

“Exploring a Water/Energy Trade-off in Regional Sourcing of Livestock Feed Crops”

Martin Heller

October 22, 2015

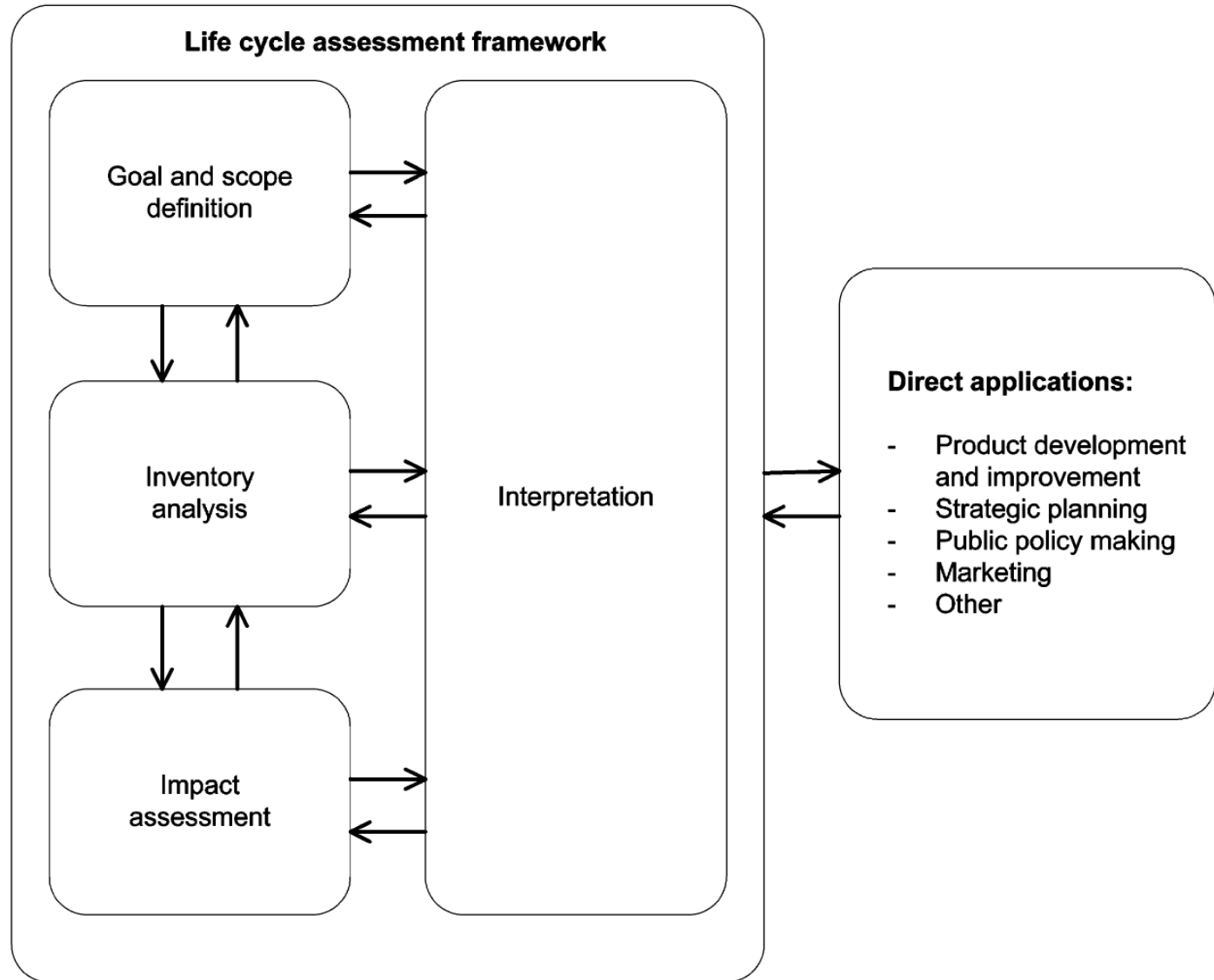


(Heller & Keoleian, Environ. Sci. Technol. 2011, 45, 10619–10626)

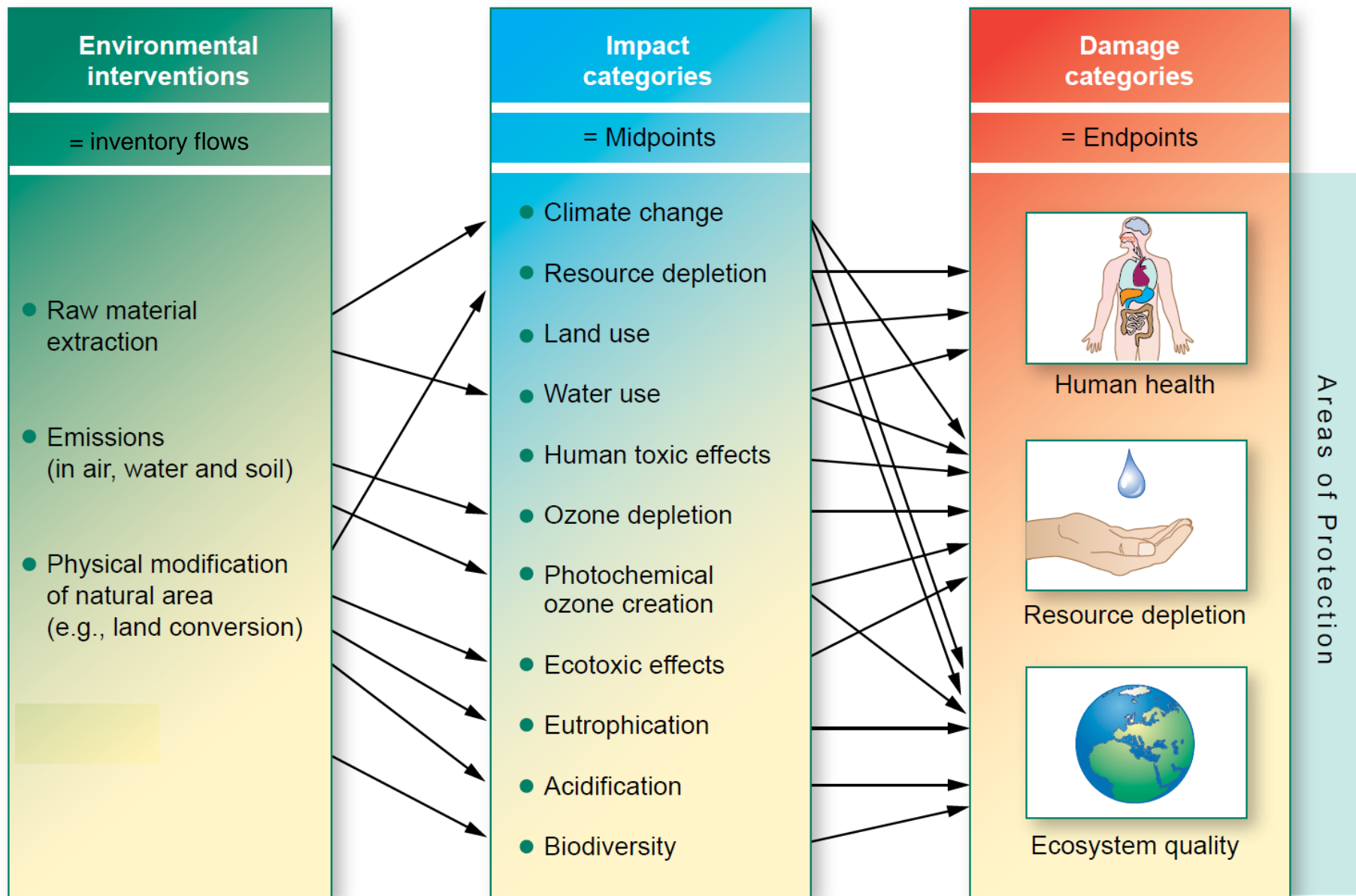


CENTER FOR SUSTAINABLE SYSTEMS
UNIVERSITY OF MICHIGAN

LIFE CYCLE ASSESSMENT: the “compilation and evaluation of the inputs and outputs and the potential environmental impacts of a product system throughout its life cycle” (ISO 14040)



Impact Assessment Methods



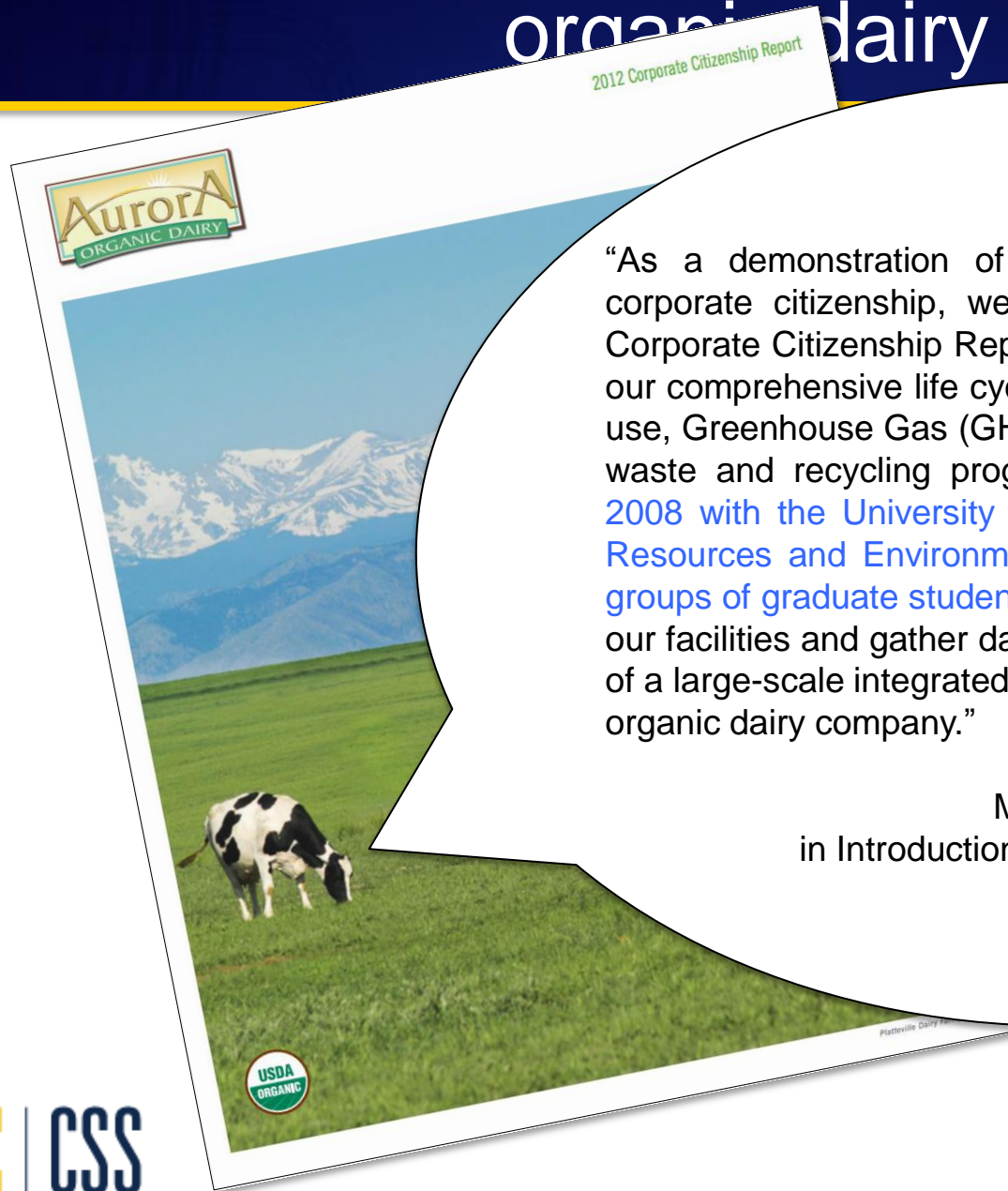
LCA of large-scale vertically integrated organic dairy



