A Salinity Chemistry and Transport Module for SWAT

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Colorado State University

Outline

1. The Salinity Problem
2. Development of Salinity Transport Module for SWAT
3. Application to Arkansas River Basin, Colorado
4. Future Work

The Salinity Problem

Salinity in Agricultural Groundwater Systems

Semi-Arid / Arid Agricultural Areas:

- Excessive irrigation
- Seepage from earthen canals
- Inefficient drainage systems
- Consequent evaporative concentration

→ High soil salinity
High groundwater salinity

→ Reduction in crop yield

https://www.agric.wa.gov.au/soil-salinity/dryland-salinity-extent-and-impact

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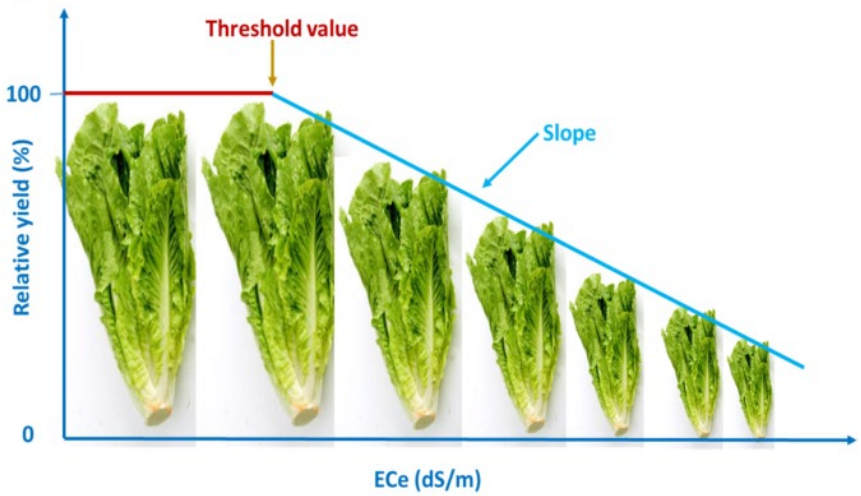


- Threshold: the EC of soil saturated extract (ECe) when yield starts decrease.
- Slope: % of yield decrease when ECe increased by 1 dS/m.

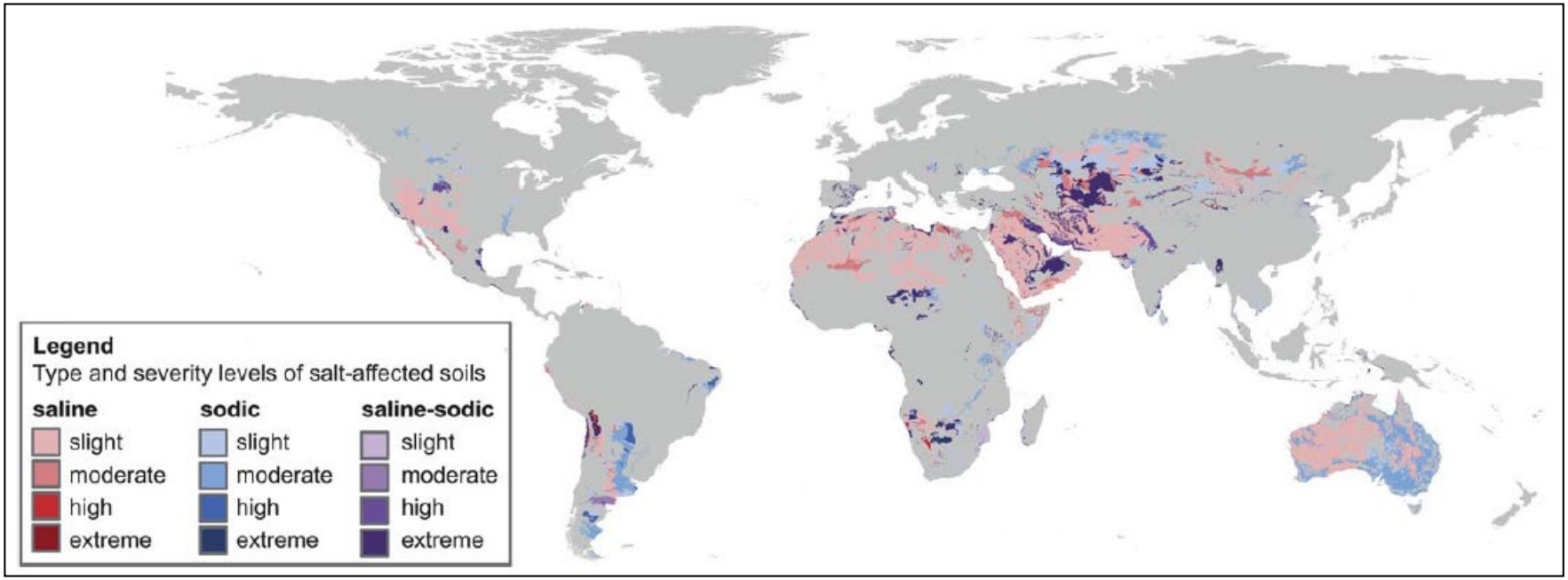
ucanr.edu/sites/Salinity/Salinity_Management/

The Salinity Problem

Salinity in Agricultural Groundwater Systems

Global Salt-Affected Soils

Wicke et al. (2011) *Energy and Environmental Science*

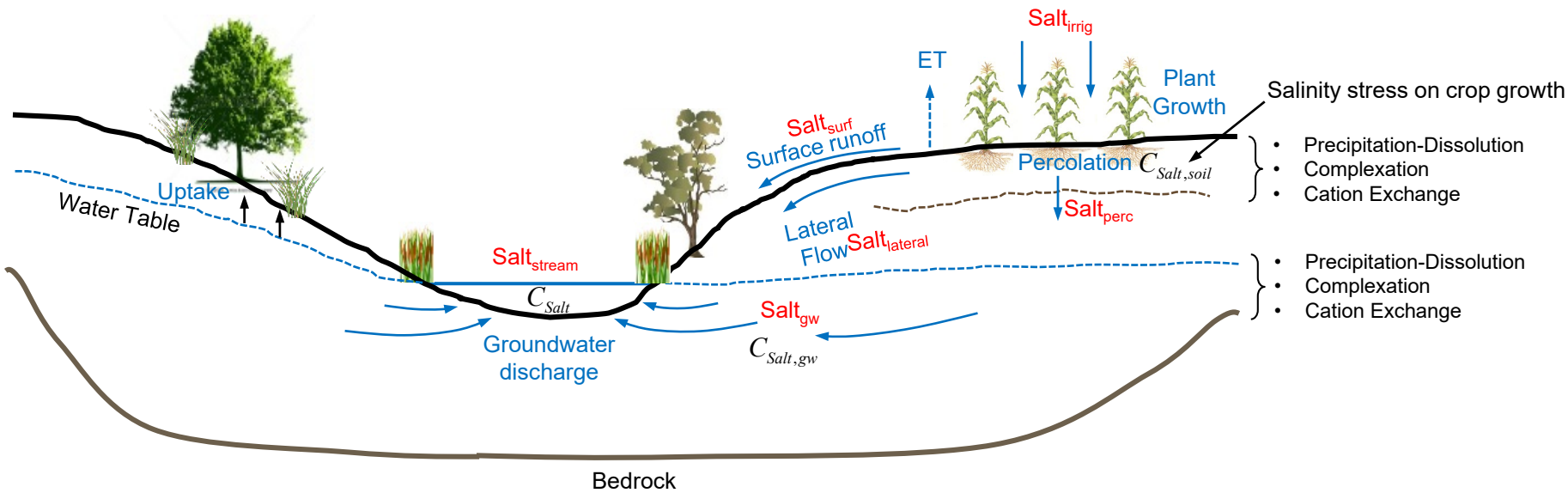


- 230 million ha of irrigated land → 20-25% severe salinity
- Salt-affected area increases by 1-1.5 million ha / year
- 27-28% of irrigated land → decline in crop productivity

