SDSU Extension

Ag Drainage Practices and Issues

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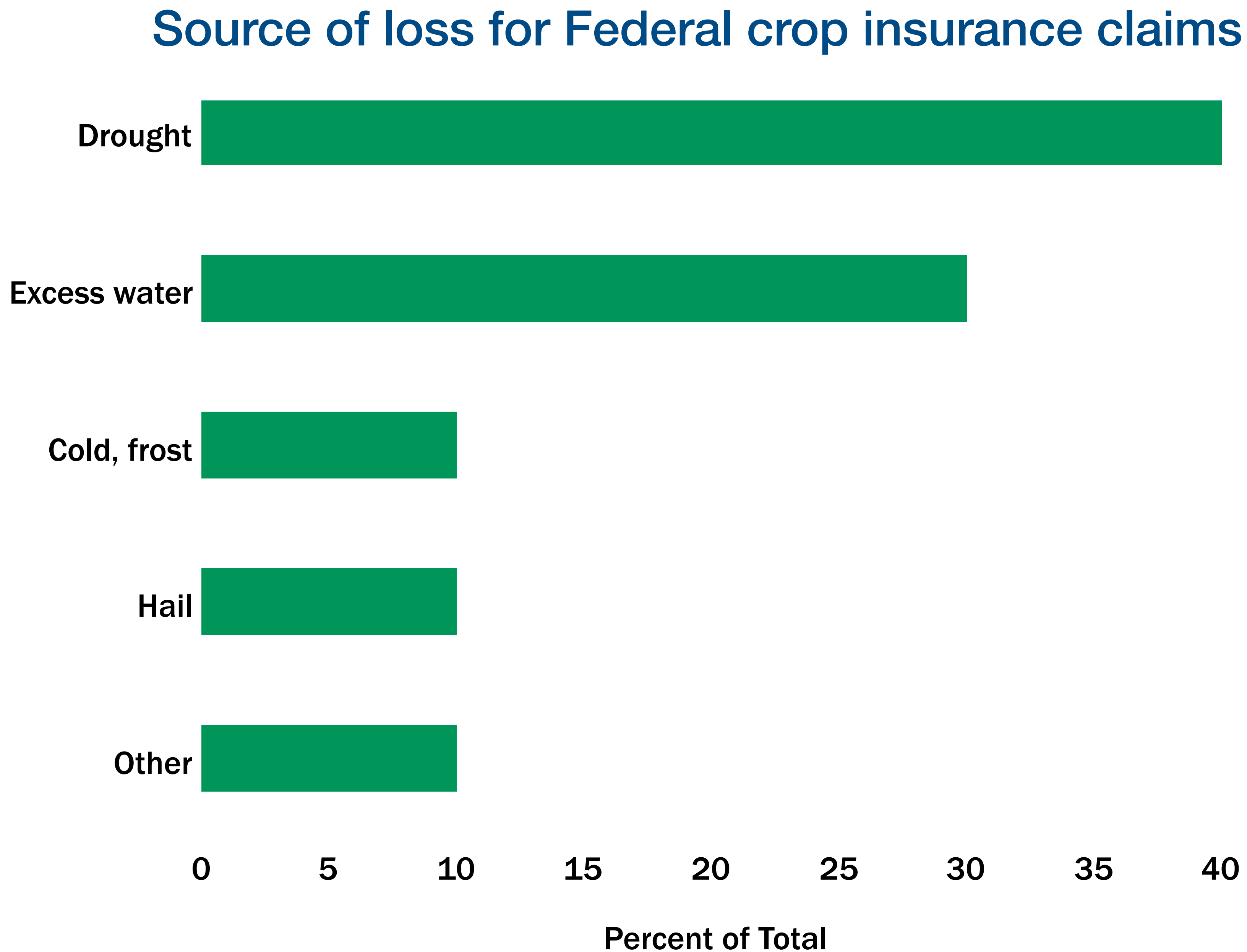
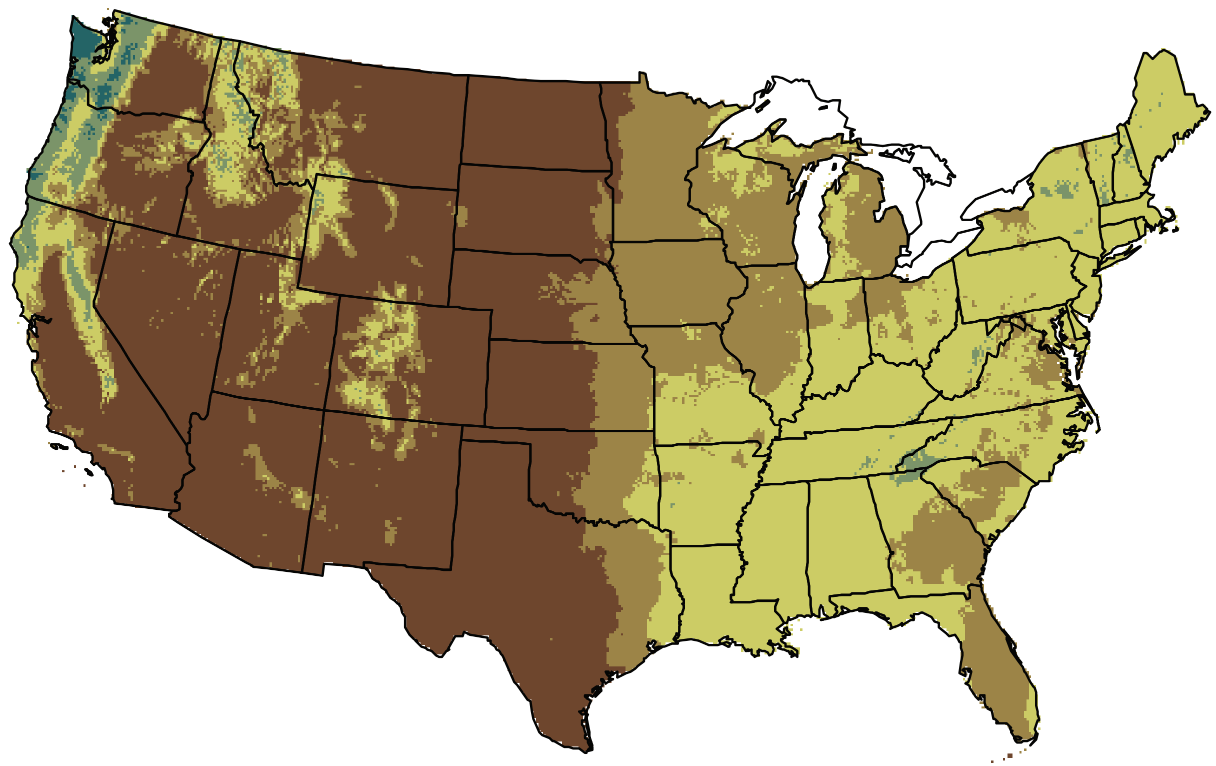
Ag & Biosystems Engineering

Water is a major environmental factor limiting plant growth



Source: USDA RMA

Eastern SD sits in a transition zone from humid to drier conditions



EXPLANATION

Precipitation-PET, in millimeters per year

- –1,600–0
- 1–318
- 319–868
- 869–1,838
- 1,839–6,656

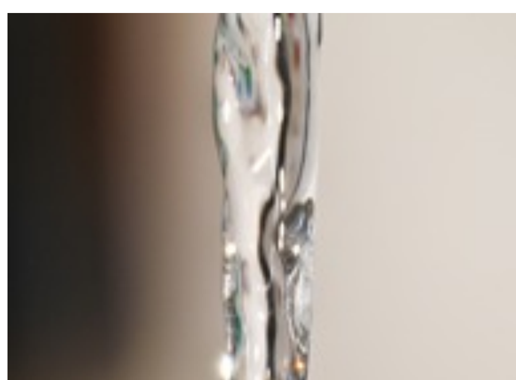
Figure 19. Difference between annual precipitation and potential evapotranspiration rates across the conterminous United States.

