NWISRL

Northwest Irrigation & Soils Research Lab, Kimberly, Idaho USDA-ARS-PWA

IRRIGATION-INDUCED EROSION, CONCEPTS AND MODELING CHALLENGES

R.E. Sojka
D.L. Bjorneberg
T.S. Strelkoff
M.A. Nearing
T.J. Trout
T.L. Spofford

If You Prefer:

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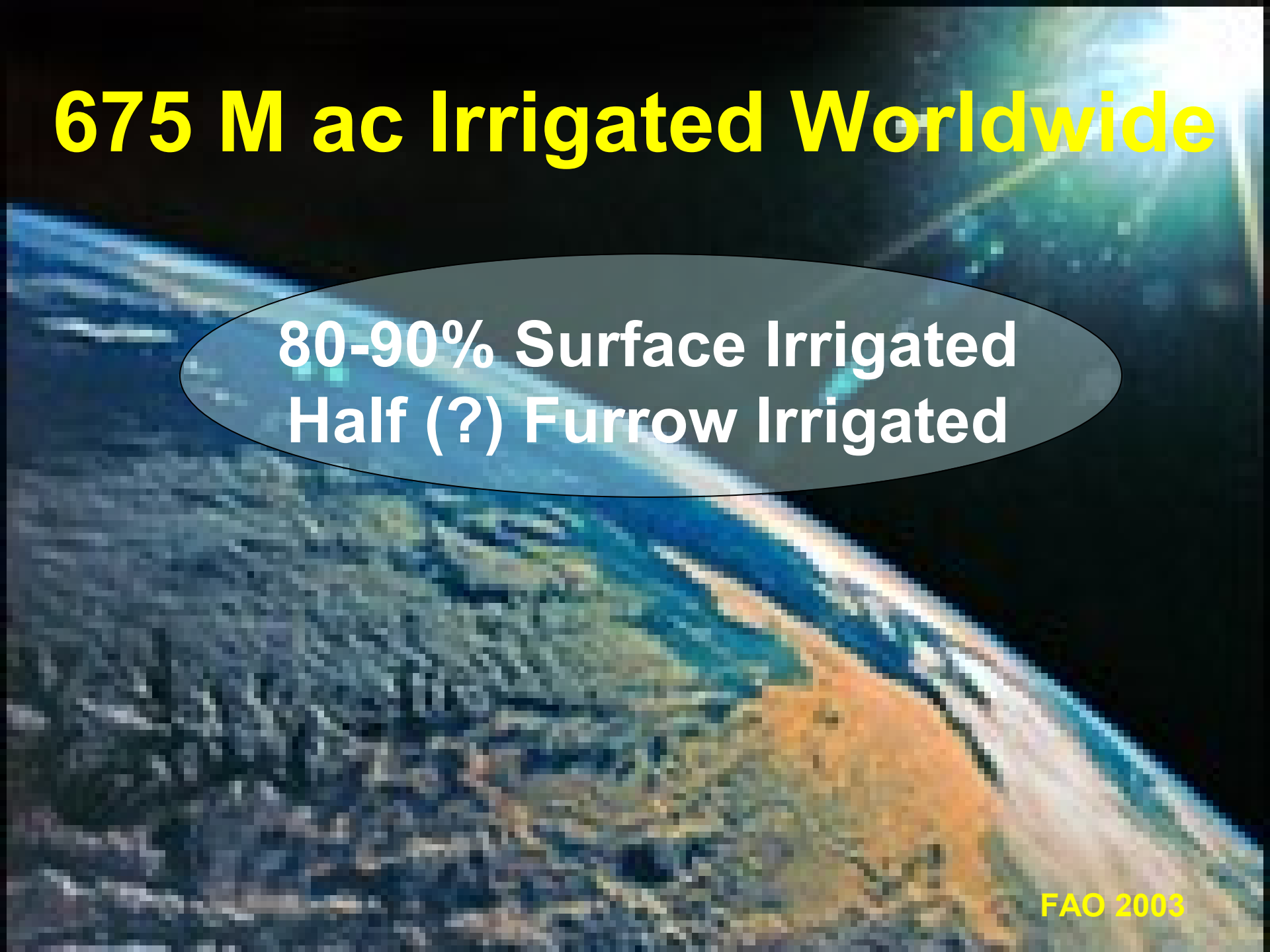
The importance and challenge of modeling irrigation-induced erosion

R.E. Sojka, D.L. Bjorneberg, T.J. Trout, T.S. Strelkoff, and M.A. Nearing

Abstract: Irrigation-induced erosion and rain-induced erosion result from very different systematics. Therefore, both cannot be predicted effectively using the same models. The average two-fold yield and three-fold economic advantage of irrigation over rain-fed agriculture, coupled with the fragility of irrigated land and the strategic importance of irrigation development to meet world agricultural production needs, has raised the urgency for the


Raise the priority of developing and validating a reliable model for wide use by NRCS and other public entities to help predict and inventory irrigation-induced erosion
Letters in 2005 from NRCS:
Lawrence Clark, Deputy Chief for Science & Technology
Barry Kintzer, Acting Director For Conservation Engineering
To ARS:
Dan Upchurch, Acting Deputy Administrator for Natural Resources & Sustainable Agricultural Systems