The Salinity Problem

Watershed Salt Transport

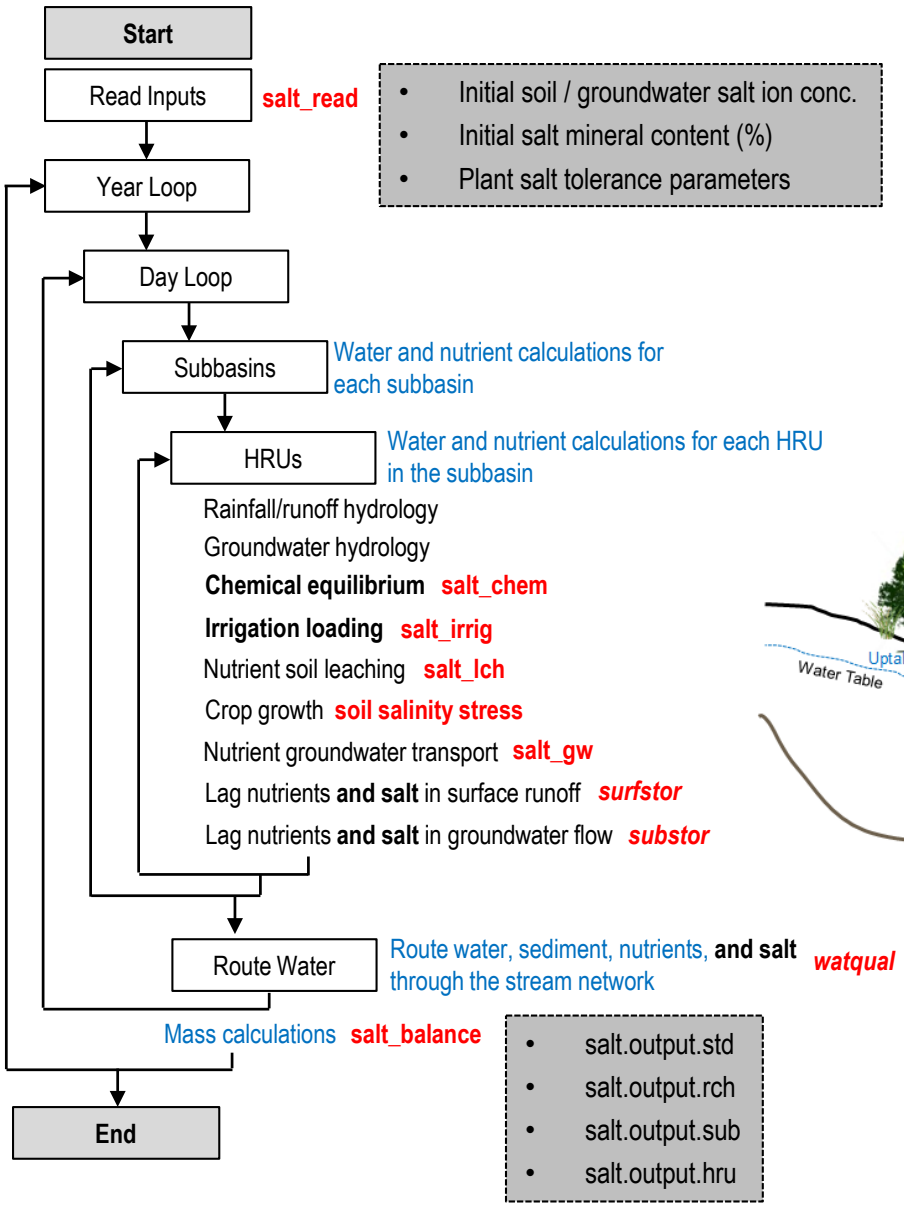
(Salt = SO_4, Ca, Mg, Na, K, Cl, CO_3, HCO_3)

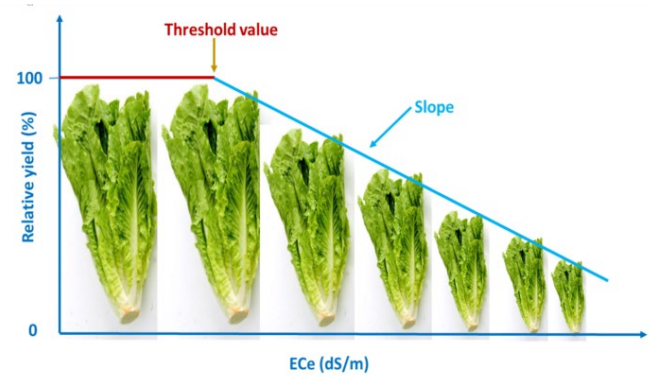


Objectives

1. Develop Salinity transport module for SWAT
2. Test model in an irrigated watershed
3. Assess Salinity and Crop Yield under changes in climate, land use, and water management strategies

Salinity Module for SWAT





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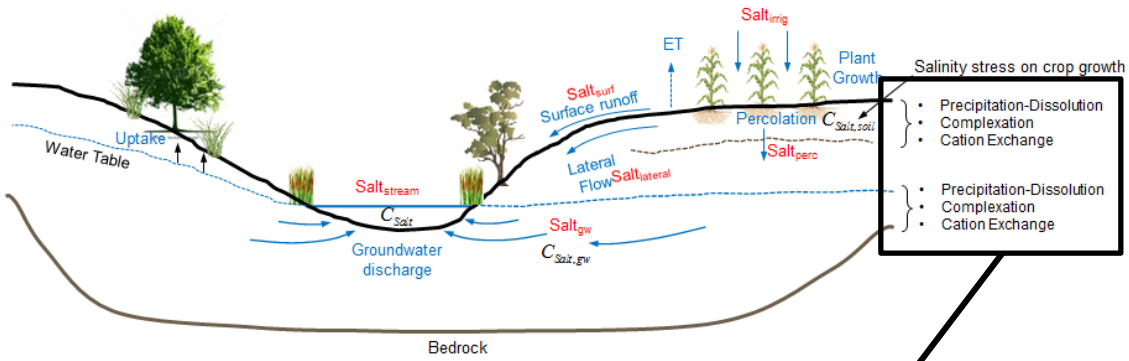
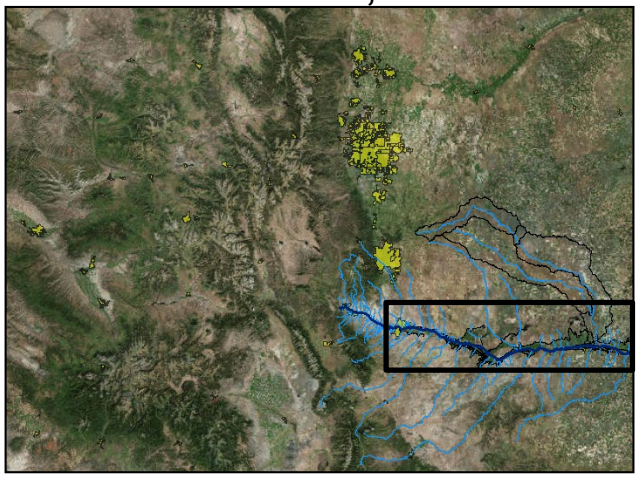


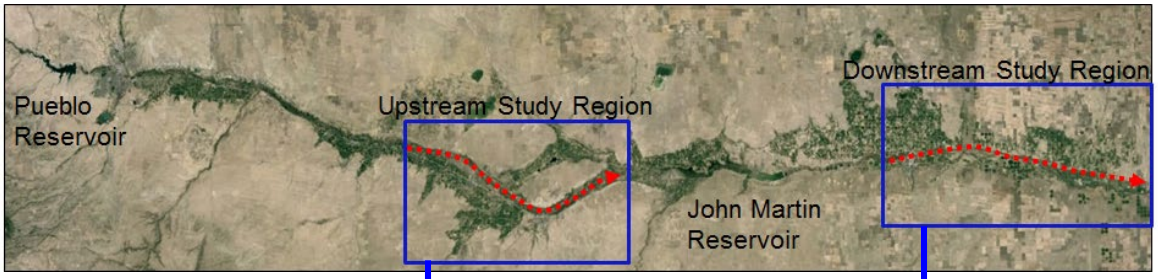
1. $CaSO_4$
2. NaCl
3. $CaCO_3$
4. $MgCO_3$
5. $MgSO_4$