- 6 farms in CO and in TX
 - Over 20,000 milking cows
- Ultra-pasteurization (UP) milk plant in CO
 - Produces over 22 million gallons of milk annually
- Largest provider of U.S. private label organic milk
- 3 successive UM SNRE Master's Projects



LCA of large-scale vertically integrated organic dairy

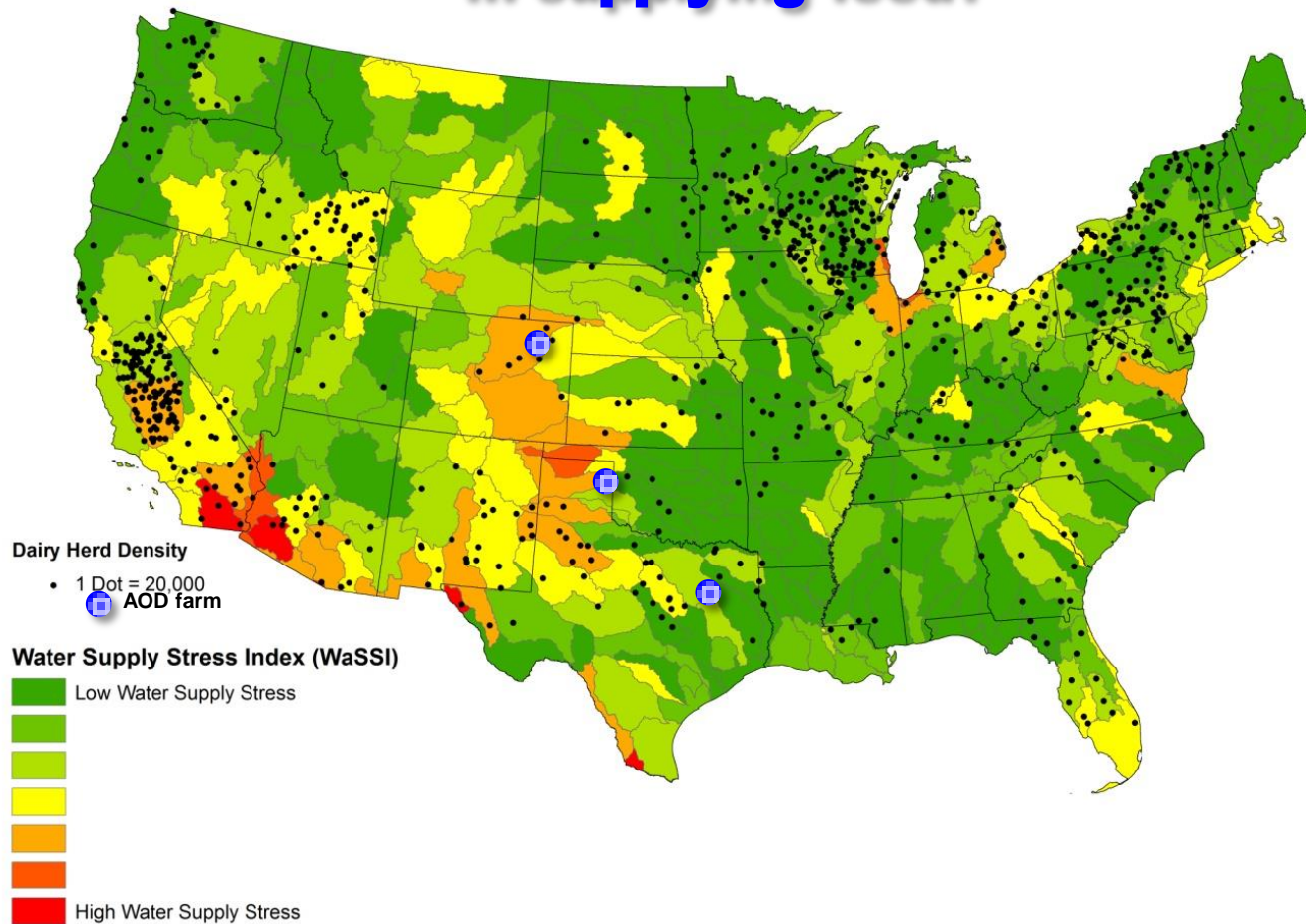


“As a demonstration of our steadfast commitment to corporate citizenship, we have developed our first-ever Corporate Citizenship Report. This report contains data on our comprehensive life cycle assessment (LCA) for energy use, Greenhouse Gas (GHG) emissions, water use, landfill waste and recycling programs. We started this work in 2008 with the University of Michigan’s School of Natural Resources and Environment. Each year, for three years, groups of graduate students came out to Colorado to study our facilities and gather data to complete the first ever LCA of a large-scale integrated organic dairy company.”

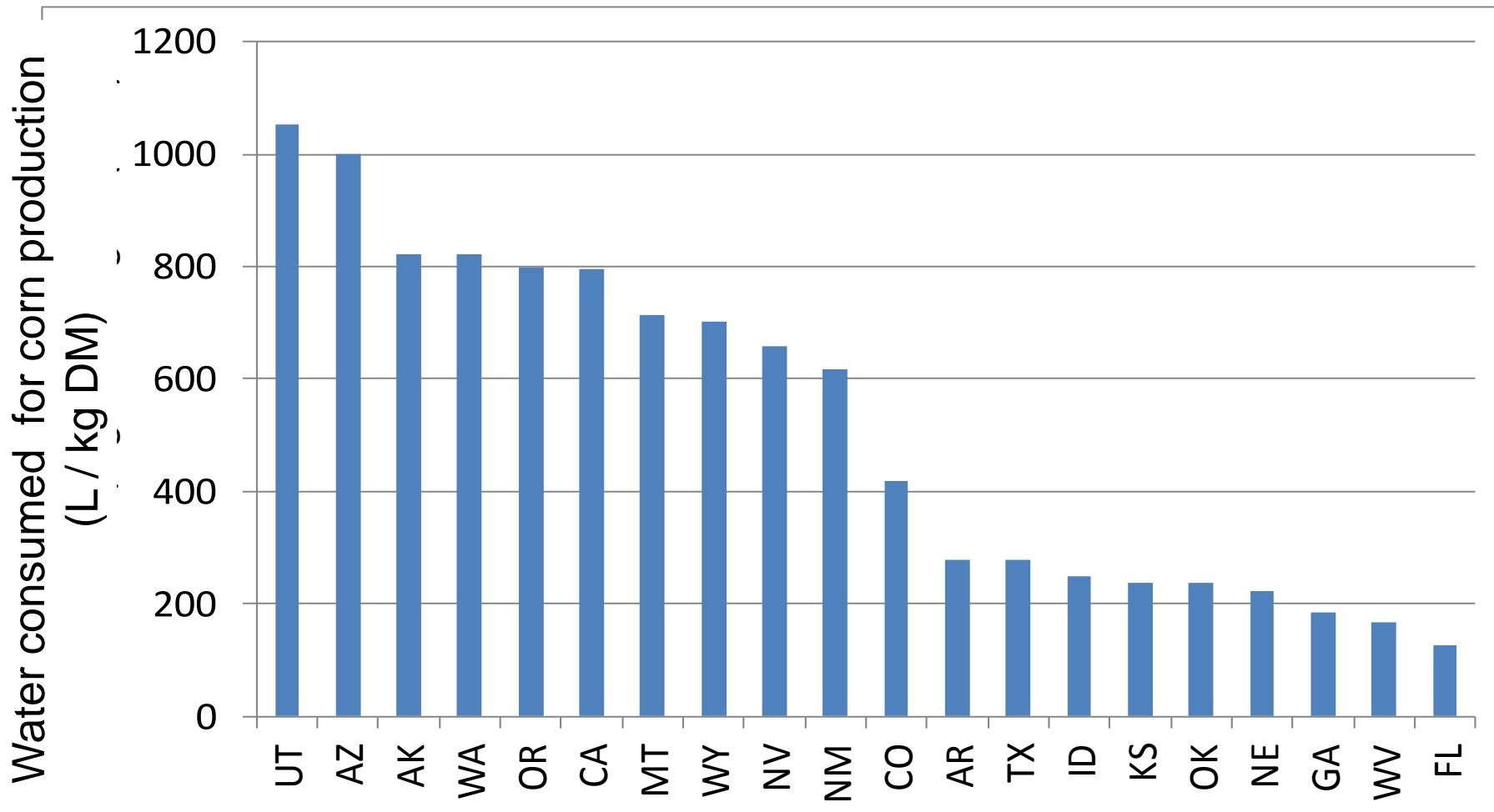
Marc Peperzak, Chairman & CEO
in Introduction to Corporate Citizenship Report

Dairies in water stressed regions

Where is the trade-off between transportation energy and water use in supplying feed?



