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Prairies without irrigation

Prairies with irrigation

Integrated studies

Groundwater to sustain agriculture in the Midwest's prairies: Interdisciplinary, integrated modeling approaches

David R. Steward, Ph.D., P.G., Professor
Kansas State University
Department of Civil Engineering

Some References

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Tall Grass Prairie (East)

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Prairies without irrigation

Prairies with irrigation

Integrated studies

Short Grass Prairie (West)

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Prairies without irrigation

Prairies with irrigation

Integrated studies

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Conceptual model

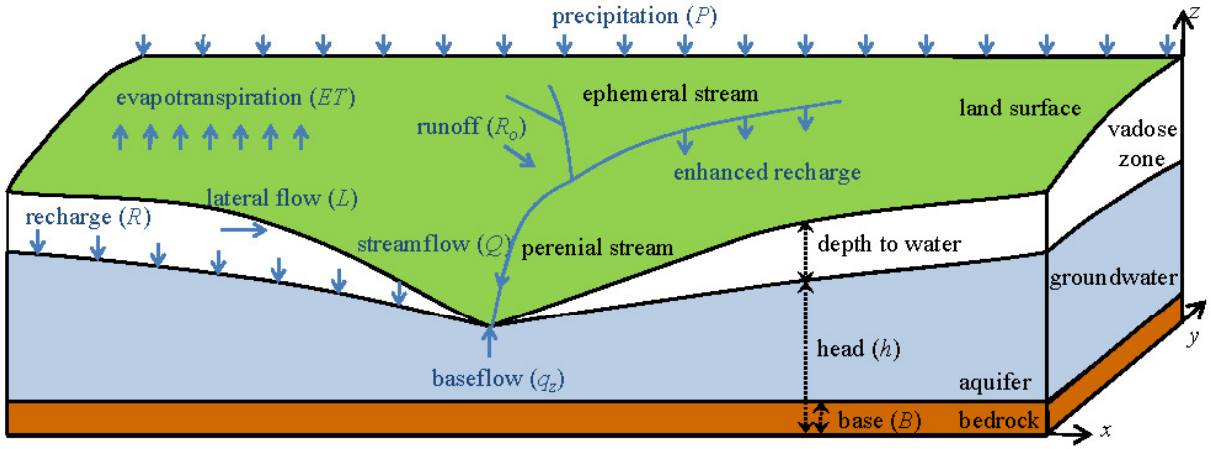
Prairies without irrigation

Prairies with irrigation

Integrated studies

(a) Perennial streams in the lowland prairie, with the Kansas River valley in the far distance to the left.

(b) Ephemeral streams in the upland prairie.



(c) Conceptual model and variables.

Steward, Yang, Lauwo, Staggenborg, Macpherson, Welch (2011)

Soils of the northern Flint Hills

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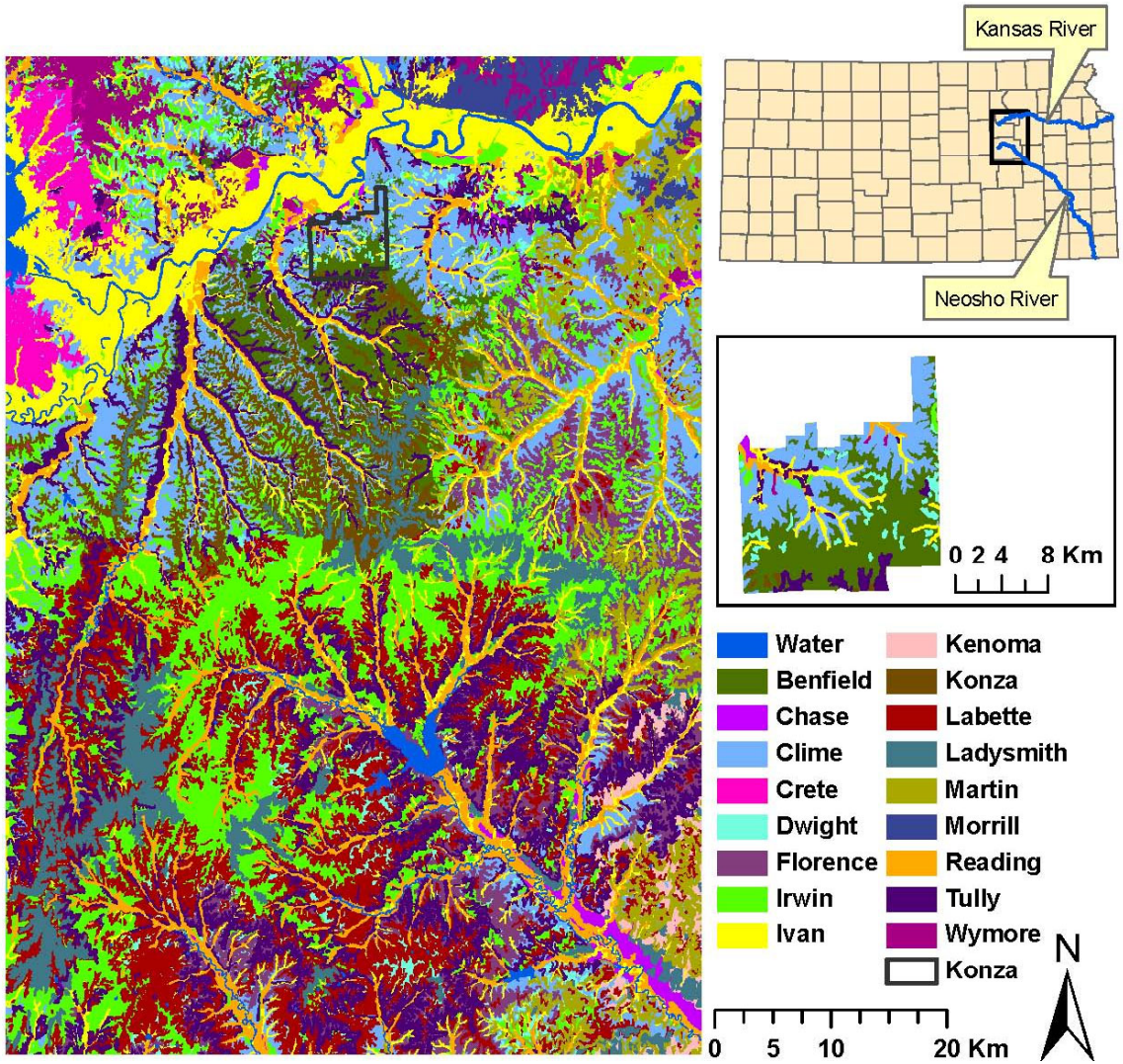
Prairies without irrigation

Prairies with irrigation

Integrated studies



Steward, Yang, Lauwo, Staggenborg, Macpherson, Welch (2011)

Surface water fluxes

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Partitioning precipitation

Prairies without irrigation

Prairies with irrigation

Integrated studies

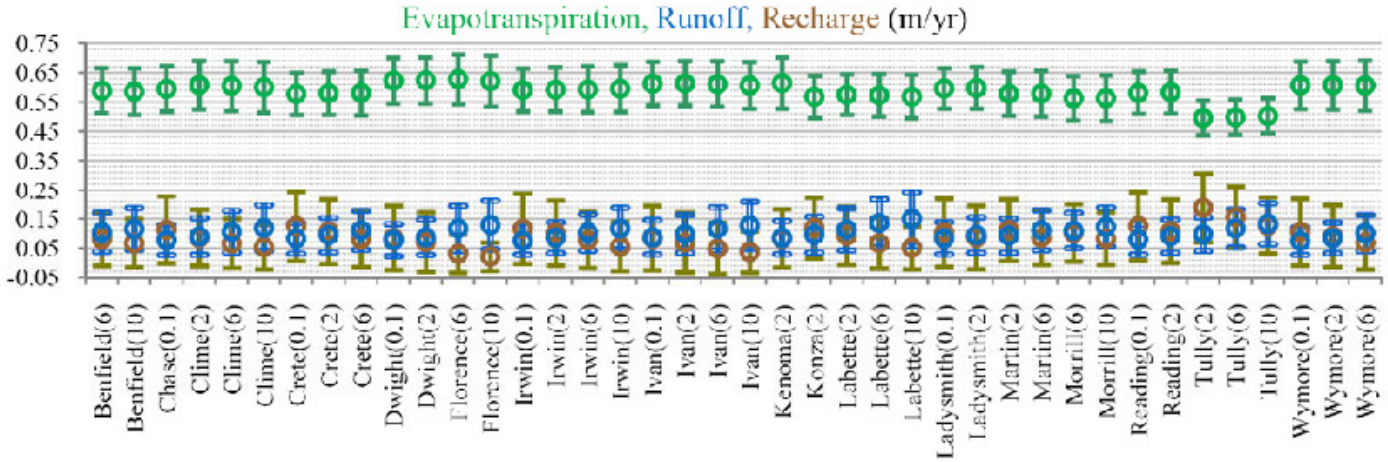

Fig. 4. Mean estimates for evapotranspiration, runoff, and recharge plus and minus one standard deviation for the soils of the study region.