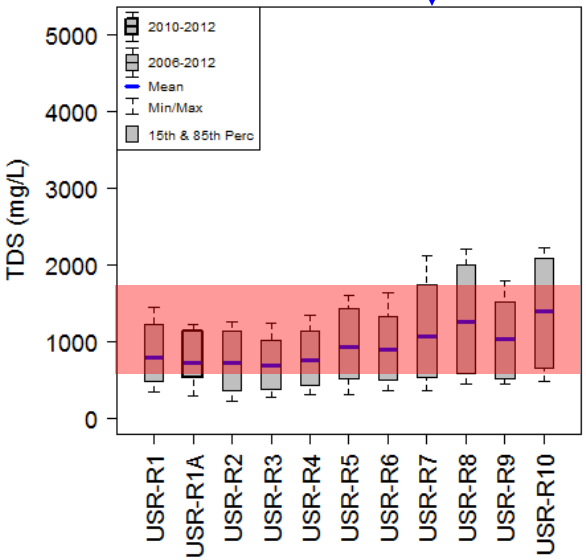
Application to Irrigated Regions

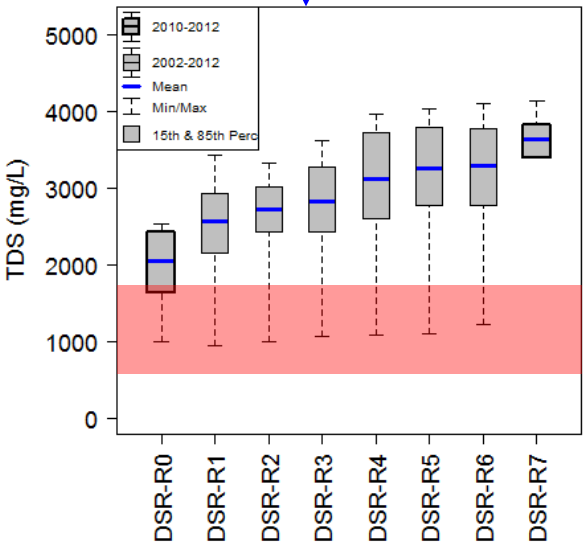
Lower Arkansas River Valley, Colorado

Colorado, USA









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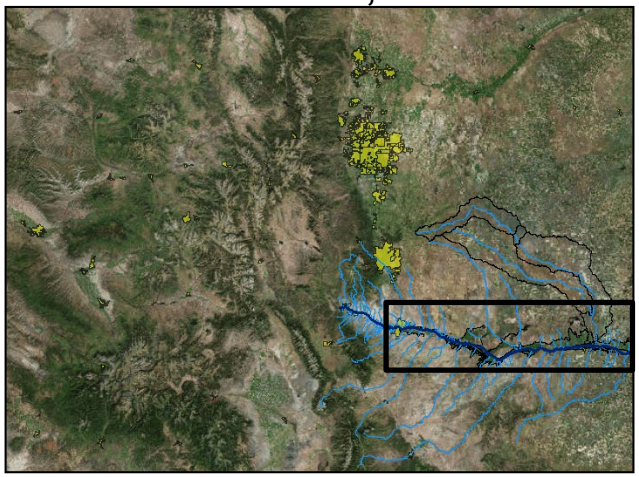

