Watershed-scale hydrologic simulation of geographically isolated wetlands

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Background:

- GIWs defined: depressional wetlands surrounded by uplands (Tiner 2003)

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- Need to quantify watershed-scale aggregate hydrologic effects

Introduction to the SWAT model

- Soil and Water Assessment Tool (SWAT)

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  - http://swat.tamu.edu/
- Free ArcGIS and QGIS graphical user interfaces:
  - ArcSWAT and QSWAT
- Data inputs: DEM, land use, soils, weather observations

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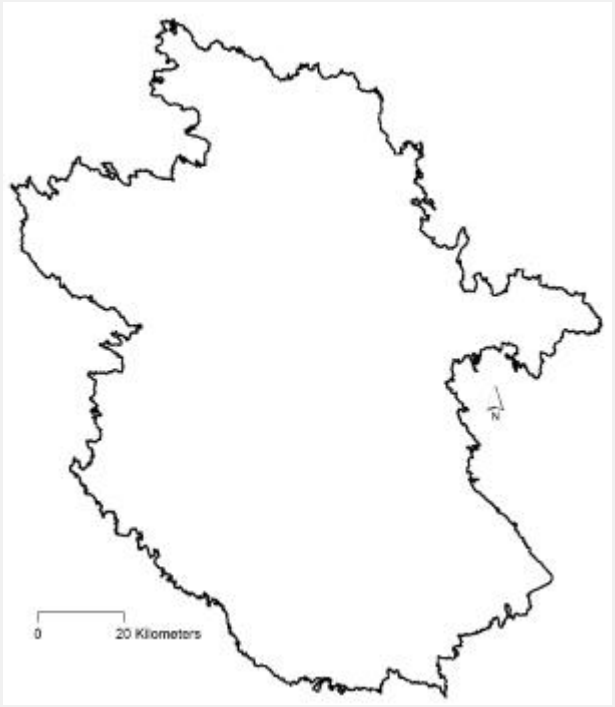
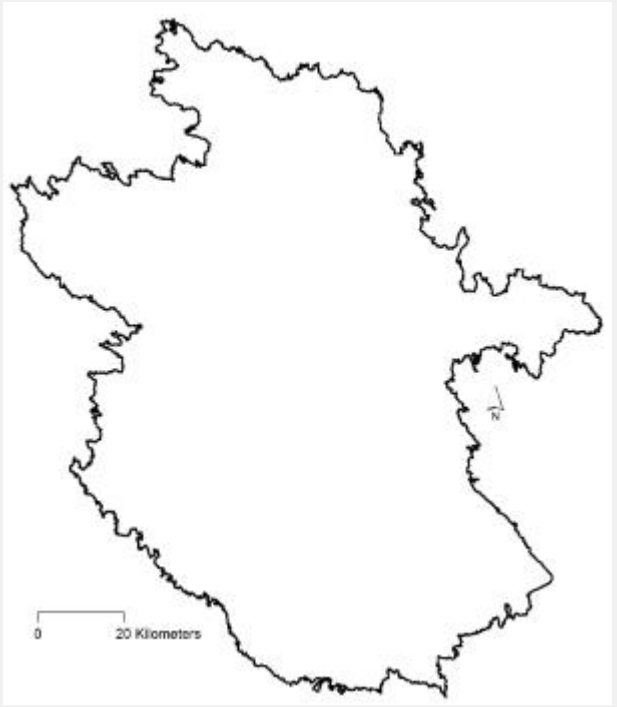
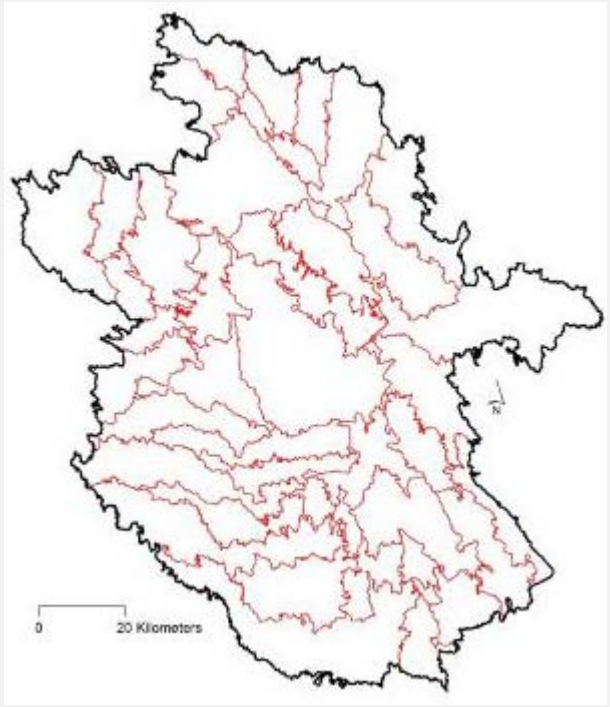
SWAT’s spatial hierarchy