675 M ac Irrigated Worldwide



Irrigation's Global Importance

Total Cropland 3-3.5 B ac
-Irrigated Ag. 0.68 B ac

- **1/3 of all of earth's harvested crops on 1/6 of the earth's croplands**
- **1/2 of the value of all crops harvested on 1/6 of the earth's croplands**
- **1/3 earth's harvested *food* grown on 125 M ac (1/30 area)**

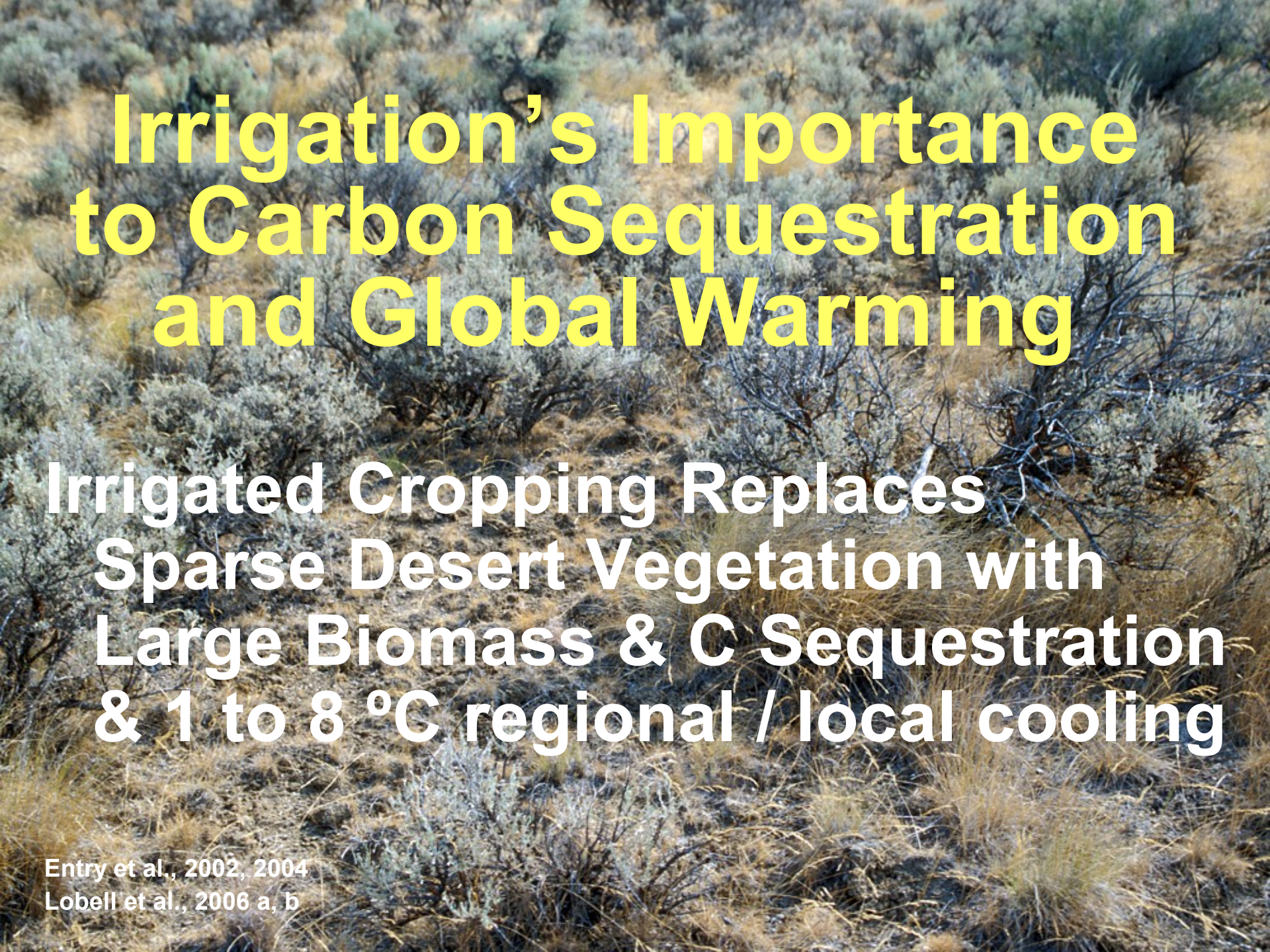
U.S. Irrigated Agriculture

2002 Census of Agriculture

- 303 M ac of *TOTAL* harvested crop land
- 55 M ac of *IRRIGATED* crop land

- $95 B *TOTAL* market value of crops sold
- $57 B market value of IRRIGATED crops sold
- >80% of U.S. fresh fruit and vegetables

