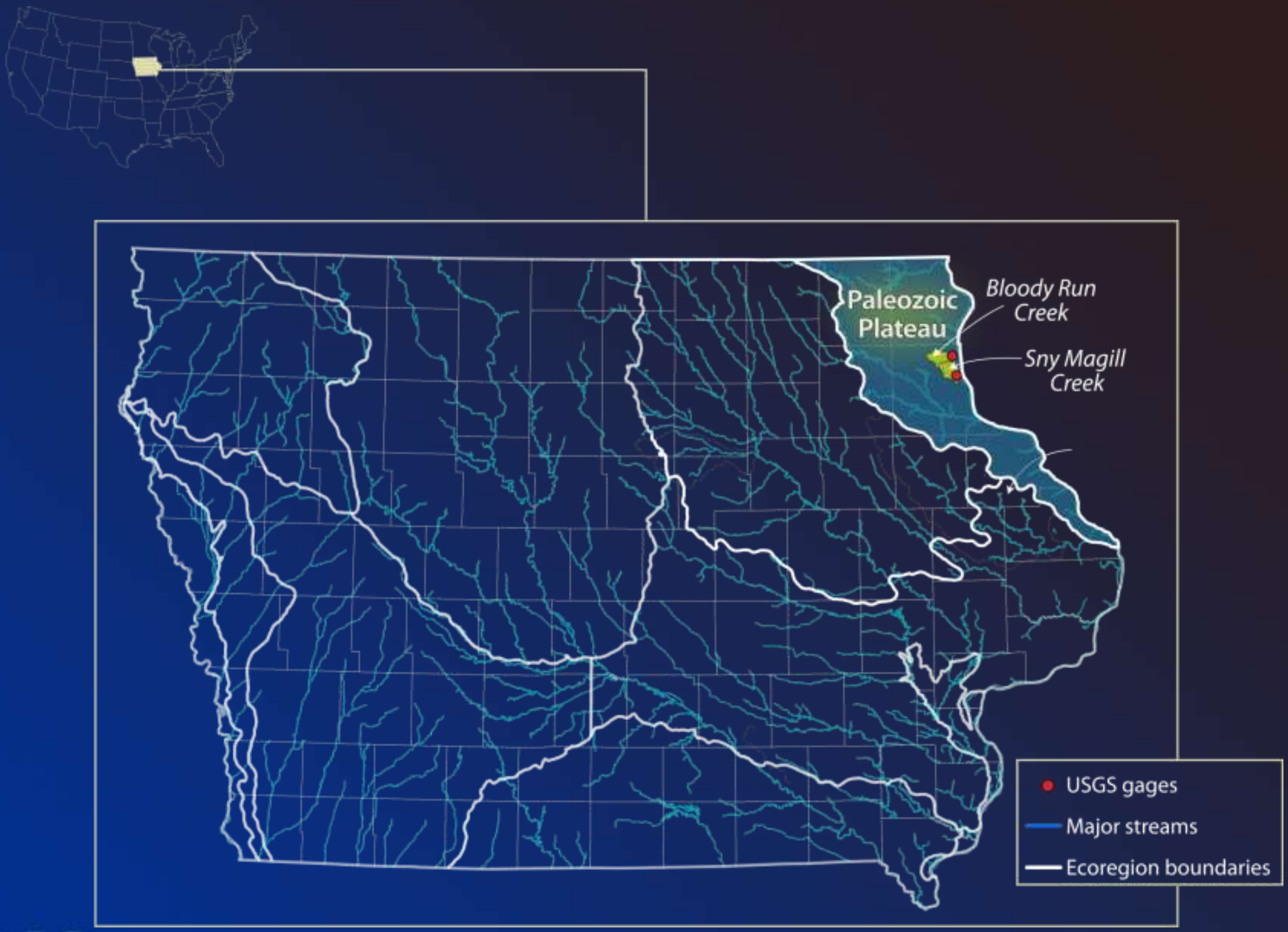
Iowa River SWAT Simulation (validated)