Steward, Yang, Lauwo, Staggenborg, Macpherson, Welch (2011)

Groundwater recharge

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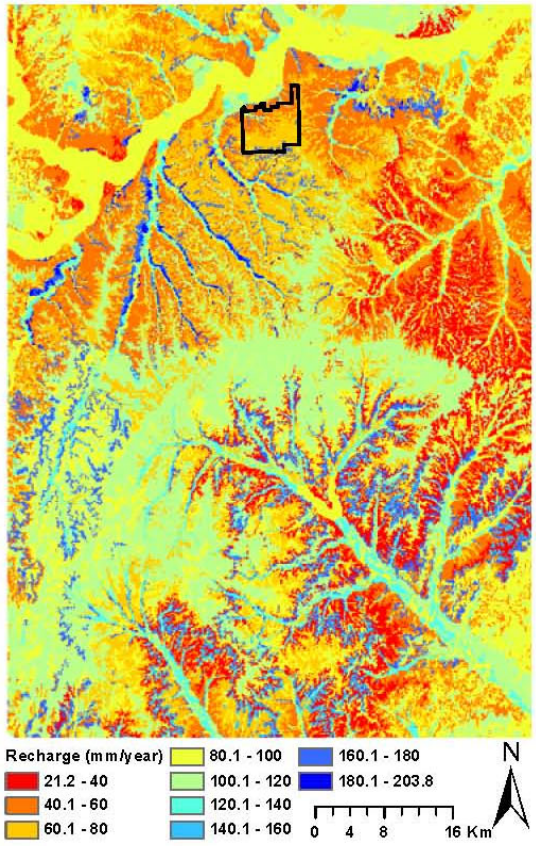
Prairies without irrigation

Prairies with irrigation

Integrated studies



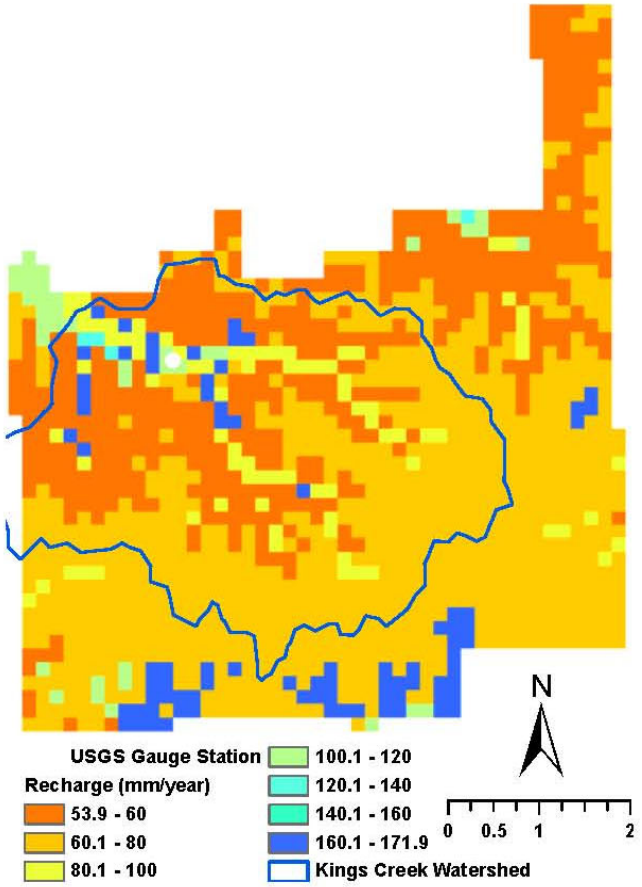


Fig. 5. Spatial distribution of recharge in the study region and at Konza LTER

Steward, Yang, Lauwo, Staggenborg, Macpherson, Welch (2011)

Depth to water

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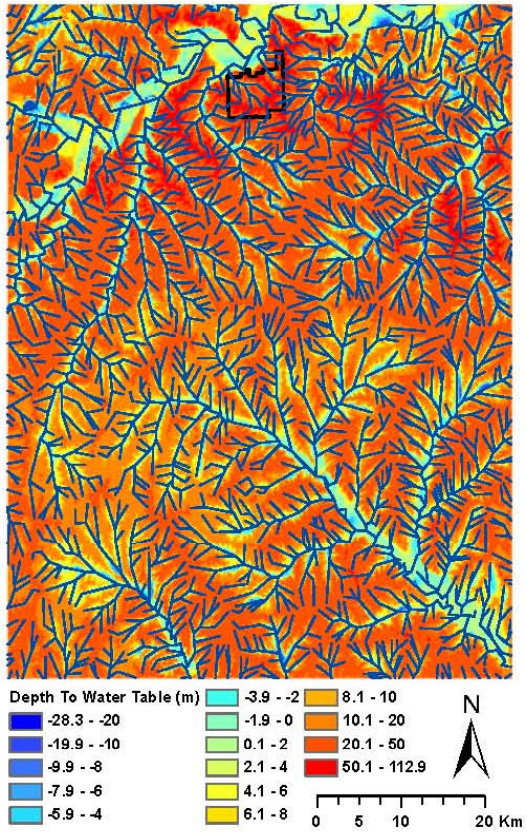
Prairies without irrigation

Prairies with irrigation

Integrated studies



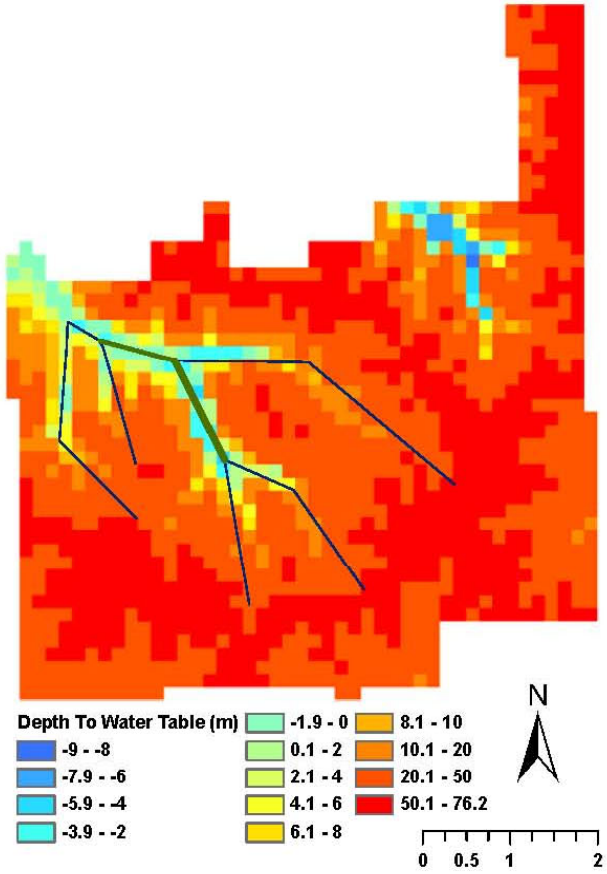


Fig. 8. Depth to water in the study region and at Konza LTER

Steward, Yang, Lauwo, Staggenborg, Macpherson, Welch (2011)