- **Irrigated land was 18% of total crop land & produced 60% of market value!**



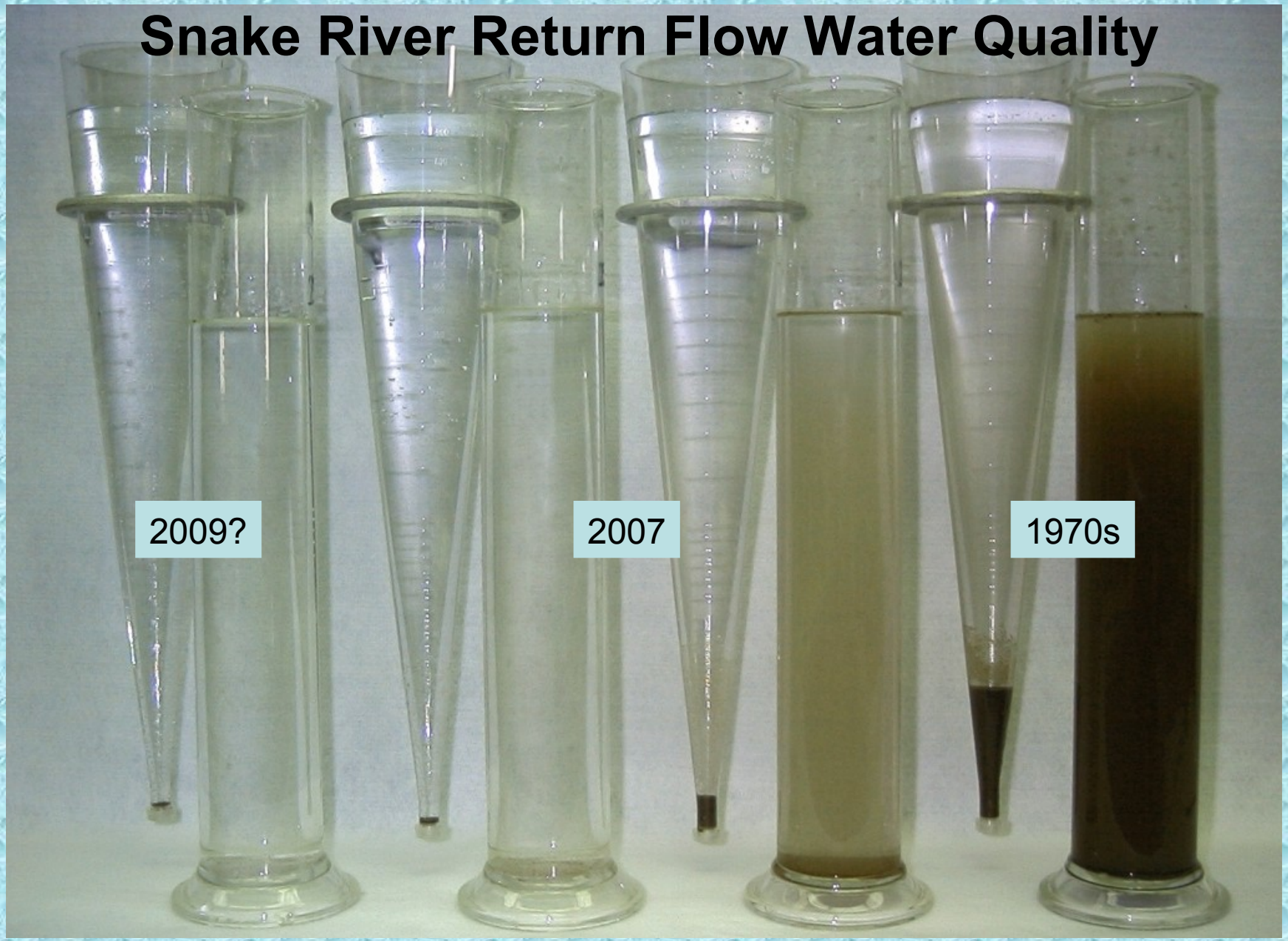
Irrigation's Importance to Carbon Sequestration and Global Warming

Irrigated Cropping Replaces Sparse Desert Vegetation with Large Biomass & C Sequestration & 1 to 8 ºC regional / local cooling