Boone and Iowa Calibration and Validation Hydrologic Balance Results

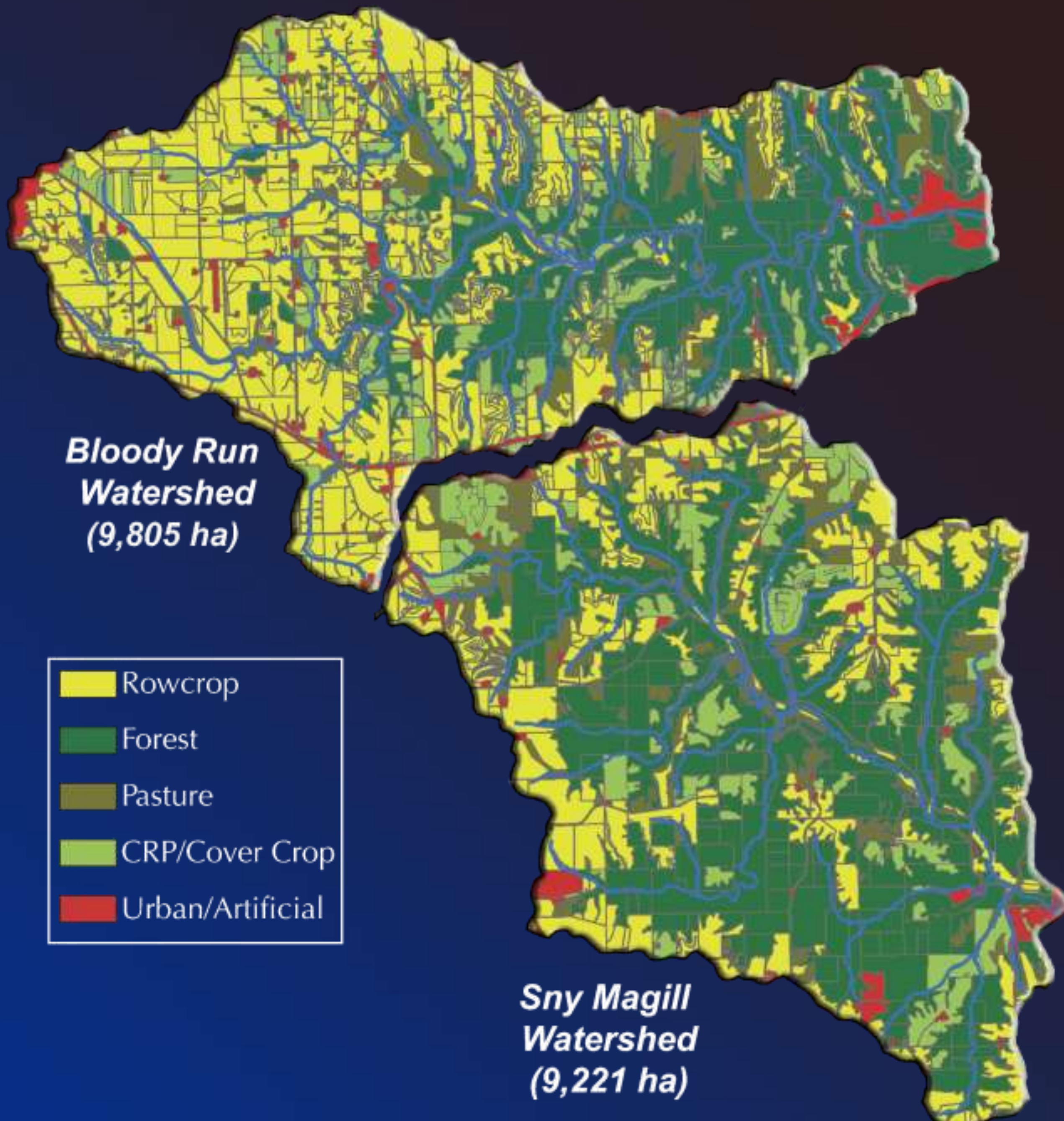
Watershed	Baseflow partition estimate	SWAT baseflow percentage	SWAT streamflow (mm)	Measured streamflow	SWAT ET Estimate (% of rainfall)
Boone	0.64	0.65	252.5	281.2	0.67
Iowa	0.69	0.57	253.5	283.9	0.65


Paleozoic Plateau
Bloody Run Creek
Sny Magill Creek
USGS gages
Major streams
Ecoregion boundaries

Bloody Run and Sny Magill

- Karst features (caves, sinkholes, and springs)
- Coldwater streams that support put-and-take trout fishing
- Steep slopes and considerable non row crop land
  - considerable relief between upland areas and outlets at the Mississippi River
- Extensive installation of terraces and other erosion control practices have occurred