Source: USGS

This presentation will cover:

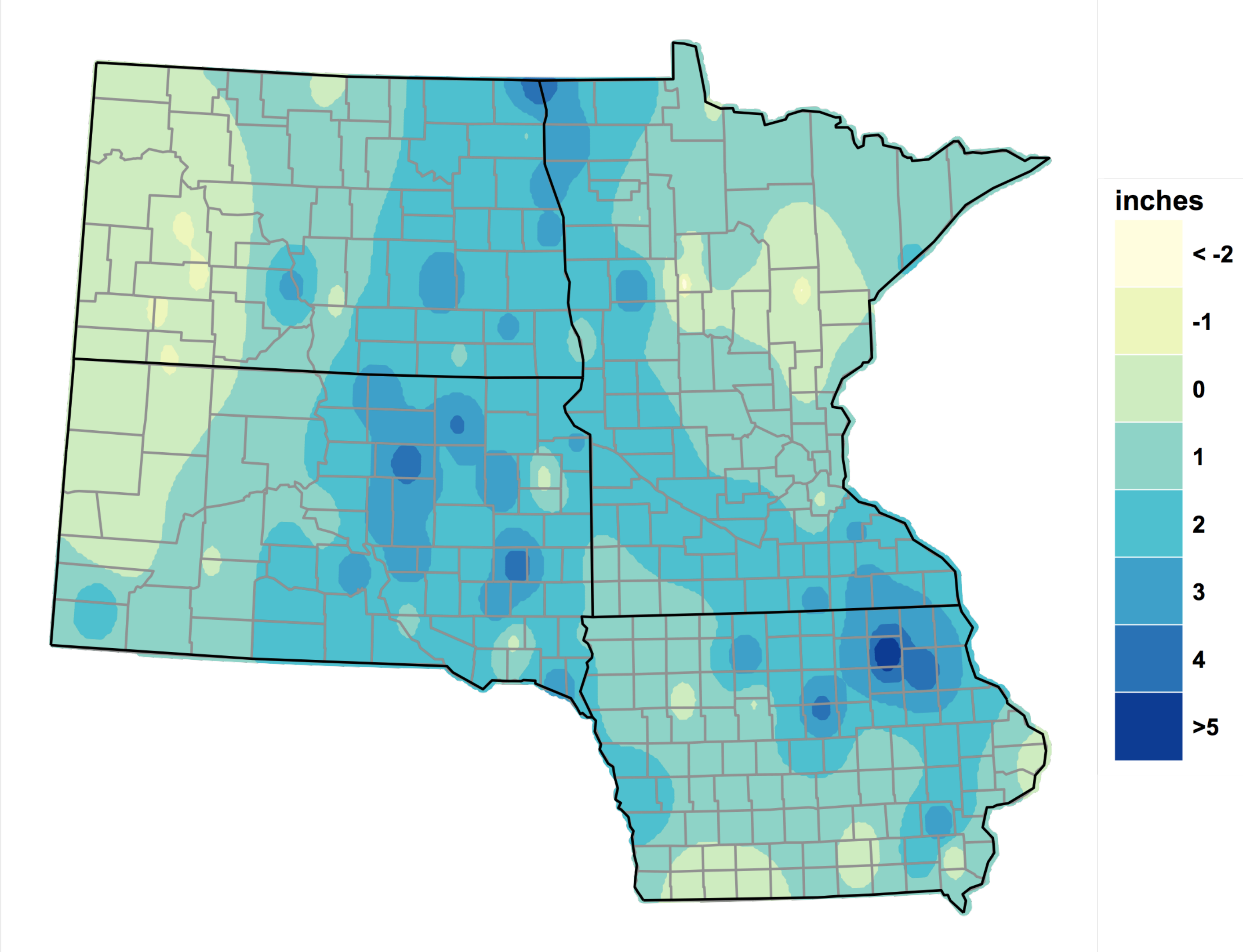
Why are SD farmers tiling?

How does tiling impact hydrology and streamflow?



How does tiling impact water quality?

Precipitation has increased

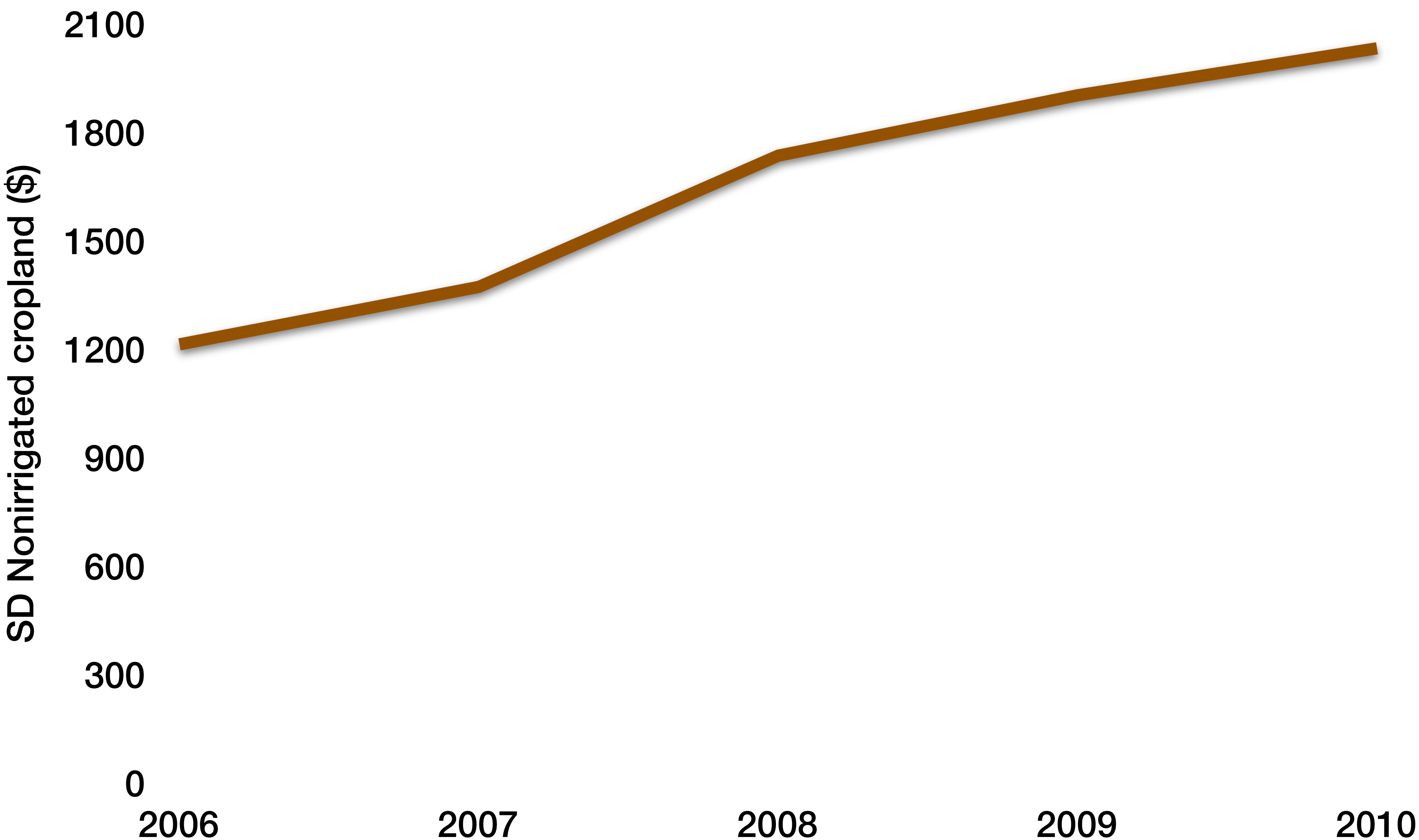


Change in mean annual precipitation (inches) for the period of 1991–2009 as compared to 1961–1990

Commodity prices have increased

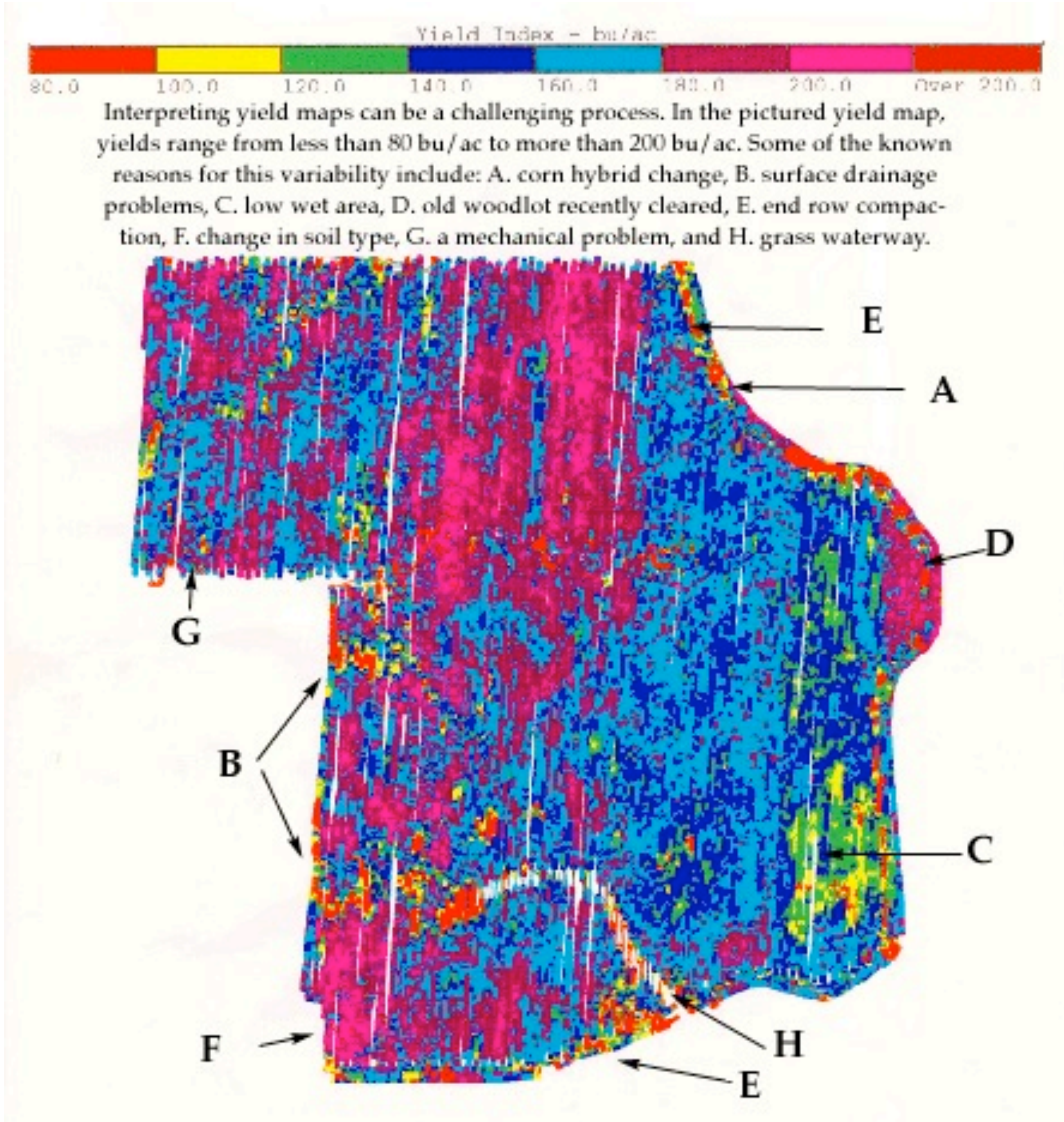
Source: ISU Extension

Land prices have increased



Source: Janssen et al. (2010)