Groundwater models

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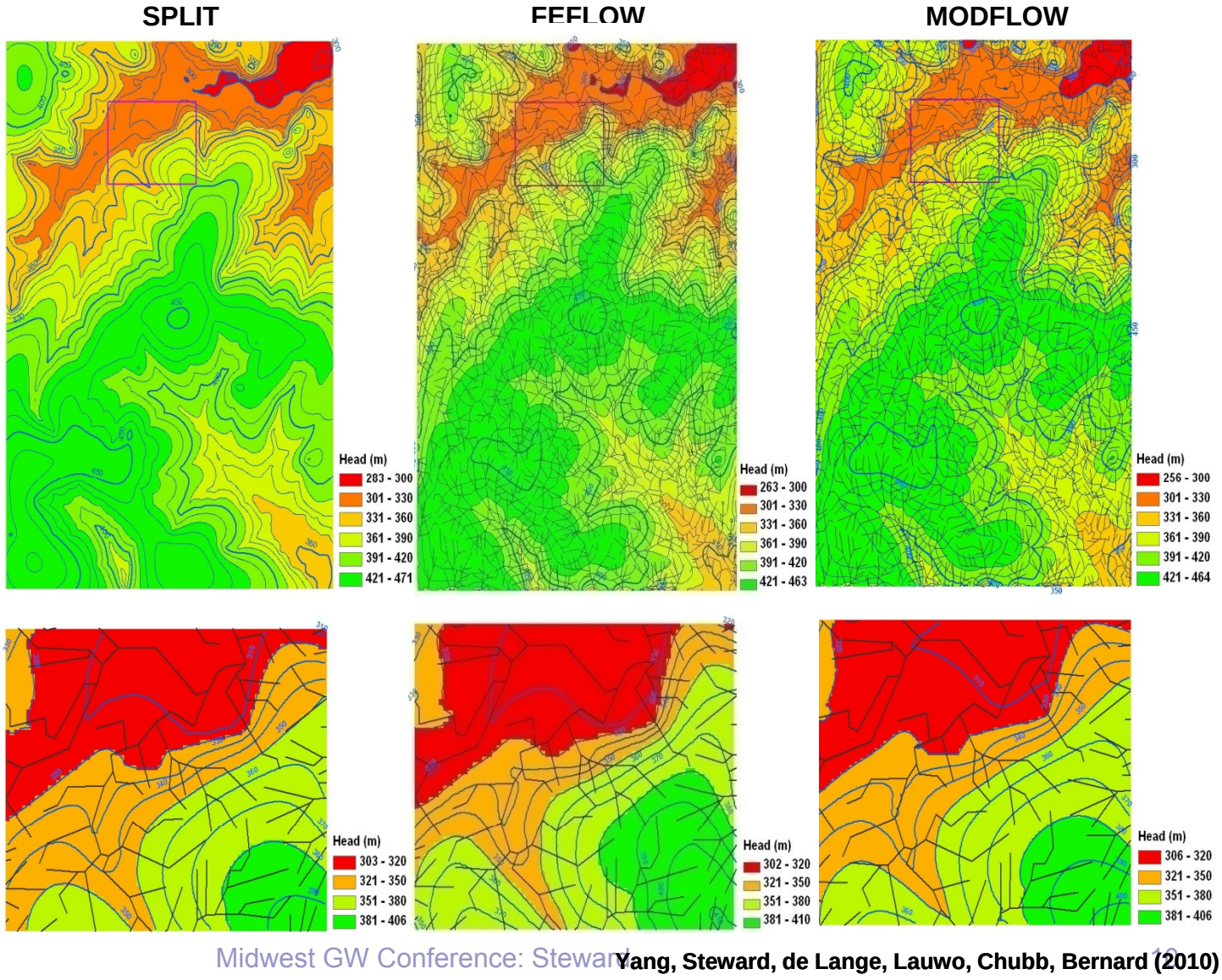
Different model; same results

Prairies without irrigation

Prairies with irrigation

Integrated studies



Yang, Steward, de Lange, Lauwo, Chubb, Bernard (2010)

Western Kansas: High Plains Dryland Wheat

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Prairies without irrigation

Prairies with irrigation

Integrated studies

Western Kansas: High Plains Irrigated Corn

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Prairies without irrigation

Prairies with irrigation

Integrated studies

Groundwater Depletion

Estimated Usable Lifetime

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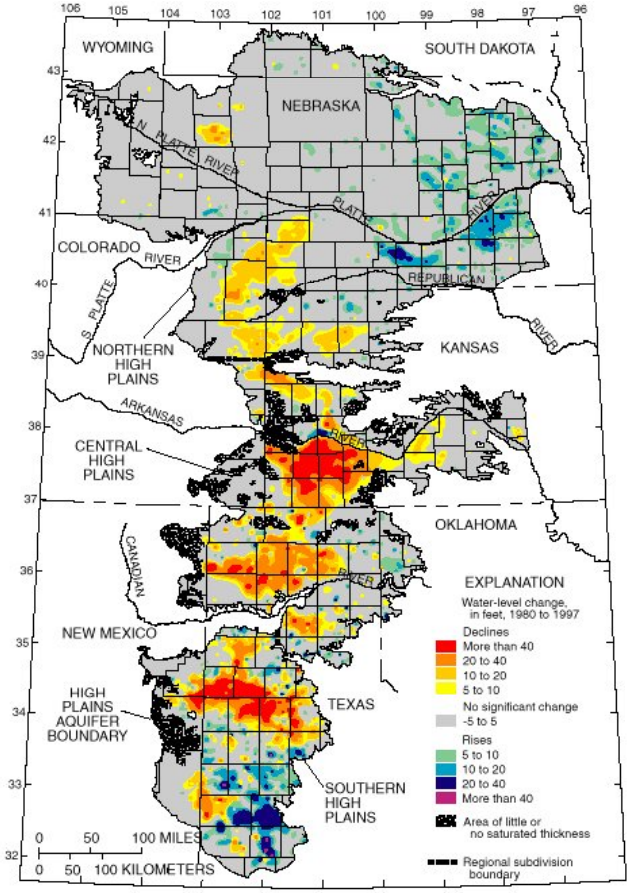
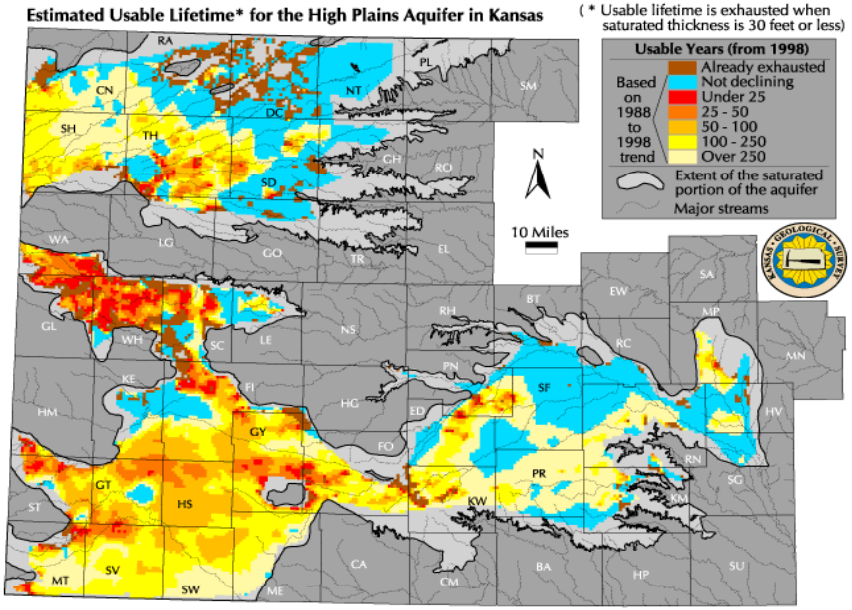
Prairies without irrigation

Prairies with irrigation

Integrated studies



Source: USGS (water.usgs.gov)



Source: KGS (www.kgs.ukans.edu)

