Biofuels and Water: Lessons from California

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Roundtable on Sustainable Biofuels
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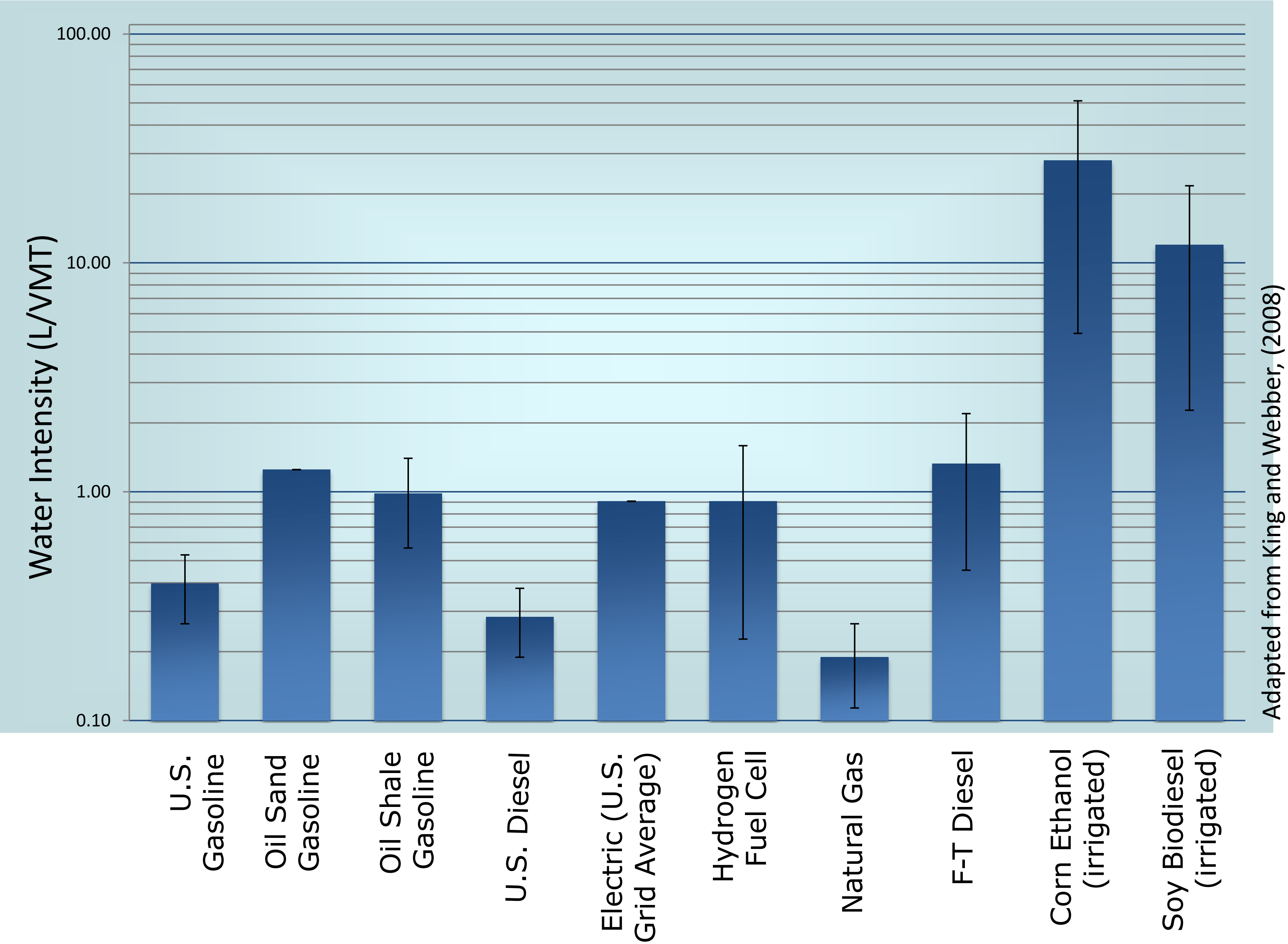
November 25th, 2011