Yield mapping makes it easier to see areas of poor drainage



Source: Lotz (1997)

Technology has changed

Improved drainage benefits agricultural production by:

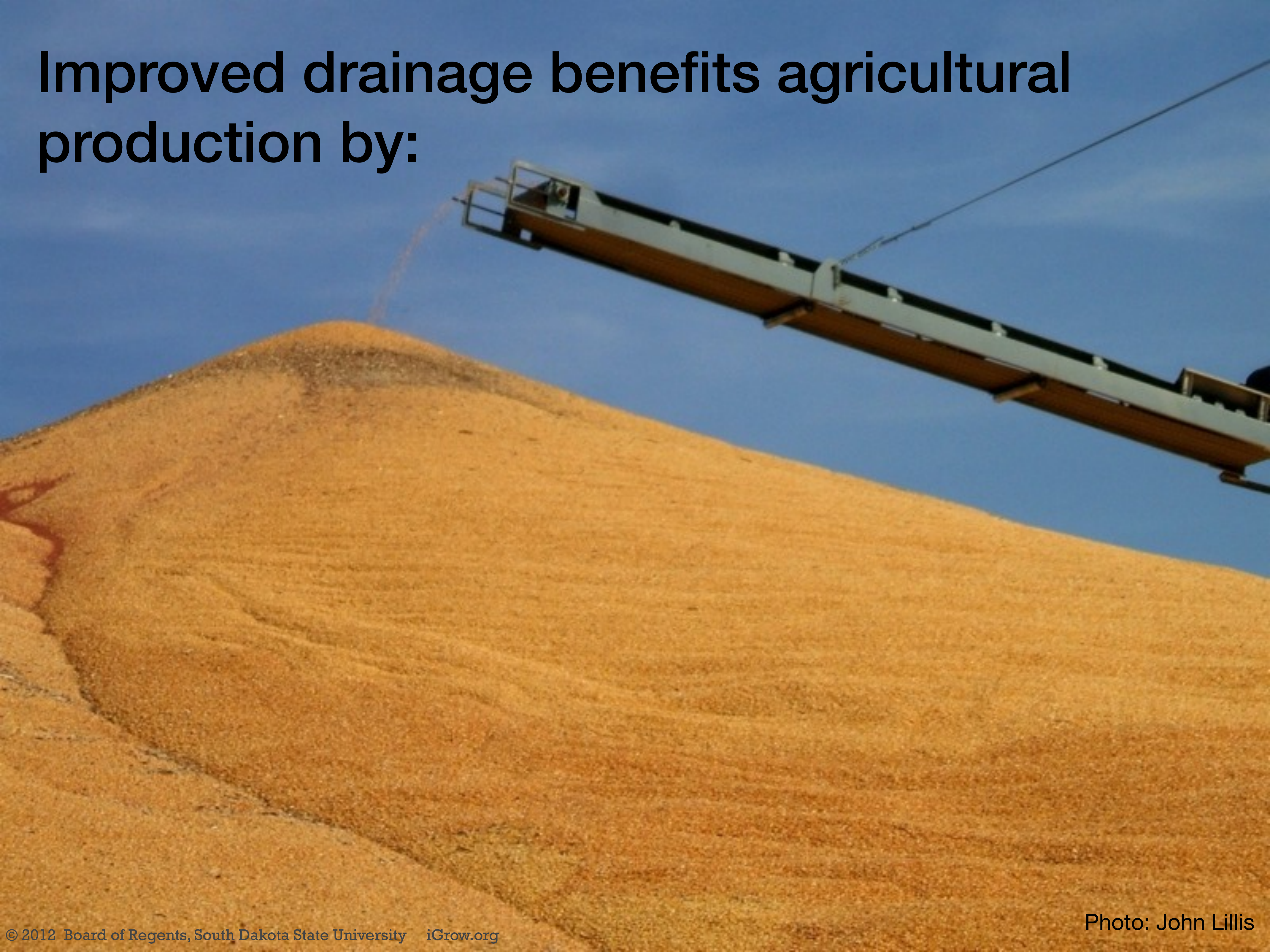


Photo: John Lillis

Allowing for more timely field operations

Photo: USDA NRCS

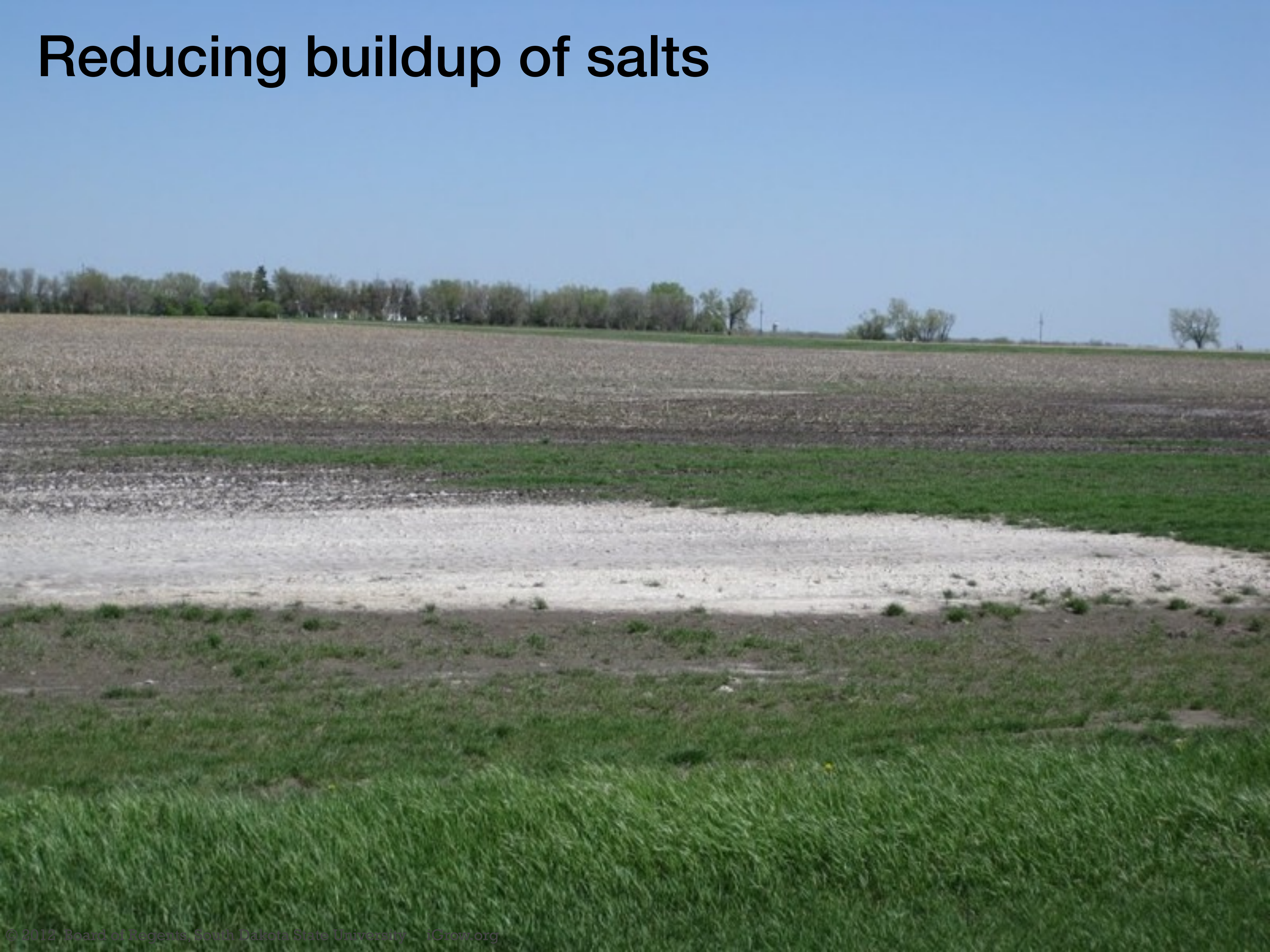
Reducing crop stress due to excess water and high water tables

Photo: Sonya Green

Reducing soil compaction

Photo: Pigsaw

Reducing buildup of salts



Typical yield increases from improved drainage in the Midwest

- Corn: 10–30 bu/ac
- Soybeans: 5–10 bu/ac
- Winter wheat: 17 bu/ac
- Spring wheat: 11 bu/ac
- Reduced year-to-year variability