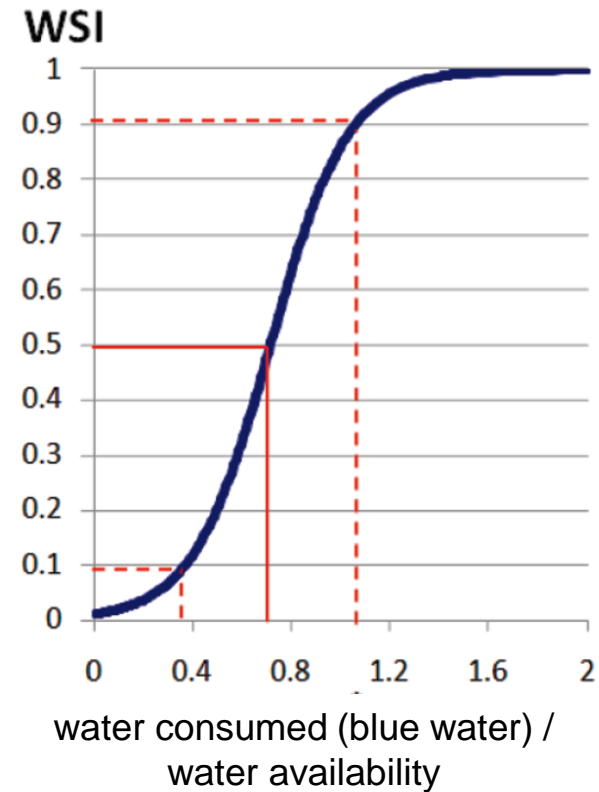
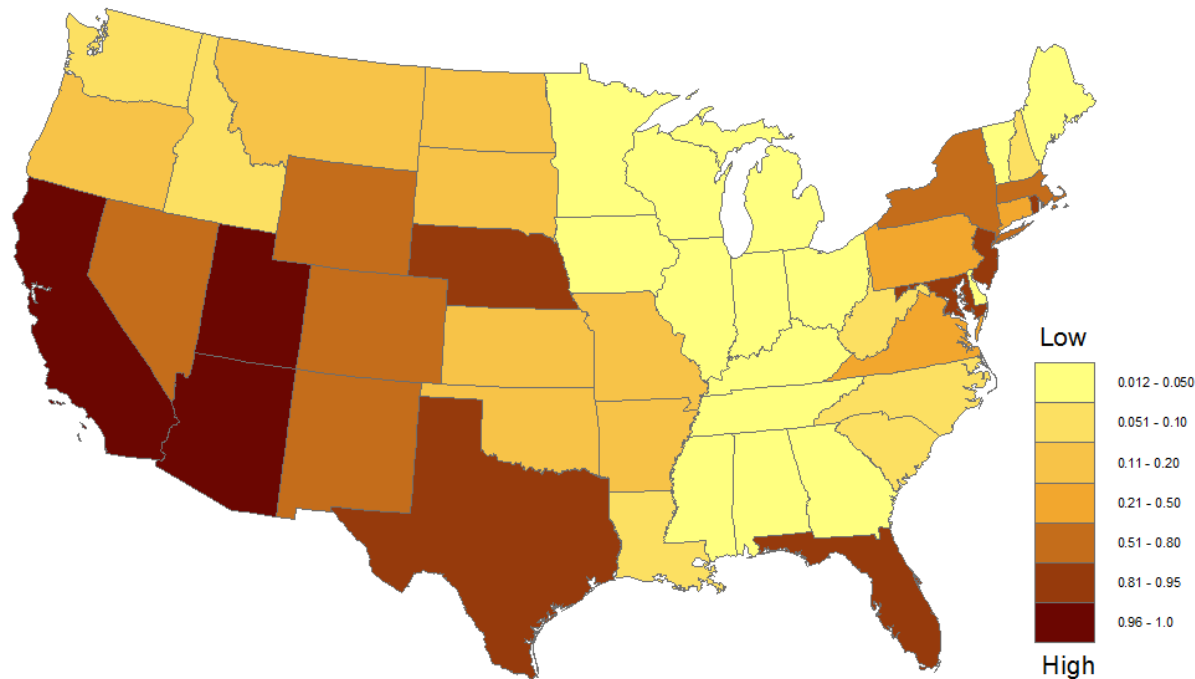
Inventory varies: corn irrigation



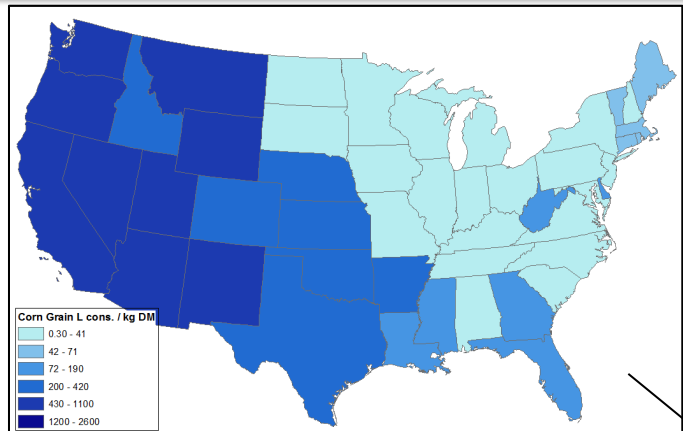
Source: USDA Farm and Ranch Irrigation Survey (FRIS) (1998-2008 avg.)

Impact varies: water stress

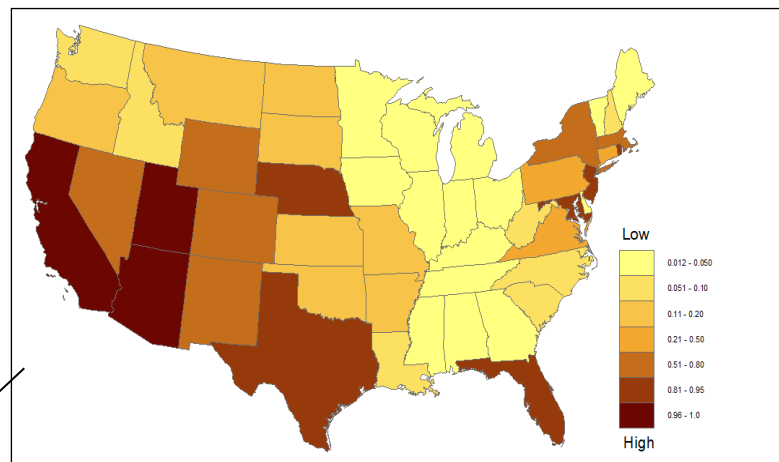
Water Stress Index (WSI) represents competition for water, as a function of use and availability



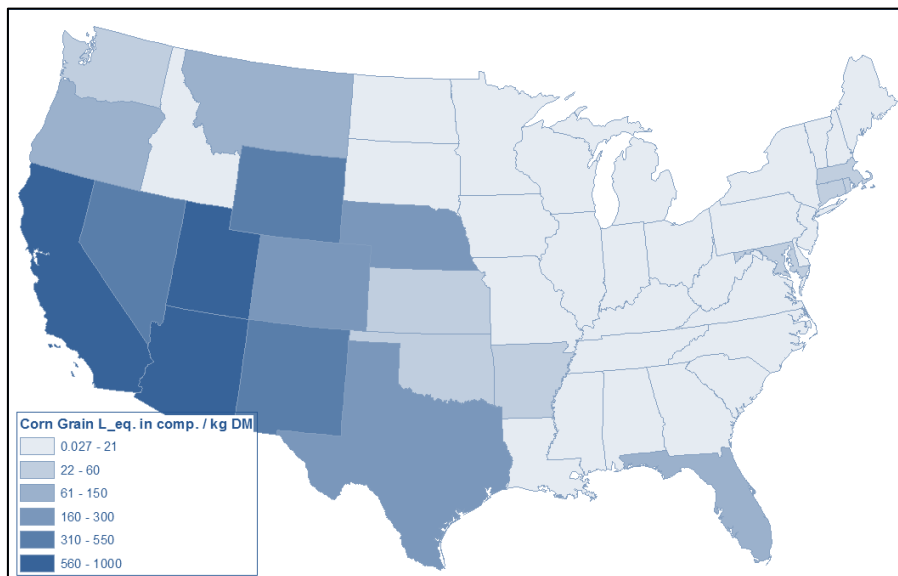
Water in competition (impact) = consumption x stress



L consumed /kg corn



Water Stress Index (L in comp / L cons.)