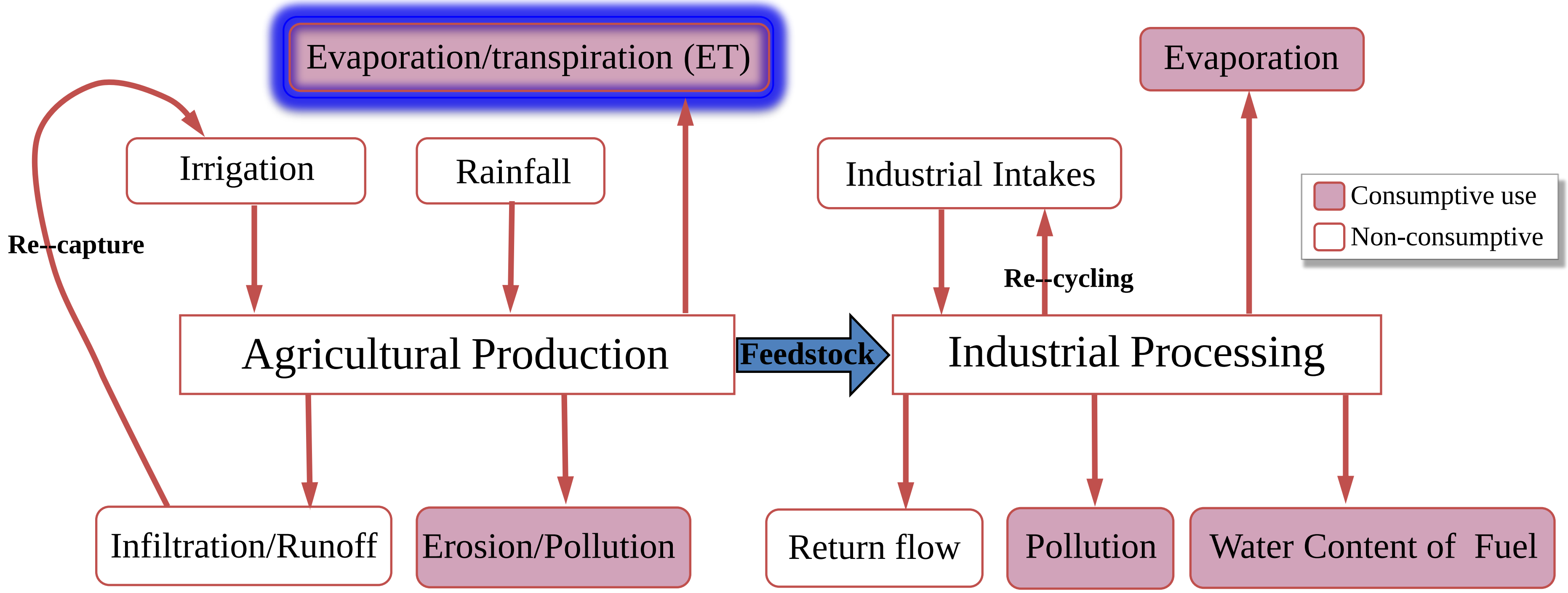
Sneak preview

- Some water intensity figures
- Why they’re wrong (or at least incomplete)
- What questions should we be asking? How?
  - California case study
- What else should we address?