2005 Land Use



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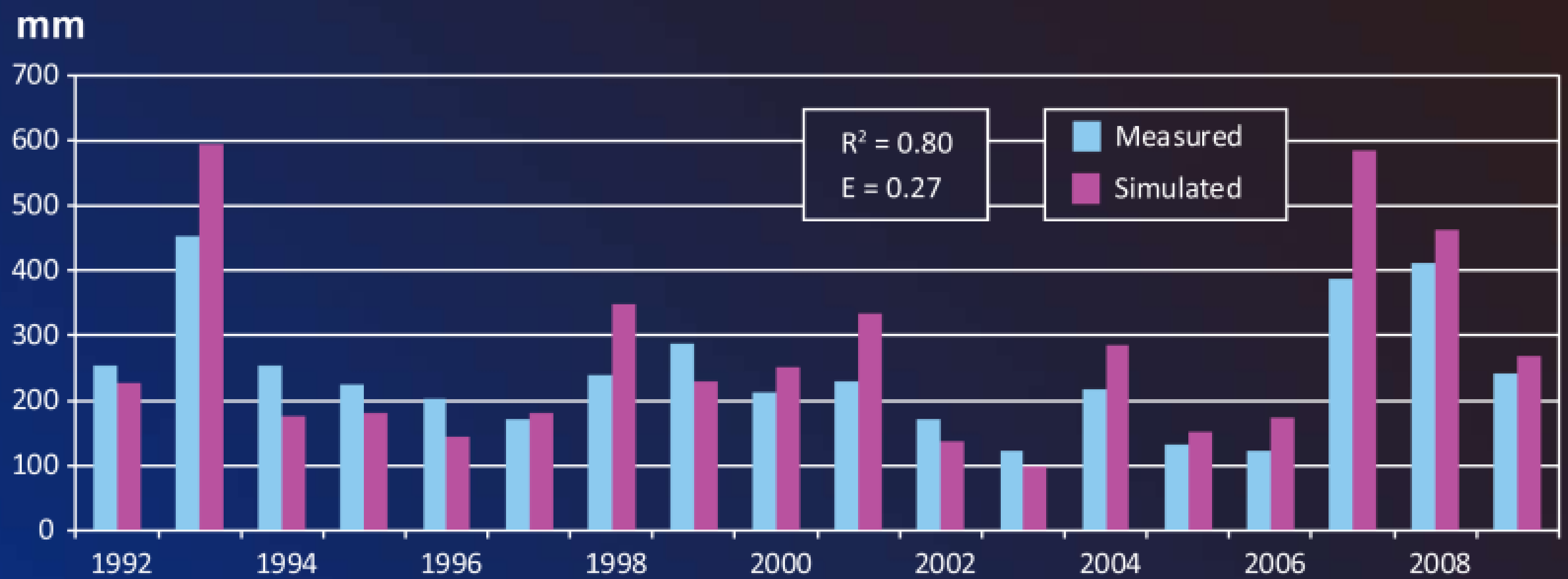
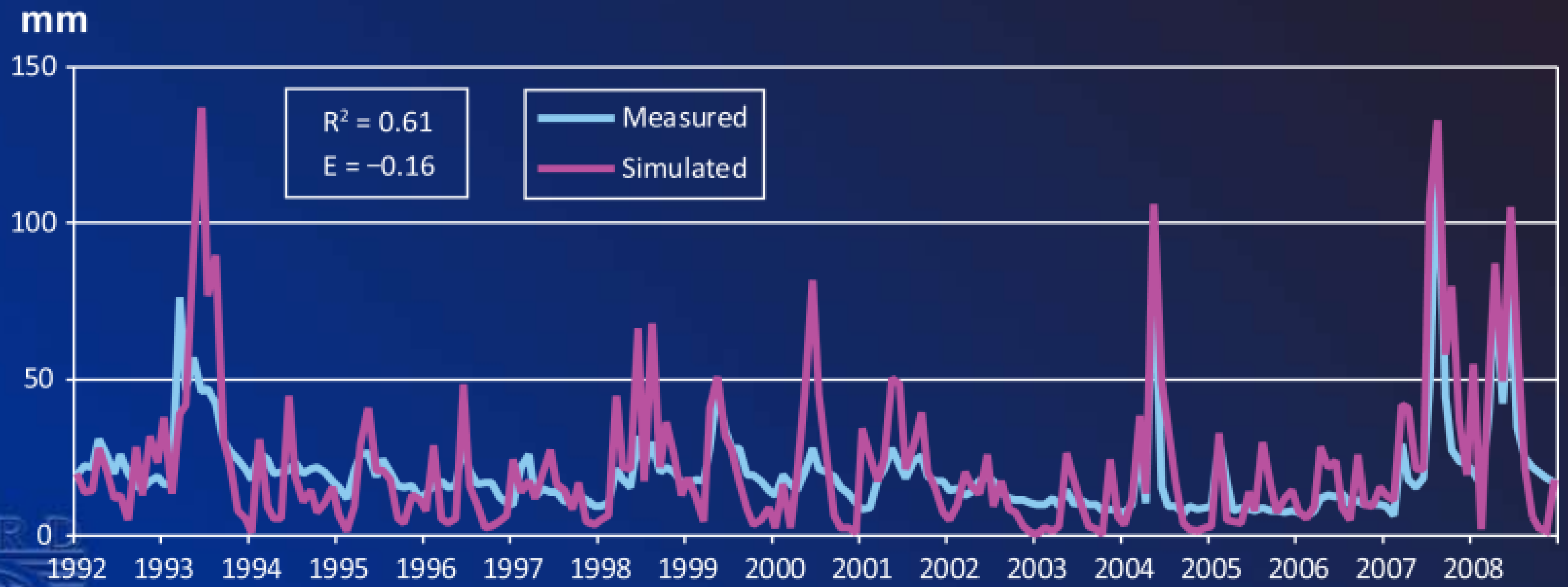
Bloody Run and Sny Magill Characteristics