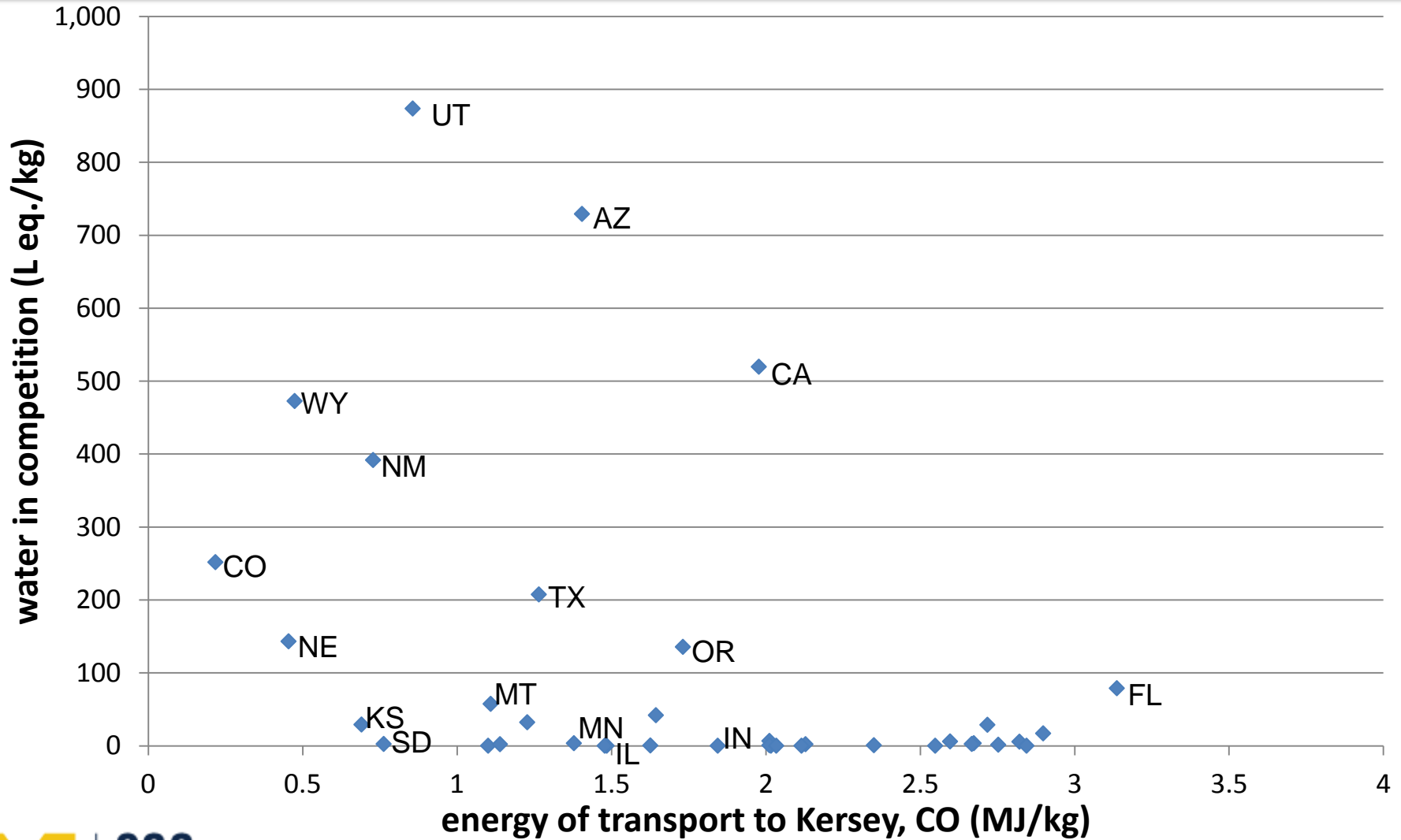


water in competition
due to corn

Data sources

- USDA NASS 2008 Farm and Ranch Irrigation Survey
 - Irrigation rates by crop and by state
 - Combined with acres irrigated and total crop production (USDA census) → state-level “irrigation intensity” per kg harvested crop
 - Irrigation energy expenses by fuel type
 - Combined with fuel costs (EIA) → pumping energy per kg harvested crop
- Transportation energy per kg
 - Rough distance: center of producer state to hypothetical farms in Kersey, CO and Rosendale, WI (Google Maps)
 - LC energy demand for diesel truck or rail transport (Franklin Assoc.)

Corn Grain: water use impact vs. transport



Damage to Water Resources

(from Pfister et al., 2009 *Environ. Sci. Technol.*)

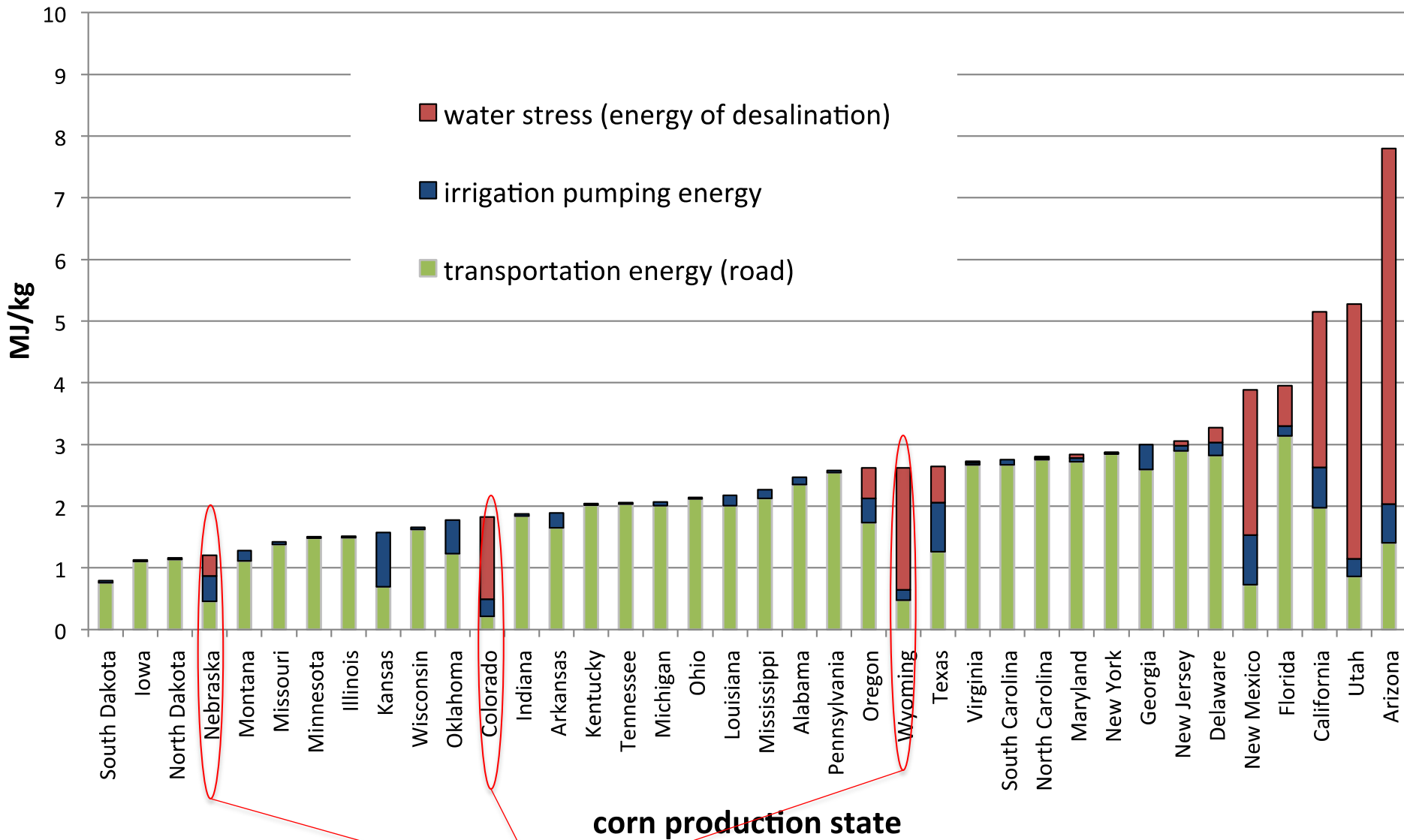
$$\text{water stress} = WTA = \frac{\text{total annual freshwater withdrawals}}{\text{hydrological availability}}$$

$$\begin{array}{l} \text{fraction of freshwater consumption} \\ \text{that contributes to depletion} \end{array} = F_{\text{depletion}} = \begin{cases} \frac{WTA - 1}{WTA} & \text{for } WTA > 1 \\ 0 & \text{for } WTA \leq 1 \end{cases}$$

- Backup-technology concept: “surplus energy” to make the resource available in the future
 - Energy of desalination
 - Theoretical indicator to make water use comparable to other types of resource use

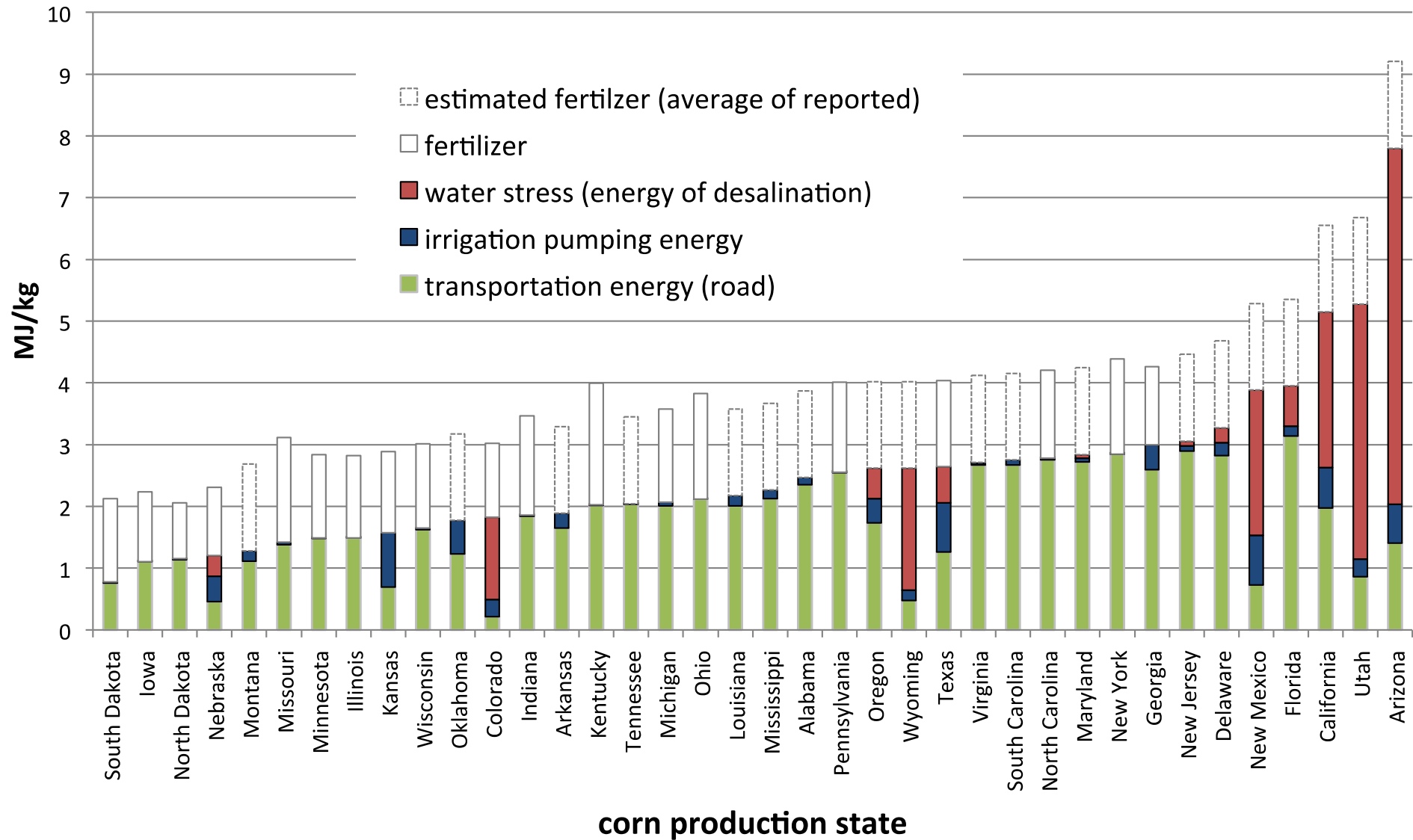
$$\Delta R = E_{\text{desalination}} \cdot F_{\text{depletion}} \cdot WU_{\text{consumptive}}$$

Corn grain delivered to Kersey, CO



Water stress impacts outweigh transport.