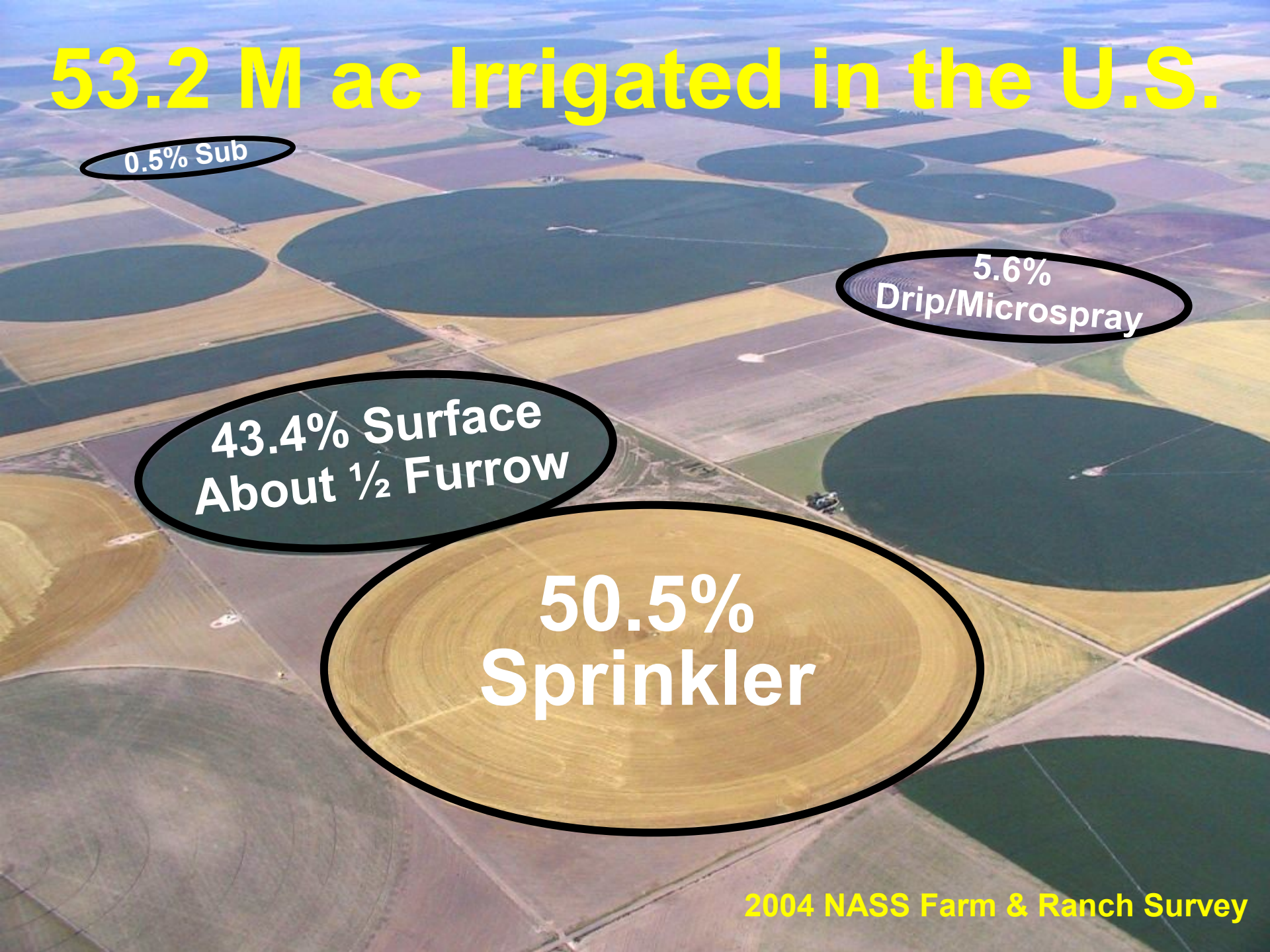
Entry et al., 2002, 2004
Lobell et al., 2006 a, b

Arid Soils Dominate Irrigation --They Are Fragile Soils

Snake River Return Flow Water Quality



50 ppm 100 ppm 1000 ppm 10000 ppm


53.2 M ac Irrigated in the U.S.
0.5% Sub
5.6%
Drip/Microspray
43.4% Surface
About ½ Furrow
50.5%
Sprinkler
2004 NASS Farm & Ranch Survey

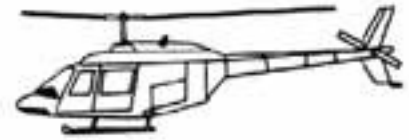
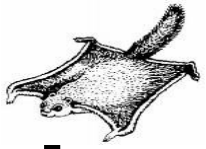
Rain-Derived Models

USLE	Statistic Event-Based
RUSLE	Statistic Event-Based
WEPP	System Process-Based

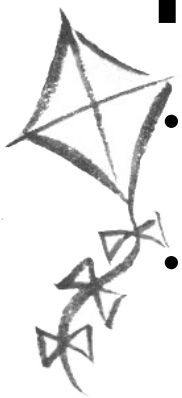
Attempts to apply these models to irrigation have failed to accurately predict IIE & runoff/infiltration, especially from surface irrigation, especially from small application rates

Storm events are vastly different from irrigation

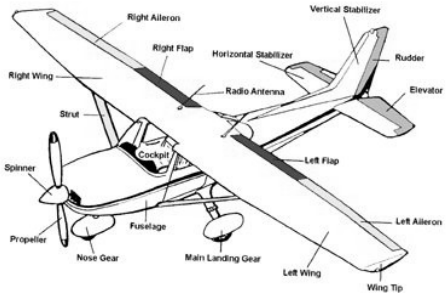
Process systematics differ between rain-induced and irrigation-induced erosion

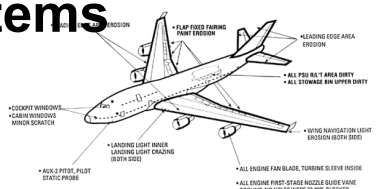



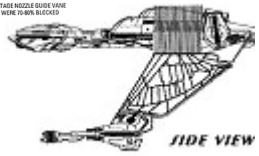

Process Systematics Differ?

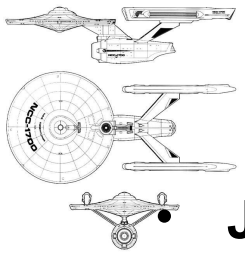


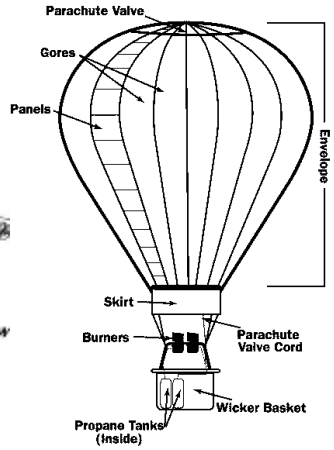
- Chemical & physical processes affecting erosion are the same
- Some processes are more/less prominent, with irrigation vs. rain thus components assemble into different systems
  - Sequence & duration
  - Spatial relationships
  - Energy & mass balances (intensity)
  - Component chemistries
- Just as all means of flight draw from common chemical and physical processes, a single system model cannot easily describe all flight