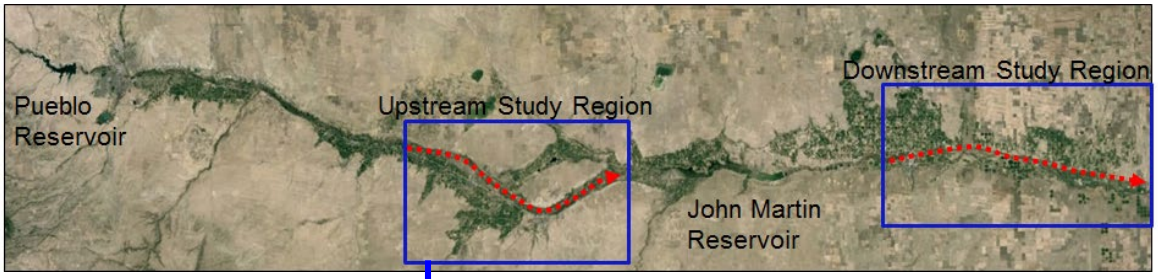

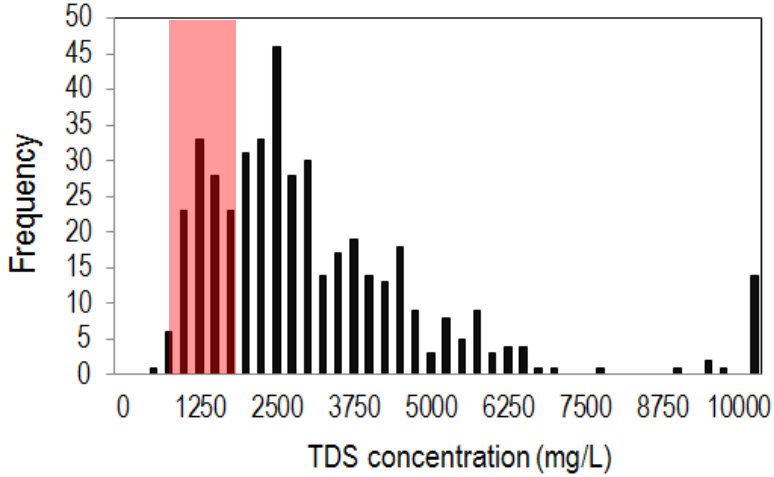

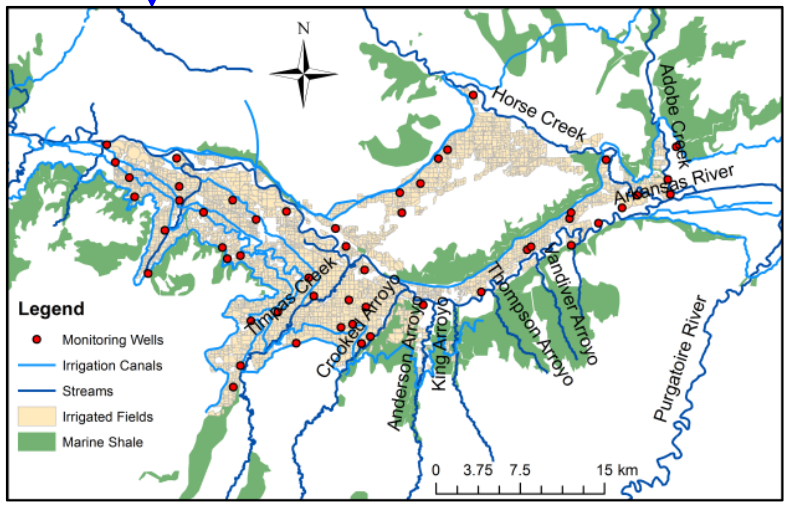

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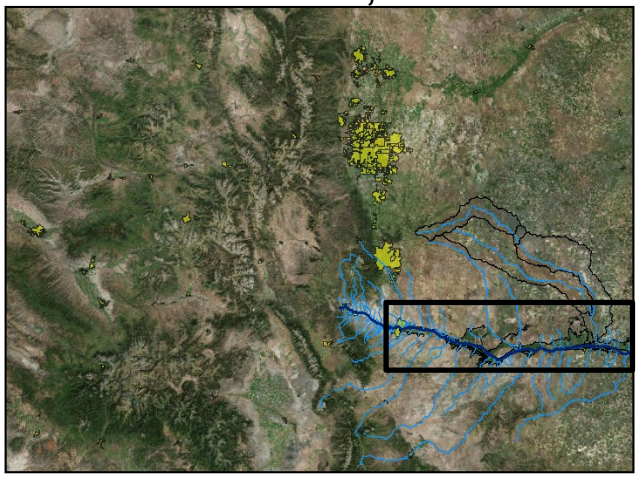
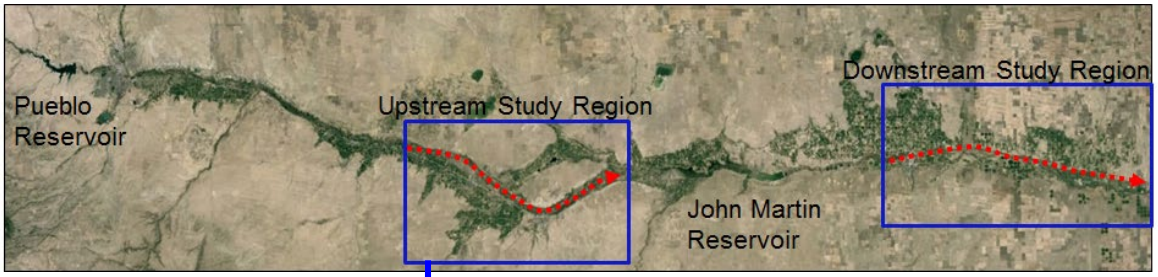
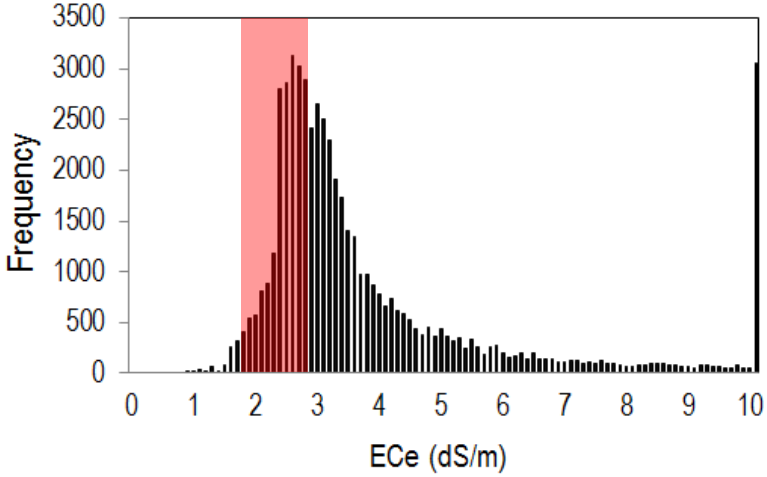
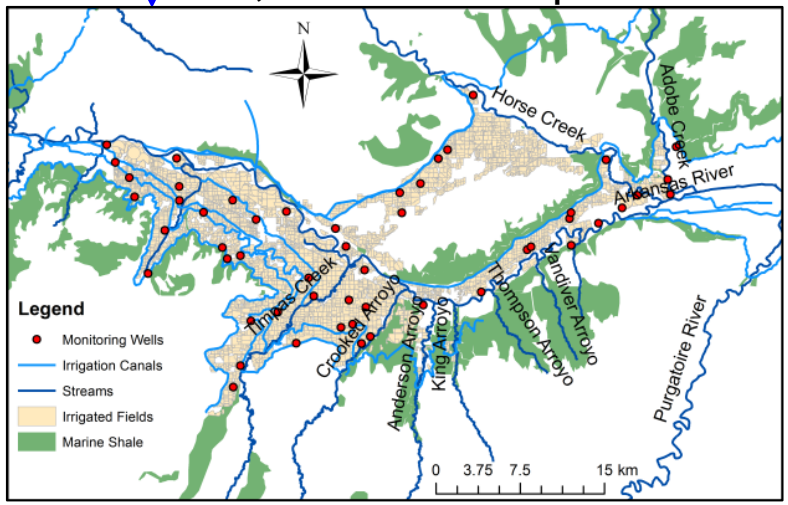




54,723 Soil Samples





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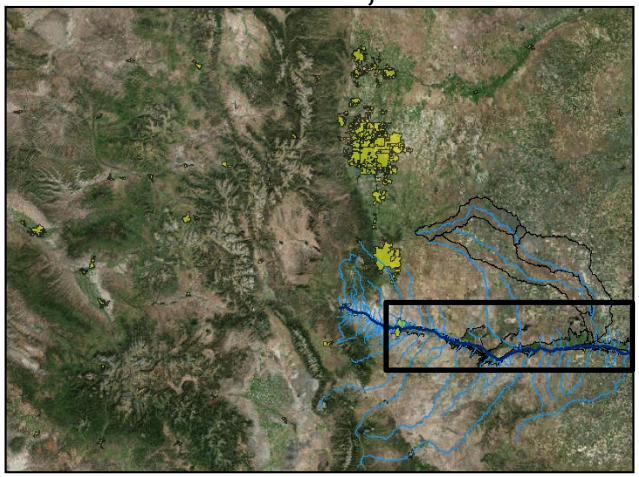
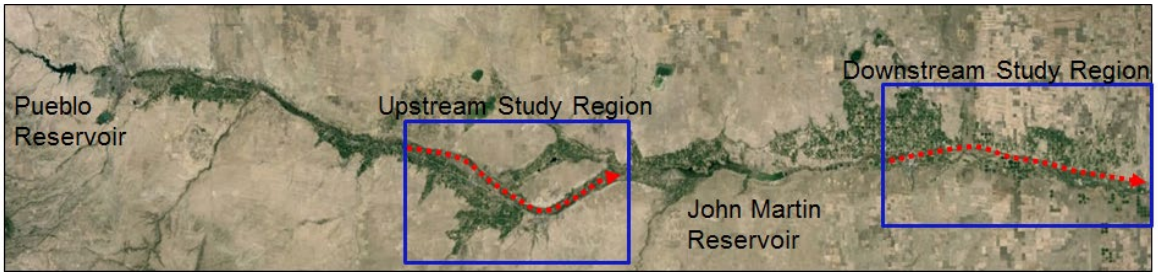
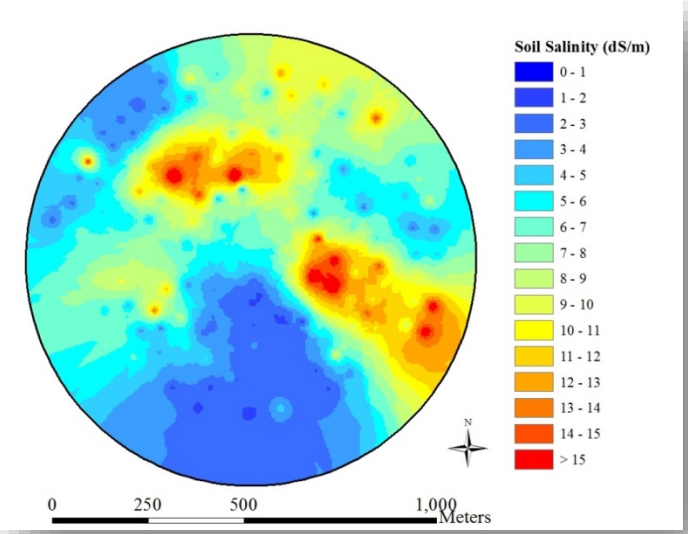
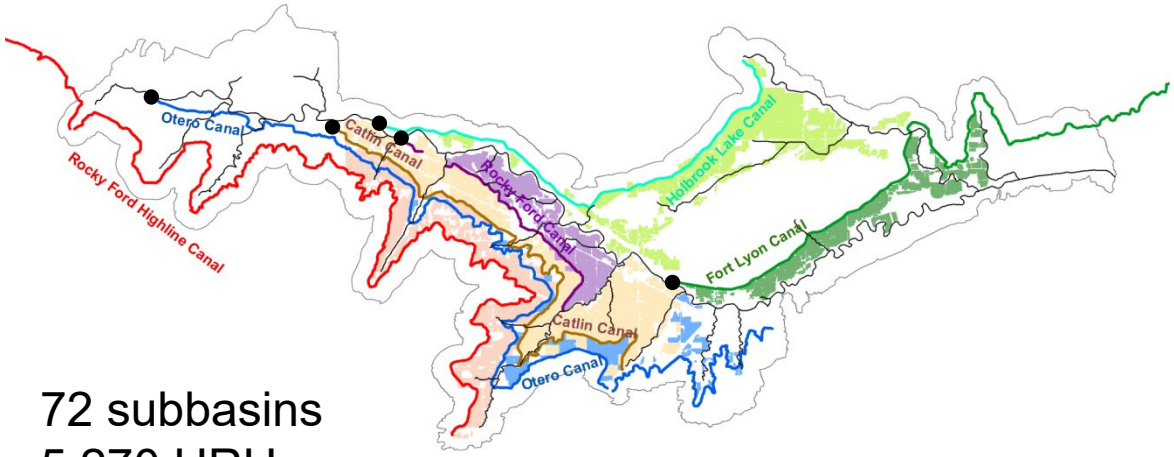