Corn grain delivered to Kersey, CO

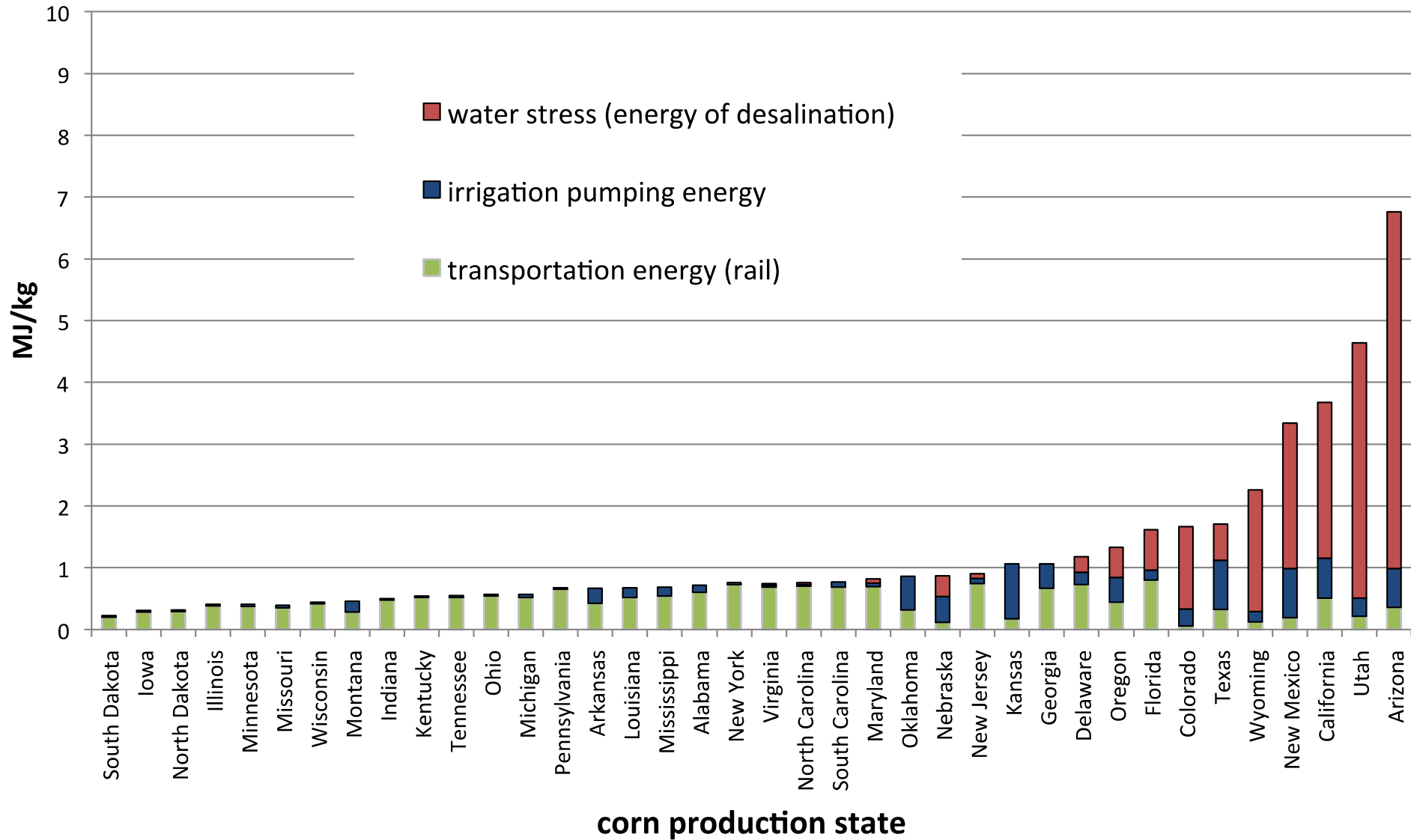


Energy for fertilizer is important,

but does not impart a clear trend to the ranking



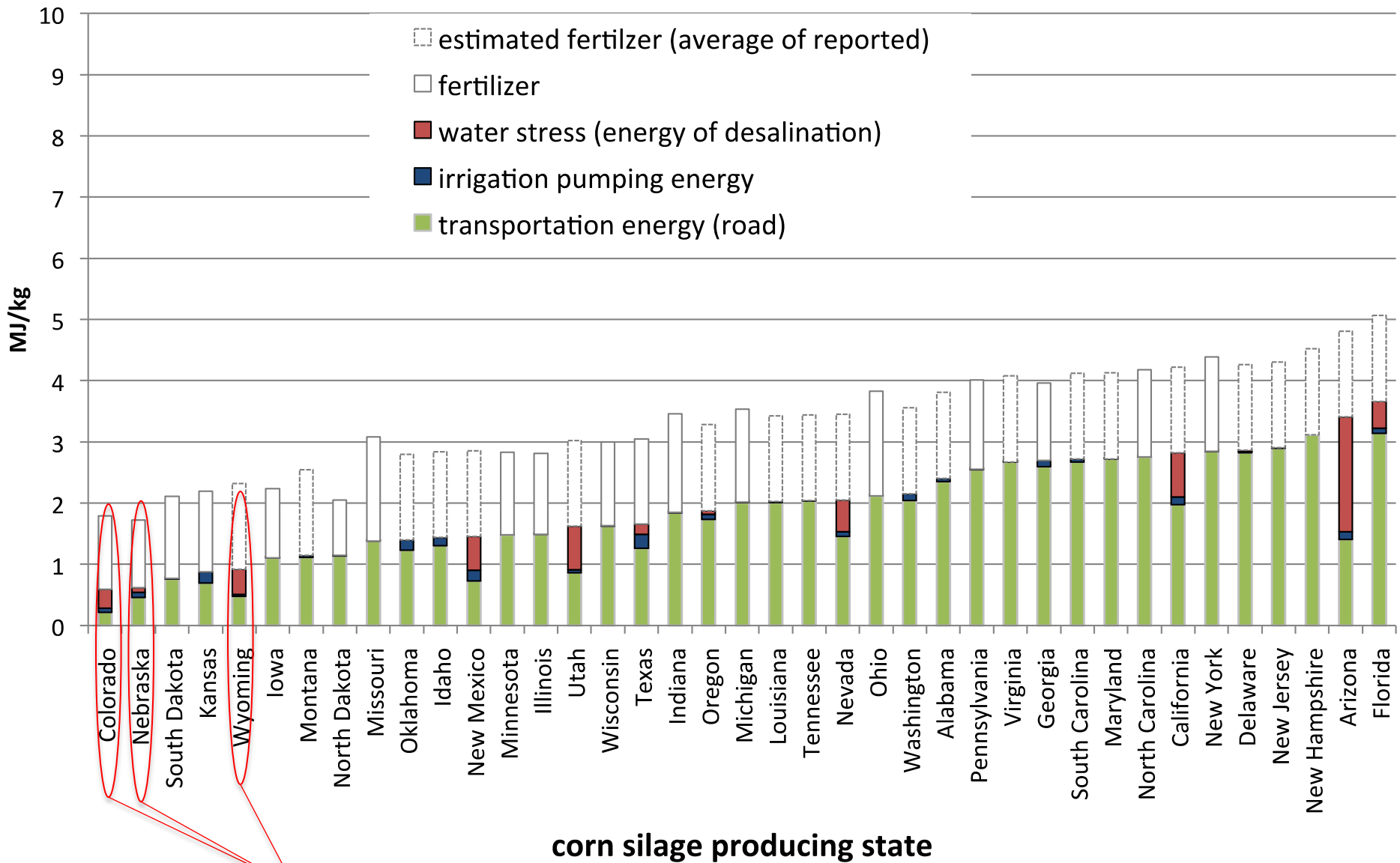
Corn grain delivered to Kersey, CO by RAIL



Transport by rail makes water use impacts even more relevant
 Actual transport is likely a blend of rail and road