Ogallala Aquifer

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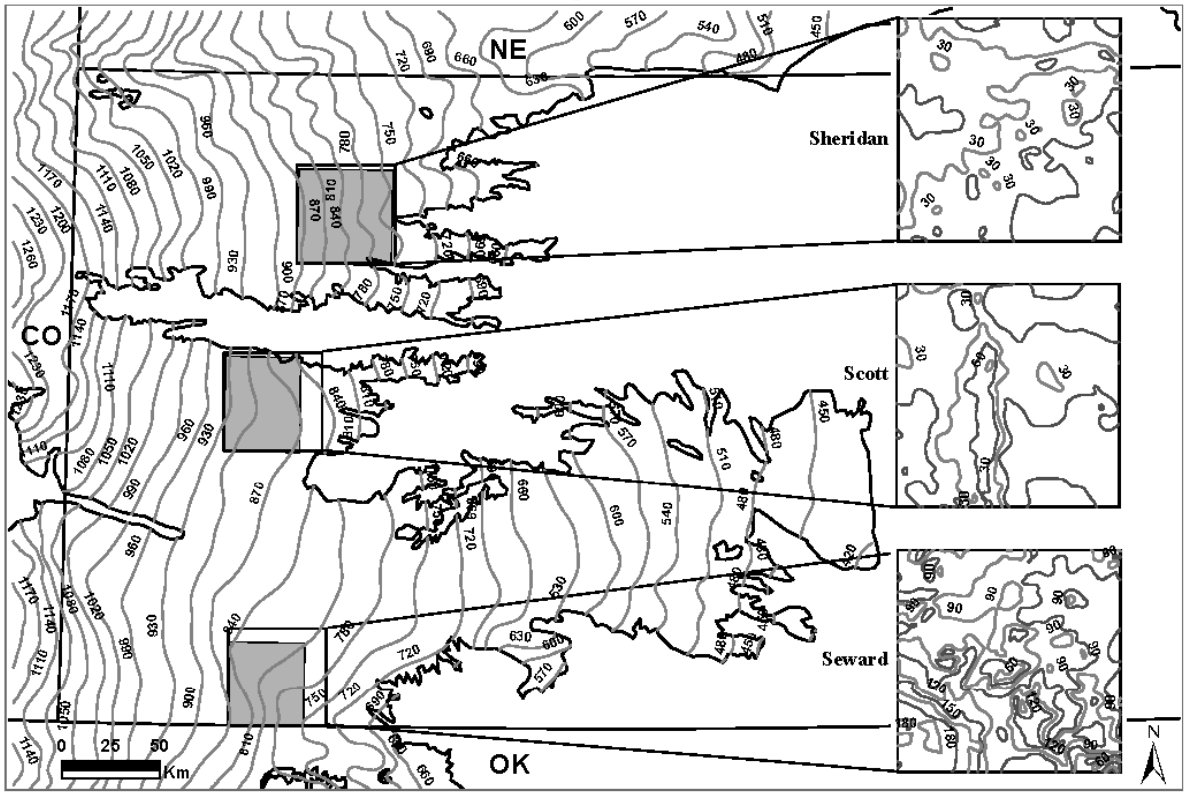
Ogallala Aquifer with sloping base

Prairies without irrigation

Prairies with irrigation

Integrated studies

Predevelopment groundwater elevation [m above m.s.l.] and predevelopment saturated thickness [m] in three s regions.



Wells and observed changes in saturated thickness ΔH [m] from predevelopment to 2005

Steward, Yang, Chacon (2009)

Ogallala Aquifer

Water Use

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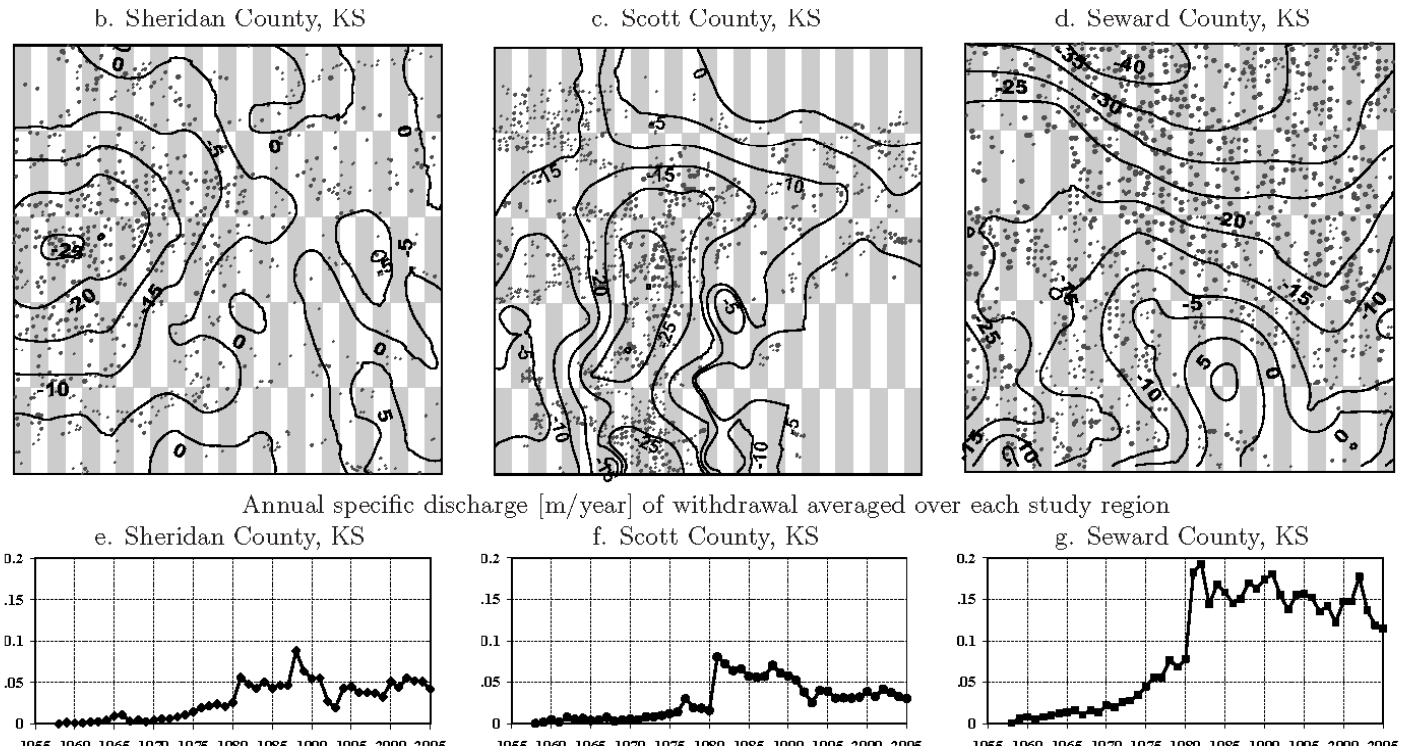
Prairies without irrigation

Prairies with irrigation

Integrated studies



Steward, Yang, Chacon (2009)

Ogallala Aquifer

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Groundwater Declines: Existing and Projected

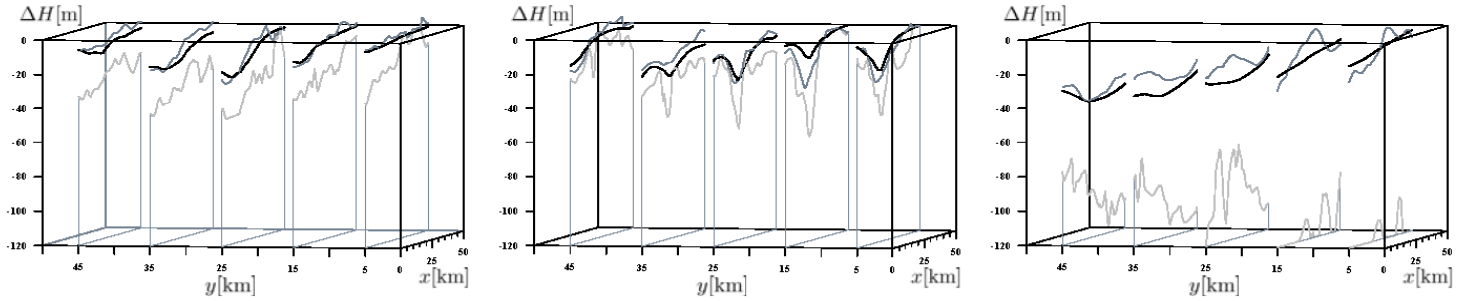
Prairies without irrigation

Prairies with irrigation

Integrated studies

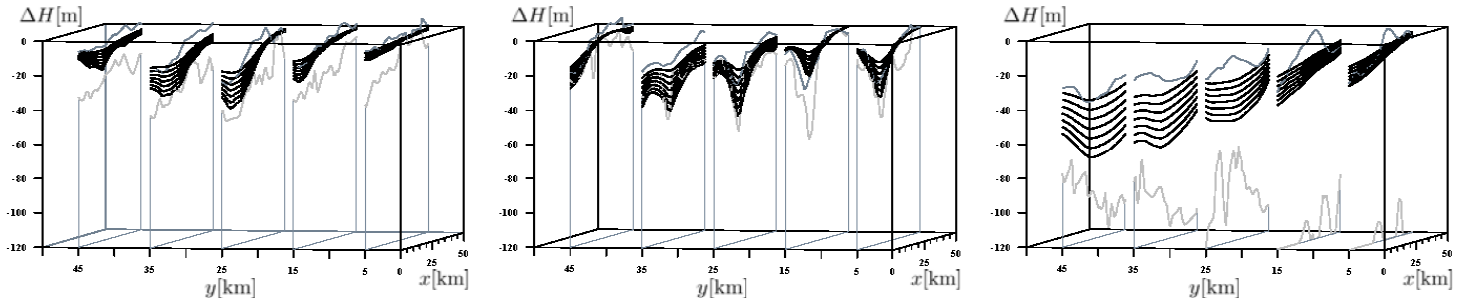
Modeled and observed change in saturated thickness over the time of historical water-use records (1958–2005)