Basin

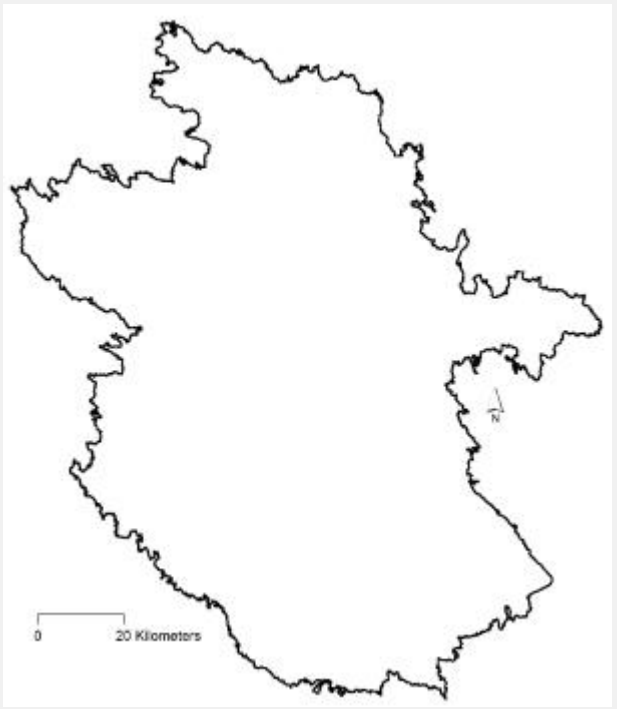
SWAT's spatial hierarchy

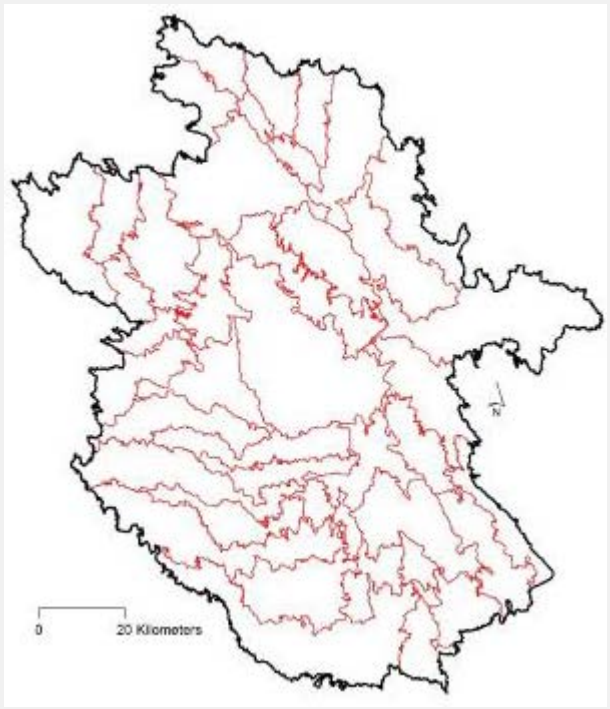


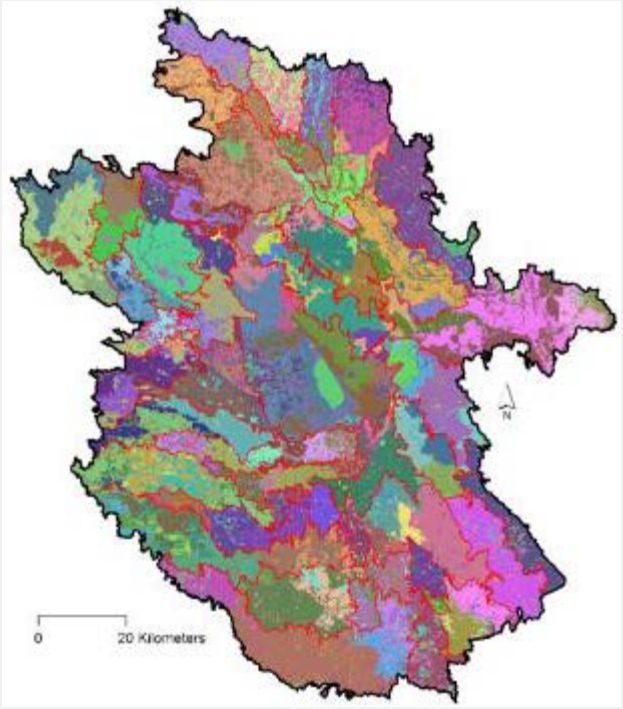


Basin > Subbasins

SWAT's spatial hierarchy

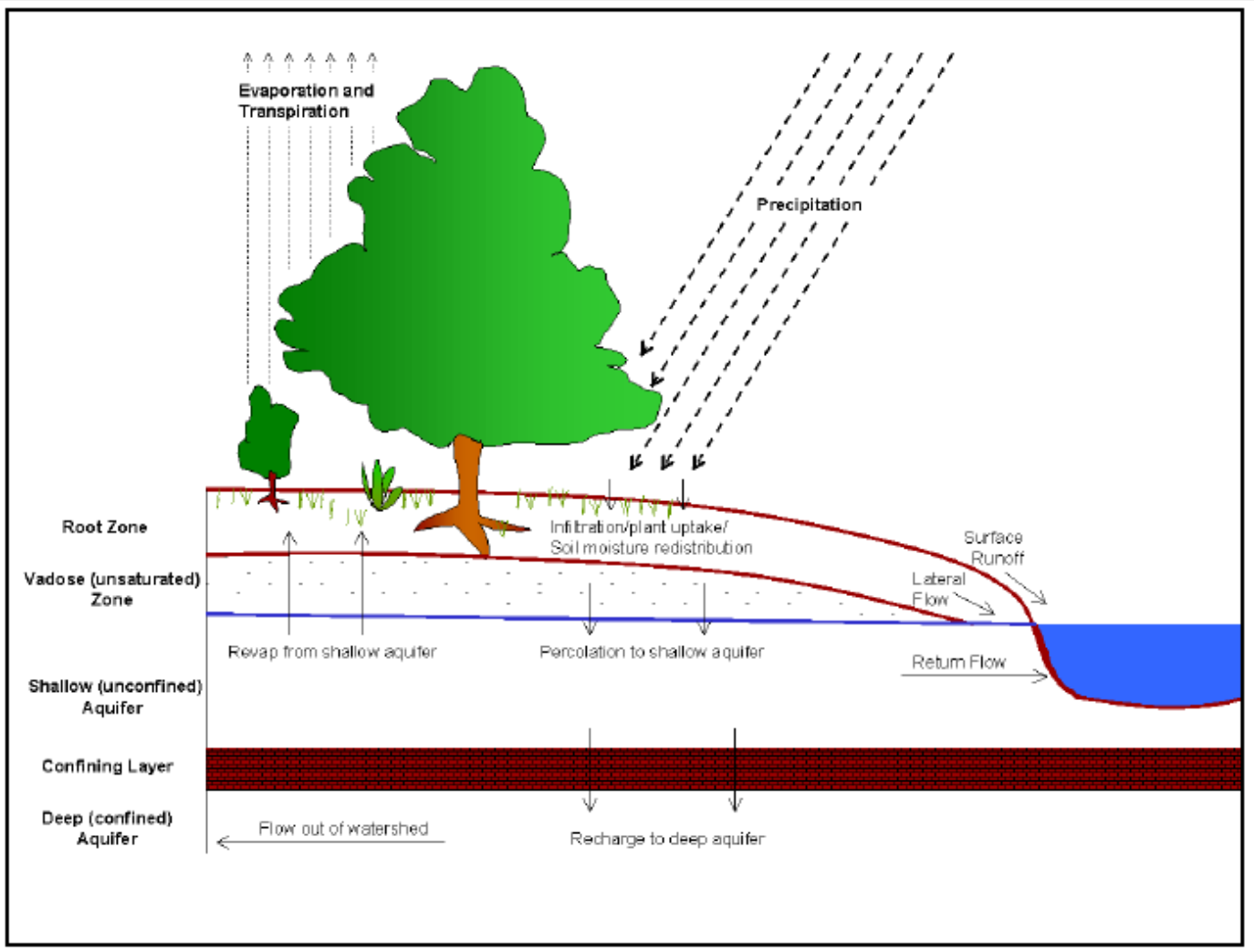






Basin > Subbasins > Hydrologic response units (HRUs)

Inside a hydrologic response unit (HRU):



Neitsch et al. (2011) (SWAT Theoretical Documentation)

GIW Identification and Volume Estimation

Lane and D'Amico 2016 (*JAWRA*)

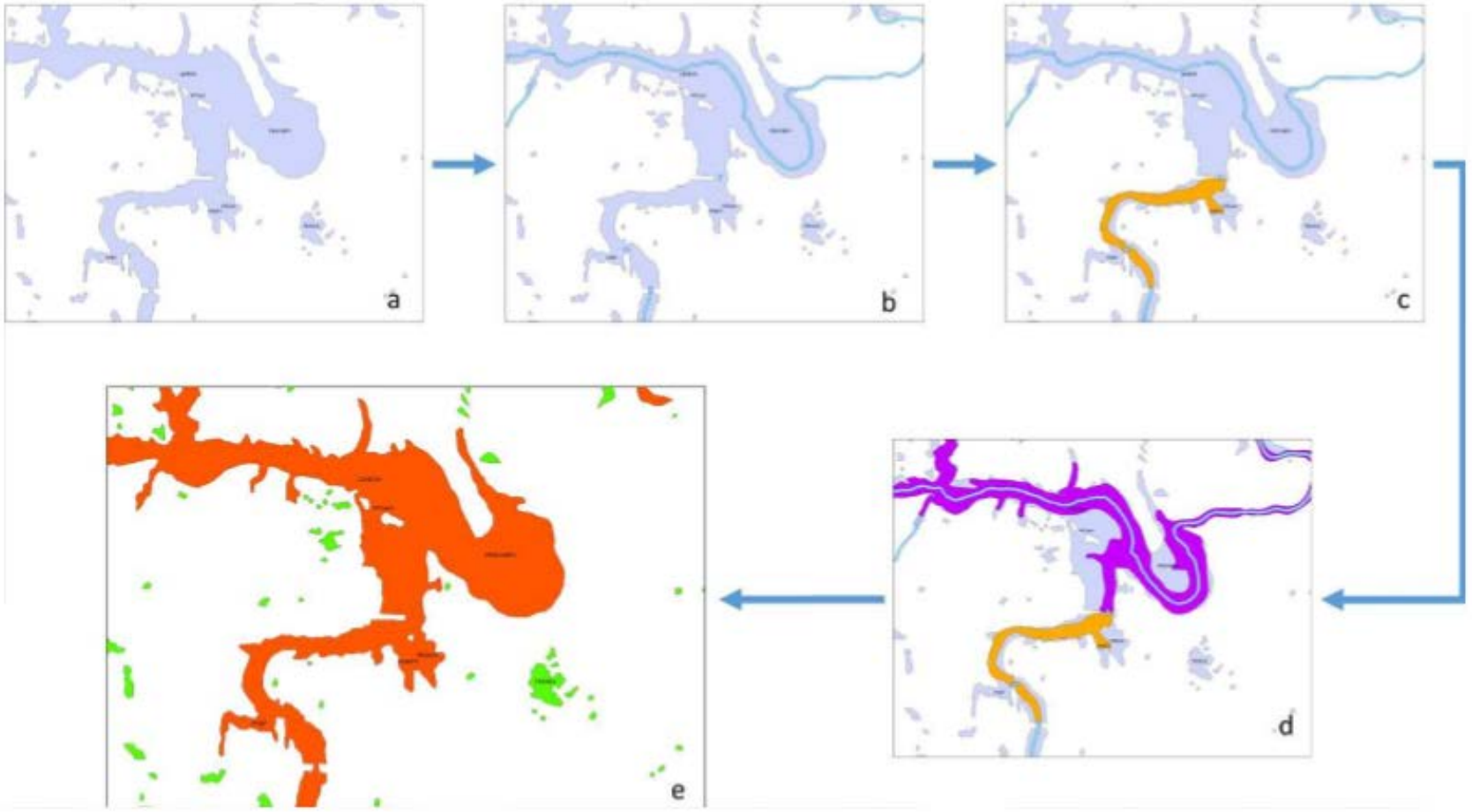


FIGURE 2. Example of the Buffering Process Used to Identify Putative Geographically Isolated Wetlands (GIWs): (a) Aggregated National Wetlands Inventory Polygons, (b) 10-m Buffering of National Hydrography Dataset (NHD) Flowline, (c) 10-m Buffering of NHD Area, (d) 10-m Buffering of NHD Waterbody, (e) Example Output (Green Polygons — putative GIWs; Red Polygons — not GIWs).