Sources: Wright and Sands (2001) and Irwin (1998)


Photo: Susan Drackett

Enhances the ability to use other conservation practices

Factors that may necessitate drainage for agricultural production

- Slow permeability soils
- Restrictive soil or geologic layers
- Flat or depressional topography
- Compacted soil layers
- Soil salinity
- Too much rain at the wrong time

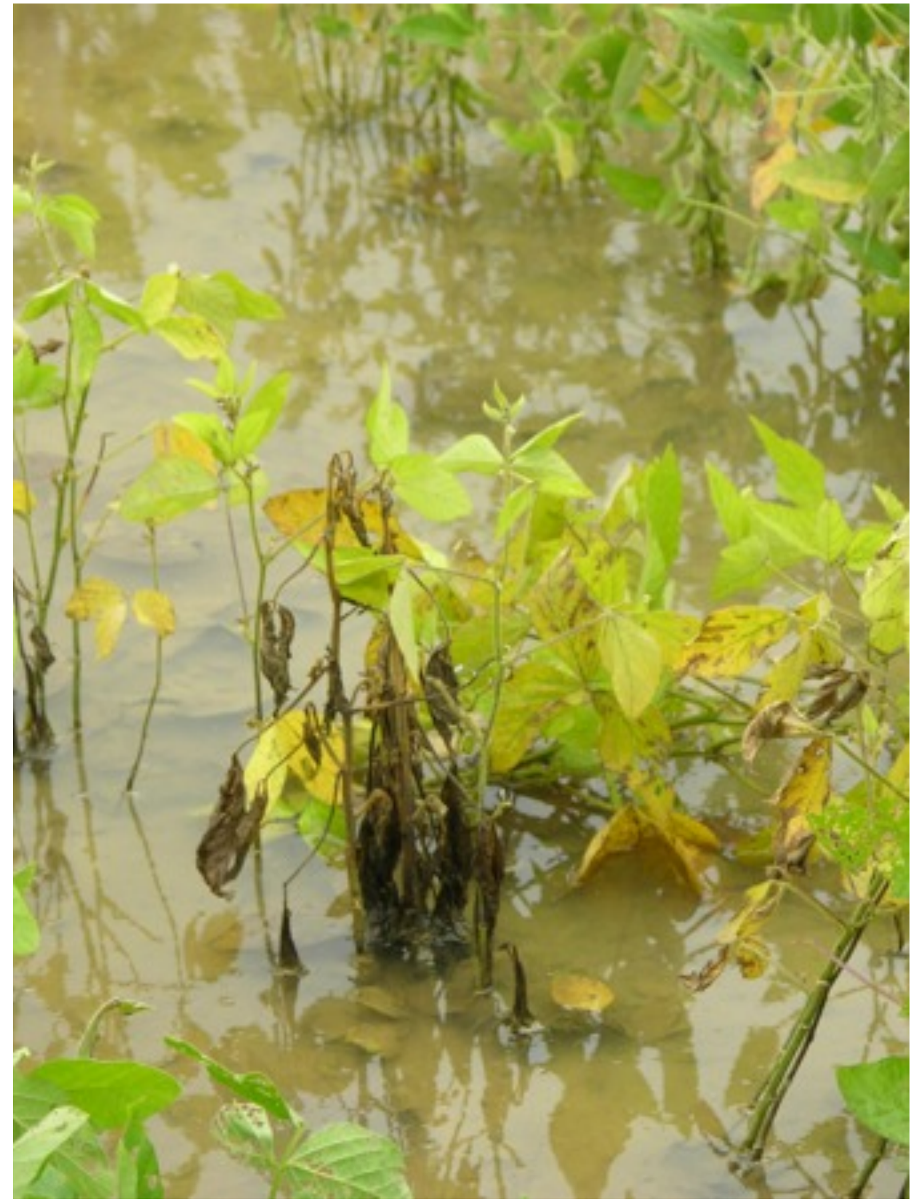
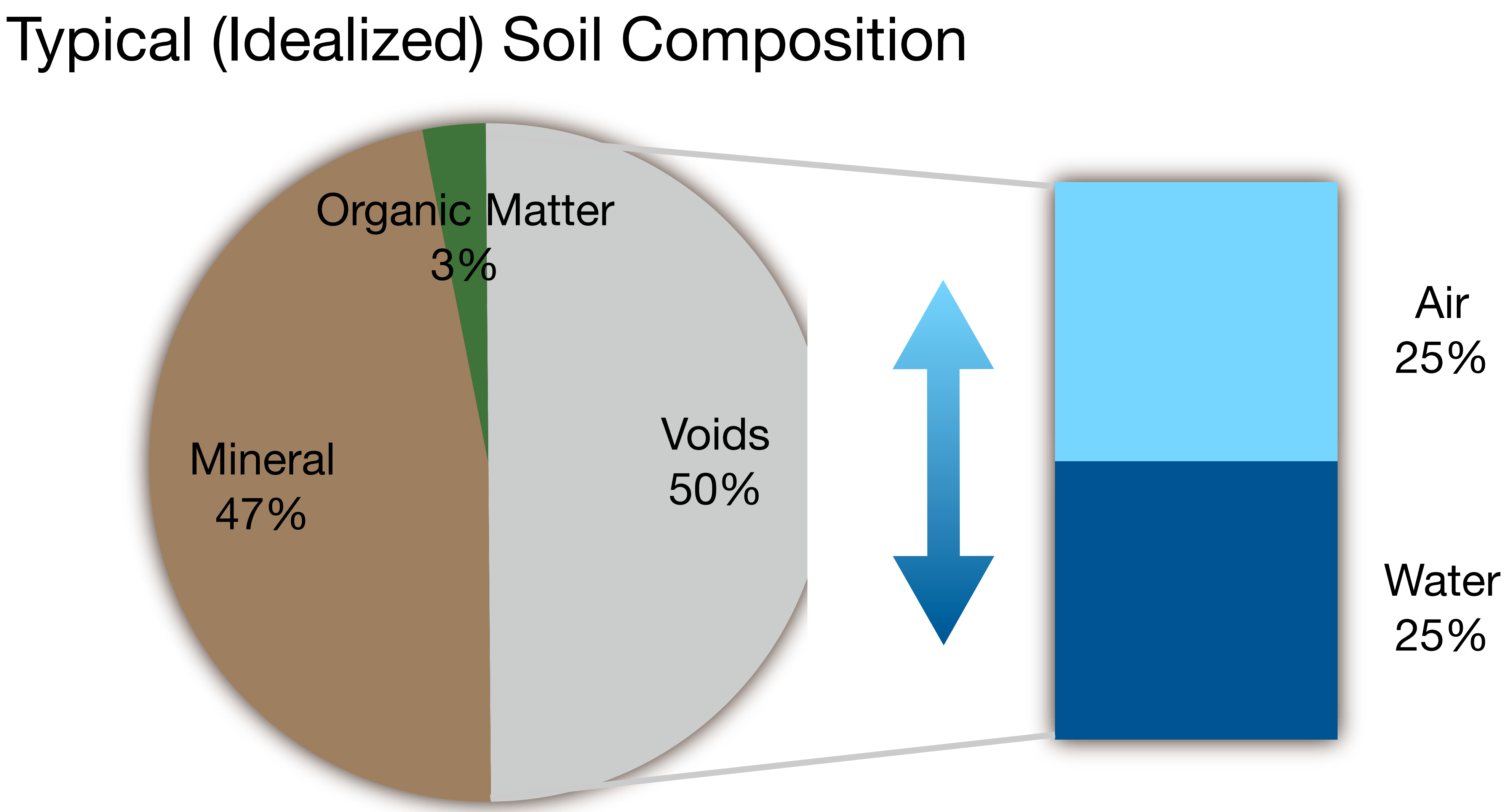
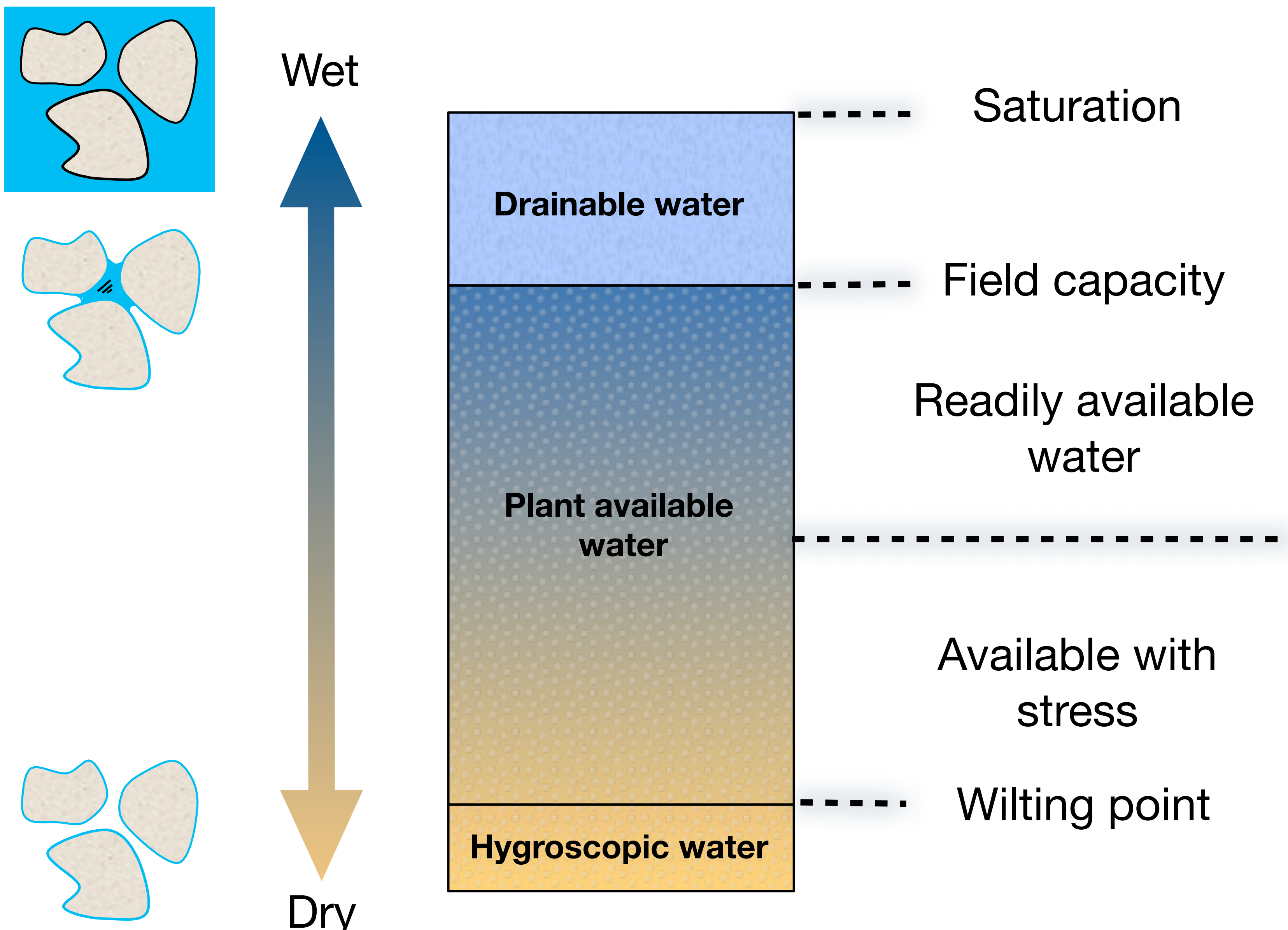