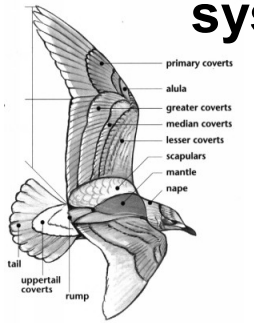


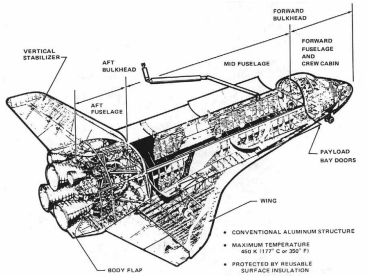


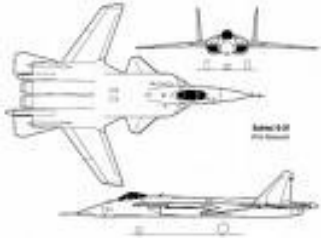


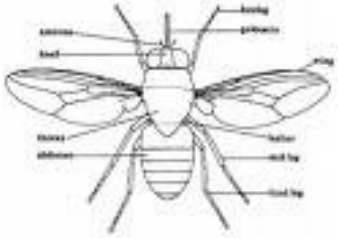


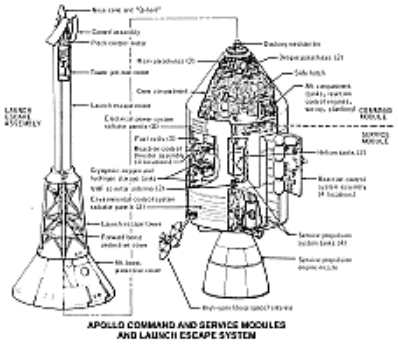












Two Broad Categories

Surface / Furrow

Sprinkler

Model of Furrow Erosion