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Lane and D’Amico 2010 (*Wetlands*)

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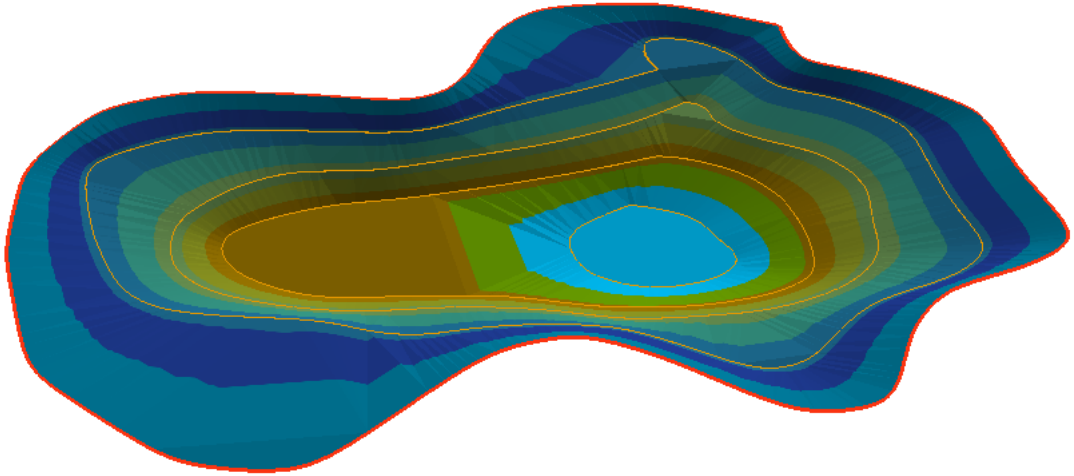

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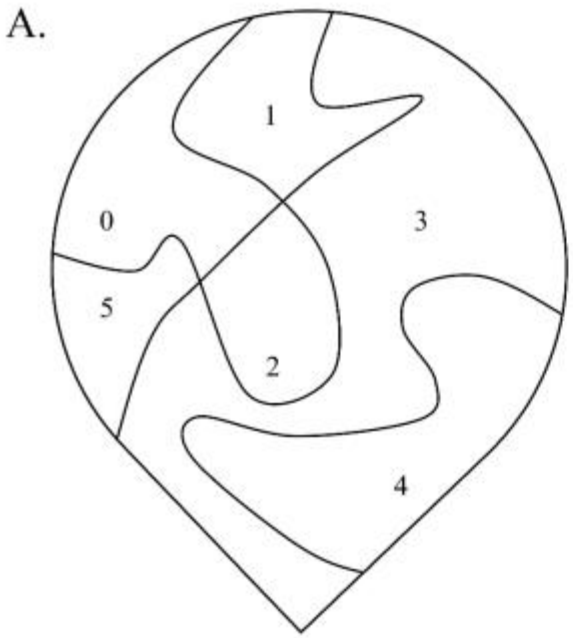
SWAT with GIW HRUs and fill-spill hydrology



Evenson et al. 2016 (*Hydrological Processes*)

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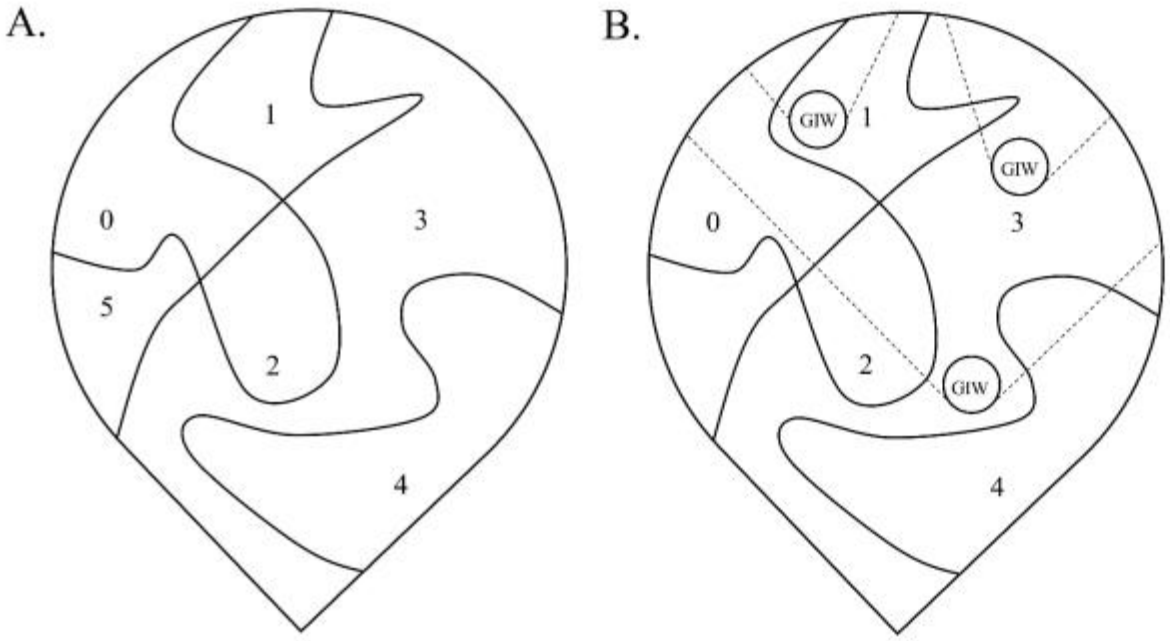

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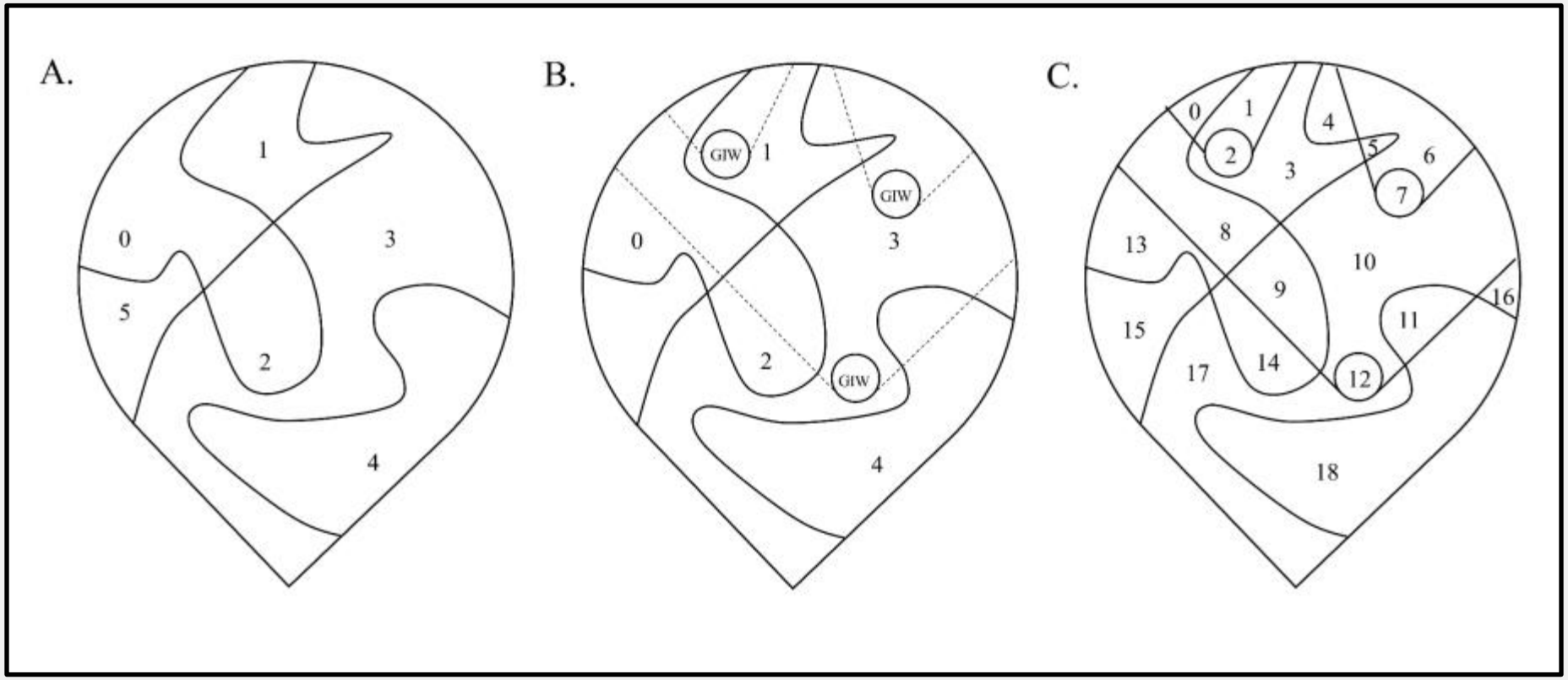