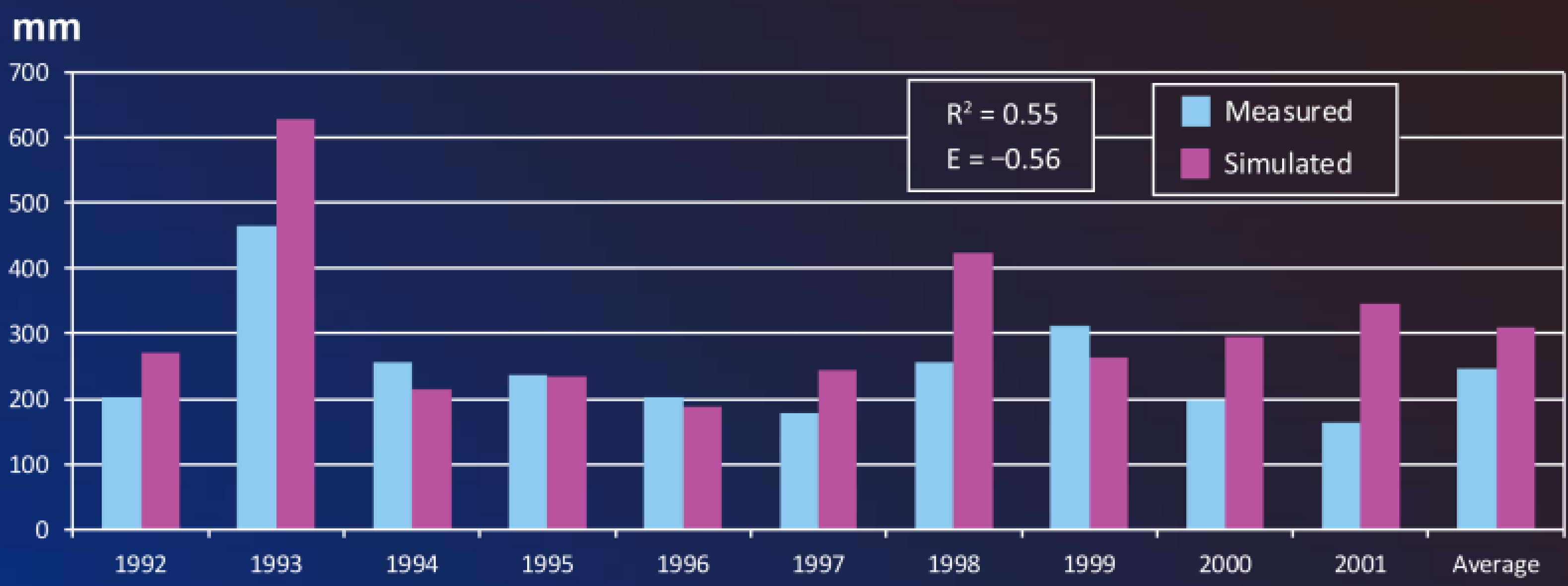
Waterhed	Calib. or valid?	Area (km^2)	Sub-watersheds	Total HRUs	Tile drained (%)	
Bloody Run	Calibration	87.2	16	1107	0	
Sny Magill	Validation	74.3	12	868	0	
Watershed	**Row crop (%)**	**Forest (%)**	**Grass / pasture (%)**	**Slope (5-9%)**	**Slope (9-14%)**	**Slope (>14%)**
Bloody Run	45.2	23.5	7.9	33.8	16.9	21.3
Sny Magill	21.3	44.8	11.4	25.1	26.4	33.8