Inflow

Source

Detachment

Infiltrating furrow stream

Transport

Deposition

Runoff and sediment loss

Tail Ditch

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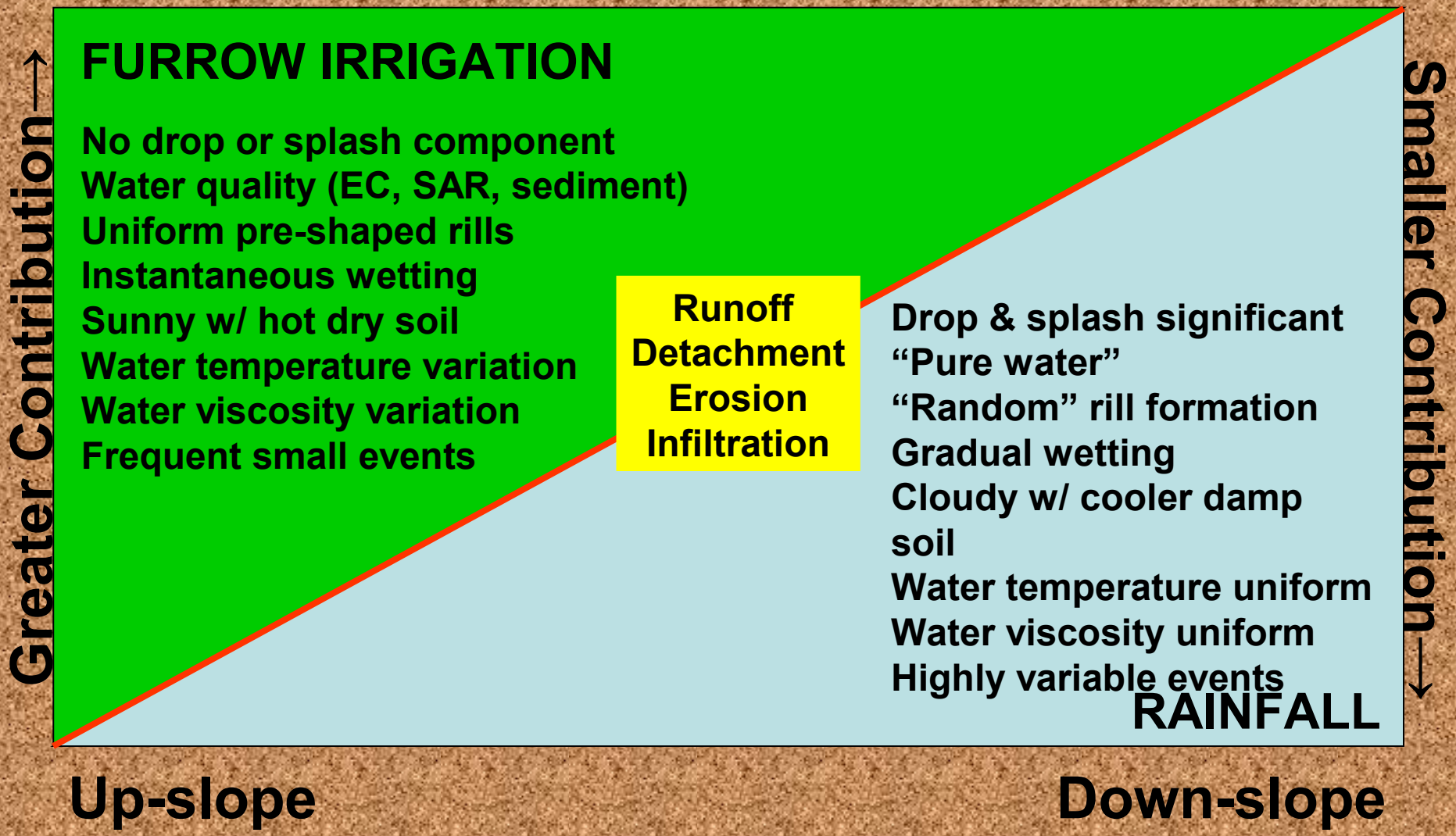
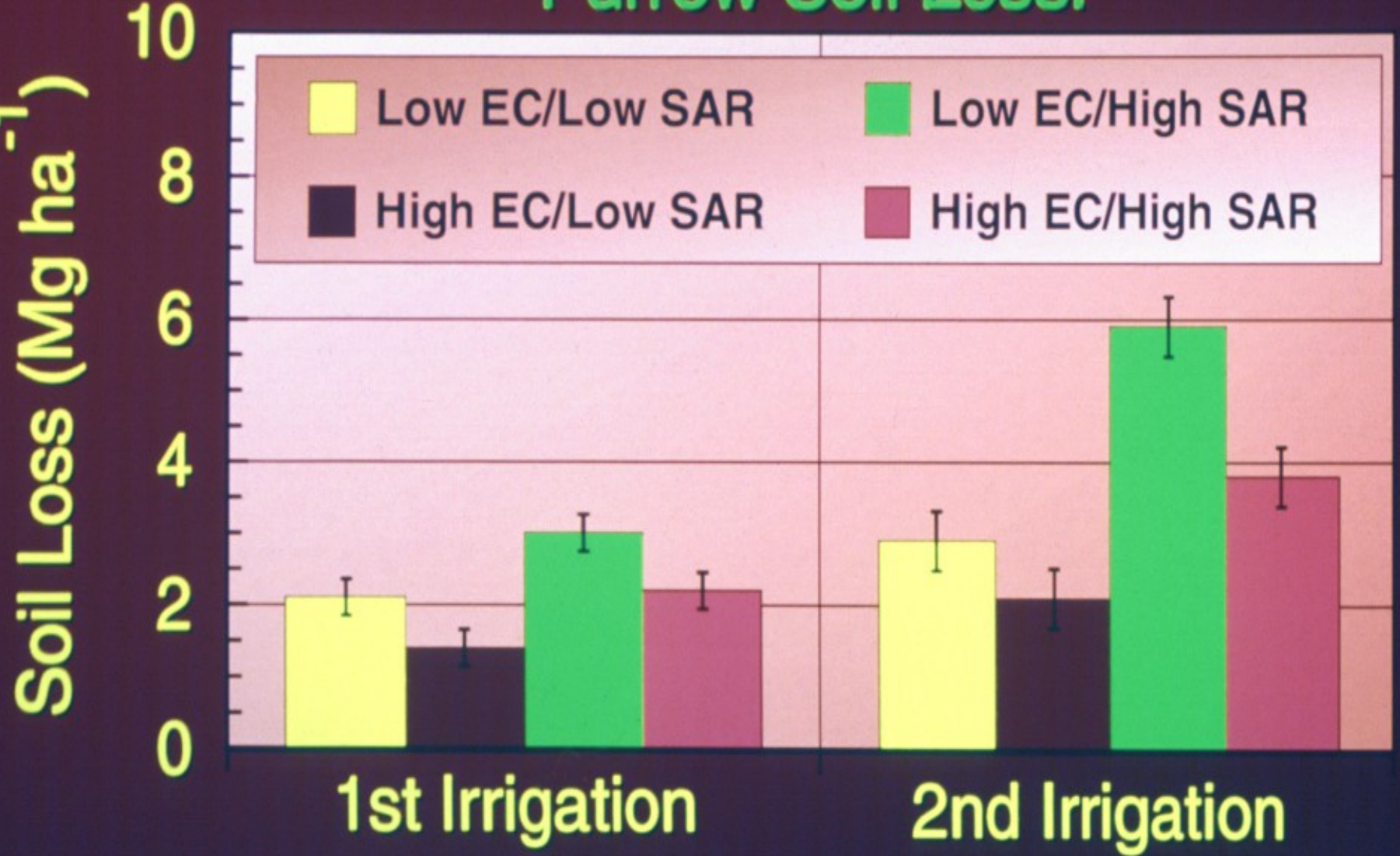
Same Processes – Different Systematics