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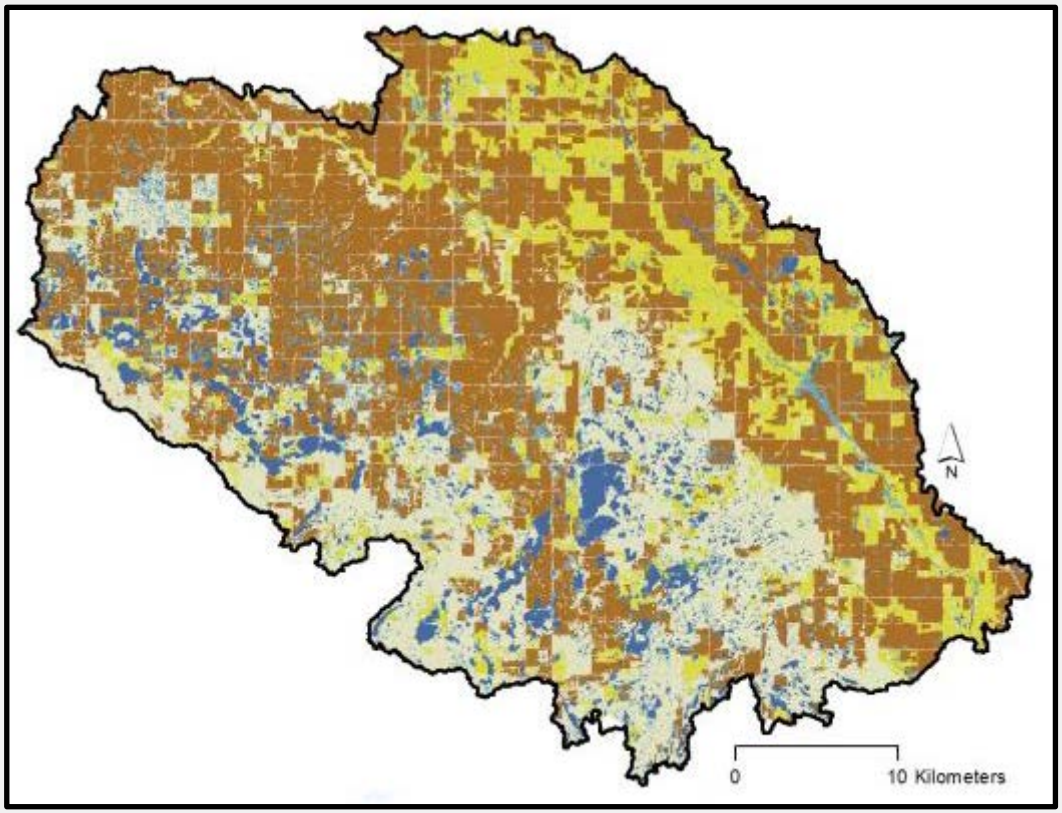
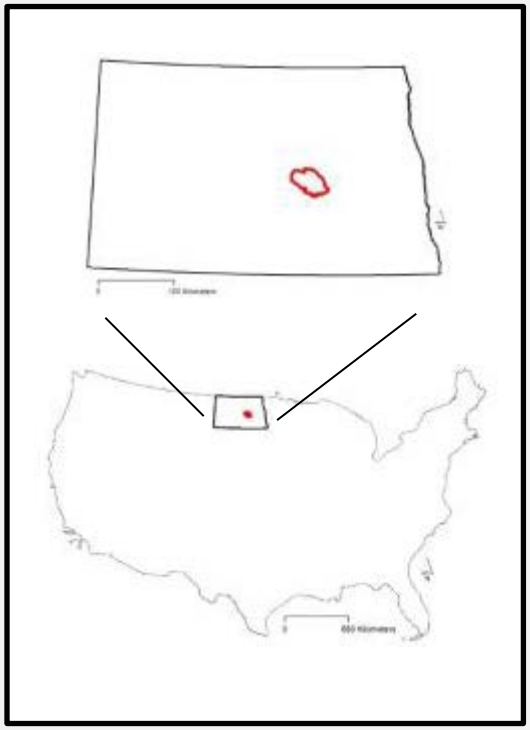
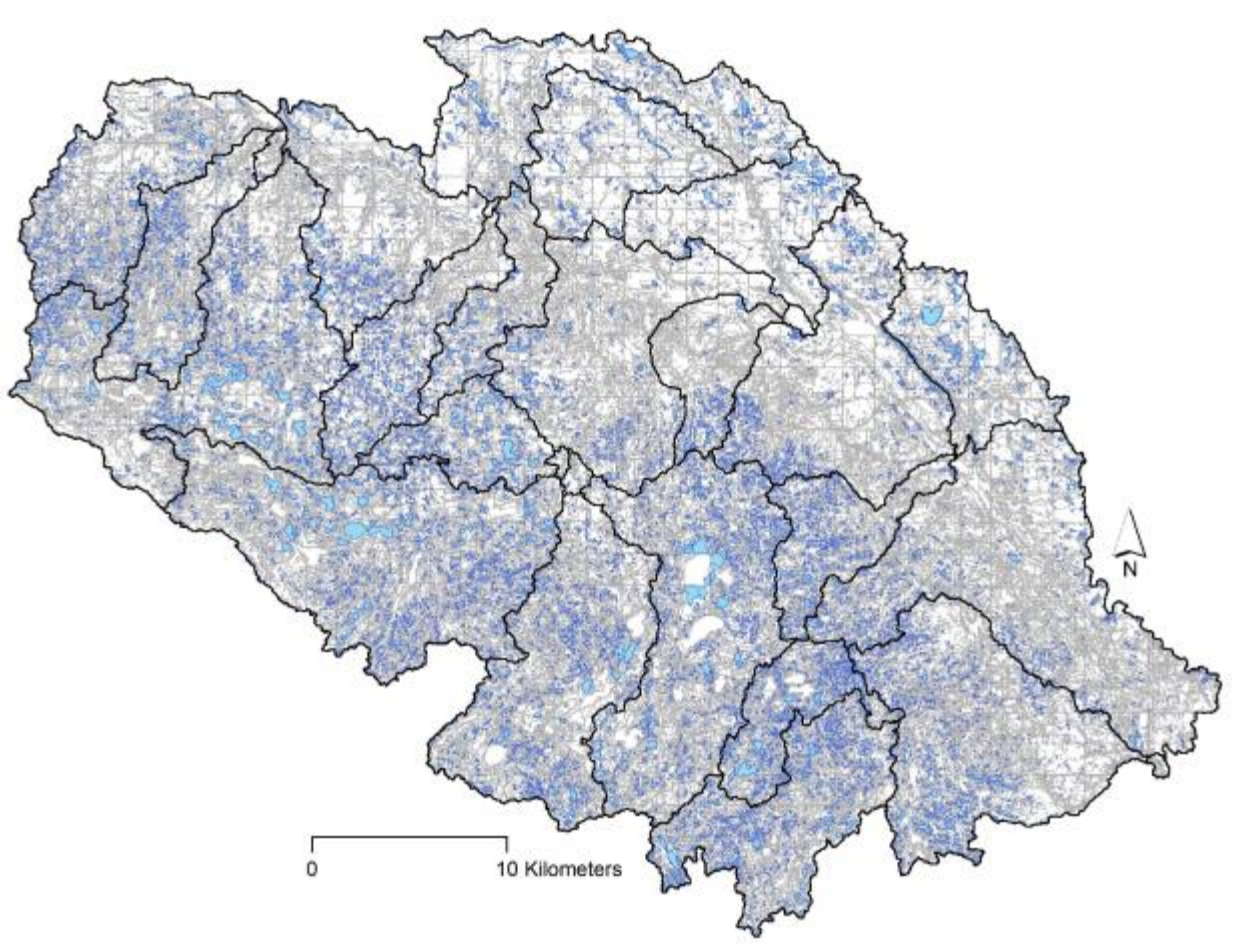




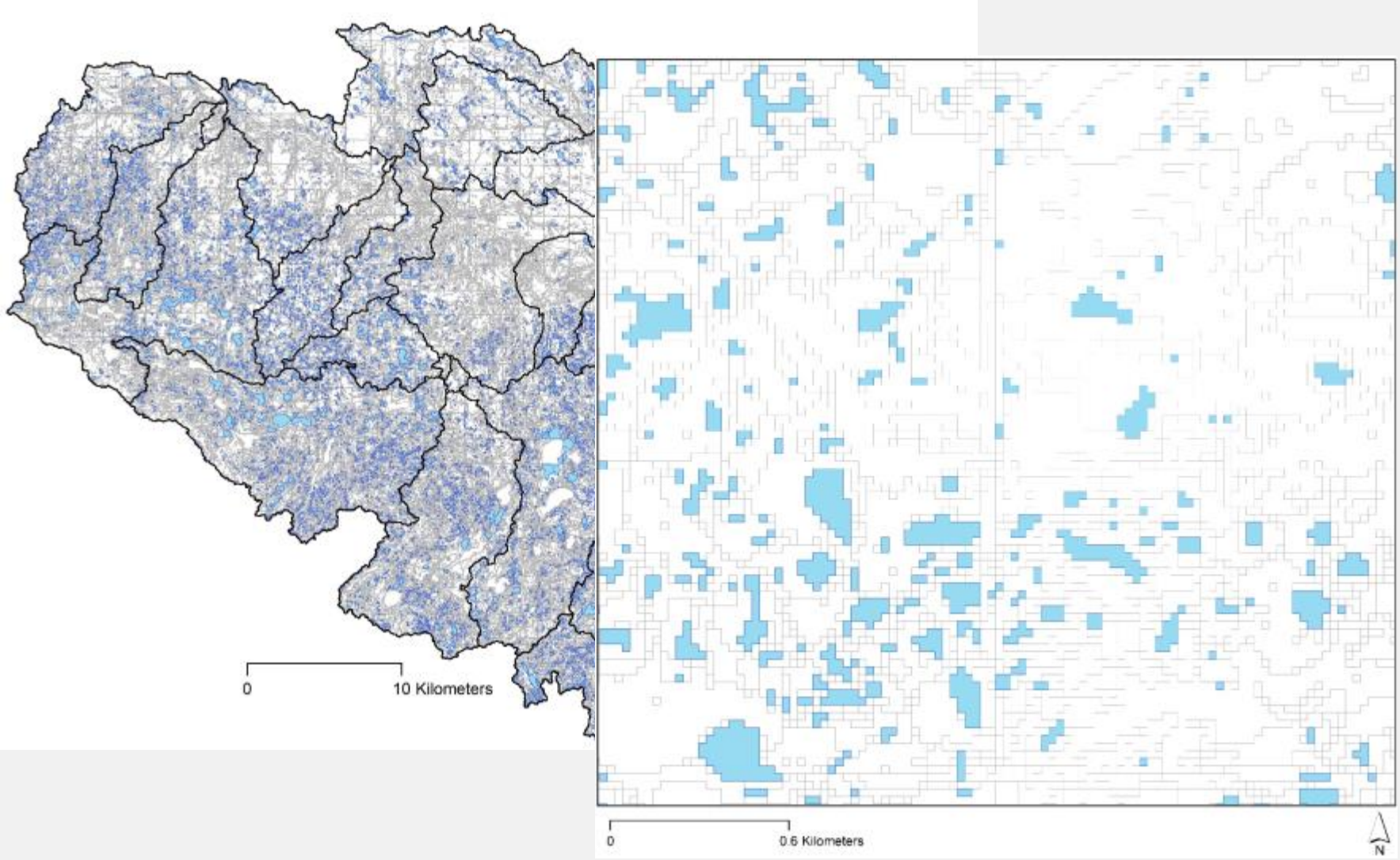
Pipestem Creek Watershed, North Dakota, USA