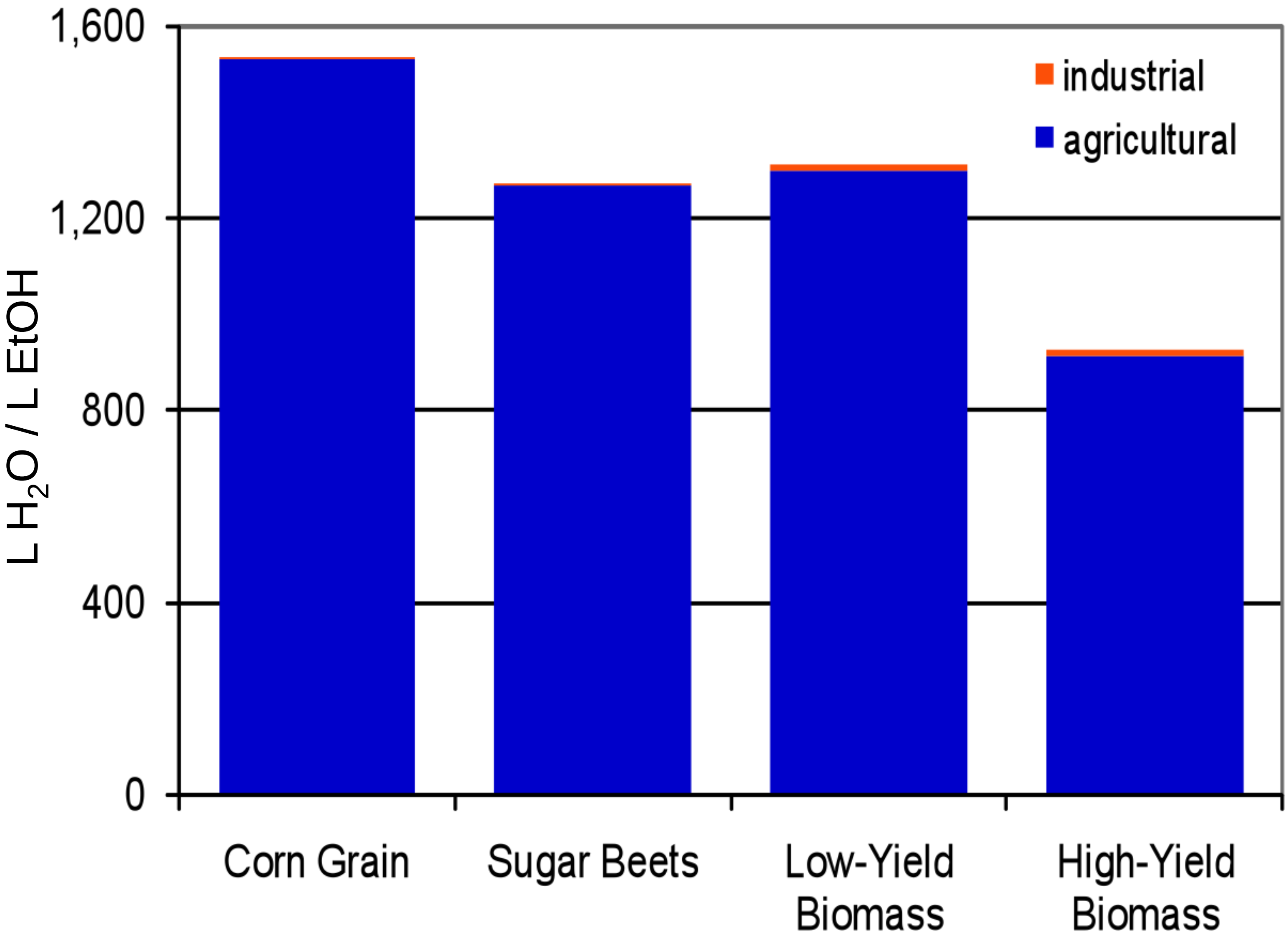
Transportation energy water use



Water resources in the biofuel life cycle



Fuel embedded water



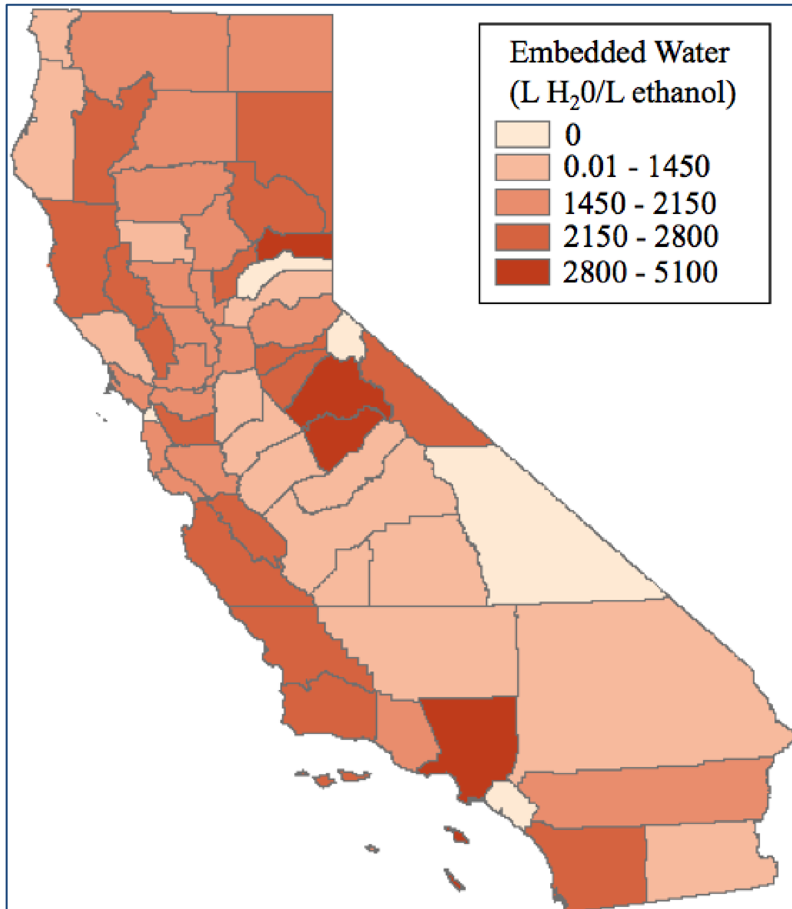
Fingerman et al, 2010

Tools in use

- “Water footprint” and water LCA
- Footprint value is attractive, but is of limited utility
  - Spatial heterogeneity in use *and* impact
  - Does not adequately capture impacts
- LCA for greenhouse gases is “easy”
  - Impact is global wherever emission occurs
  - Global Warming Intensity can be used to normalize across emission types
  - We can’t make these simplifying assumptions for water…

Spatial Problem

Ethanol Water Footprint
(L per L ethanol)