Photo: USDA ARS

Soils are a mixture of minerals, air, water, and organic matter

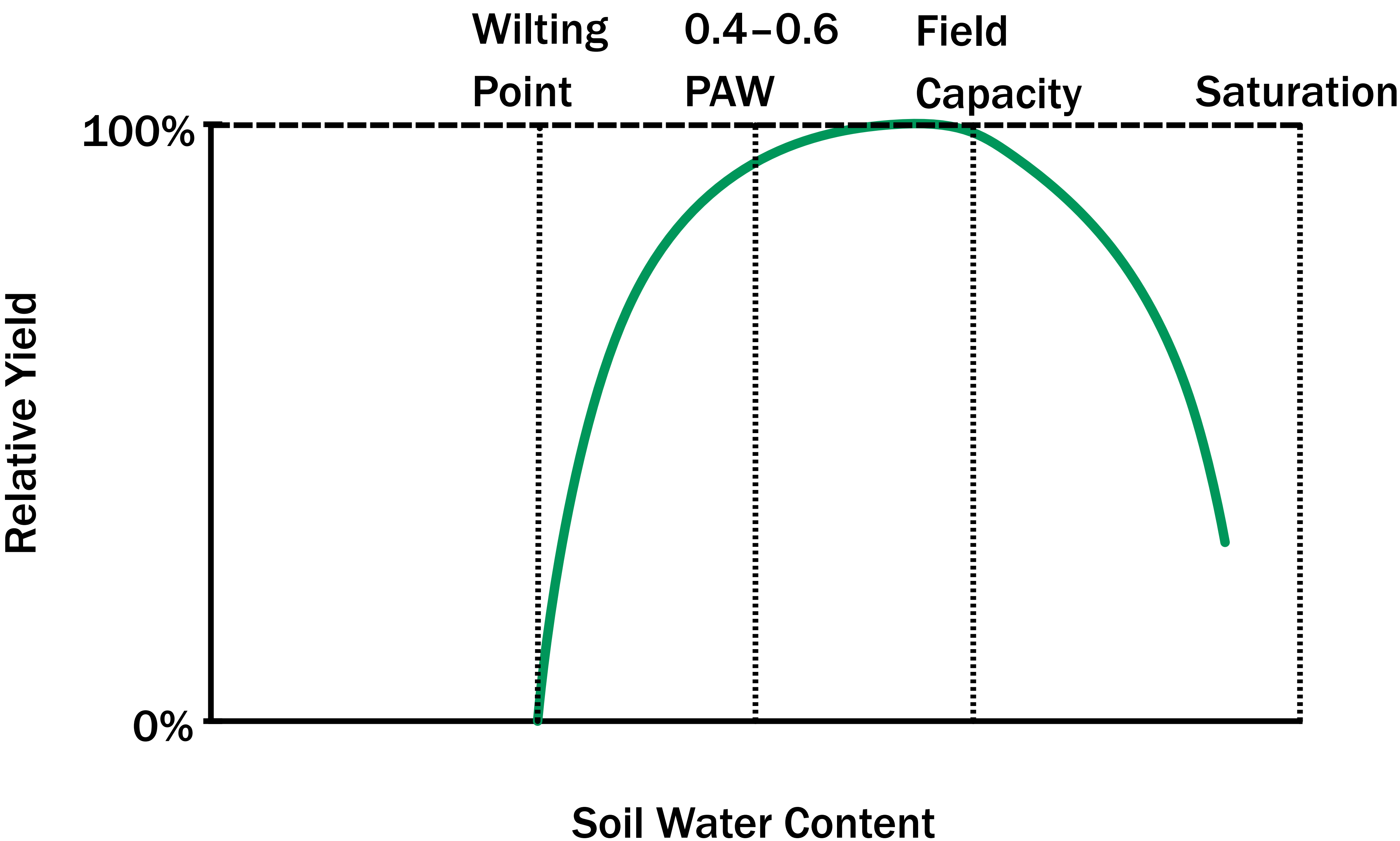


Soil water is stored in the pore spaces of the soil



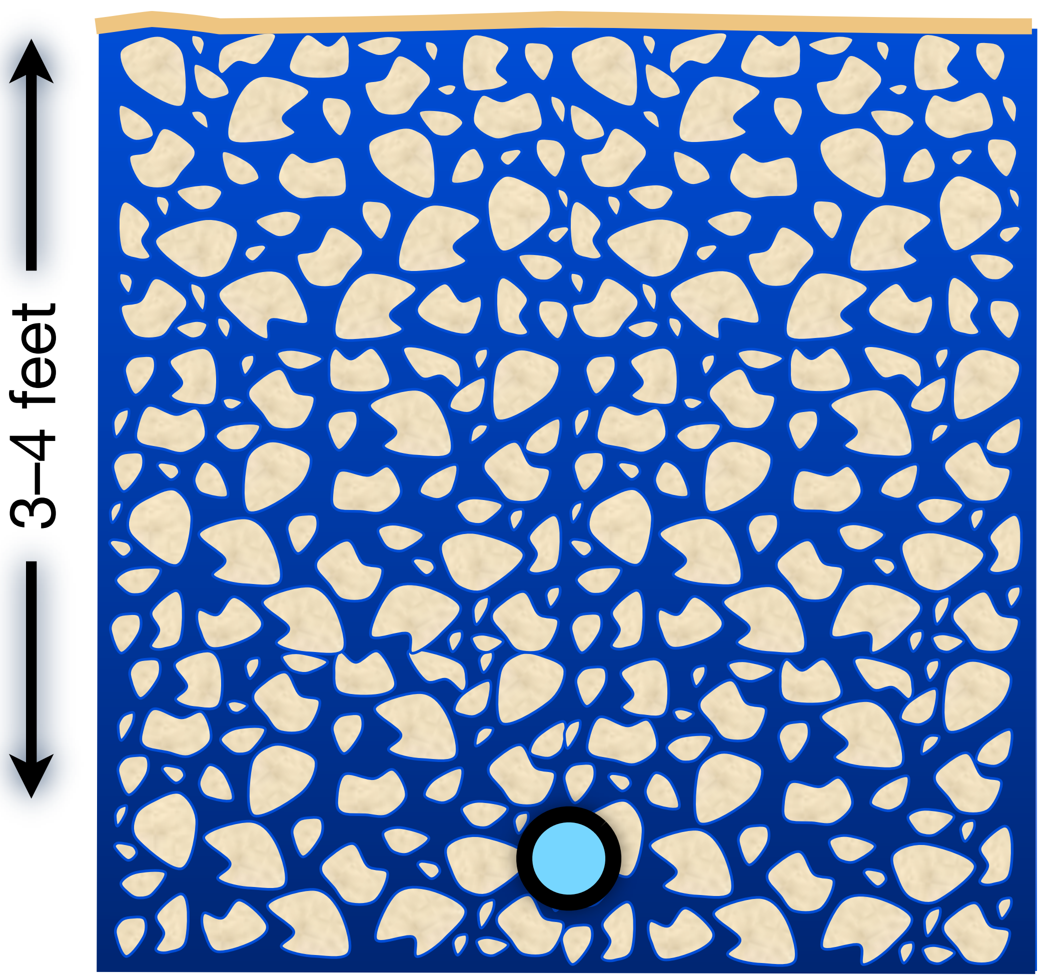
Graphics courtesy of or adapted from Gary Sands