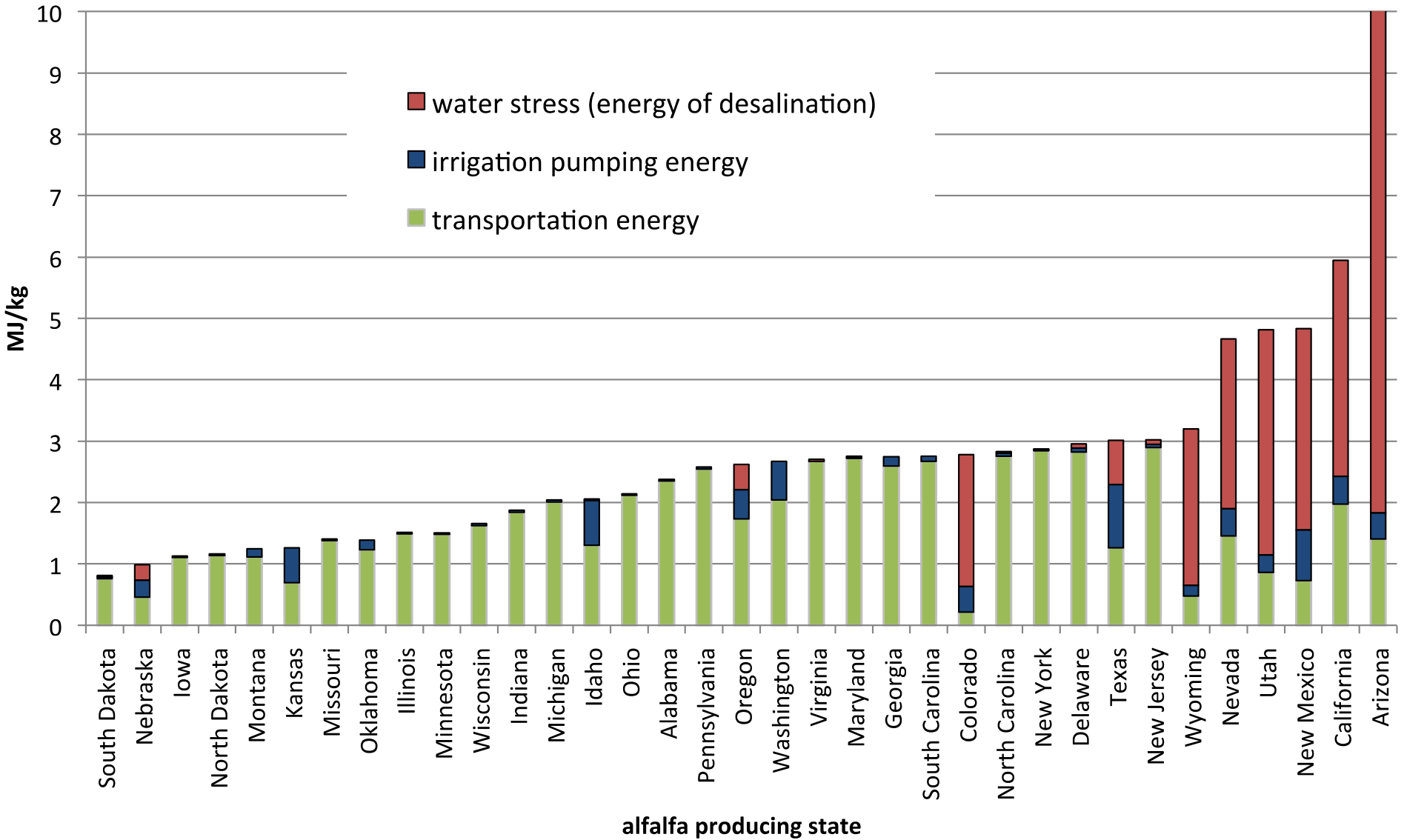
Corn silage delivered to Kersey, CO



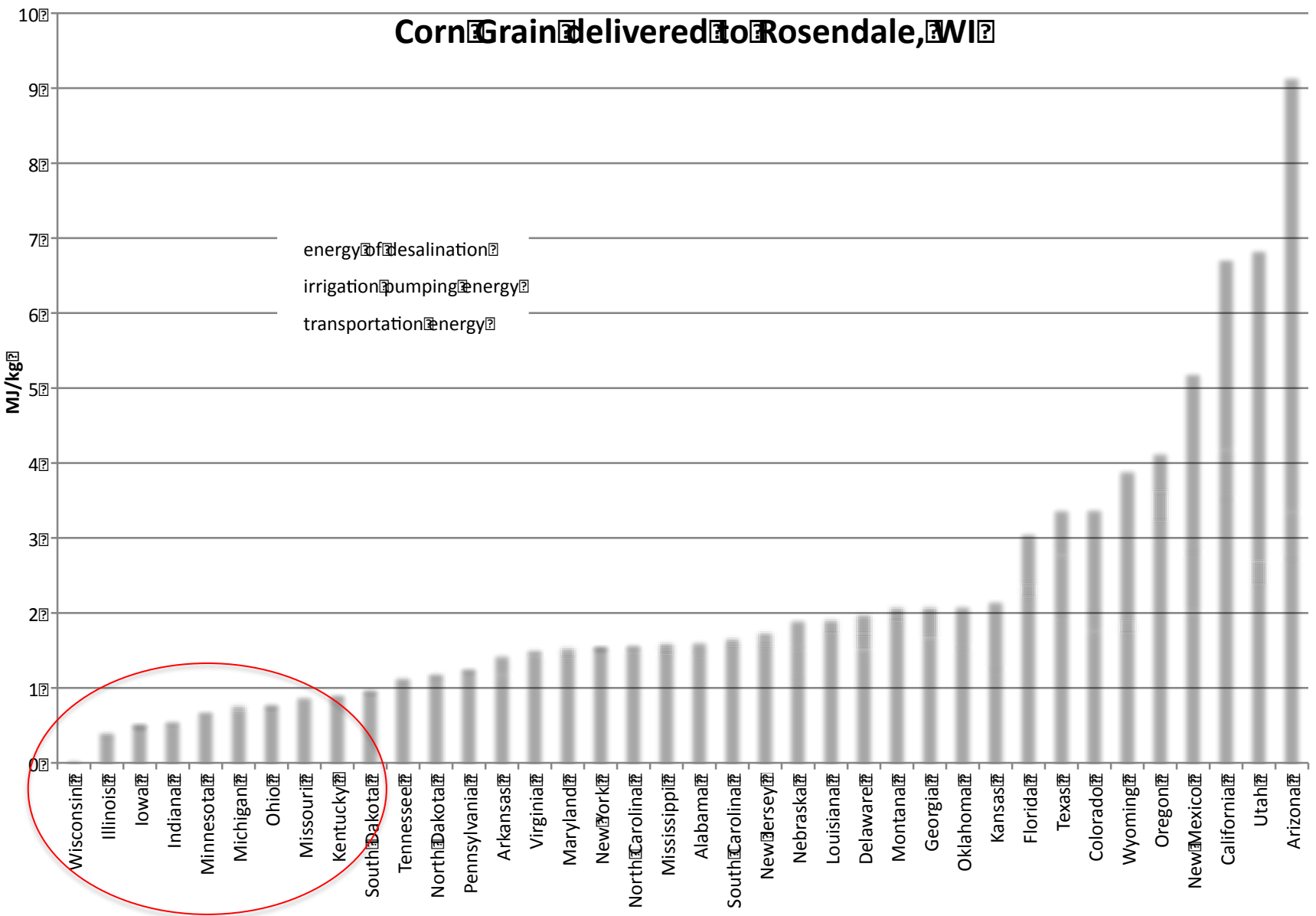
Transport per kg more important: favors local production



Alfalfa hay delivered to Kersey, CO



Corn Grain Delivered to Rosendale, WI



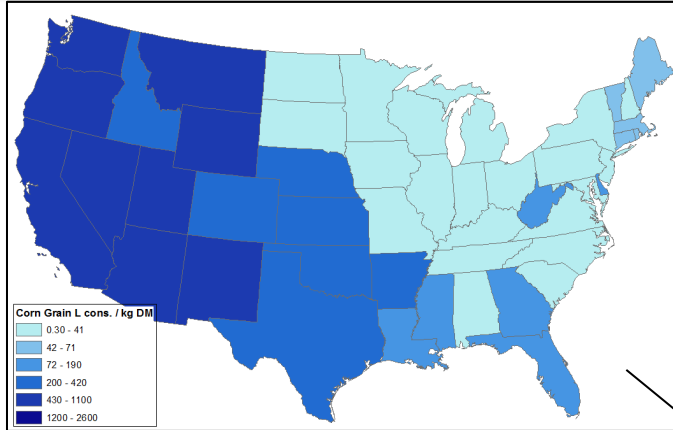
Low irrigation needs; not water stressed; favors local production

Spatial LCA:
Feeds & production across regions in the dairy context

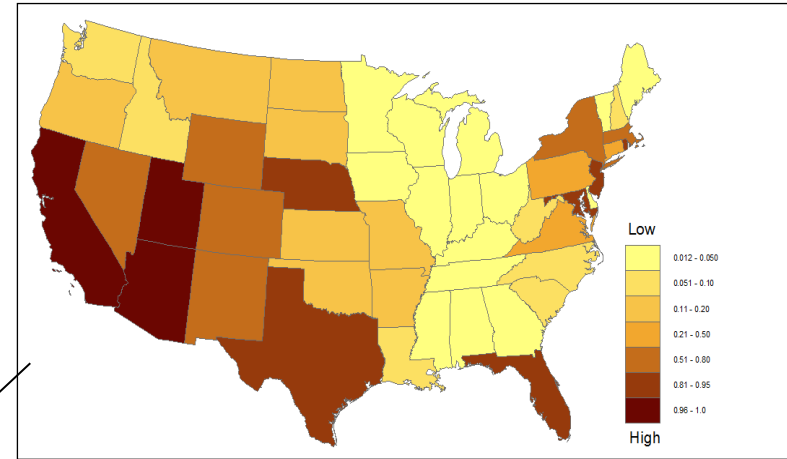
Andrew Henderson, Anne Asselin, Martin
Heller, Olivier Jolliet

Work supported by Dairy Research Institute

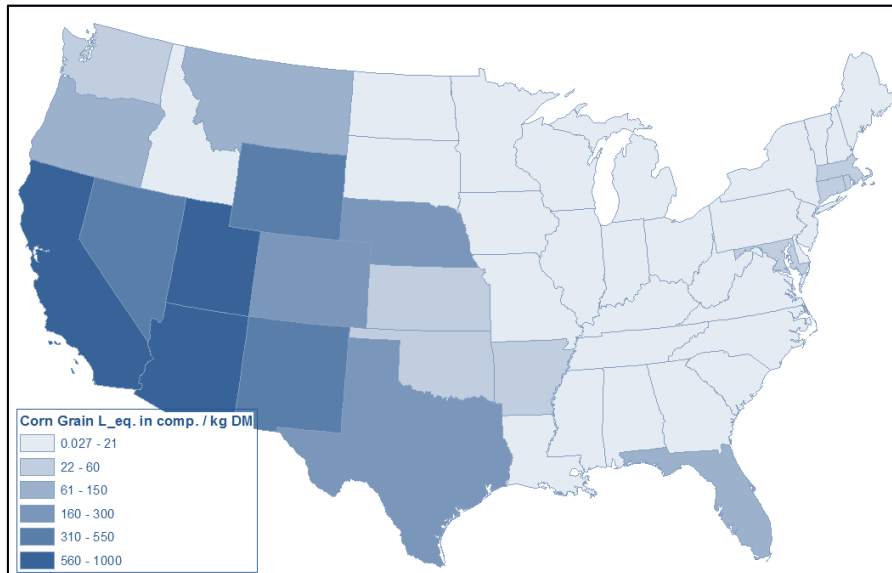
Water in competition (impact) = consumption x stress



L consumed /kg corn



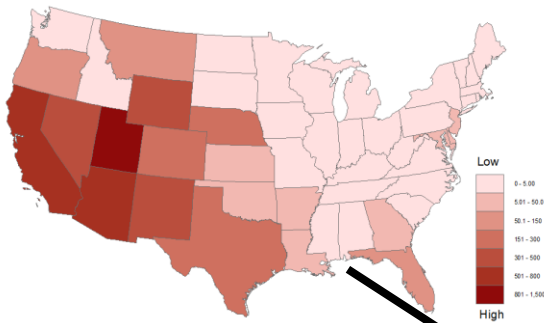
Water Stress Index (L in comp / L cons.)