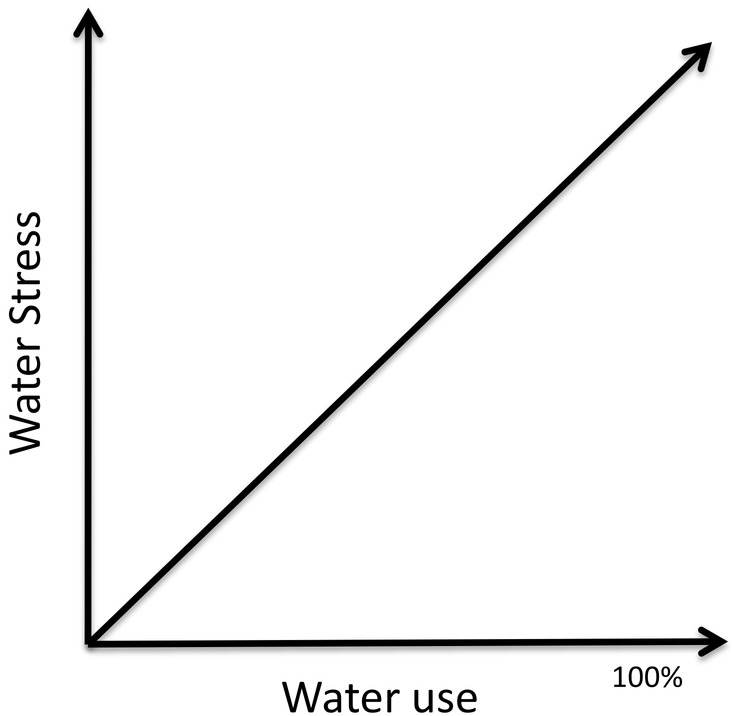


Water consumption (ET) for “low-yield biomass” cellulosic ethanol - Fingerman *et al.* 2010