a. Sheridan County, KS b. Scott County, KS c. Seward County, KS



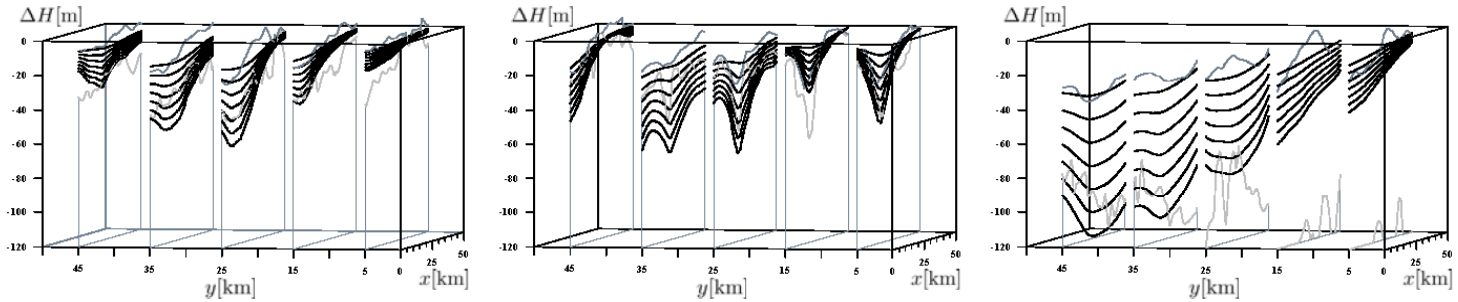
Forecasted change in saturated thickness occurring 20 years after historical water-use records (2025)

d. Sheridan County, KS e. Scott County, KS f. Seward County, KS



Forecasted change in saturated thickness occurring 50 years after historical water-use records (2055)

g. Sheridan County, KS h. Scott County, KS i. Seward County, KS



Steward, Yang, Chacon (2009)

Conceptual Model

Well-Parcel Relationship

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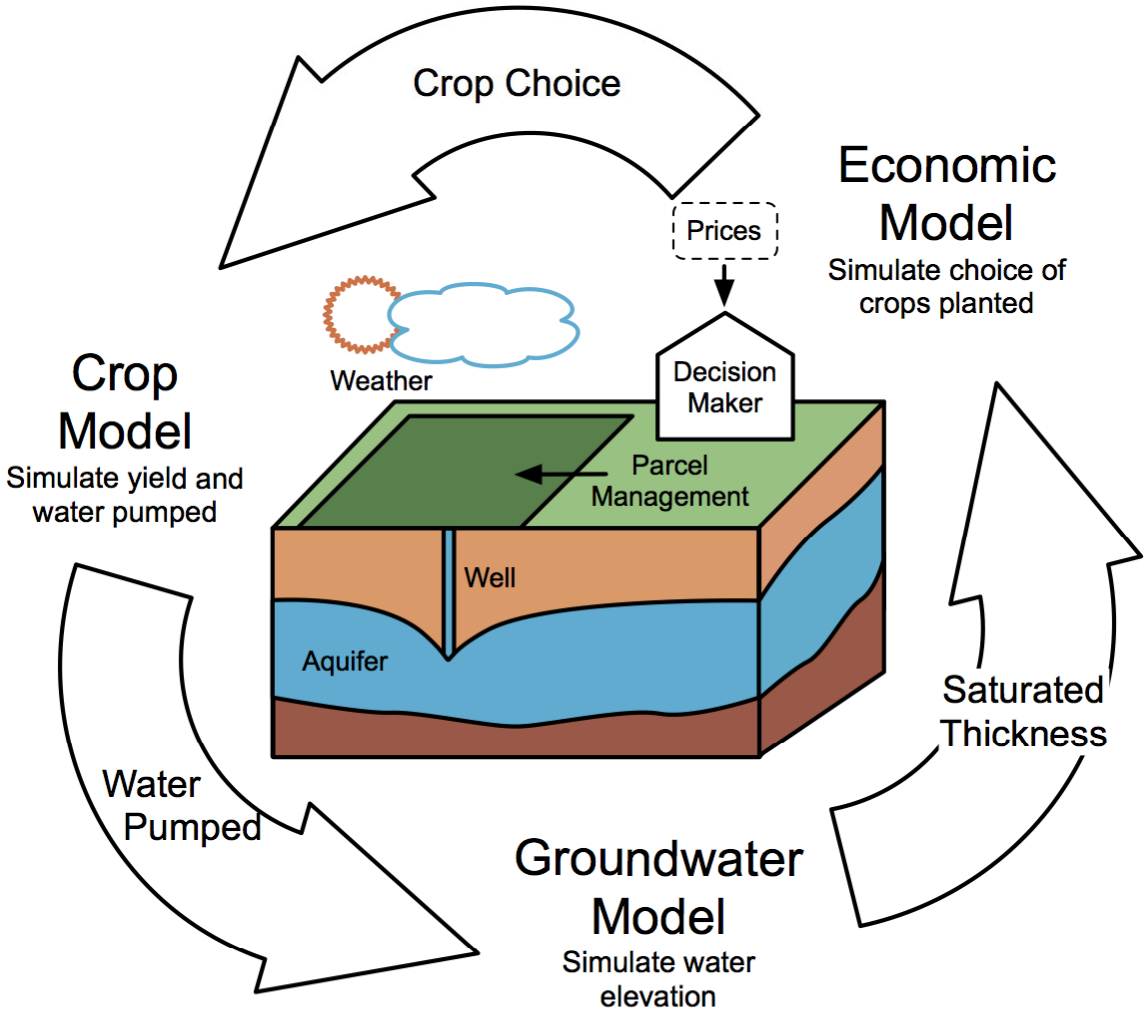
Prairies without irrigation

Prairies with irrigation

Integrated studies



Bulatewicz, Allen, Peterson, Staggenborg, Welch and Steward (2012)

Open Modeling Interface (OpenMI)

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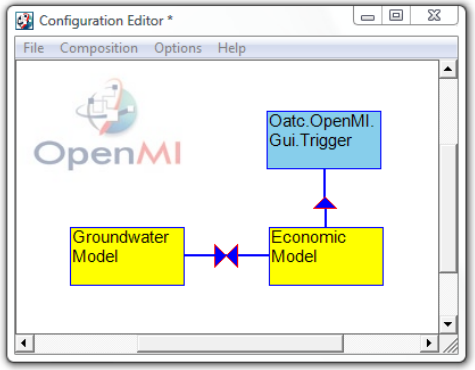
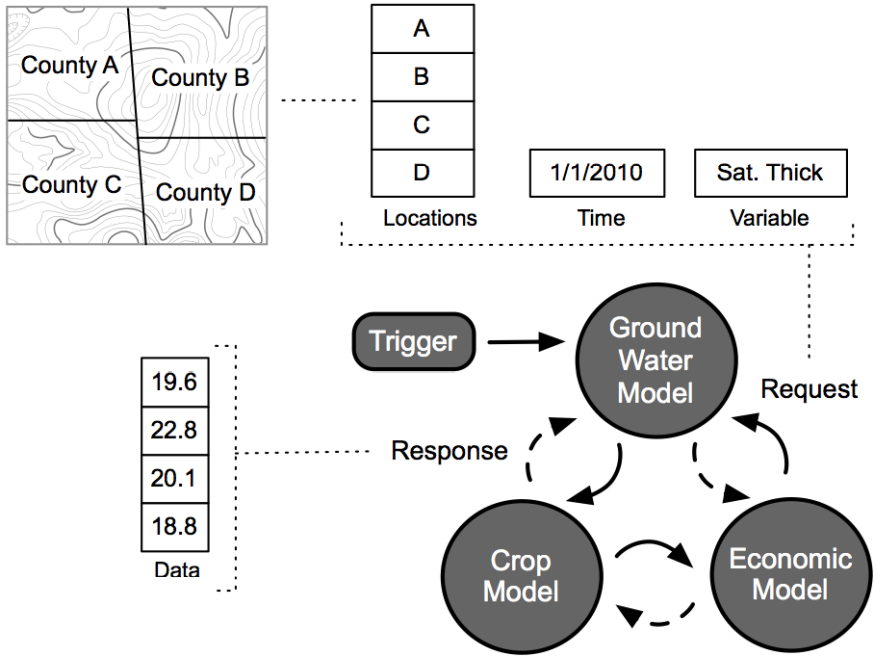
Prairies without irrigation