Application to Irrigated Region



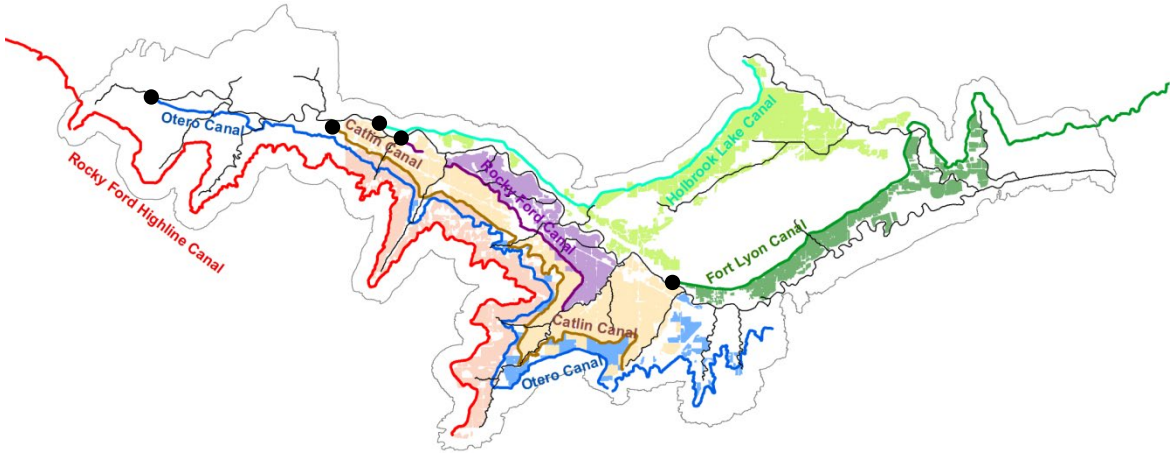
72 subbasins
5,270 HRUs

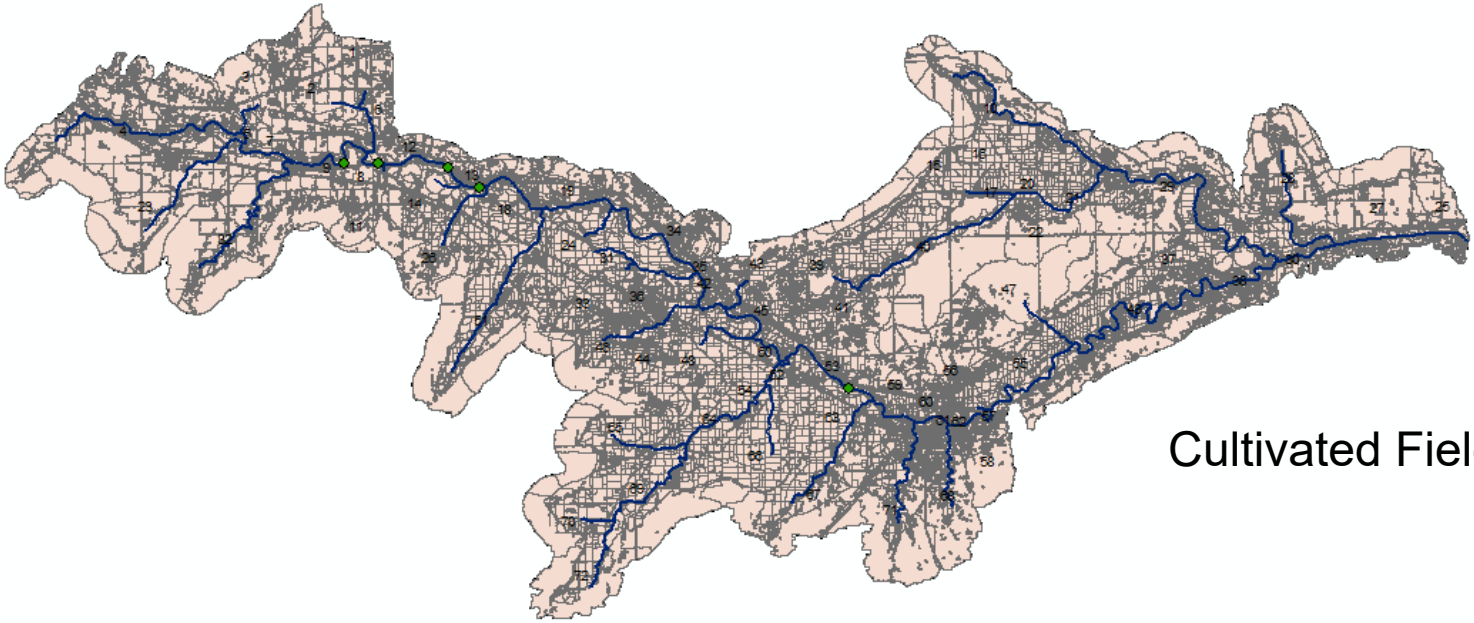
SWAT Model

- Relates total applied irrigation water to the volume diverted from the river, according to water rights
- Includes <u>seepage from earthen irrigation canals</u> to the shallow aquifer
- **1999-2009** simulation period
- Tested against streamflow at 5 gages (3 in River, 2 tributaries)

Wei, X., Bailey, R.T., and A. Tasdighi (2018), Using the SWAT Model in Intensively Managed Irrigated Watersheds: Model Modification and Application. *J. Hydrologic Engineering*, in press.

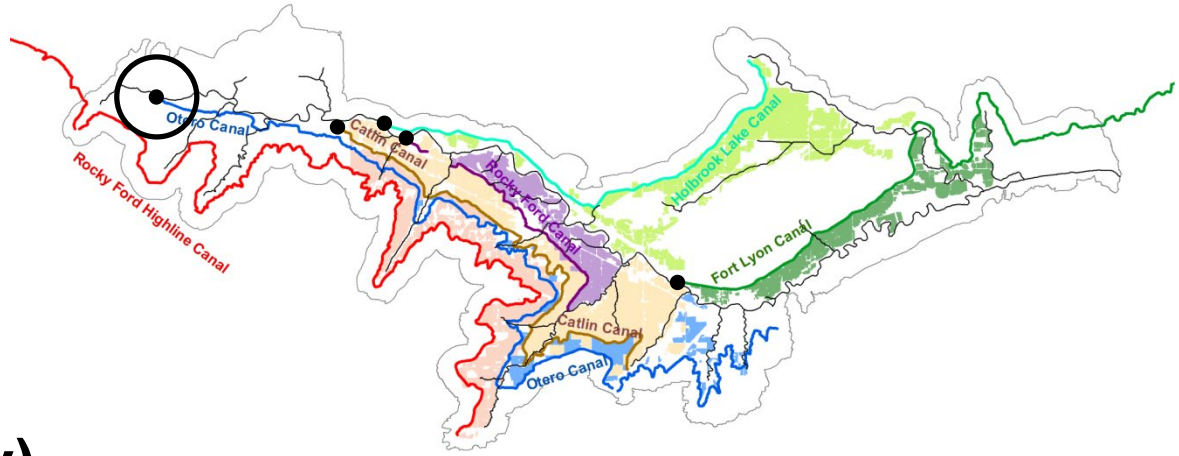
Application to Irrigated Region





Cultivated Field = HRU

Application to Irrigated Region

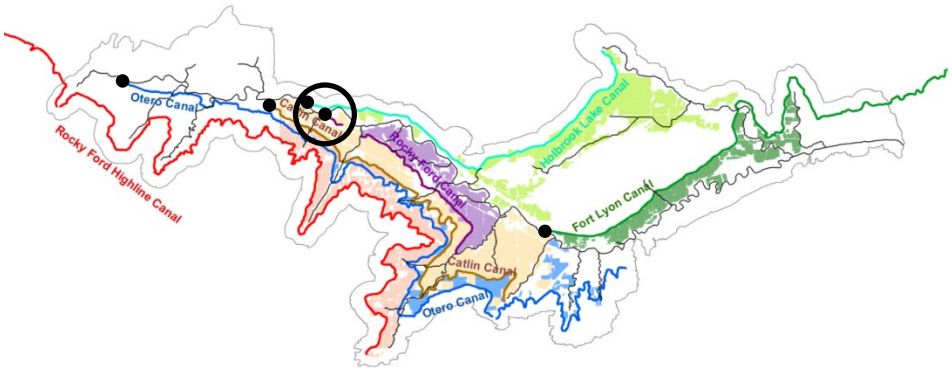


SWAT Model (Salinity)

- Initial gw salt ion conc. / salt mineral → based on field data / NRCS soil survey
- Initial soil water ion conc. / salt mineral → based on field data / NRCS soil survey
- Chemical equilibrium parameters → based on literature
- Mass loading of Salt ions (kg/day) at inlet → Gage data (flow, EC)