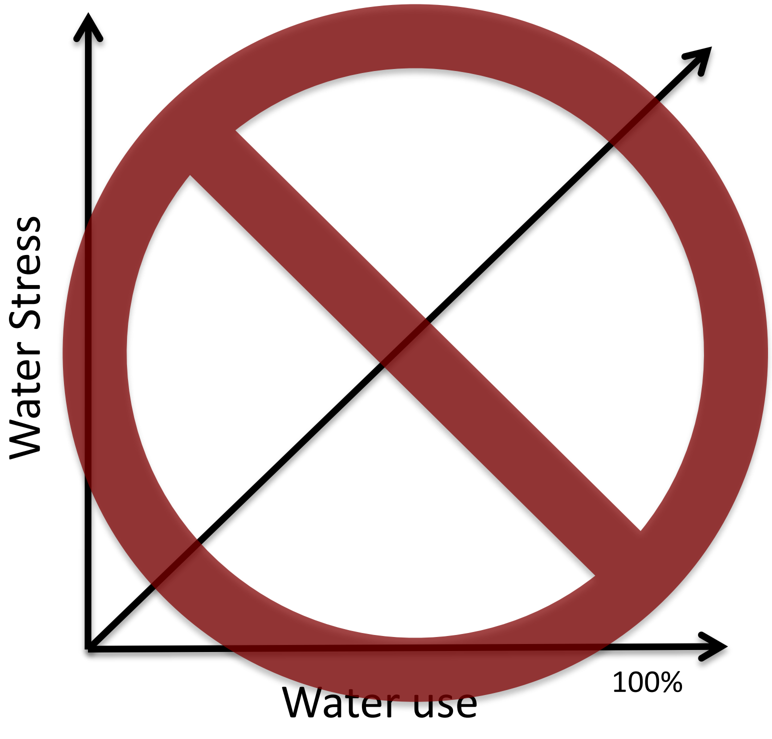
Evaluating the resource base

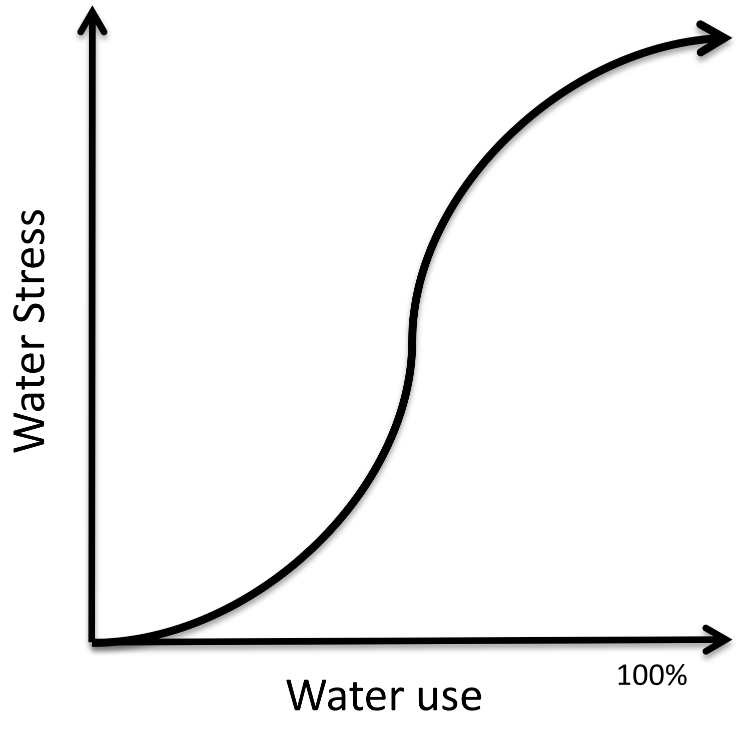
- Can't always do *comprehensive* analysis, but need to identify risks and opportunities.
- There are several tools. I have picked strengths from each and have added new elements.
- "Water Stress Indicator" (Smakhtin)
  - Start with "Water use per Resource"
  - Account for environmental flows
- Incorporate effective precipitation (green water)
- Account for rainfall variation (Pfister)
- Account for the non-linearity of stress effects

Use vs. Stress



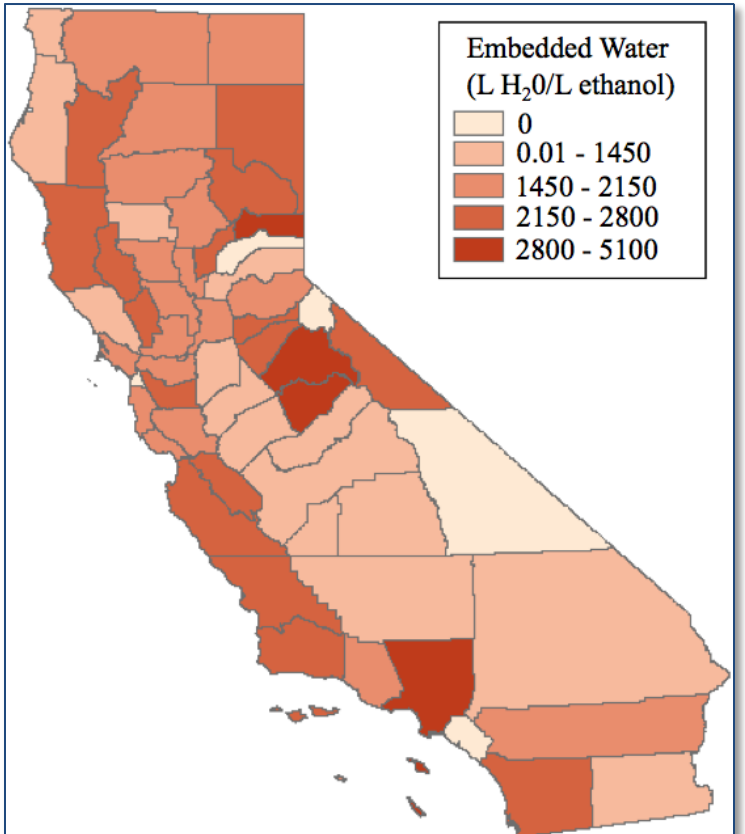
Use vs. Stress





Impact Assessment

Ethanol Water Footprint
(L per L ethanol)