Prairies with irrigation

Integrated studies

- Developed as part of the EU's Water Framework Directive
- Requires a model to be able to answer the question: What is the value of quantity X at time Y and place Z?
- Allows for highly-automated integration





Bulatewicz, Allen, Peterson, Staggenborg, Welch and Steward (2012)

Linked Models

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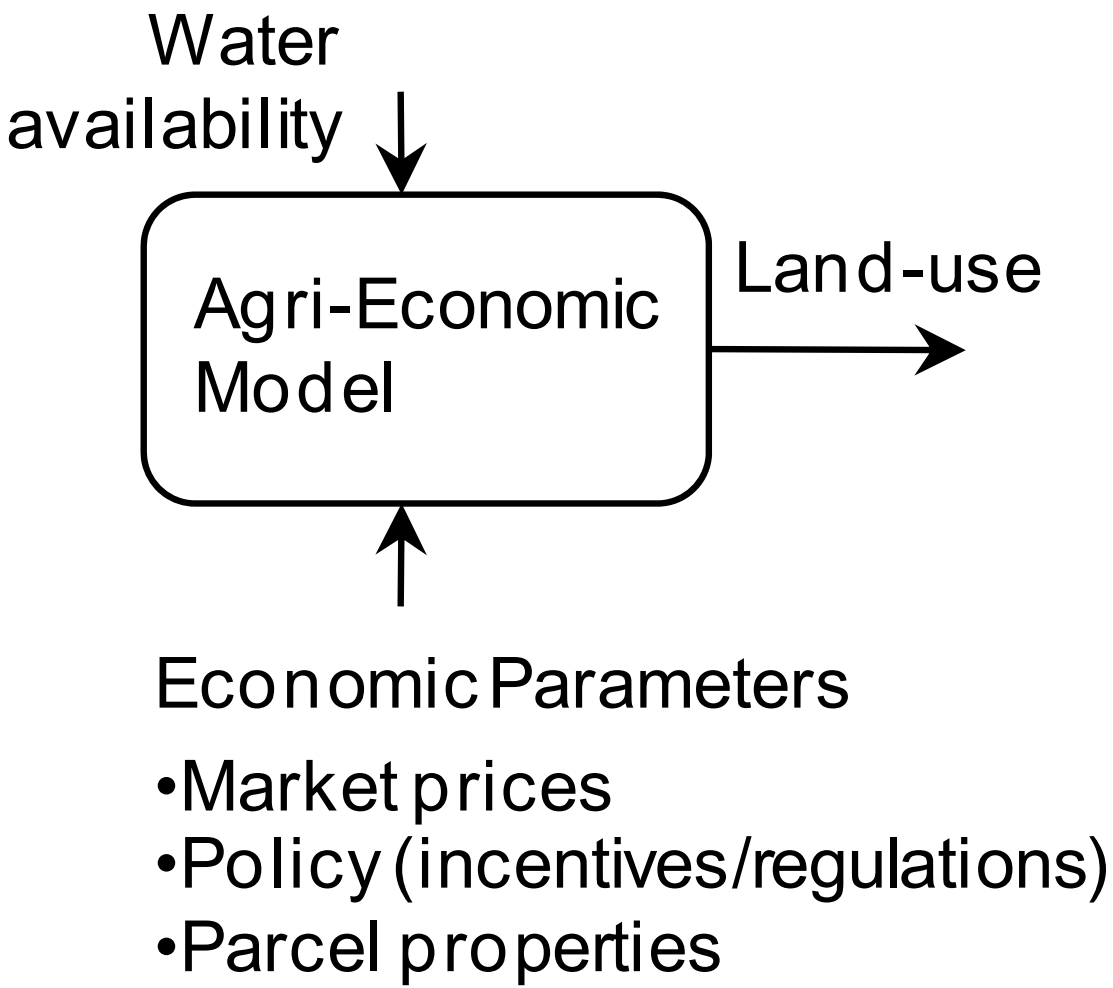
Economics

Prairies without irrigation

Prairies with irrigation

Integrated studies



Steward, Peterson, Yang, Bulatewicz, Herrera, Mao, Henderson (2009)

Linked Models

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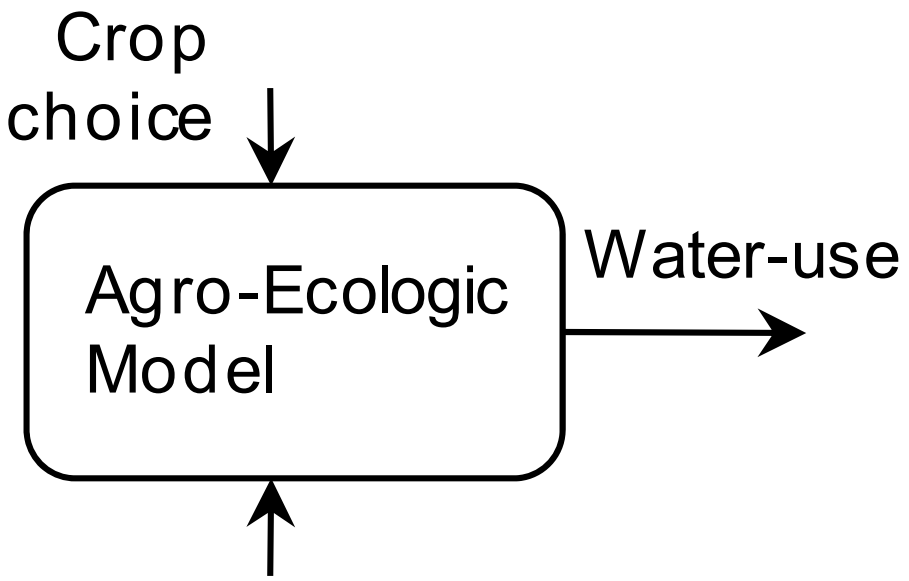
Agriculture

Prairies without irrigation

Prairies with irrigation

Integrated studies



Agriculture Parameters

- Crops
- Management choices
- Soils
- Weather

Bulatewicz, Jin, Staggenborg, Lauwo, Miller, Das, Andresen, Peterson, Steward and Welch (2009)

Linked Models

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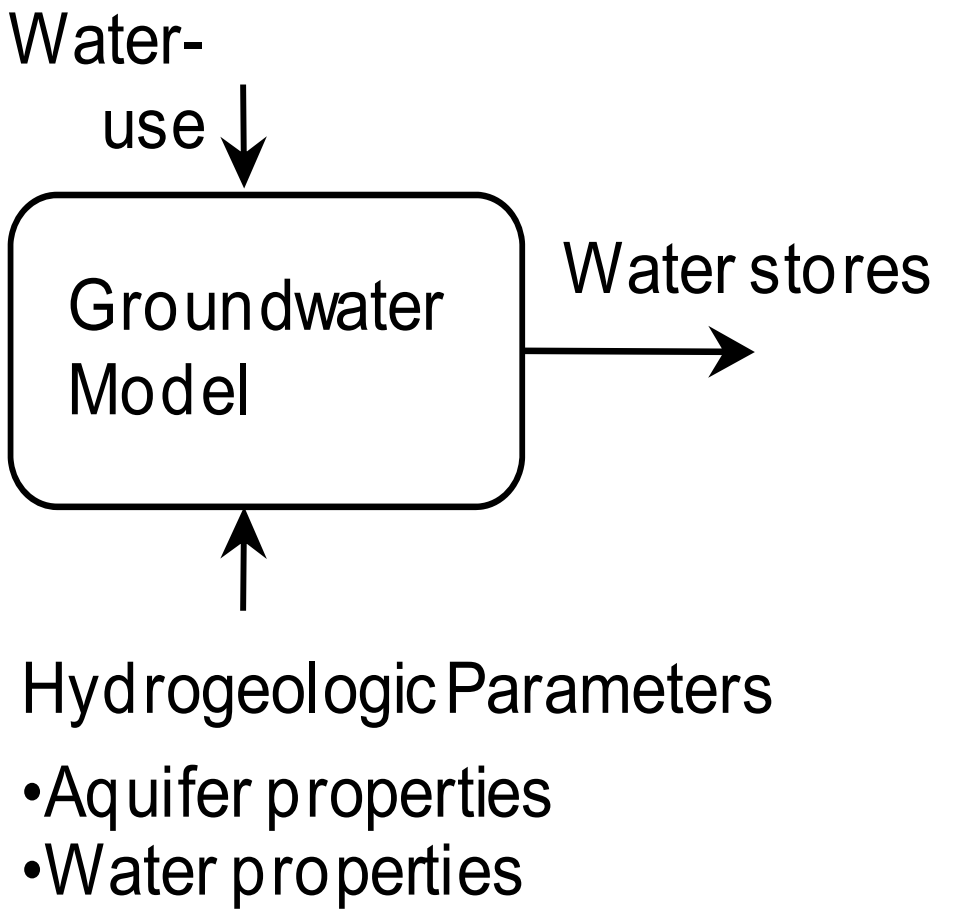
Groundwater