Yield is related to water availability



Adapted from Ward and Trimble (2004)

We can lower a high water table through drainage



- "Gravitational" or "free" water removed (from largest pores)
- Water remains in smaller pores
- Drier towards the surface
- Water table occurs over hours to days

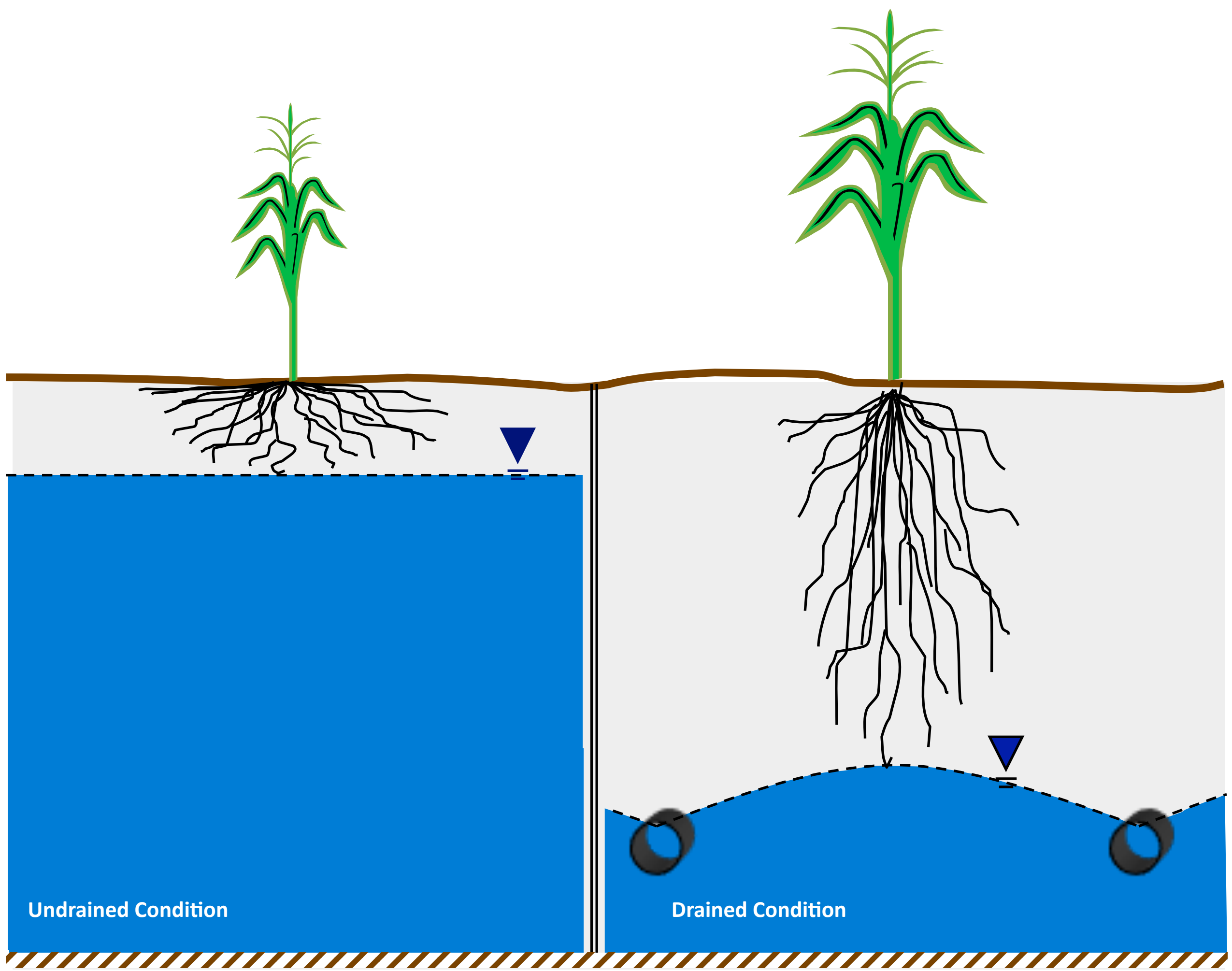
Graphics courtesy of Gary Sands

Drainable porosity determines the amount of water that will be drained

Soil Type	Range
Clay	1%–8%
Clay loam	1%–14%
Silt, silt loam	3%–14%
Loam	8%–14%
Sandy loam	8%–21%
Sand	19%–35%

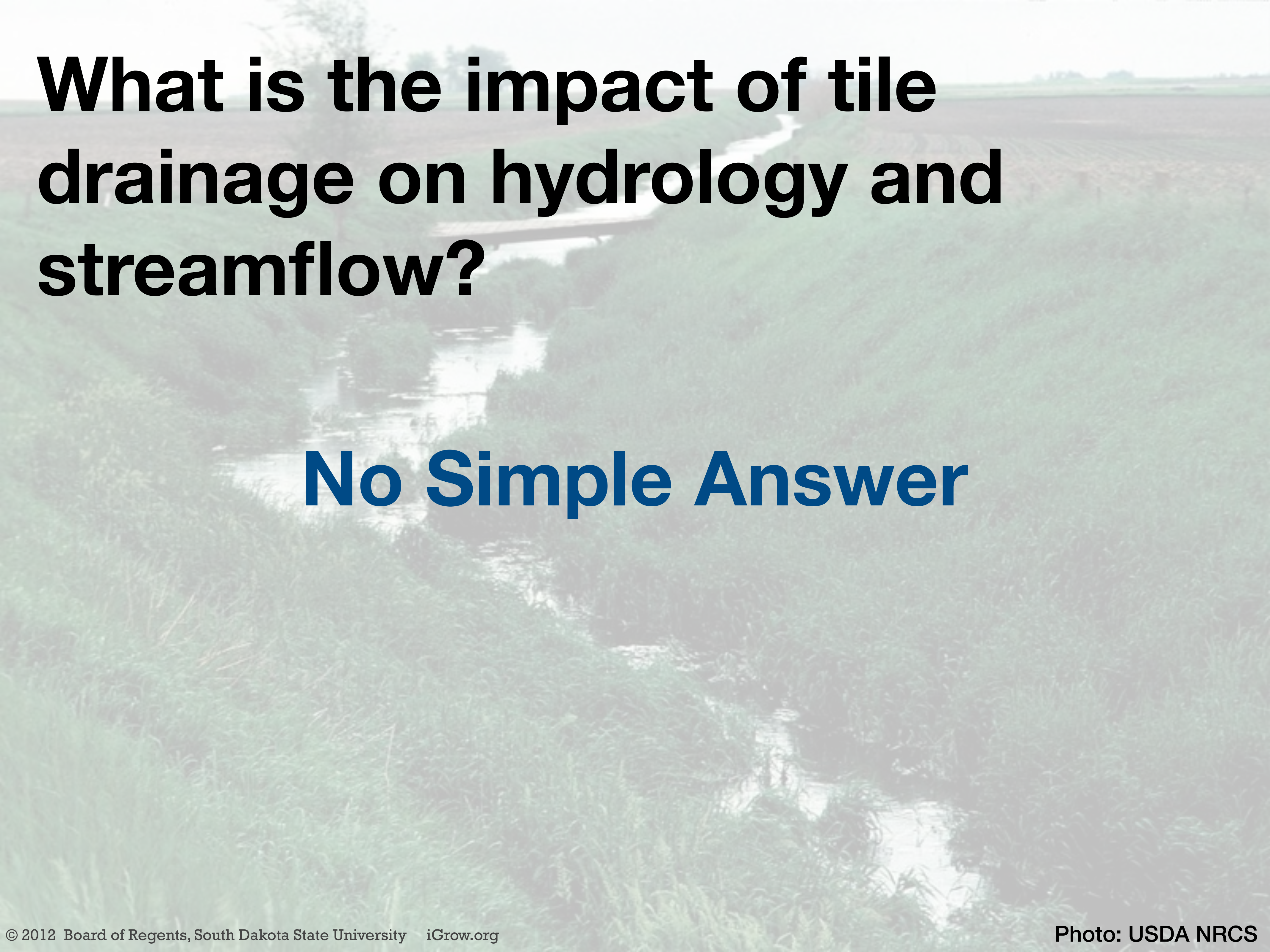
USBR (1978)

Goal is to create a deep-rooted, healthy crop



Graphics courtesy of Gary Sands

What is the impact of tile drainage on hydrology and streamflow?



No Simple Answer

Photo: USDA NRCS

Do we know with certainty what the impacts are?

Not really

Drainage, hydrology, and streamflow depend on many factors

Factors change continuously over both time and space

Photo: USDA NRCS

What do we know?