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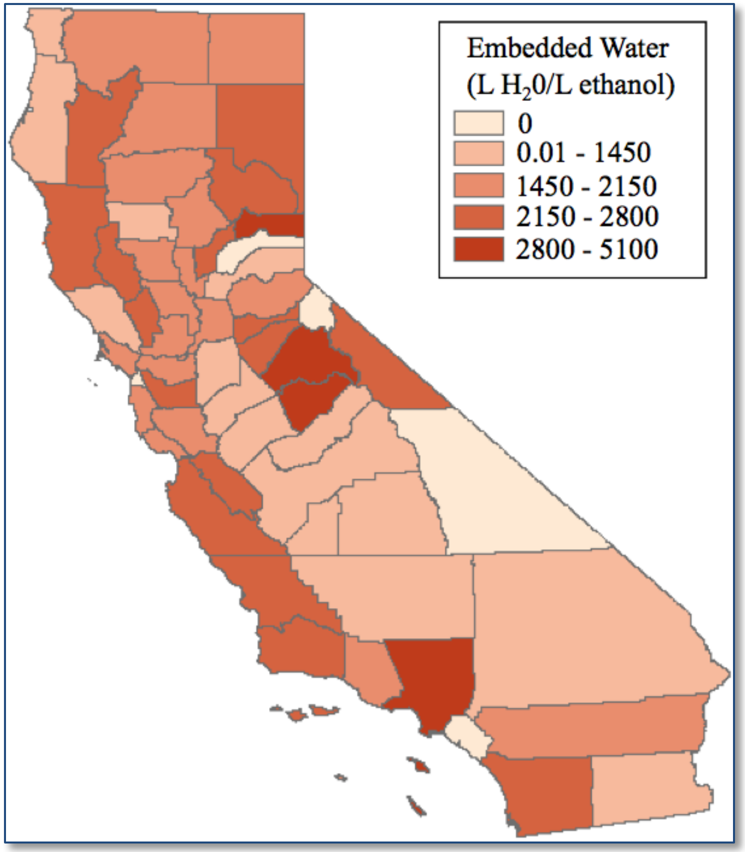
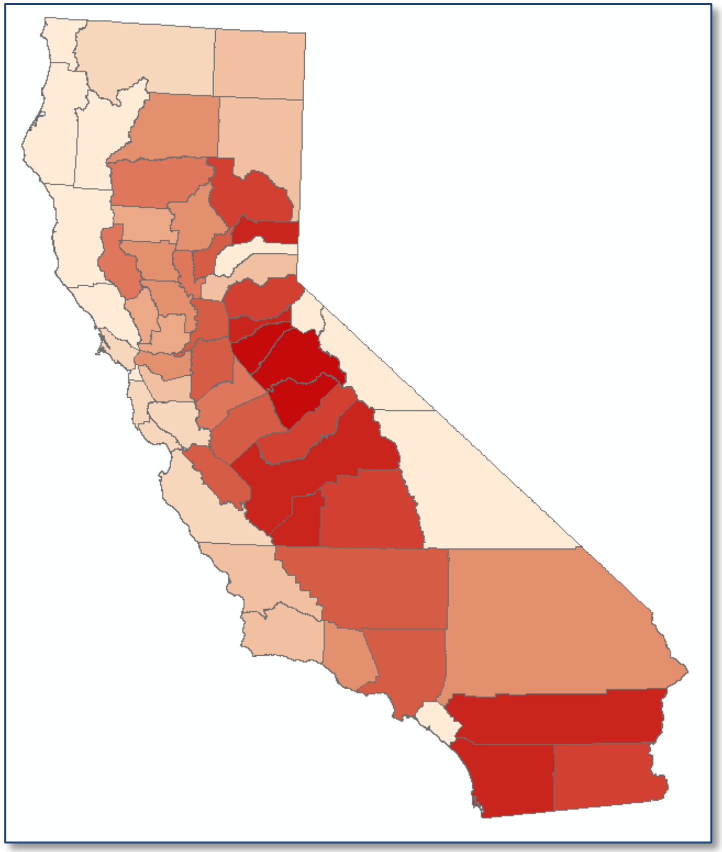


Ethanol Water Footprint
(stress-weighted)



Water consumption (ET) for "low-yield biomass" cellulosic ethanol - Fingerman *et al.* 2010

Impacts beyond LCA

- Individual projects vs. cumulative effect
- Impact on key habitats such as aquifer-recharge zones, wetlands, and floodplains
- Acute local ecological toxicity, eutrophication, or health effects even from small pollution flows
- Indirect “Water Use Change”
- Water shortage for humans often due to social realities
- Ability to adapt

Thank you!

Acknowledgements:

- Daniel Kammen
- Margaret Torn
- Michael O'Hare
- Göran Berndes
- Stefan Pfister
- Stuart Orr
- Brian Richter
- Pim Vugteveen
- Morteza Orang
- Daniel Harman

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How these calculations are done…