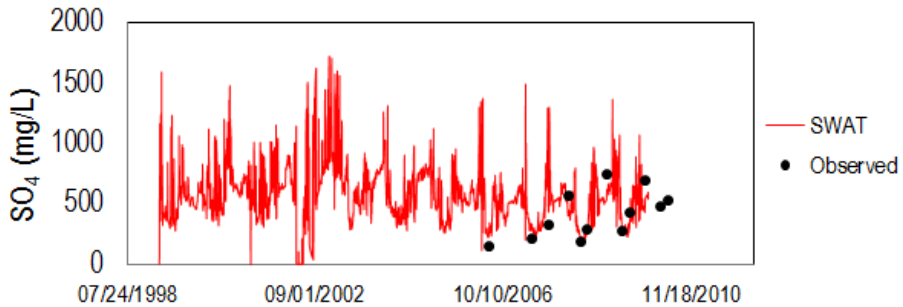
Application to Irrigated Region

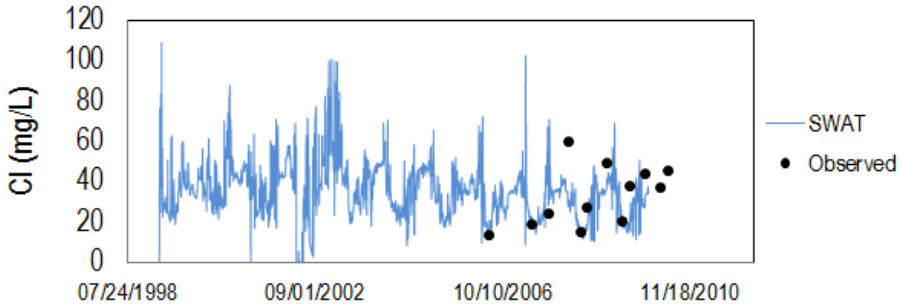
SWAT Model

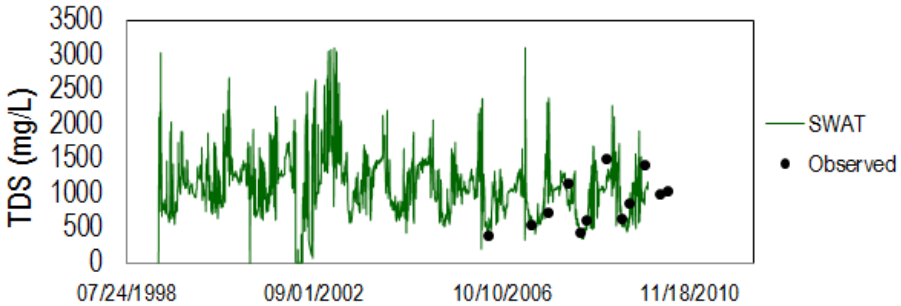


Results

Arkansas River Concentration

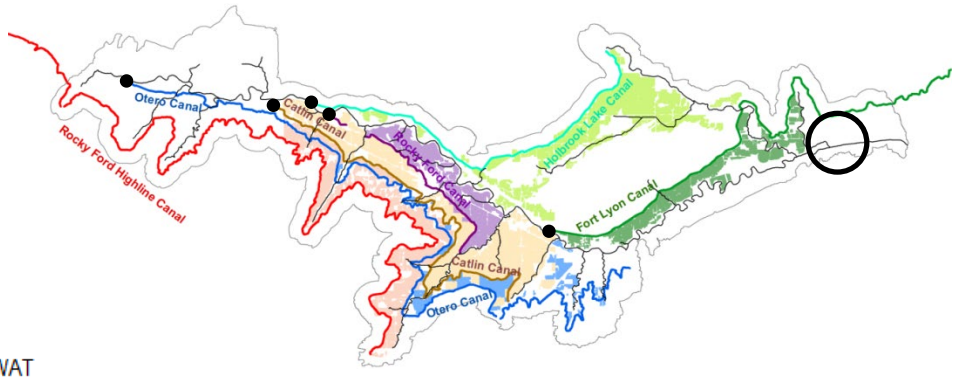






Application to Irrigated Region

SWAT Model



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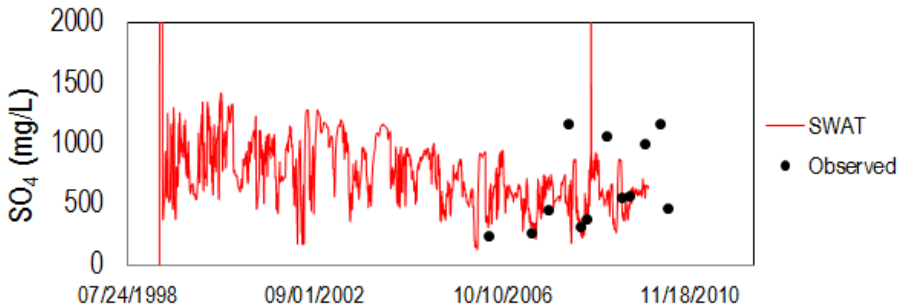
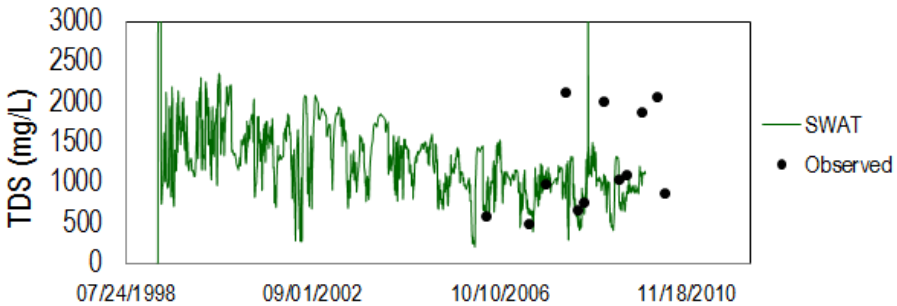
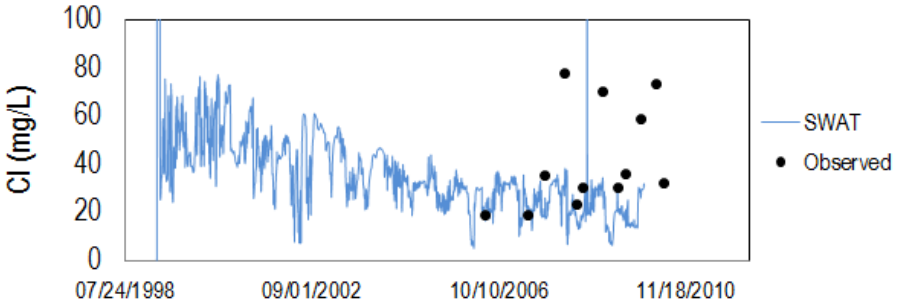
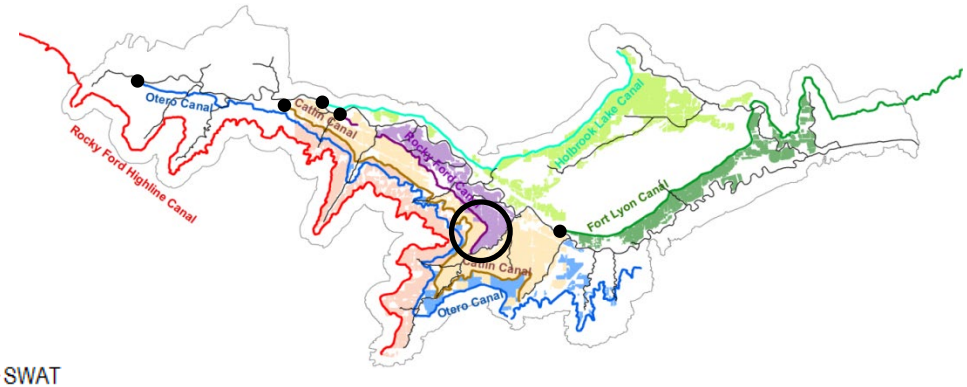