- ~1,600 km^2
- 42% Cultivated crops; 26% Herbaceous; 15% Hay/pasture

GIW Fill-spill Relationships in the Pipestem Watershed



GIW Fill-spill Relationships in the Pipestem Watershed



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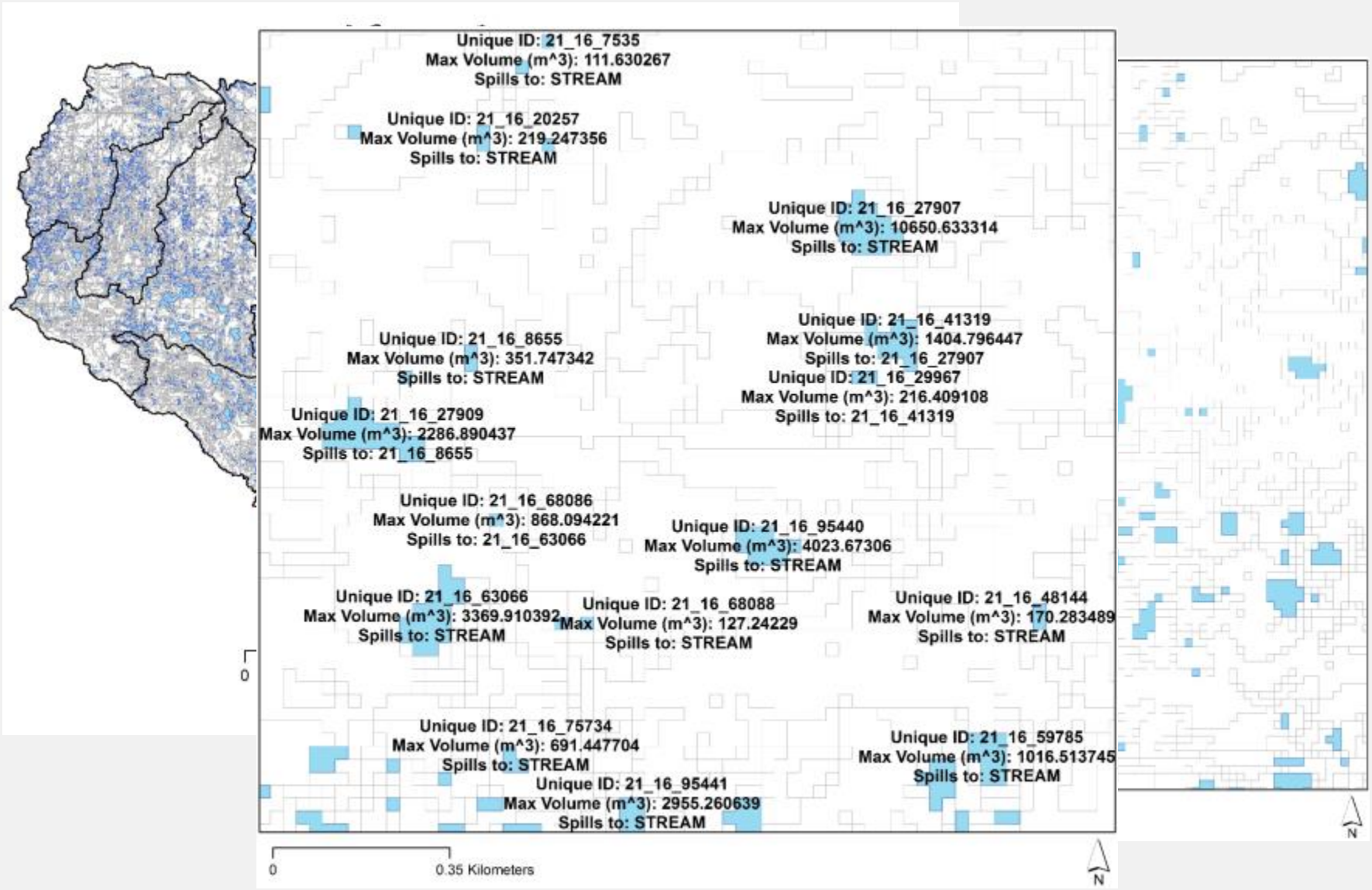
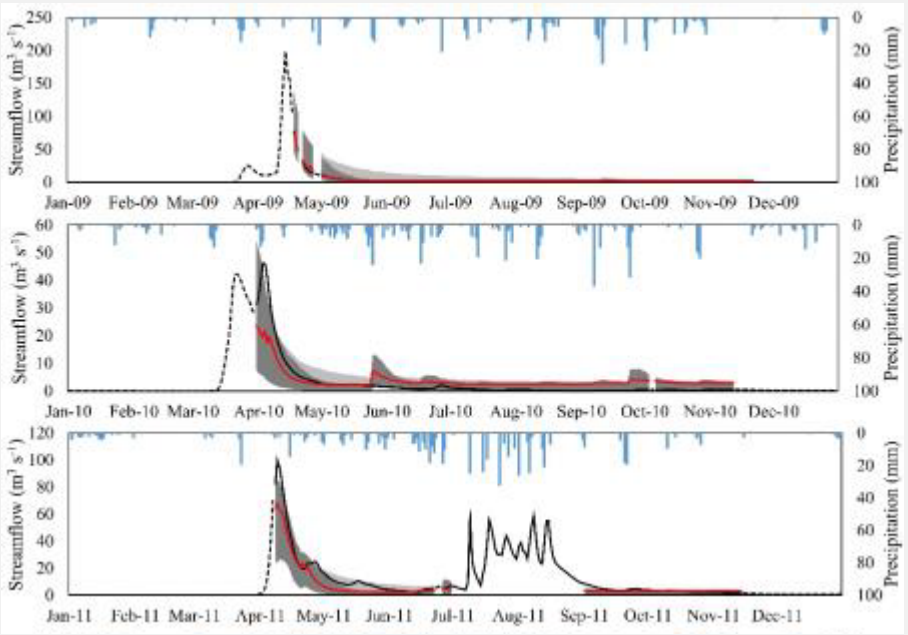
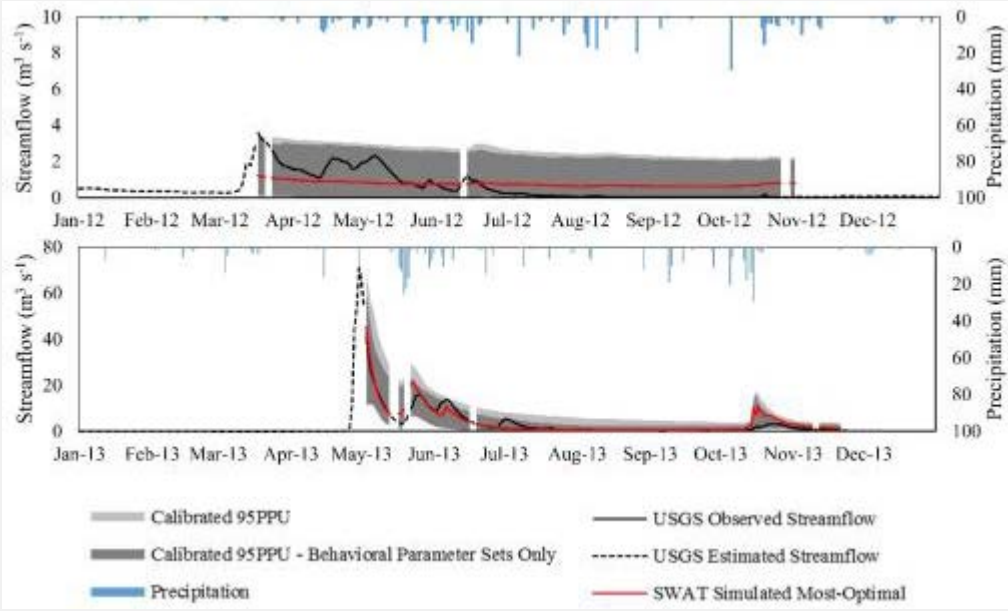