FAO - Penman-Monteith Model

Heat loss into soil

Solar radiation

Constant related to humidity

Crop Characteristics

Evapotranspiration

Temperatur
e

Climate characteristics

Climate

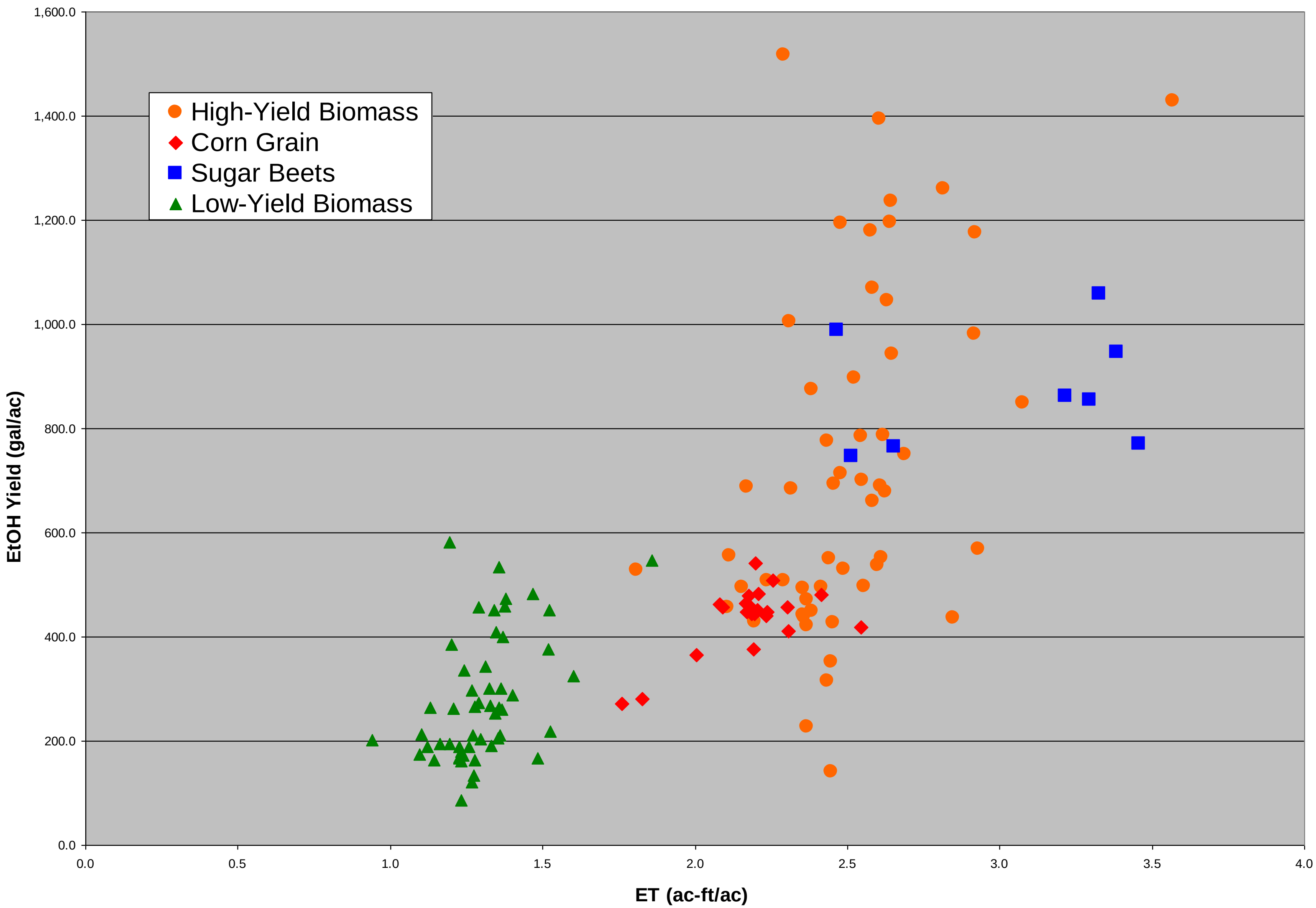
$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 U_2)}$$

“Vapor pressure deficit”

Constant related
to humidity

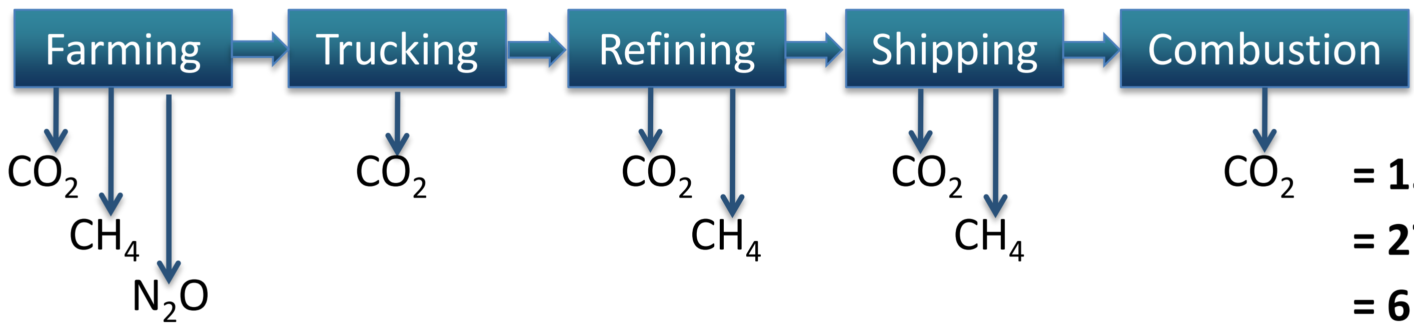
Wind speed

Yield and ET by County



GHG LCA is "easy"

- Life Cycle Inventory (LCI)