We know what the important factors are and general relationships among them

Computer models help us deal with complexity and understand the system

Photo: USDA NRCS

To understand hydrologic impacts, we need to understand how drainage impacts the water balance

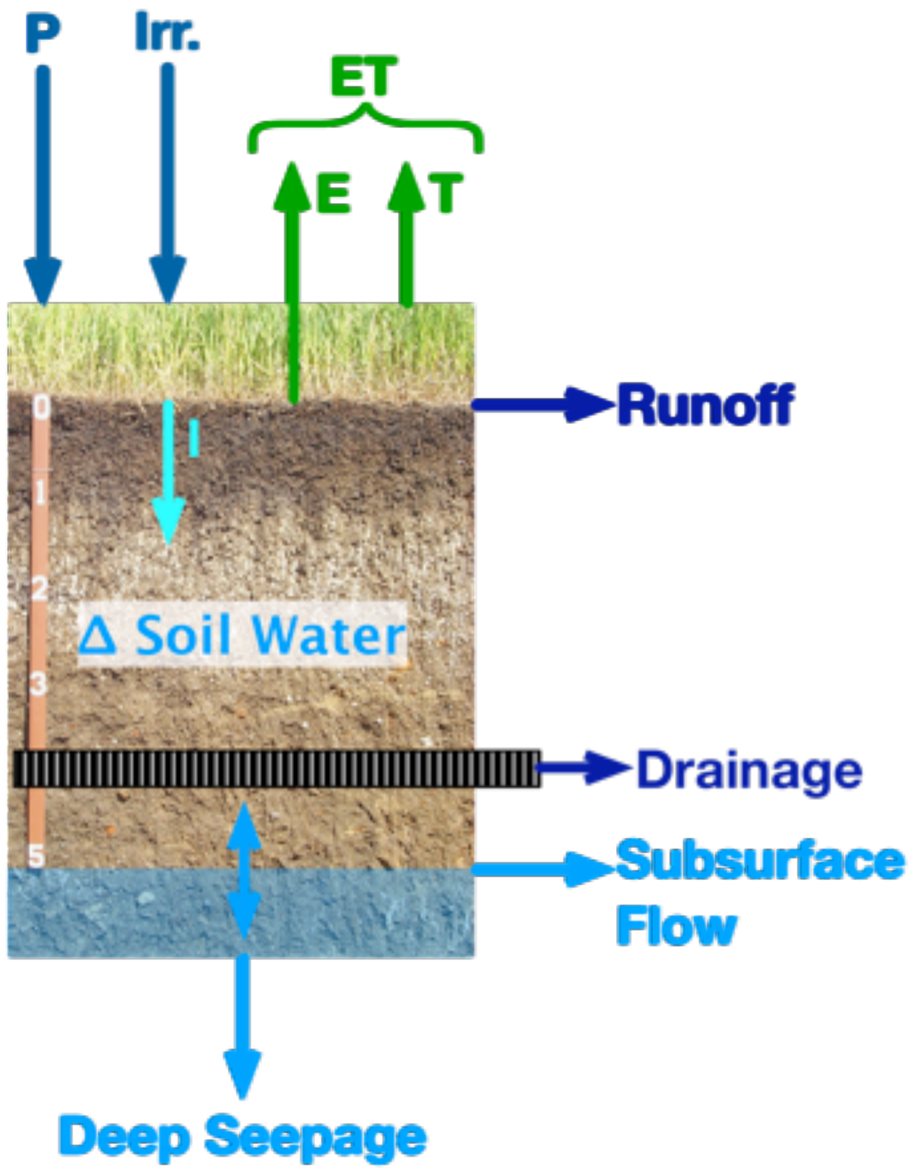
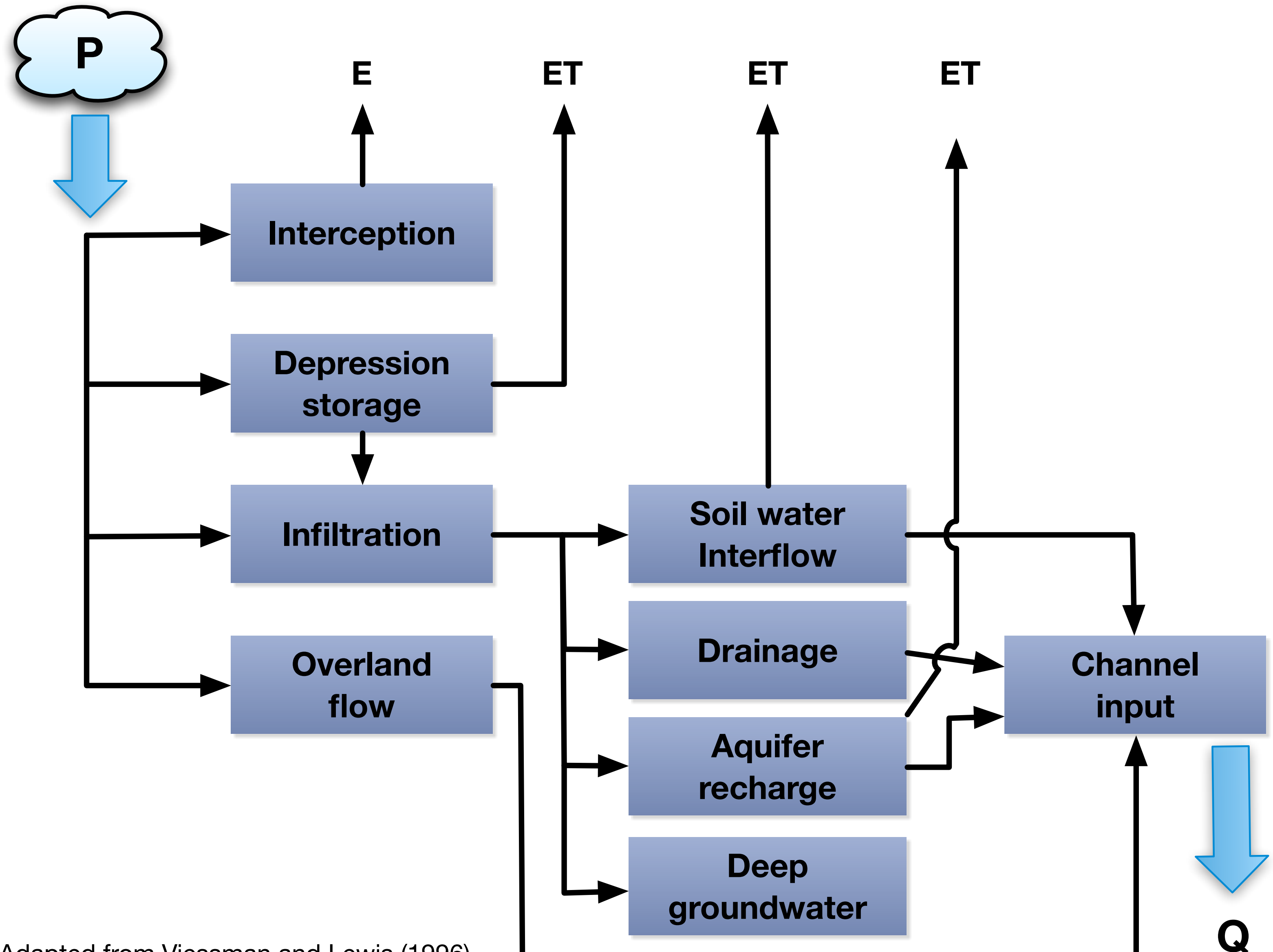


Photo: USDA NRCS

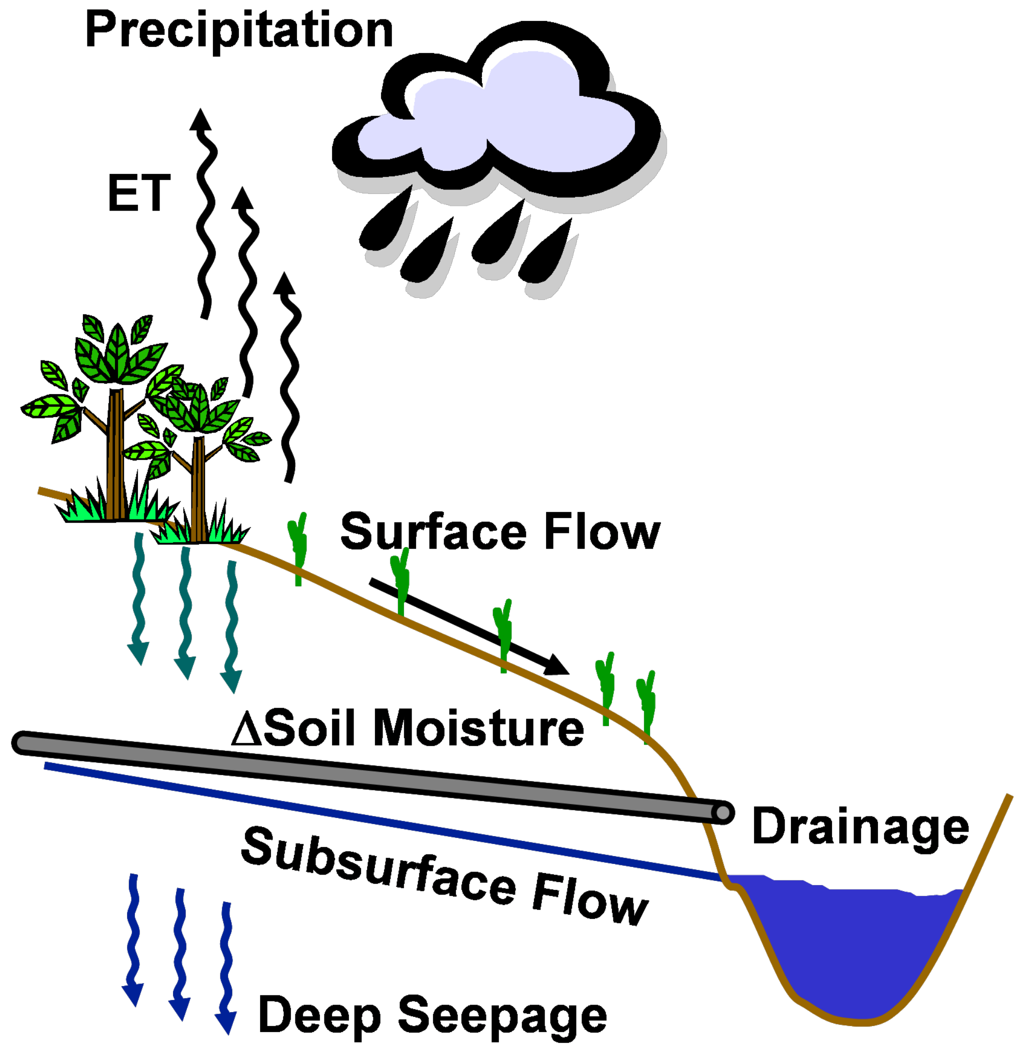
To understand impacts on streamflow, we need to understand all the pathways that precipitation can take