Model calibration and validation

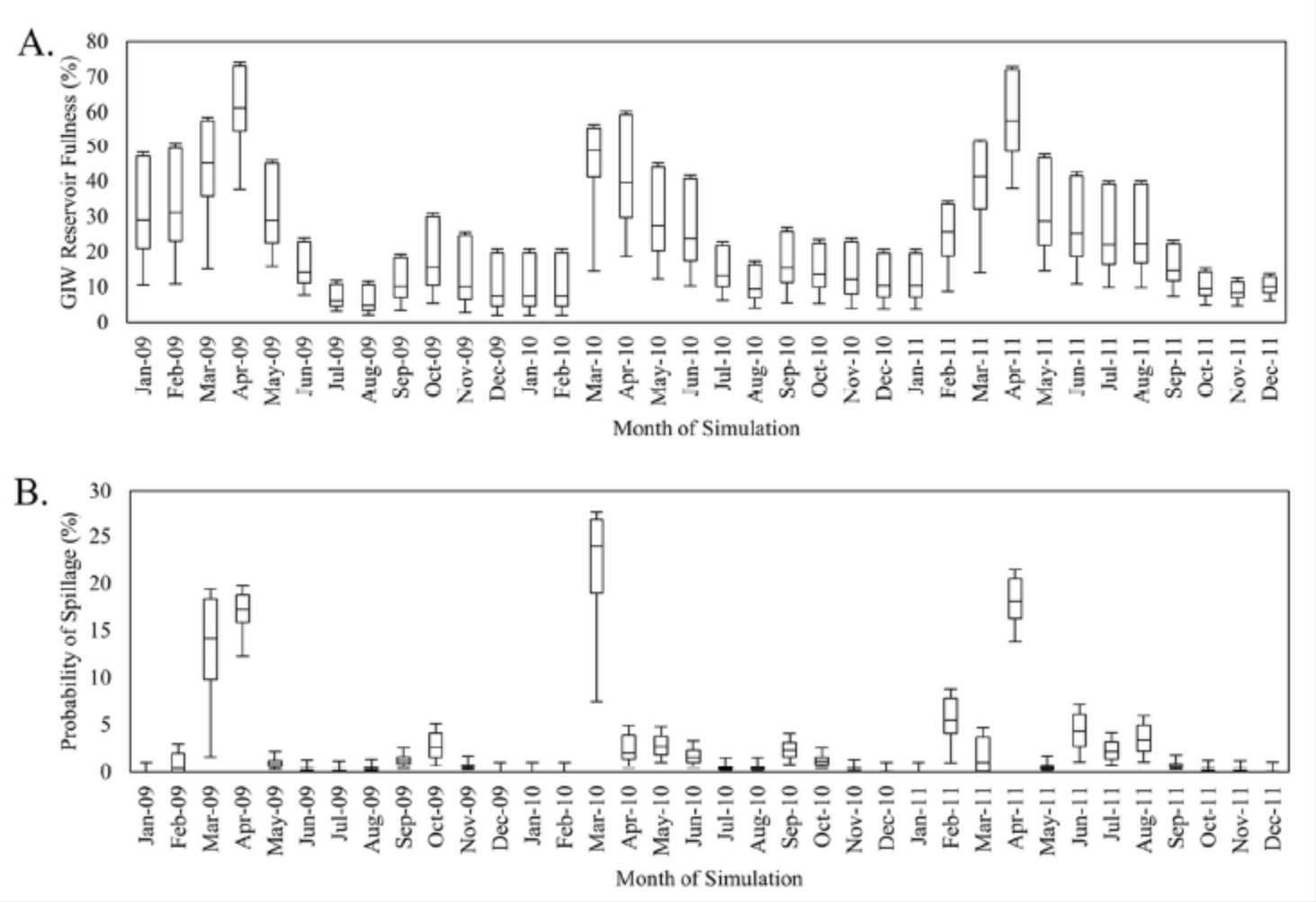




Evenson et al. 2016 (*Hydrological Processes*)

- Calibrated for 3 years (2009-2011), “validated” for 2 years (2012-2013)
- 250 “behavioral” parameter combinations with NSE > 0.5

Fill-spill “soft data” validation



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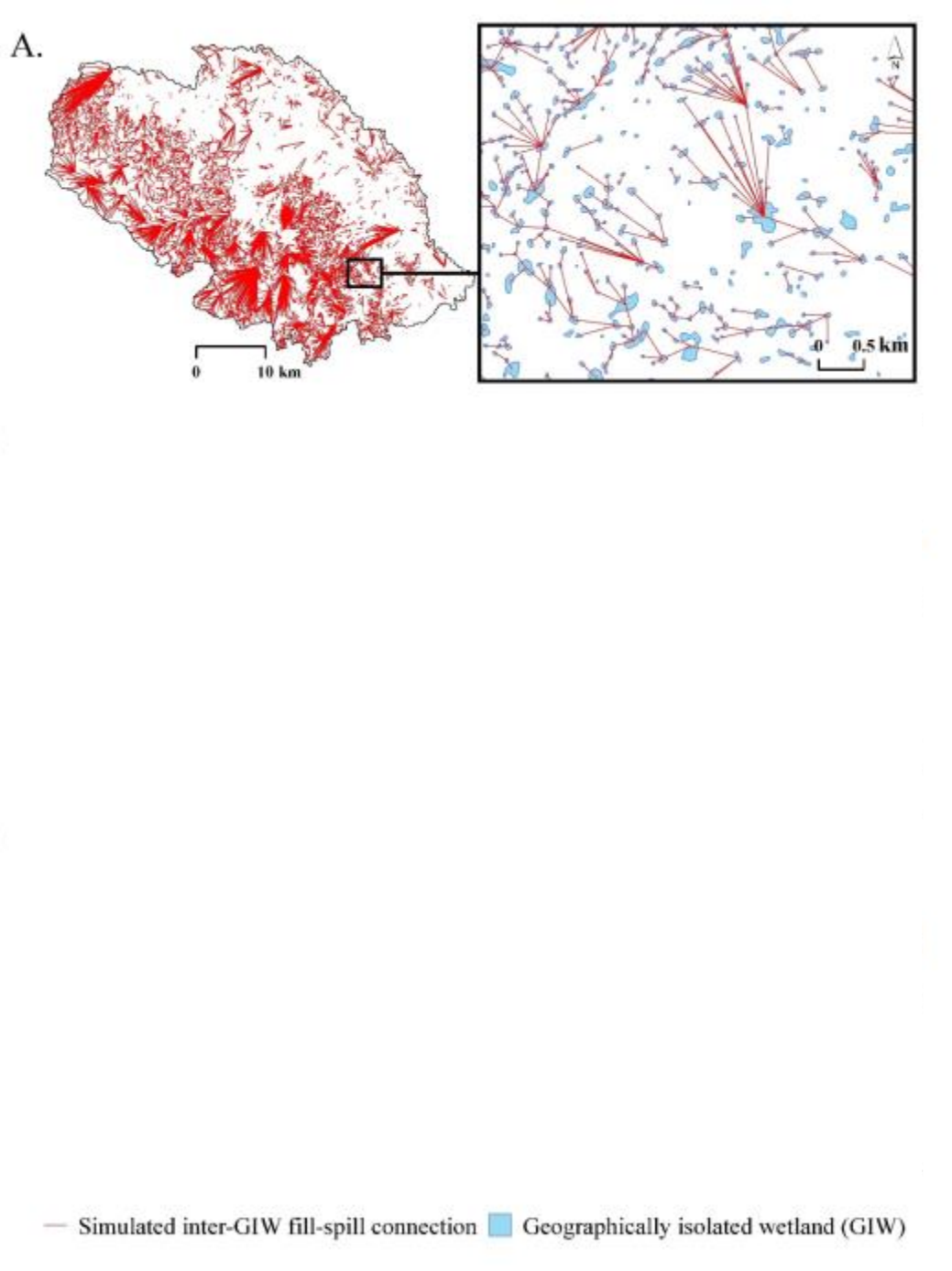