= 1500 kg CO_2

= 27 kg CH_4

= 6 kg N_20

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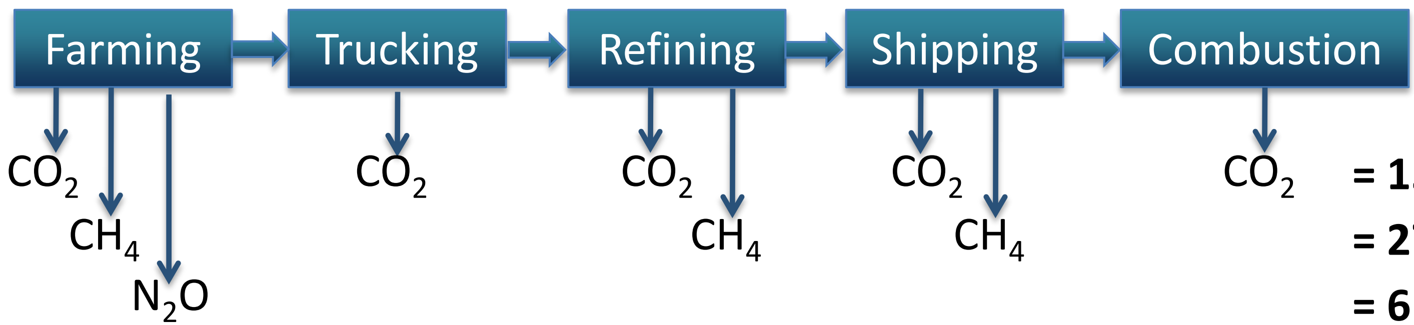


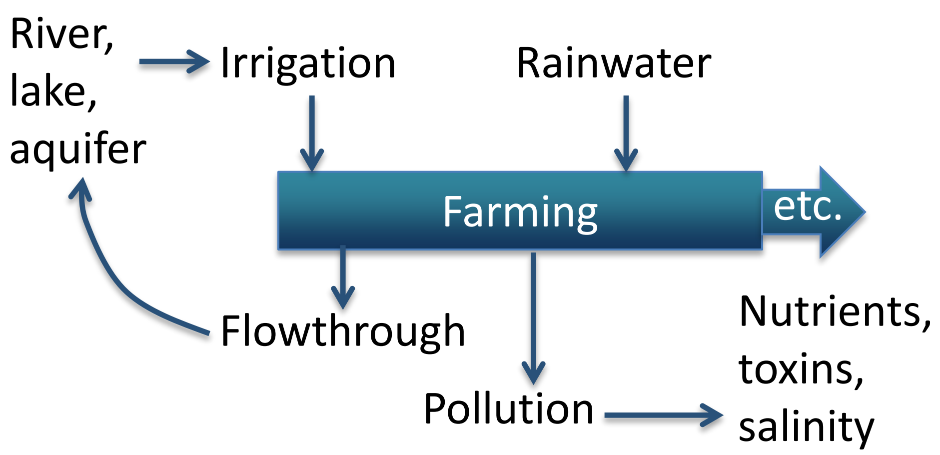
= 1500 kg CO_2
= 27 kg CH_4
= 6 kg N_20

- Life Cycle Impact Assessment (LCIA) – Global Warming Potential as characterization factor

1500 kg CO_2 x 1 = 1500
27 kg CH_4 x 25 = 675
6 kg N_20 x 298 = 1788

= 3,963 kg CO_2 equivalent

Water LCA is HARDER



How many L of rainwater is one L of groundwater worth? Irrigation? One "unit" of eutrophication?...

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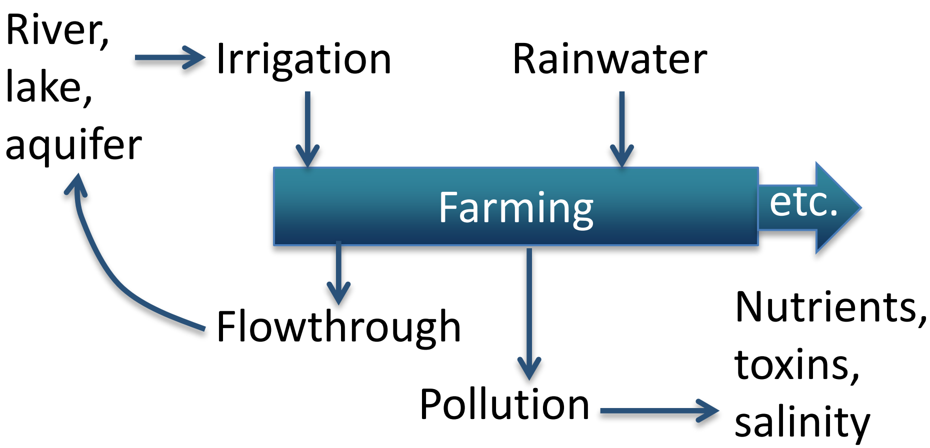

How many L of rainwater is one L of groundwater worth? Irrigation? One "unit" of eutrophication?...

...Then there's the issue of where...

...and when...