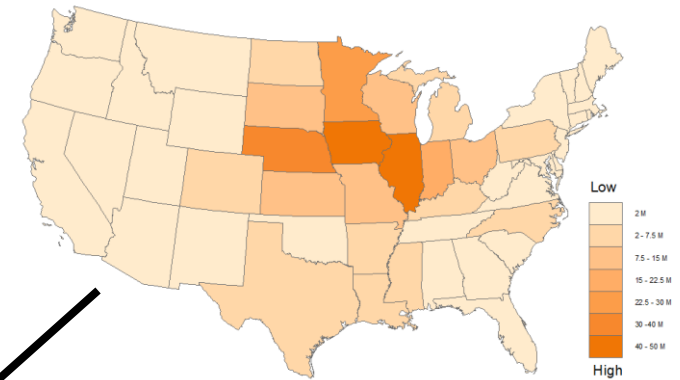
water in competition
due to corn

Corn water stress at the national level

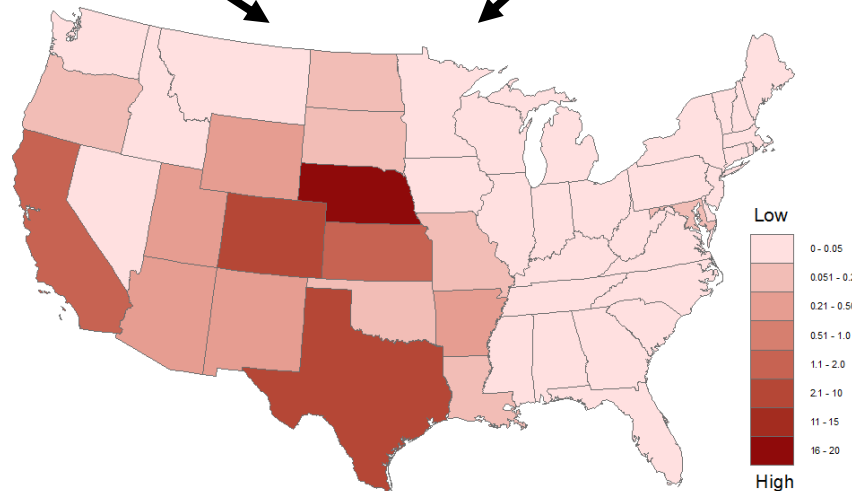
Water in competition
 $L_{eq} / \text{kg state corn grain}$



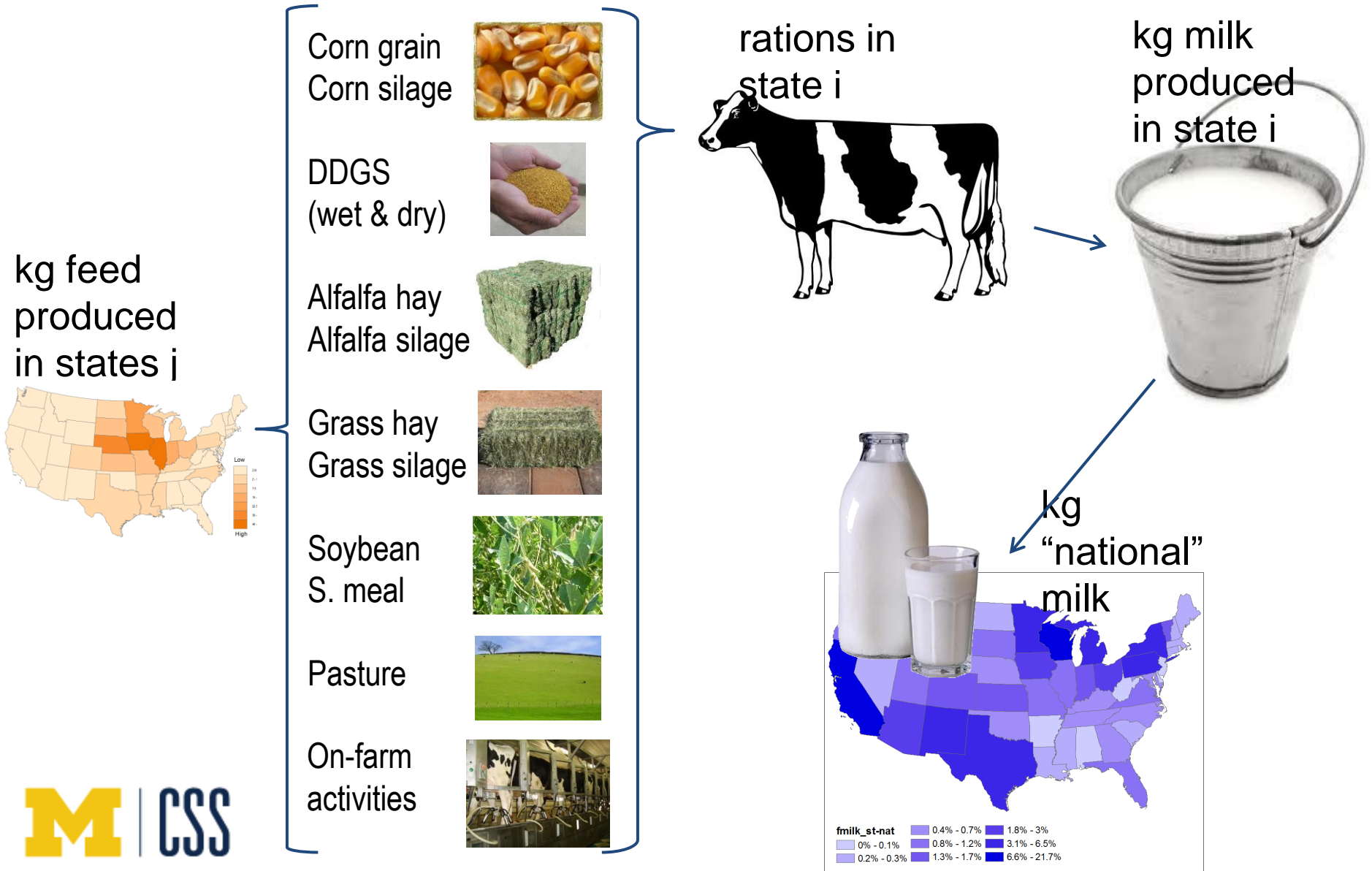
Weight by US corn grain
production:
mainly in the corn belt!



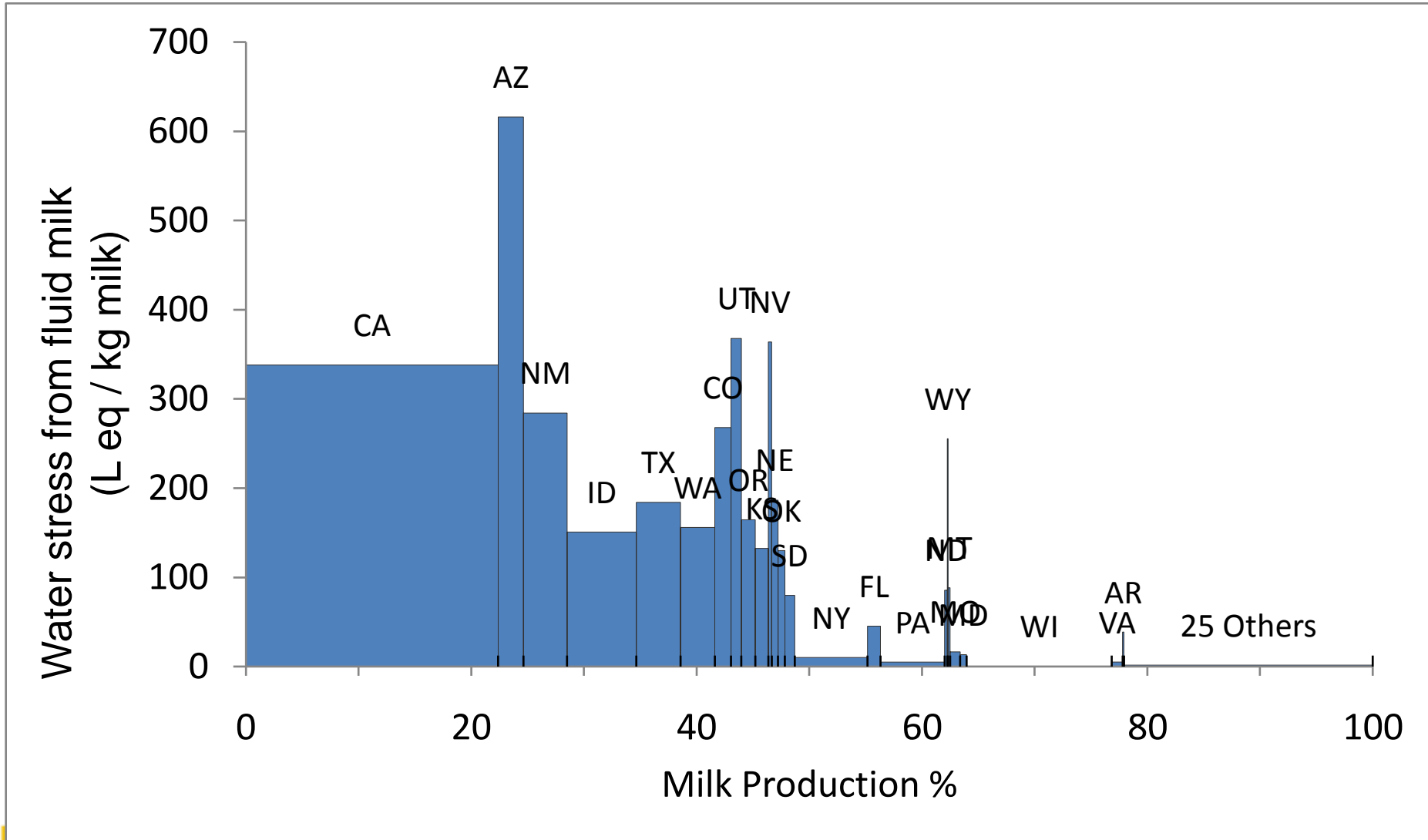
Contribution to
national corn grain
impact