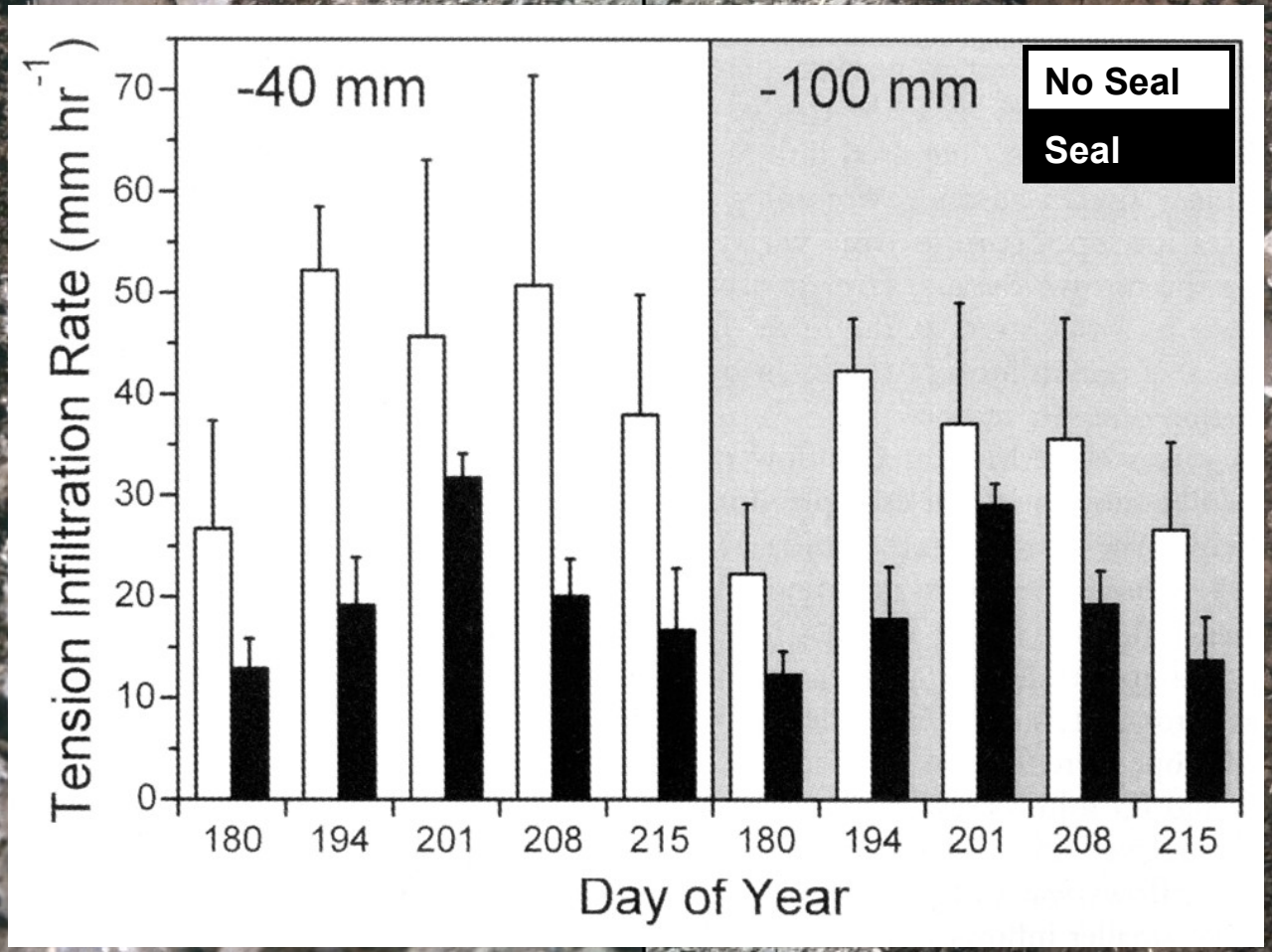


Irrigation Water-Quality Effects on Furrow Soil Loss:



Lentz, Sojka, Carter 1995

Effect of Surface Seals on Furrow Erosion and Infiltration



SPRINKLERS?

Still Have Modeling Challenges

Application & Runoff Spatial/Temporal-variability, Energy-variability, Water Quality


USDA
ars
SPRINKLERS
Potentially
100% Erosion Control
and Runoff Prevention
But…
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Poor Design, Soil & Landscape Variability, Application Rate, Wheel Ruts etc. Can Create Problems