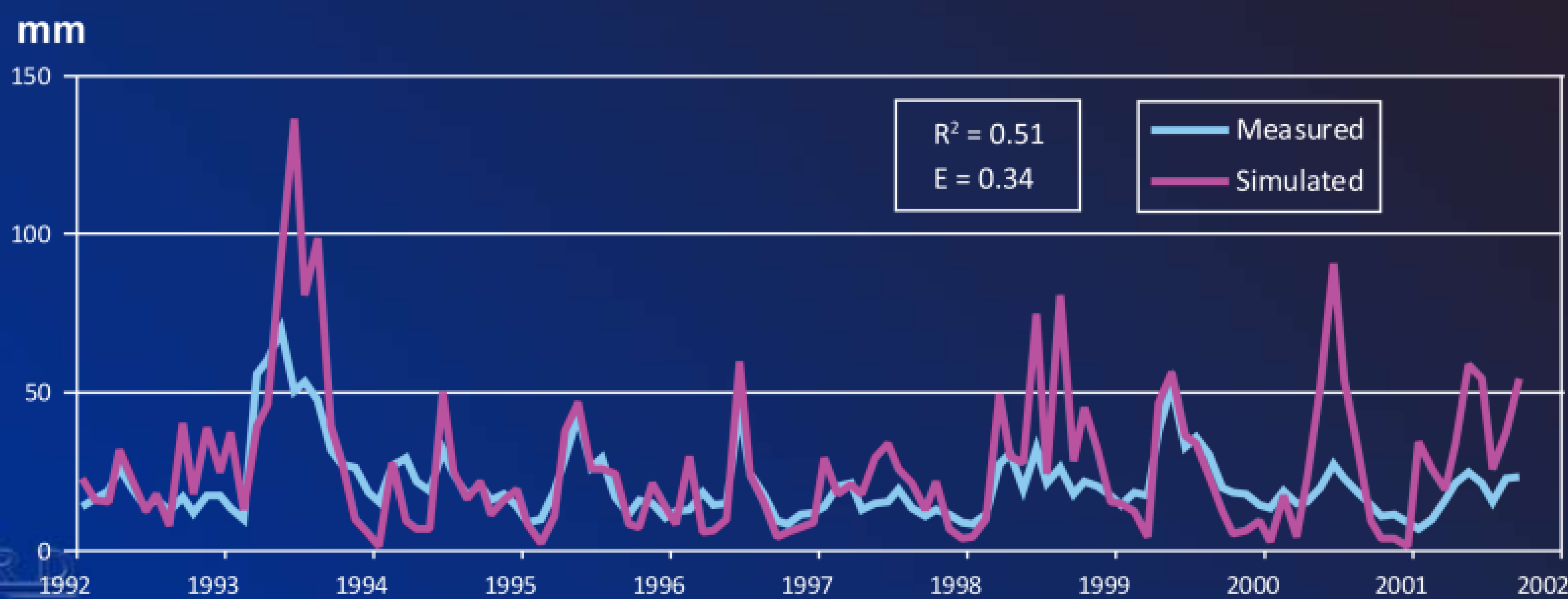
Bloody Run Creek SWAT Simulation (uncalibrated)





Sny Magill Creek SWAT Simulation (unvalidated)