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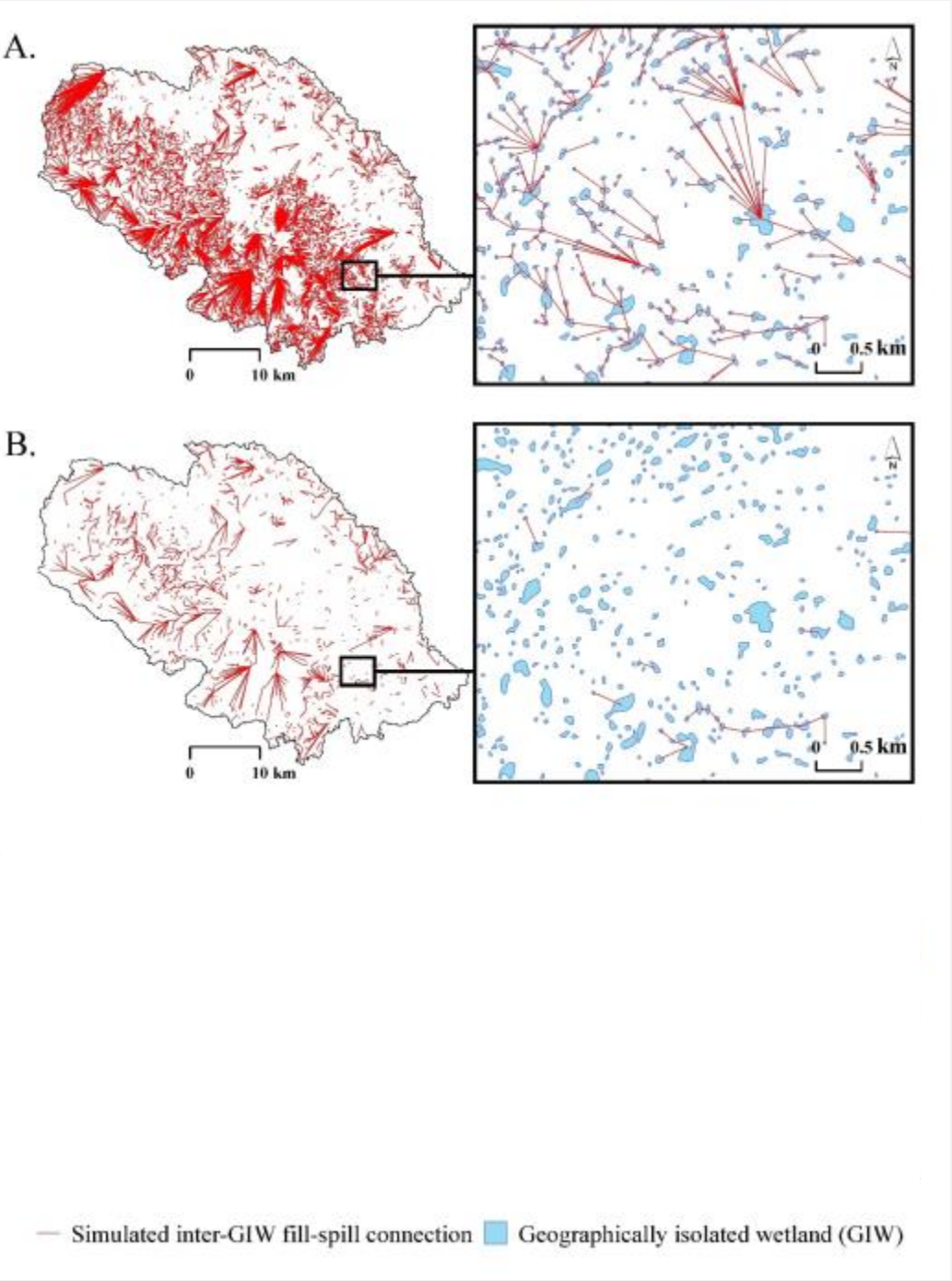

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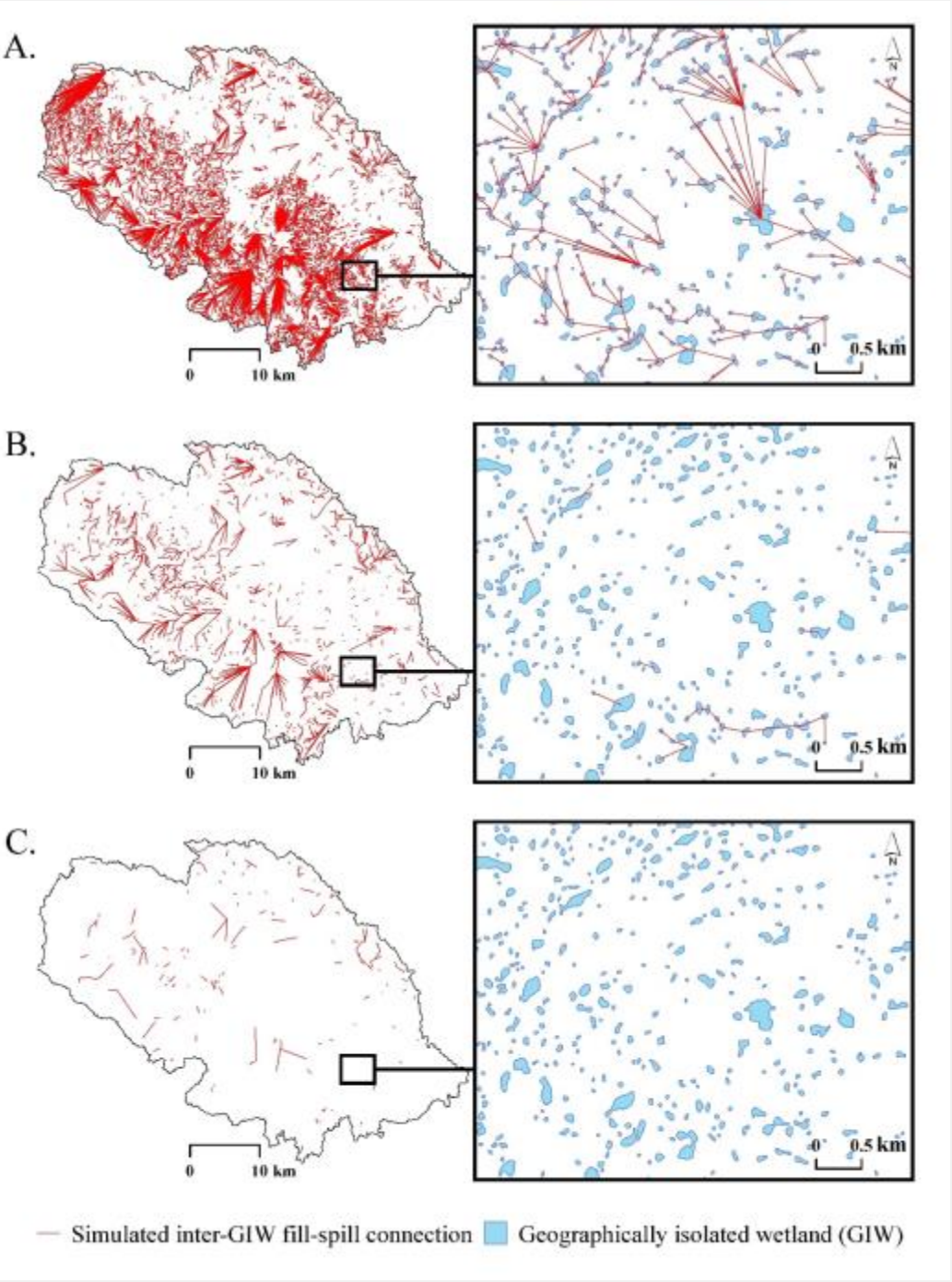

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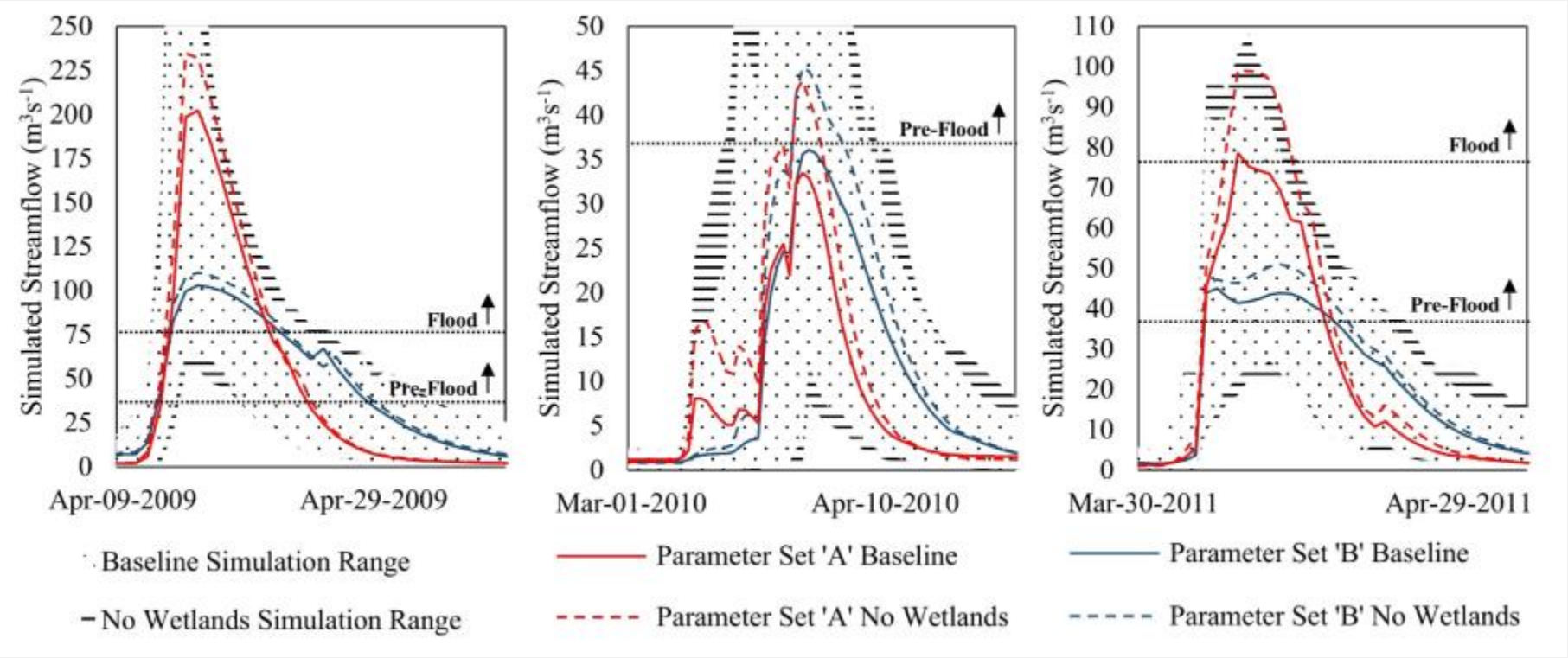
GIW Aggregate Effects