And Water Quality Remains a Factor

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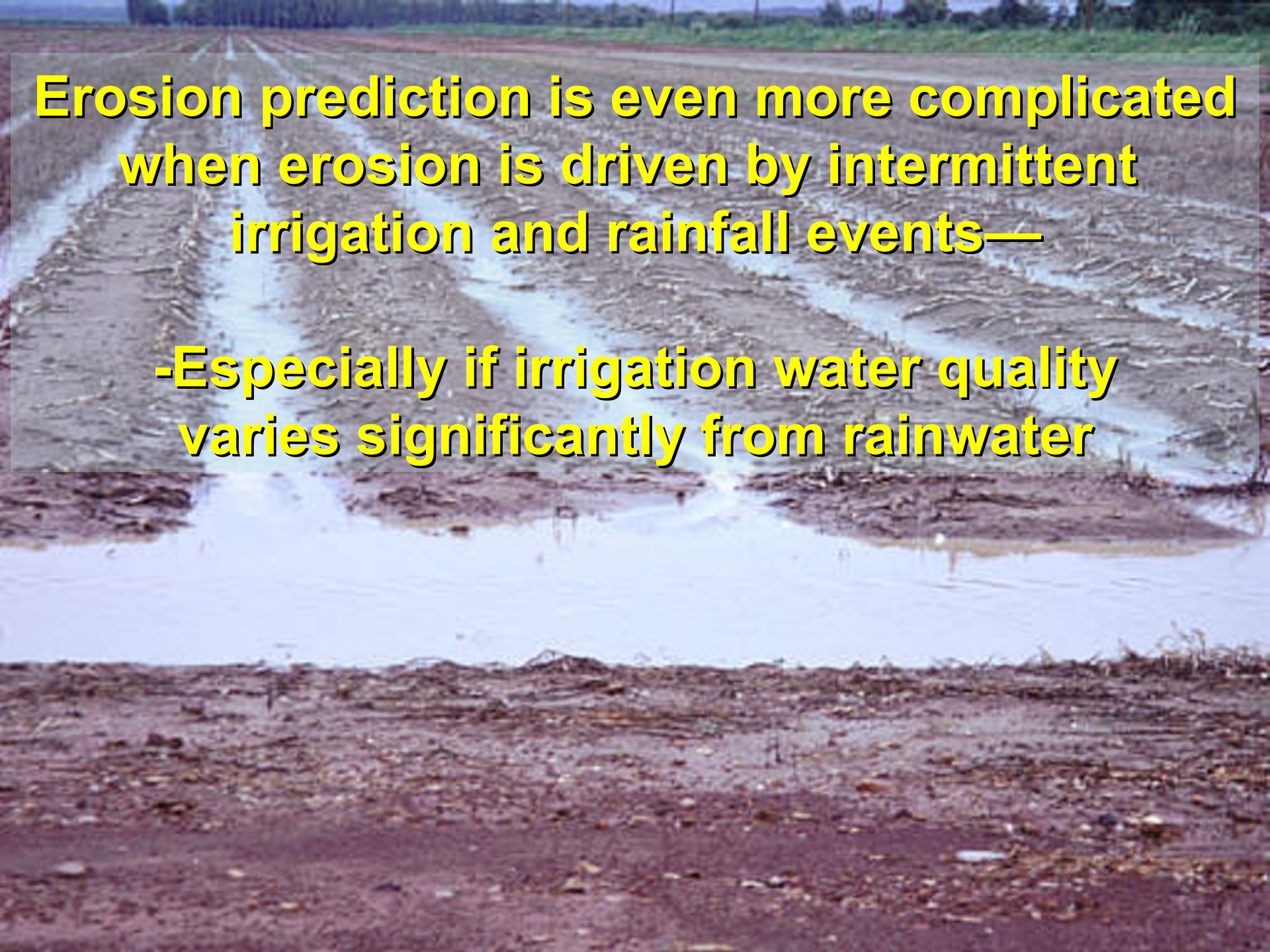
Erosion prediction is even more complicated when erosion is driven by intermittent irrigation and rainfall events—
-Especially if irrigation water quality varies significantly from rainwater


So… What's A Modeler To Do??
Ask Mark Nearing!!
USDA

Moving Forward with Irrigation Erosion Assessment Models

USDA ARS

Furrow Irrigation – SISM*

- **Current Surface-Irrigation Simulation Model is an empirical representation of furrow erosion rates:**
  - **SISL = BSL*KA*PC*CP*IP**
  - **BSL Base soil loss (from 200 furrow irrigated fields, Idaho)**
  - **KA Soil Erodibility Adjustment factor**
  - **PC Prior Crop Adjustment factor**
  - **CP Conservation Practice Adjustment factor**
  - **IP Irrigation Management Adjustment factor**

* Bjorneberg et al., 2007 – Evaluating the Surface Irrigation Simulation Model Applied Eng. In Agriculture - IDAHO

Furrow Irrigation - SRFR *

- **Current Surface-Irrigation Simulation Model represents the basic processes needed to simulate furrow erosion, including:**
  - **Numerical solution to unsteady flow equations with decreasing flow down-furrow**
  - **Selection of sediment transport equations to test**
  - **Physically-based detachment and deposition equations**

* Strelkoff, T.S., and A.J. Clemmens. 2007. Hydraulics of Surface Systems. In: Design and Operation of Farm Irrigation Systems, ASABE.

Furrow Irrigation - SRFR

- **Needed work:**
  - **Ability to represent multiple size-classes of sediment, and thus preferential deposition and associated armoring**
  - **Further testing of sediment transport equations with multiple size-class sediment**
  - **Extensive collection of data of erosion for wide range of soils and water chemistry to develop parameter estimation equations**

Furrow Irrigation - SRFR

- **Also - Similar problems as with current rainfall erosion models:**
  - **The sediment transport equations were developed for river-sized sediments**
  - **Head-cuts and furrow side-sloughing not explicitly represented**

Sprinkler Irrigation

- **Very little work has been done to advance sprinkler irrigation models**
- **Kincaid, 2002, conducted a WEPP application to sprinkler irrigation data from S. Idaho.**
  - ***"Soil loss predictions were unreliable for the small runoff amounts occurring in this study. The most reasonable use of WEPP for sprinkler irrigation would be for estimating when potential runoff might occur under center pivots for different soils, slopes, and crop management practices, and to determine limits on application depths and rates to avoid serious runoff."***

Sprinkler Irrigation

- **Current erosion models (e.g., WEPP) use a spatially homogeneous rainfall input. Not designed to take sprinkler input, which is spatially heterogeneous and moves with time across the field.**
- **A spatially-explicit model must first be developed to represent spatially & temporally variable sprinkler water input -**
- **Followed by extensive data collection, testing and parameterization (soil, water, etc.)**

Thank You

Questions?