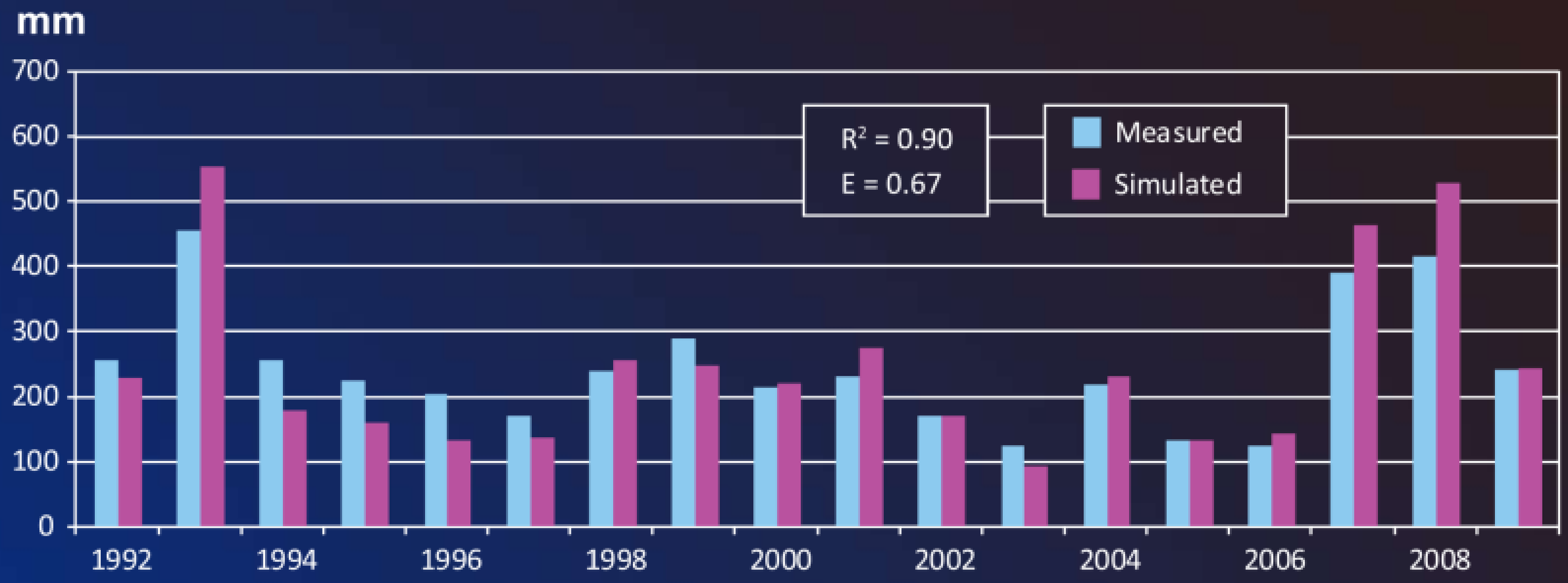
Bloody Run and Sny Magill Initial Hydrologic Balance Results

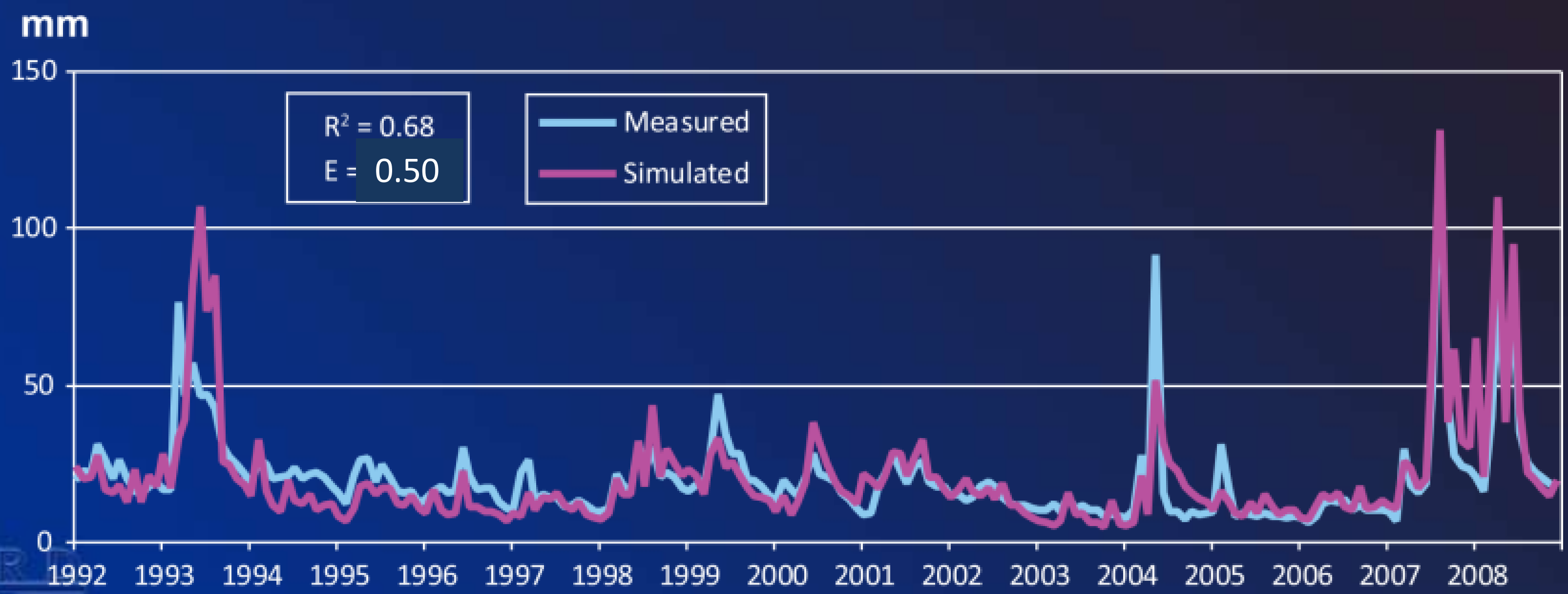
Watershed	Baseflow partition estimate	SWAT baseflow percentage	SWAT streamflow (mm)	Measured streamflow	SWAT ET Estimate (% of rainfall)
Bloody Run	0.84	0.57	268.2	240.9	68
Sny Magill	0.84	0.70	310.7	247.2	62