Prairies without irrigation

Prairies with irrigation

Integrated studies



Yang, Steward, de Lange, Lauwo, Chubb, Bernard (2010)

OpenMI Linkages

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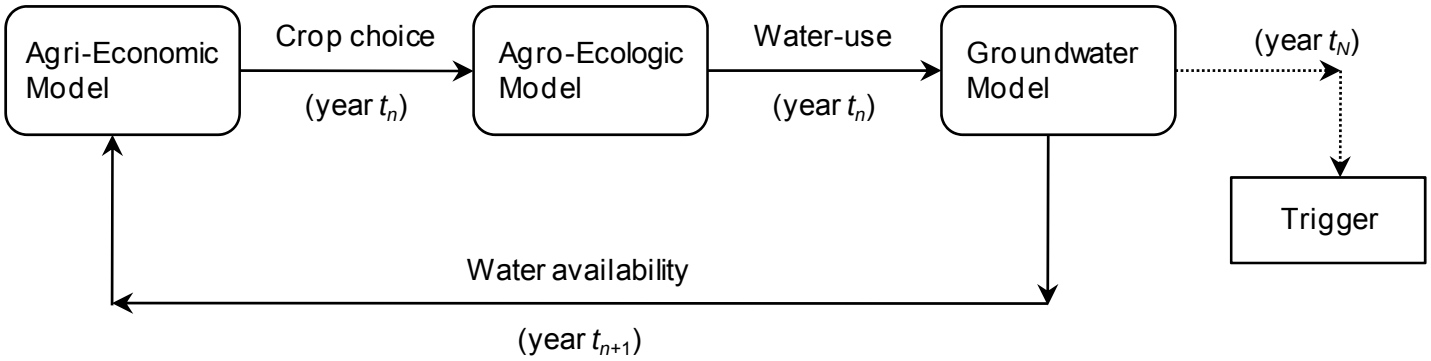
Prairies without irrigation

Prairies with irrigation

Integrated studies



Steward (2011)

- Matlab, Scilab, Python Inter-Operability

Bulatewicz, Allen, Peterson, Staggenborg, Welch and Steward (2012)

Integrated Model Forecasts

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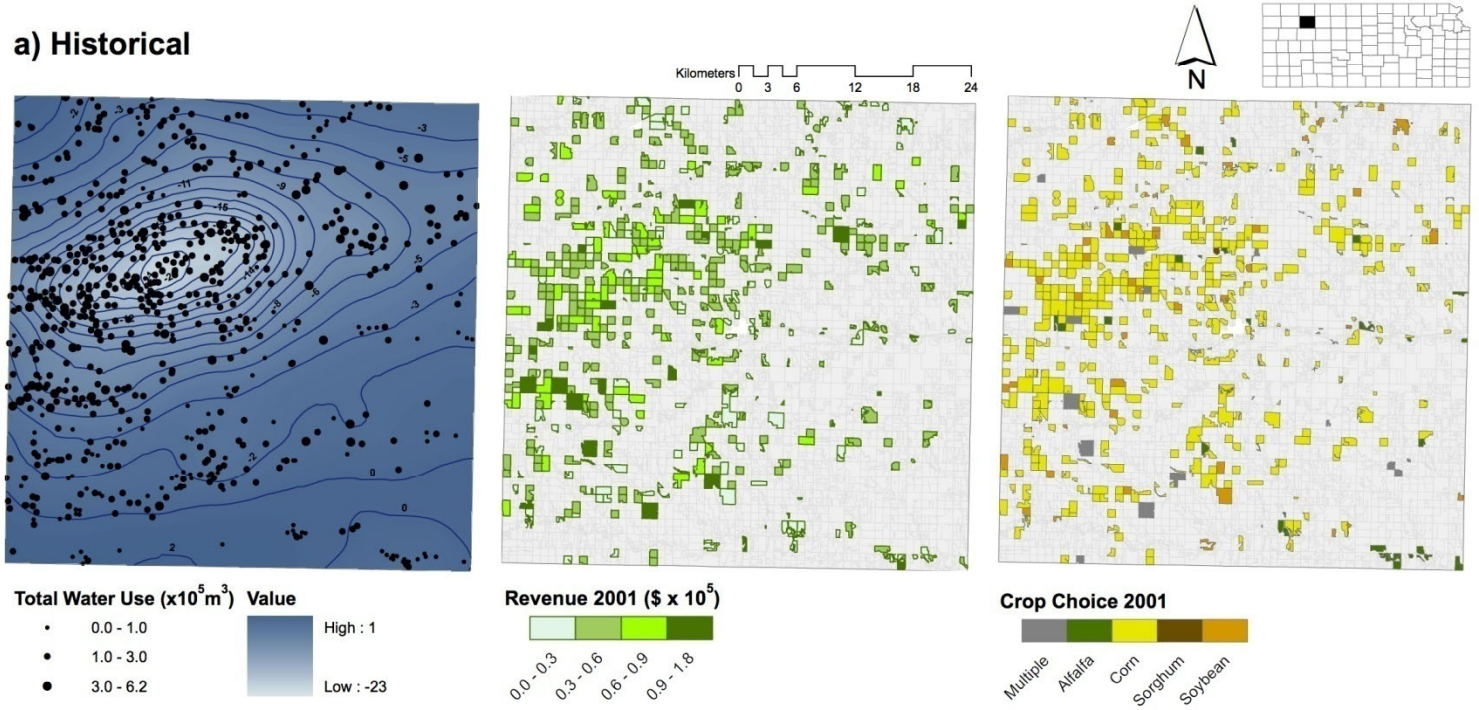
Retrospective study

Prairies without irrigation

Prairies with irrigation

Integrated studies



Bulatewicz, Allen, Peterson, Staggenborg, Welch and Steward (2012)

Integrated Model Forecasts

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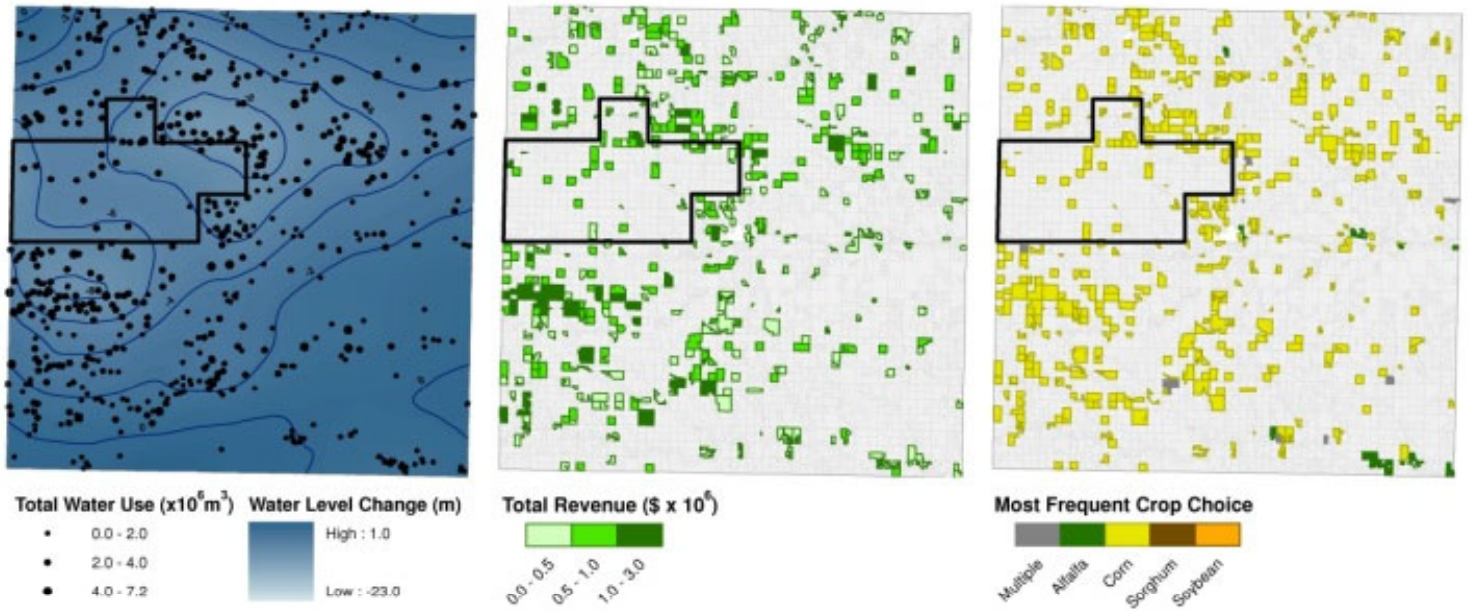
Prior appropriation in high priority area