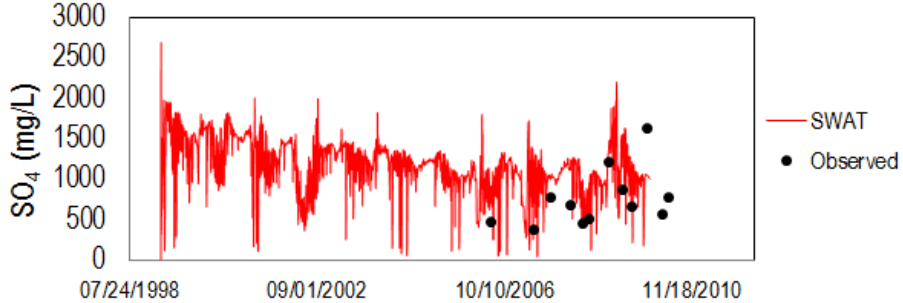
Application to Irrigated Region

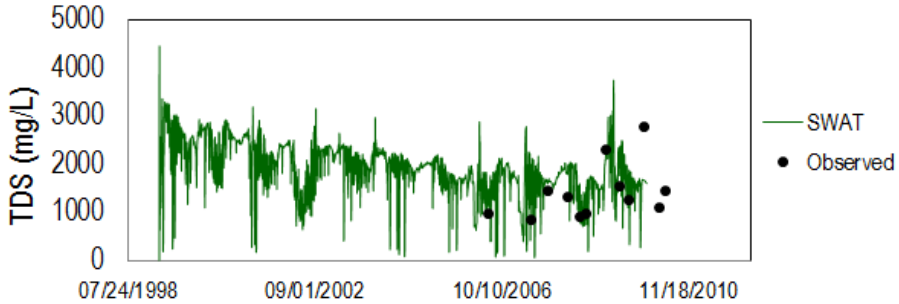
SWAT Model

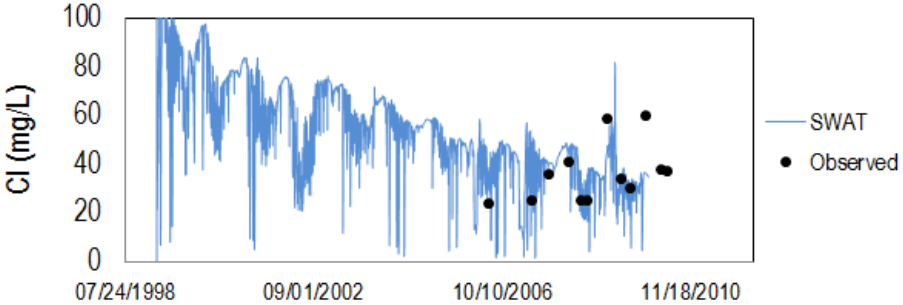


Results

Timpas Creek Concentration

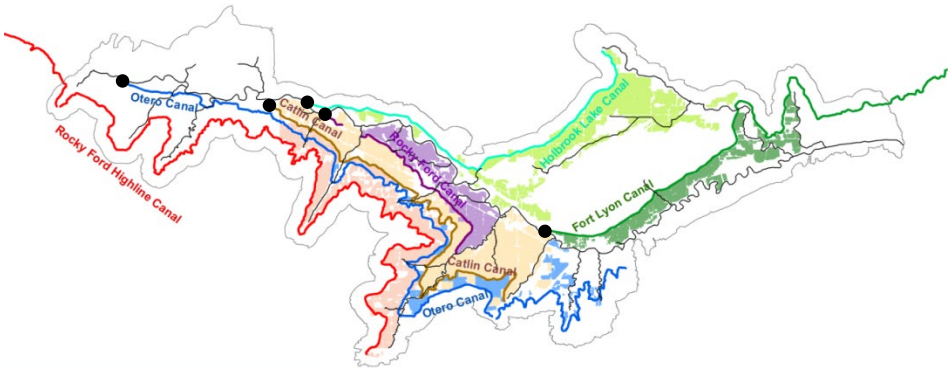






Application to Irrigated Region

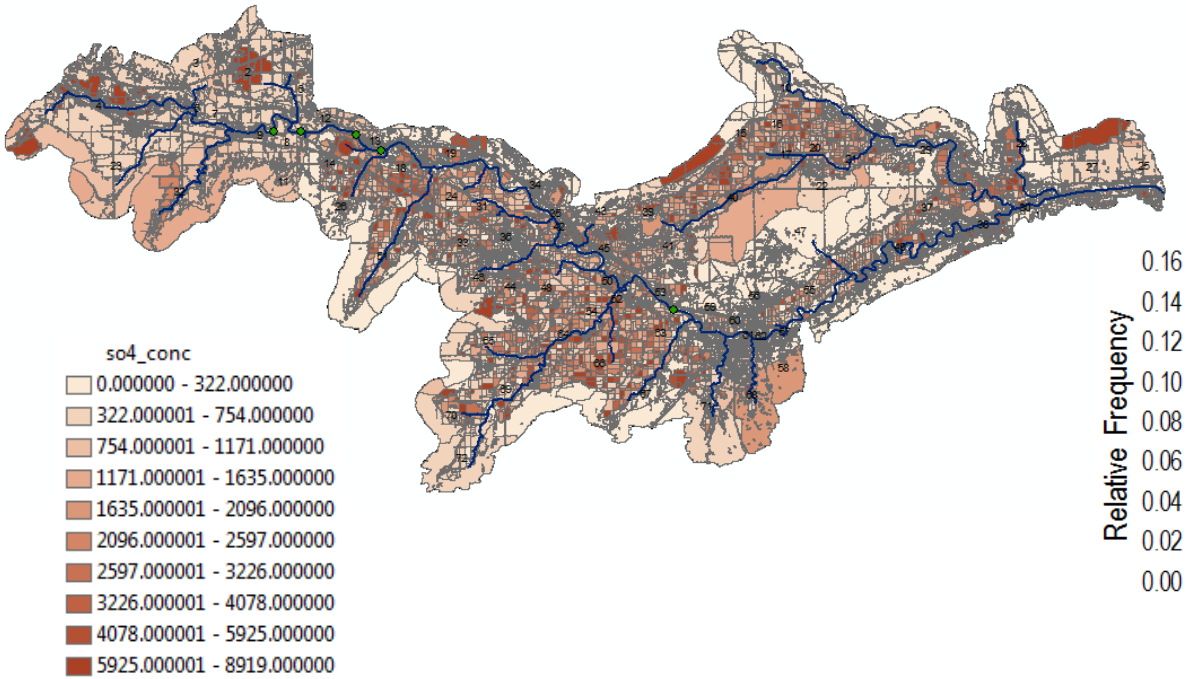
SWAT Model

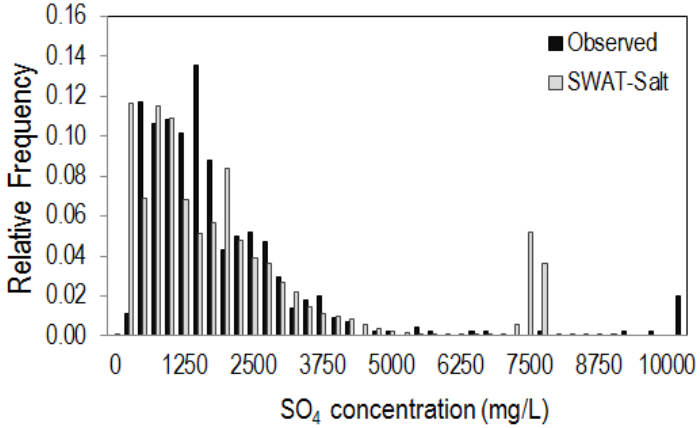


Results

Groundwater Concentration

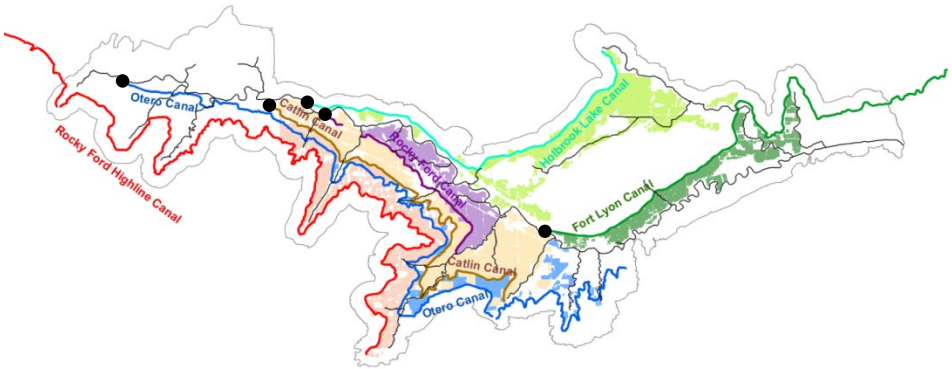
SO_4 (mg/L)