Bloody Run Calibration Steps

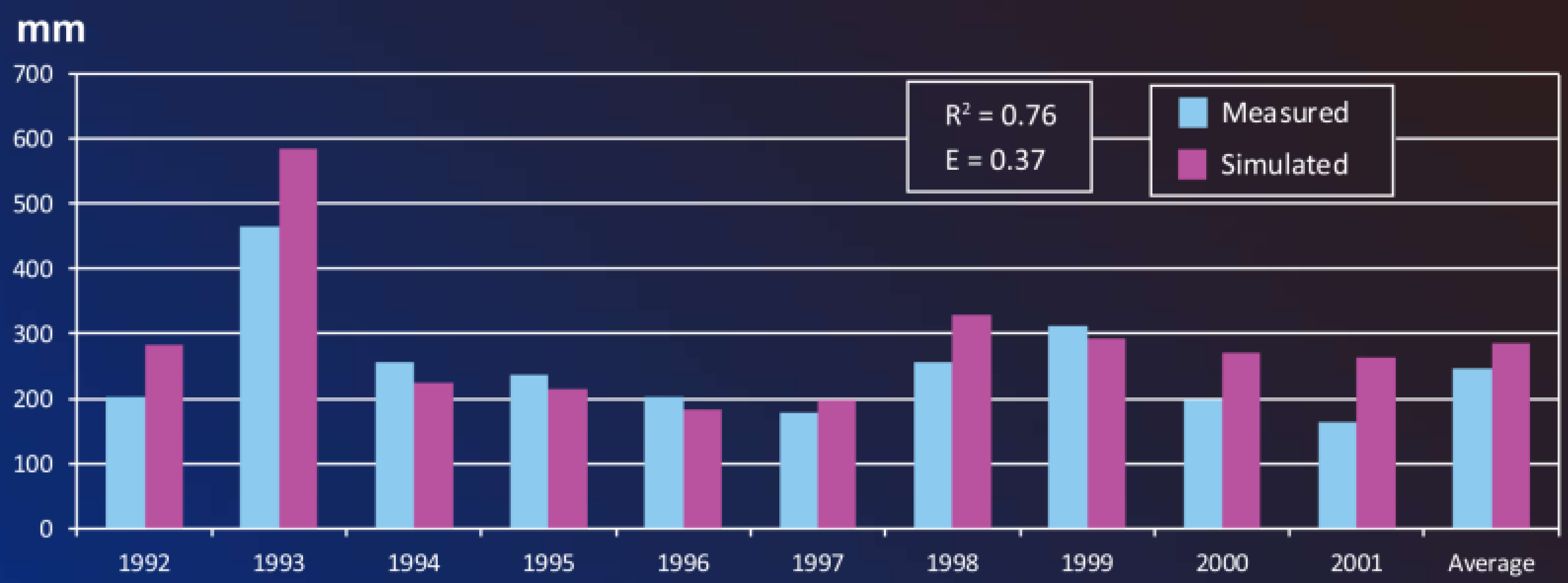
- Reduced CNs by 10%;
- Switched to alternative ET-based RCN method - CN COEFF = 0.4
- Penman-Monteith ET method (ESCO = 0.92)
- Changed GW Delay value from 30 to 200 days
  - major impacts
- Other minor adjustments of groundwater parameters