Prairies without irrigation

Prairies with irrigation

Integrated studies

b) Regulation policy



Bulatewicz, Yang, Peterson, Staggenborg, Welch, S. M., and Steward (2011)

Integrated Model Forecasts

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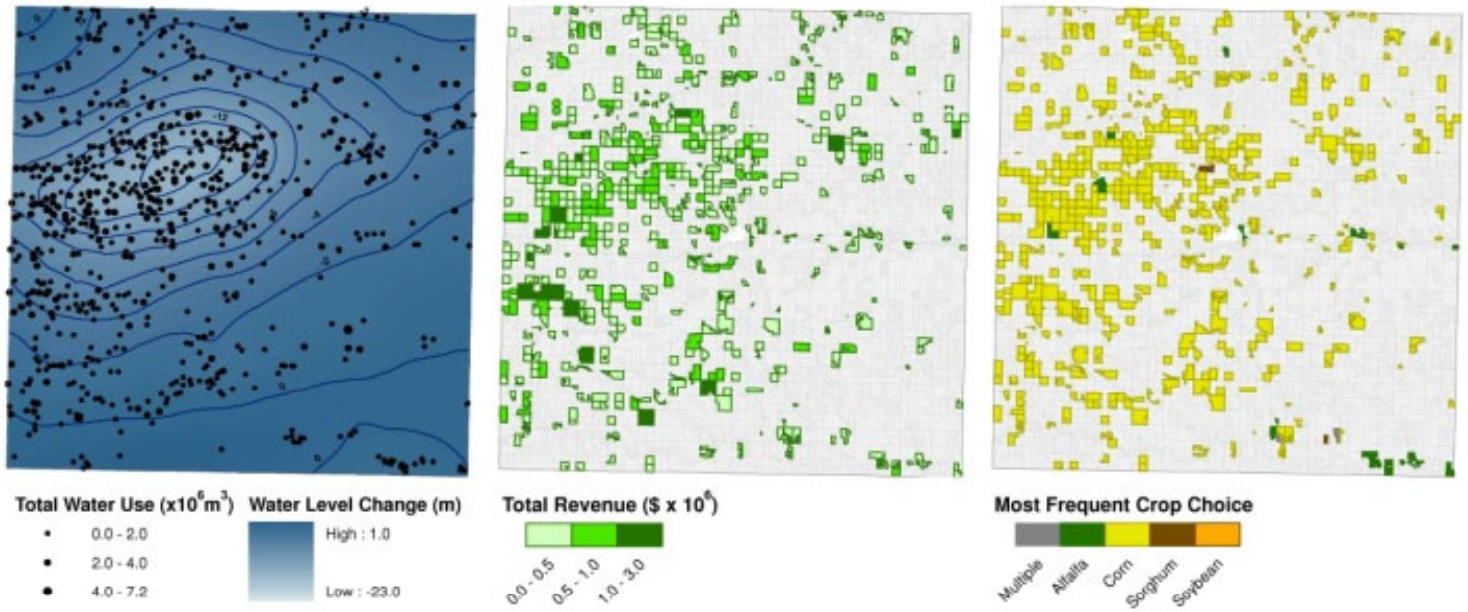
Water buyback over county

Prairies without irrigation

Prairies with irrigation

Integrated studies

c) Incentive policy



Bulatewicz, Yang, Peterson, Staggenborg, Welch, S. M., and Steward (2011)

Integrated Model Forecasts

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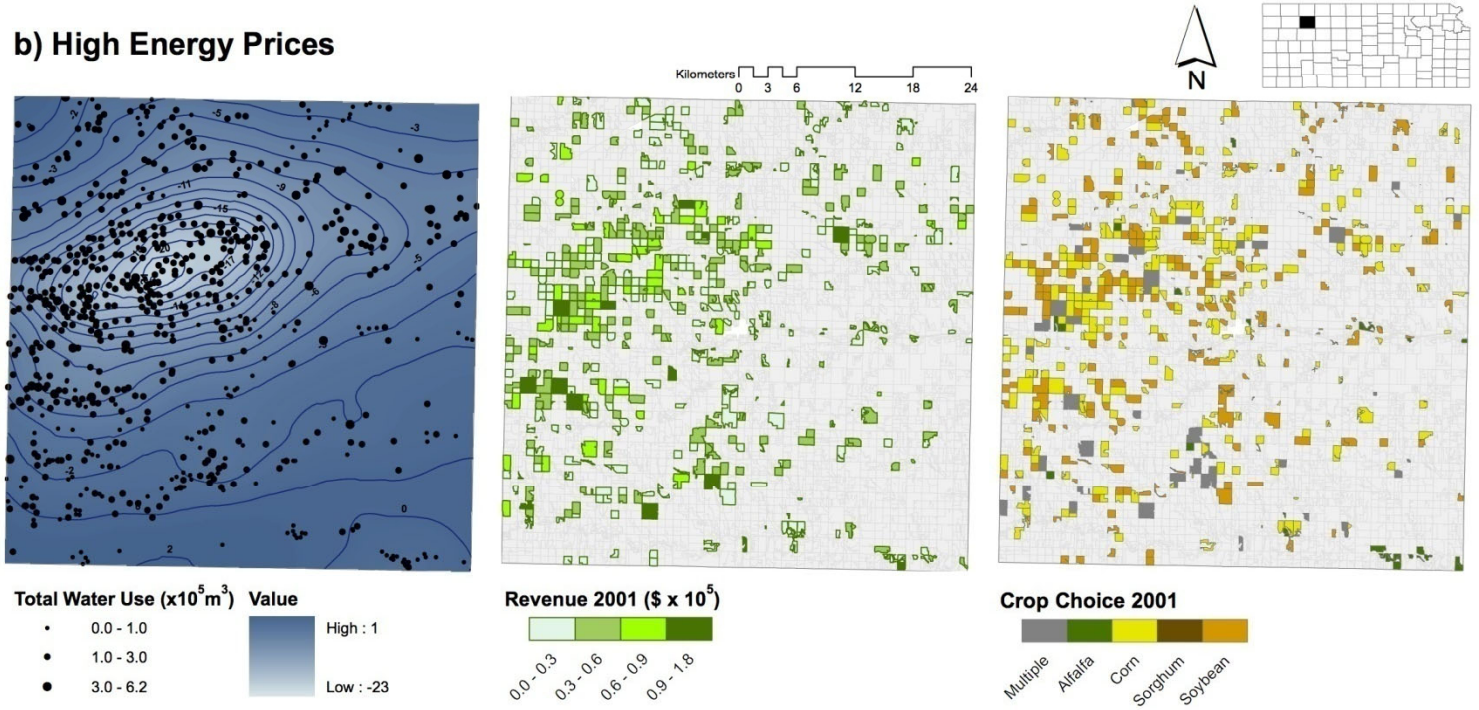
High energy prices

Prairies without irrigation

Prairies with irrigation

Integrated studies

b) High Energy Prices



Bulatewicz, Allen, Peterson, Staggenborg, Welch and Steward (2012)

What Is On Our Horizon?

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The Need for Groundwater in Irrigated Agriculture

Integrated Models and Approaches

OpenMI

Solving Problems

Integration to See More Clearly