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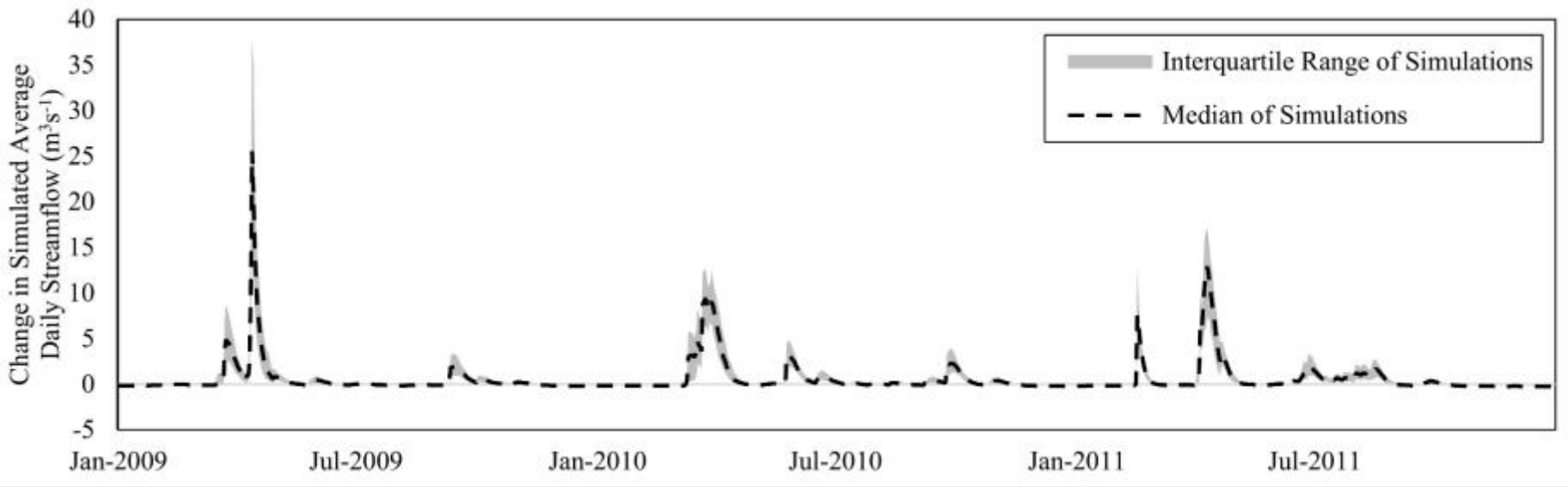
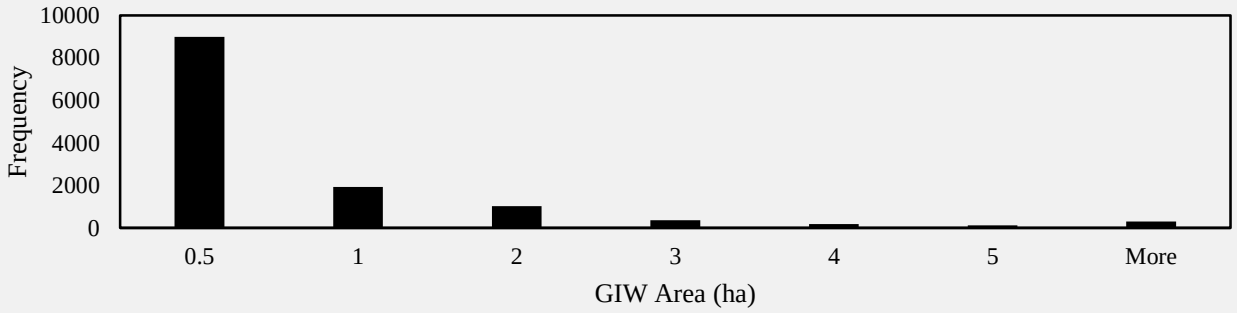


Evenson et al. (*In prep*)

Forthcoming Analyses

Evenson et al. (*In prep*)

- Remove GIWs by area



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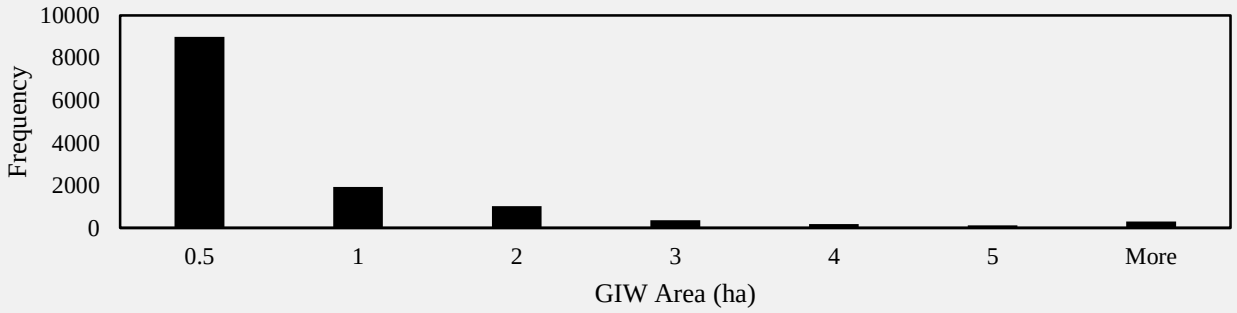
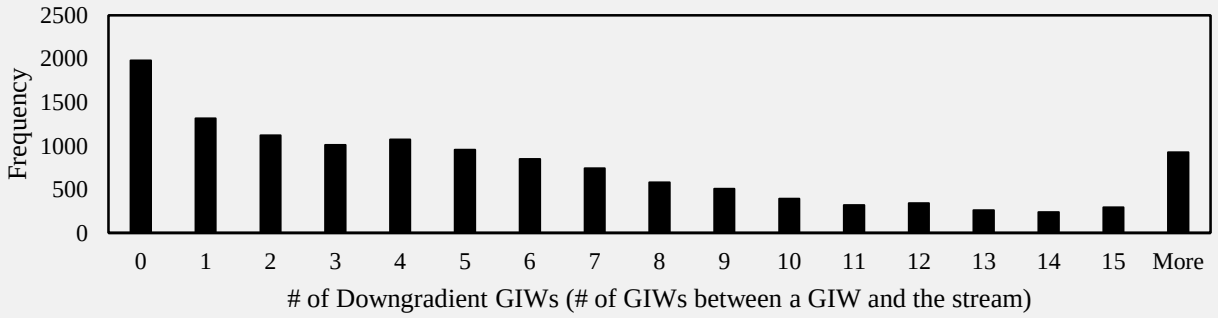


- Remove GIWs by GIW-network order



Other Work:

Baseflow versus “quickflow”

		Average daily ($m^3 s^{-1}$)				Relative change (%)			
		2001	2002	2003	2004	2001	2002	2003	2004
Baseline	Streamflow	1.33	1.51	3.42	2.24	NA	NA	NA	NA
	Baseflow	0.69	0.76	2.02	1.34	NA	NA	NA	NA
	Quickflow	0.64	0.75	1.40	0.91	NA	NA	NA	NA
Scenario 1	Streamflow	1.22	1.43	3.49	2.20	−9.12	−5.60	1.78	−1.87
	Baseflow	0.50	0.58	1.85	1.17	−38.53	−30.55	−9.30	−14.01
	Quickflow	0.72	0.84	1.64	1.03	11.26	11.60	14.25	11.97

Evenson et al. 2015 (*J. of Hydrology*)

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	Baseflow	0.50	0.58	1.85	1.17	−38.53	−30.55	−9.30	−14.01
	Quickflow	0.72	0.84	1.64	1.03	11.26	11.60	14.25	11.97

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Seasonal analysis

Average daily simulated streamflow, separation of streamflow into baseflow and quickflow components, and relative percent change for each component under Baseline and Scenario 1 through Scenario 6. SP = Spring; SU = Summer; AU = Autumn; WI = Winter.

		Average daily ($m^3 s^{-1}$)				Relative change (%)			
		SP	SU	AU	WI	SP	SU	AU	WI
Baseline	Streamflow	2.91	1.47	2.02	2.11	NA	NA	NA	NA
	Baseflow	1.61	0.89	1.04	1.27	NA	NA	NA	NA
	Quickflow	1.30	0.58	0.97	0.84	NA	NA	NA	NA
Scenario 1	Streamflow	3.03	1.27	1.91	2.13	3.97	−15.73	−5.79	0.94
	Baseflow	1.53	0.61	0.79	1.17	−5.17	−45.22	−32.18	−8.25
	Quickflow	1.49	0.66	1.12	0.96	13.32	11.71	12.81	12.09

Evenson et al. 2015 (*J. of Hydrology*)

Planned Work:

- Moving to Delmarva watershed (Maryland)
- Improving representation of upland-wetland subsurface dynamics
- Additional study areas

Ducks Unlimited Canada

Summary and Conclusions

- SWAT has been modified to include an improved representation of GIWs and fill-spill inter-GIW flows
- SWAT may be calibrated and validated using traditional streamflow and “soft” data describing GIWs
- GIWs have a watershed-scale aggregate hydrologic impact on downgradient streamflow

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