Application to Irrigated Region

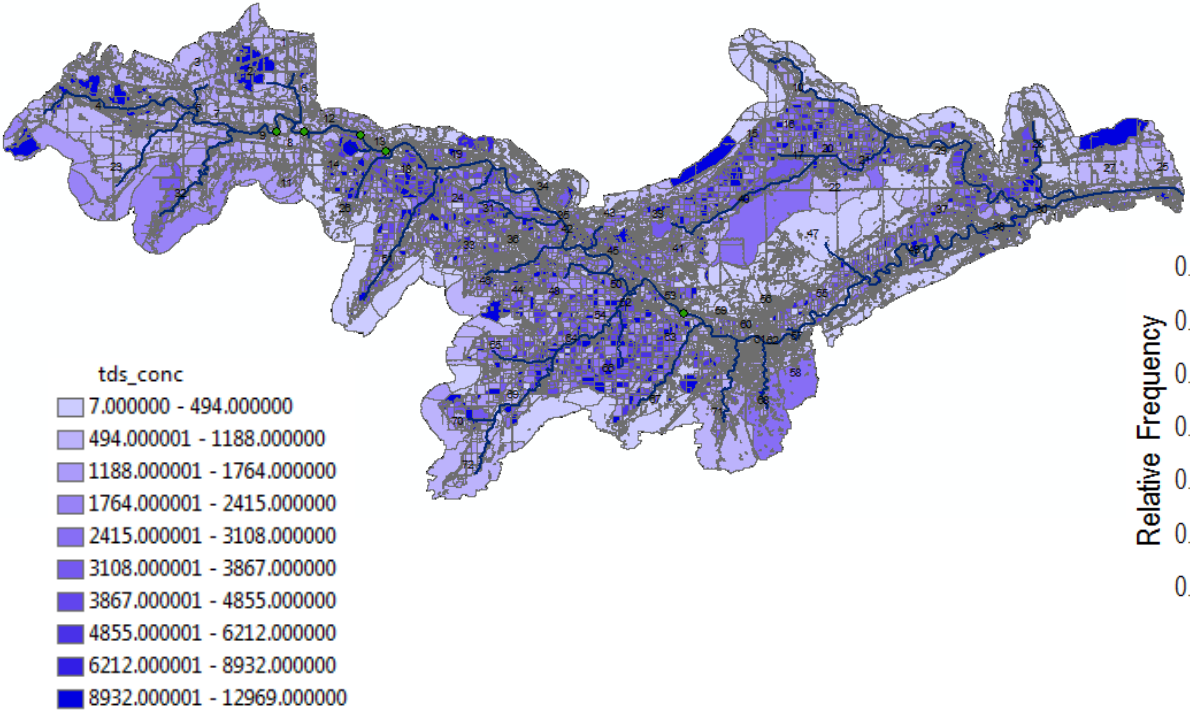
SWAT Model

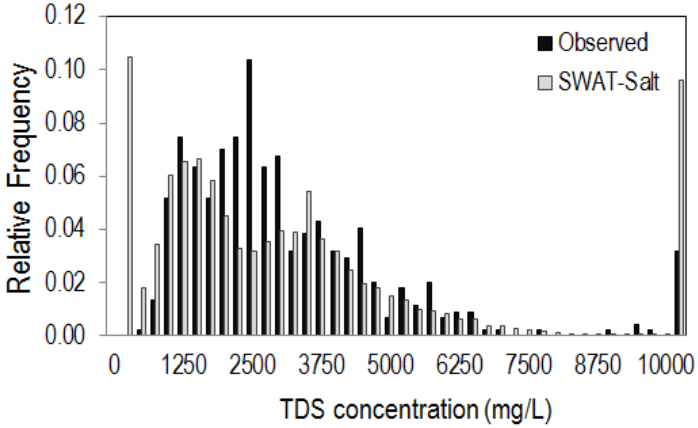


Results

Groundwater Concentration

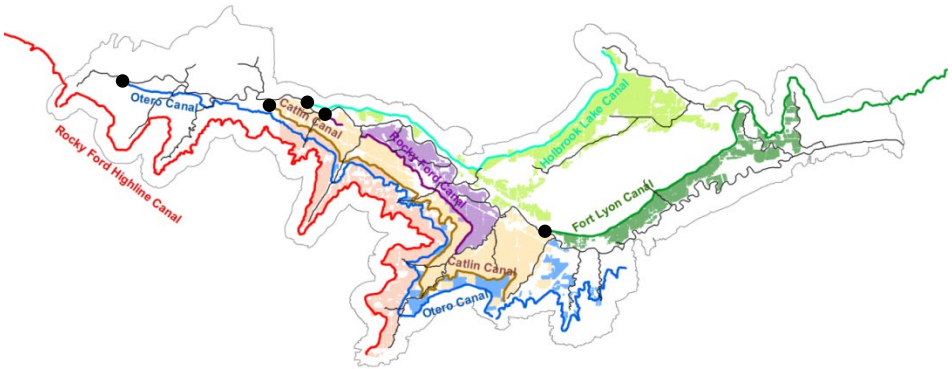
TDS (mg/L)





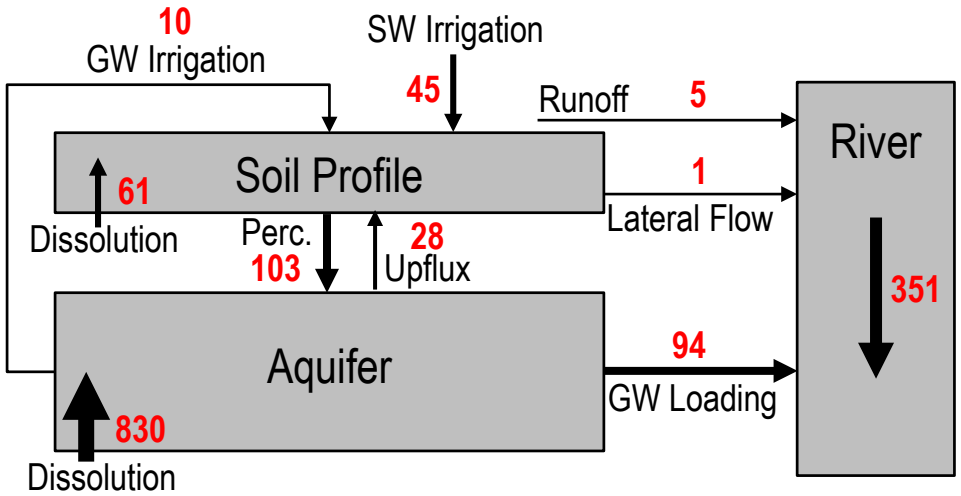
Application to Irrigated Region

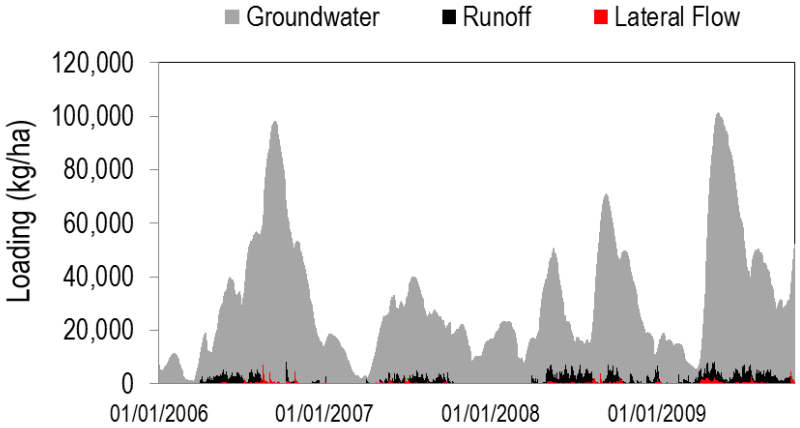
SWAT Model



Results

Mass Balance Components (total salt)





Future Work

- Further Calibration and Testing of Model
- Further assessment of salinity stress on crop yield
- Assess Salt Transport and Crop Yield under changes in climate, land use, and water management strategies