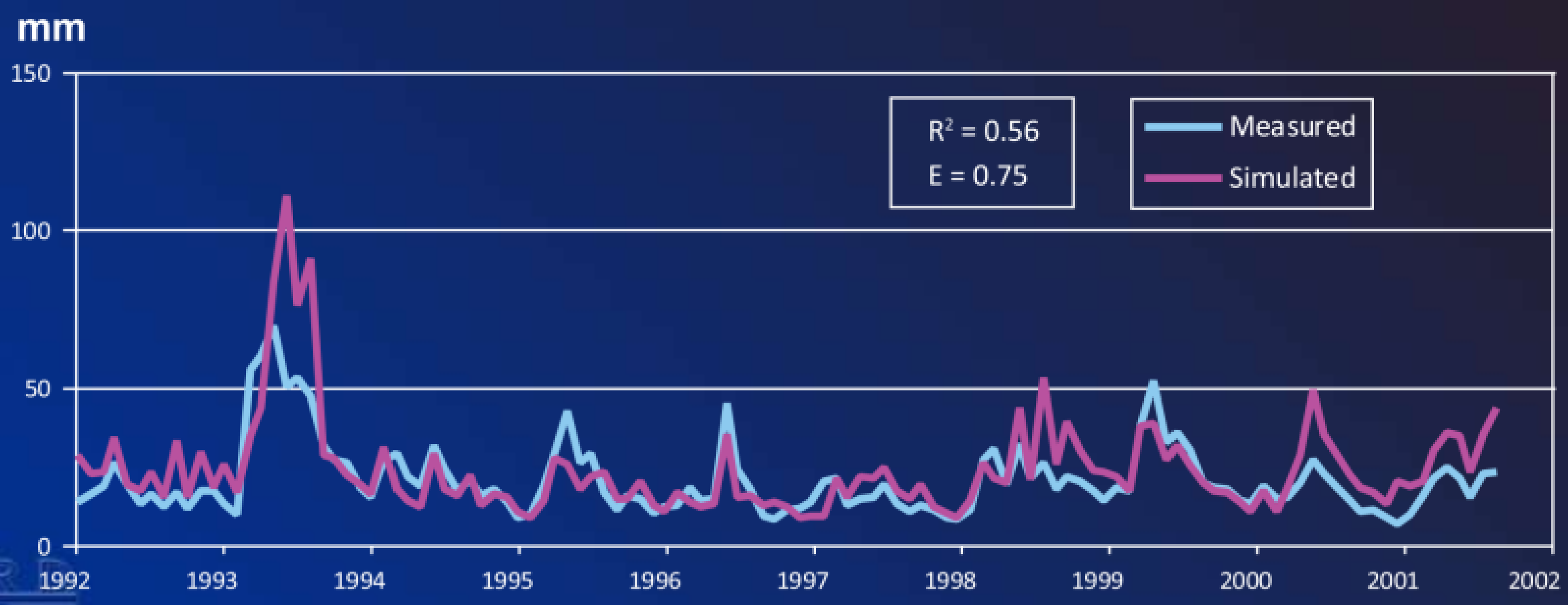
Bloody Run Creek SWAT Simulation (calibrated)





Sny Magill Creek SWAT Simulation (validated)





Bloody Run and Sny Magill Calibration and Validation Hydrologic Balance Results

Watershed	Baseflow partition estimate	SWAT baseflow percentage	SWAT streamflow (mm)	Measured streamflow	SWAT ET Estimate (% of rainfall)
Bloody Run	0.84	0.81	243.3	240.9	0.71
Sny Magill	0.84	0.92	284.9	247.1	0.65

Conclusions

- Approach of using “paired watersheds” in landform regions appears viable for developing landform region specific parameters
- Distinct and important parameter values become clear for each region

  - although less clear for some regions
- Autocalibration could improve the results
- Have encountered problems with ET- based CN approach in SWAT2009; working with Jeff to fix this (code problem or input data problem?)