From feed → state milk → national milk



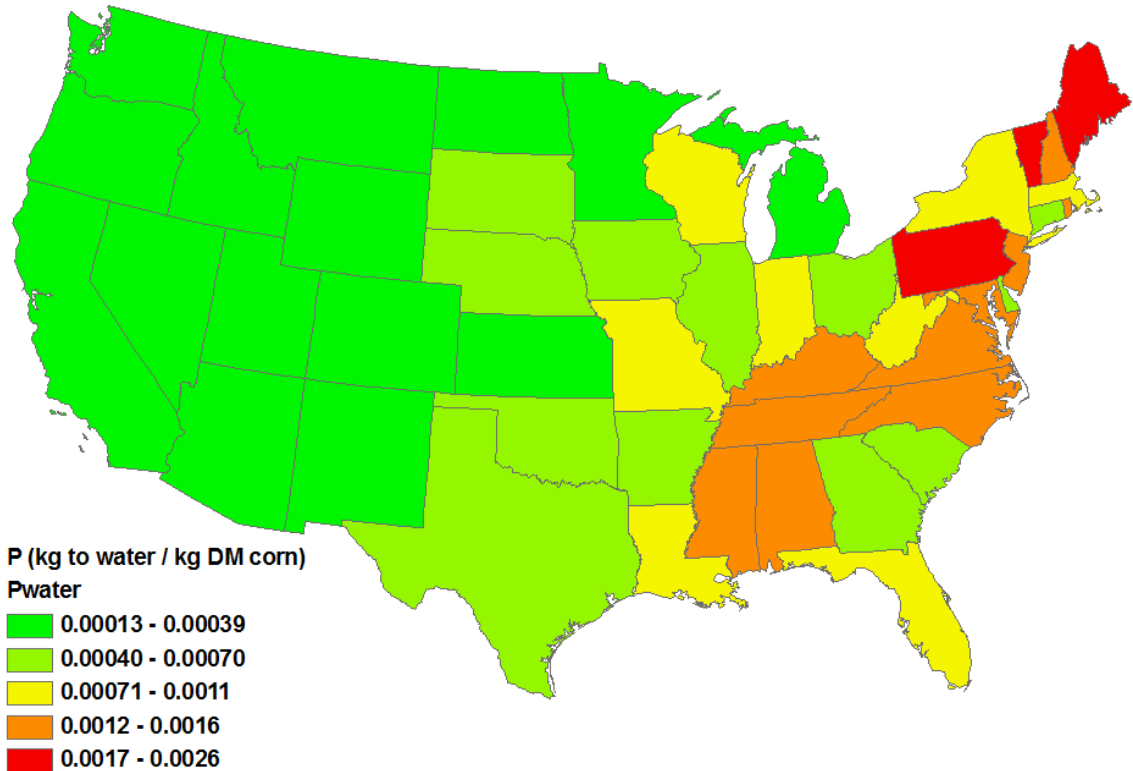
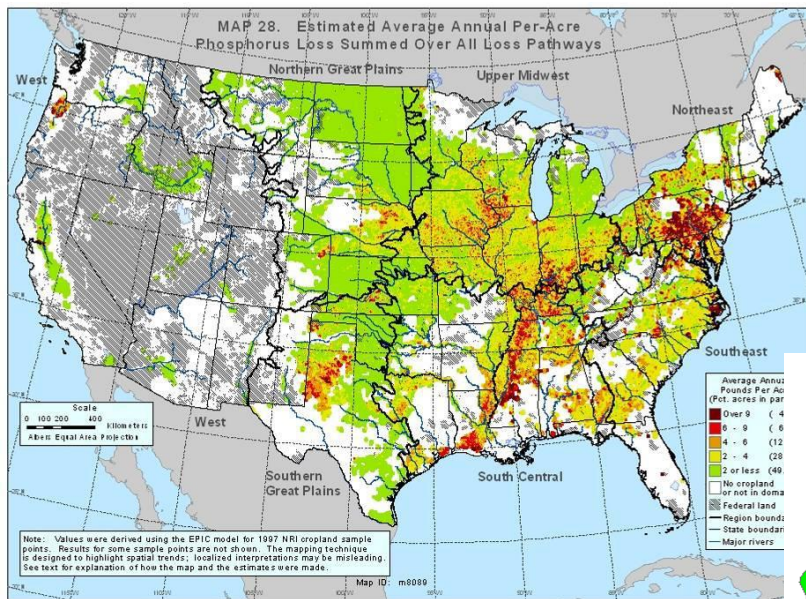
Milk water stress at national level



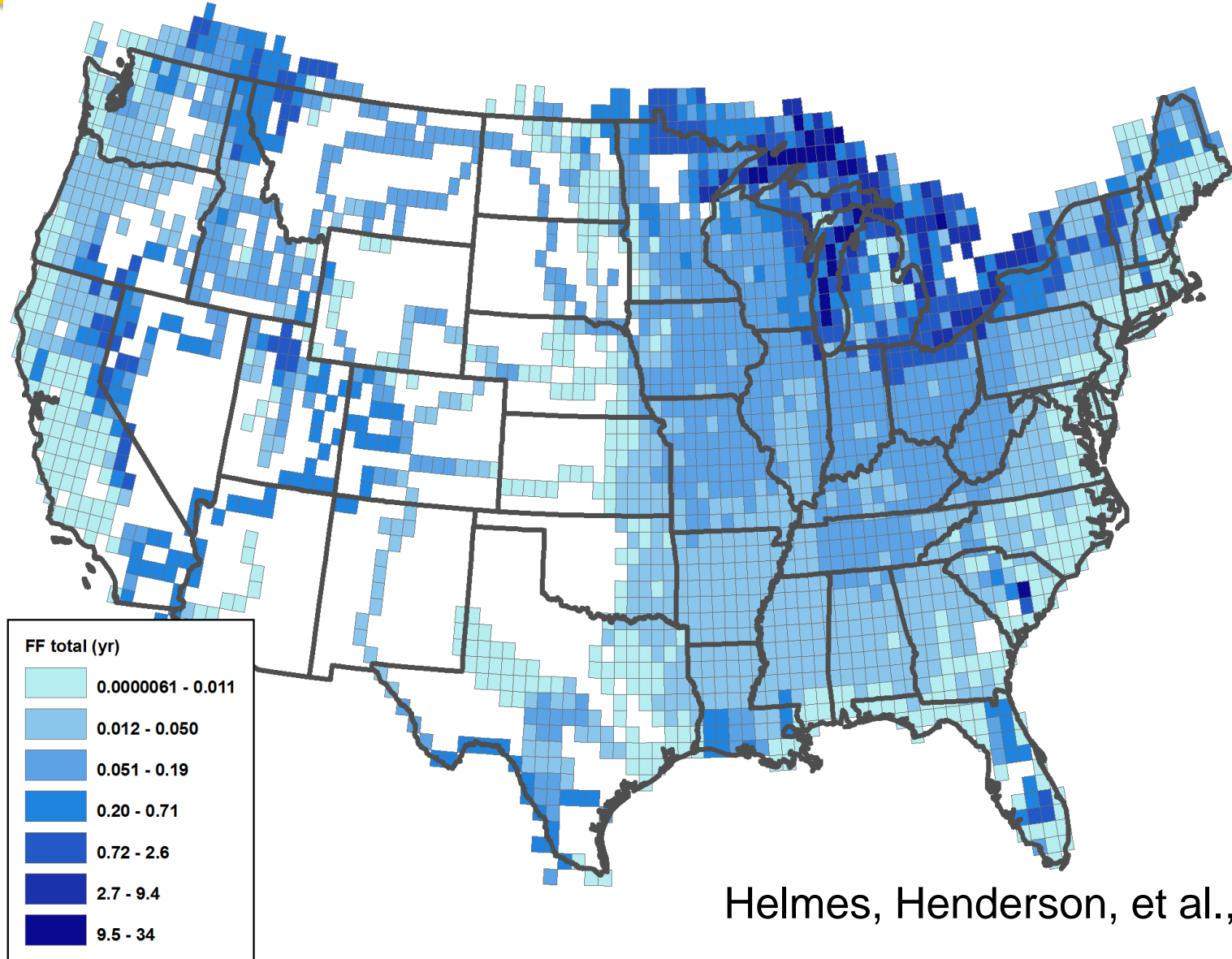
Sources: USDA Ag. Census (2007), FRIS



NNLSC: corn grain P emission



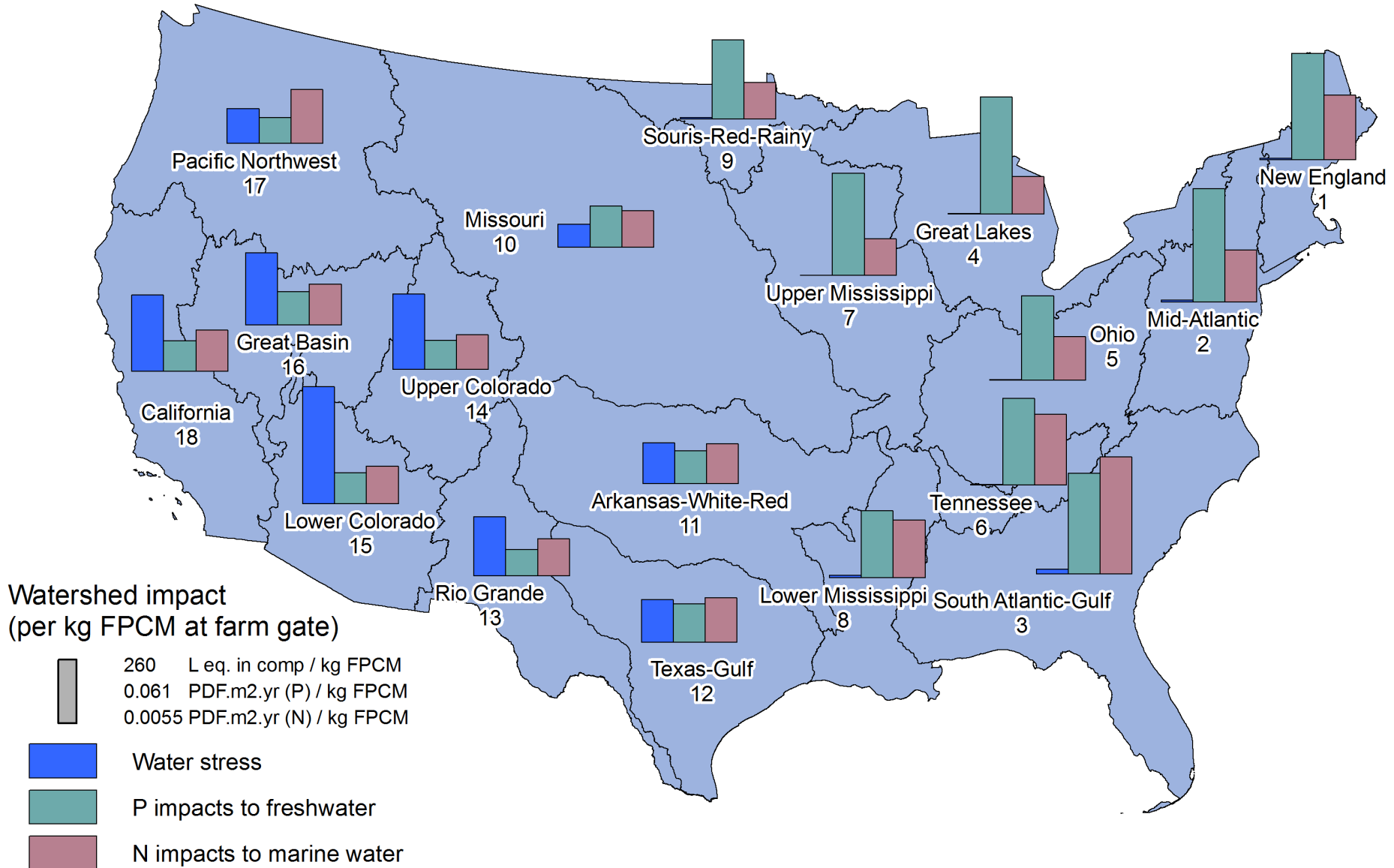
What happens to the P once it's emitted?



Helmes, Henderson, et al., 2012



Looking at different (water) impacts





Thank you!

Martin Heller
mcheller@umich.edu



CENTER FOR SUSTAINABLE SYSTEMS
UNIVERSITY OF MICHIGAN