Adapted from Viessman and Lewis (1996)

Simplified water balance equation

$$P = ET + R + Z + D$$



Graphics courtesy of Gary Sands

Impacts of drainage on hydrology depend on a number of factors

- Geologic, climatic, and land cover (soils, landscape, climate, land use)
- Chronological point of reference
- Type and extent of drainage (ditch or tile?)
- Time scale: event, season, year, long-term
- Spatial scale: field → catchment → watershed → basin

For today's discussion—not considering:

Not considering: Impacts of land conversion

Photo: cariliv

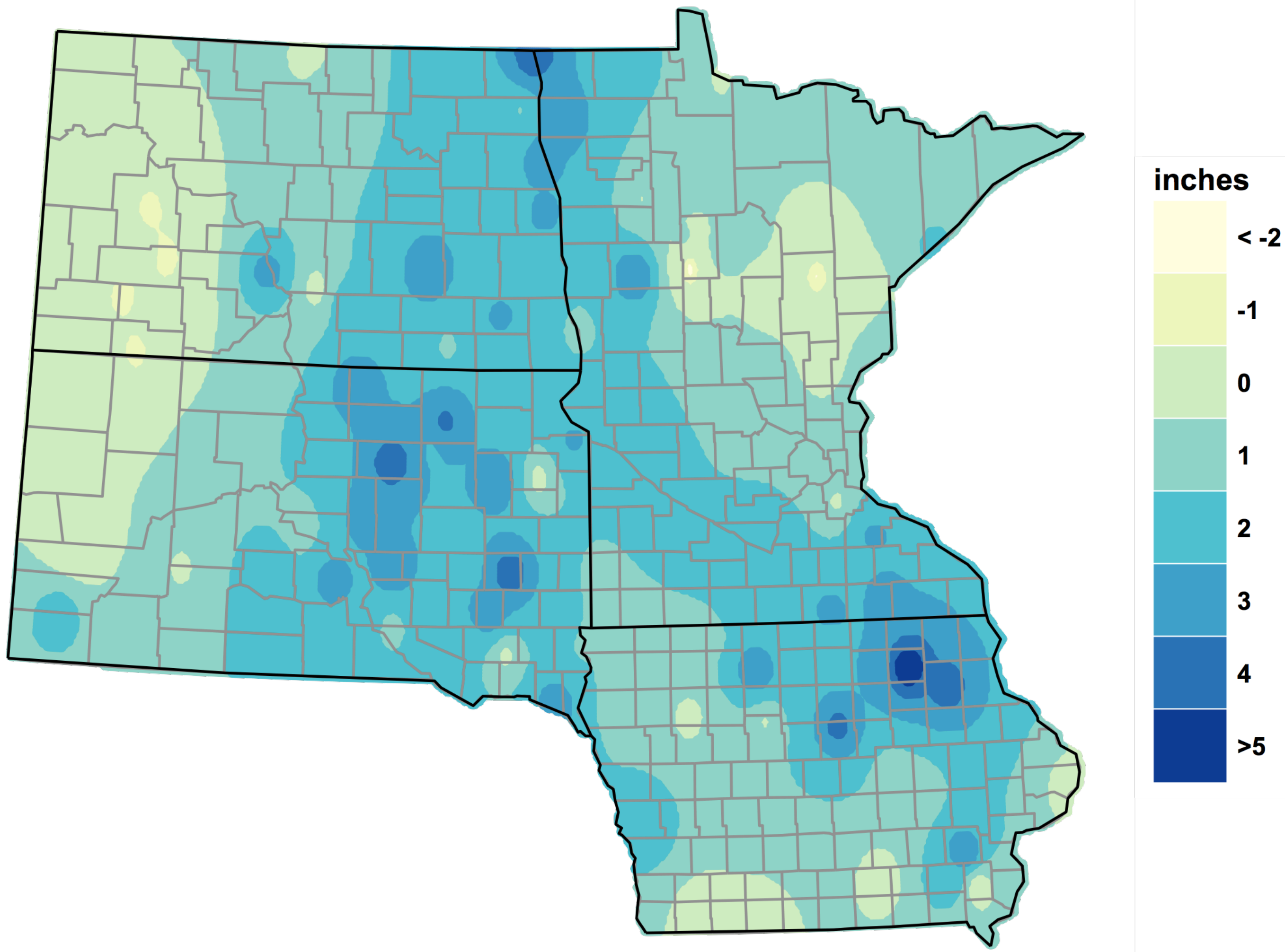
Photo: USDA NRCS

Not considering: Impacts of surface ditches

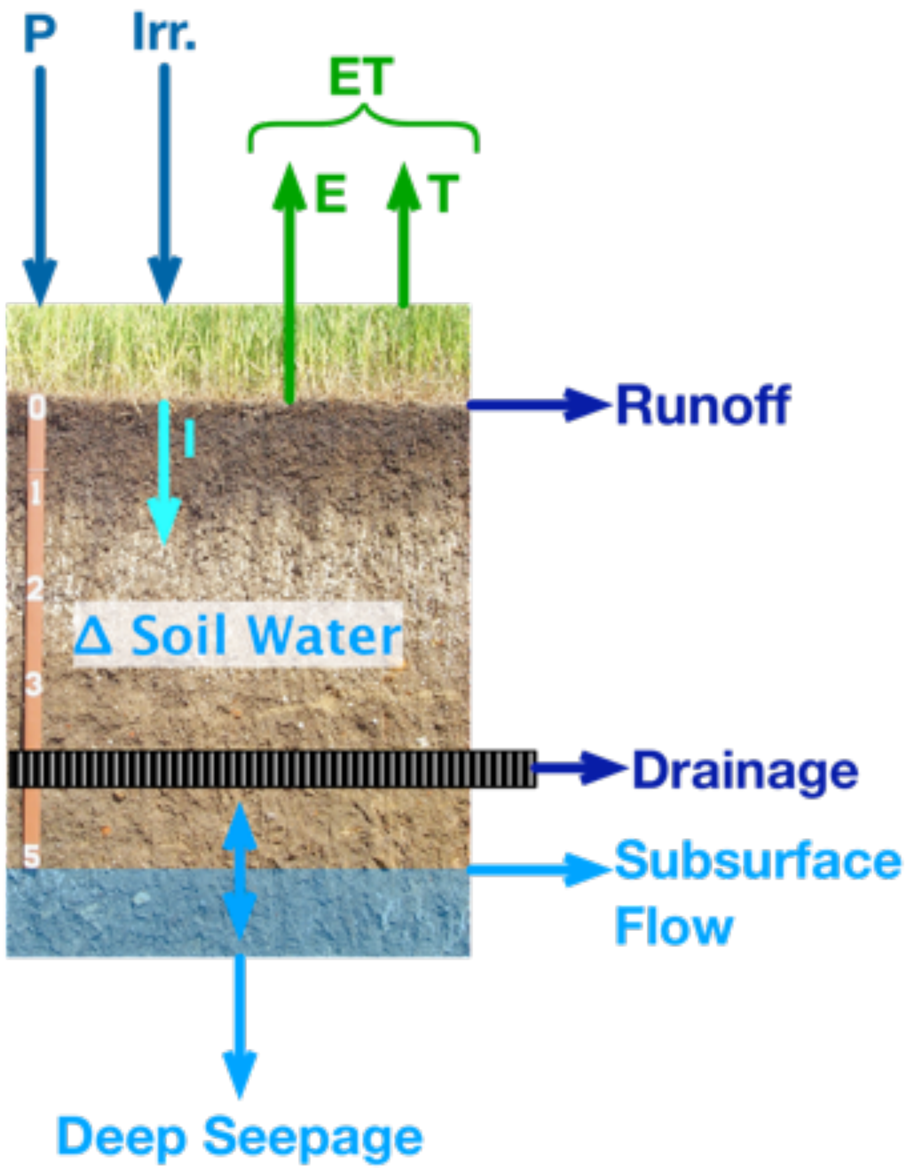
Photo: USGS

Photo: USDA NRCS

Not considering: Climate changes and trends

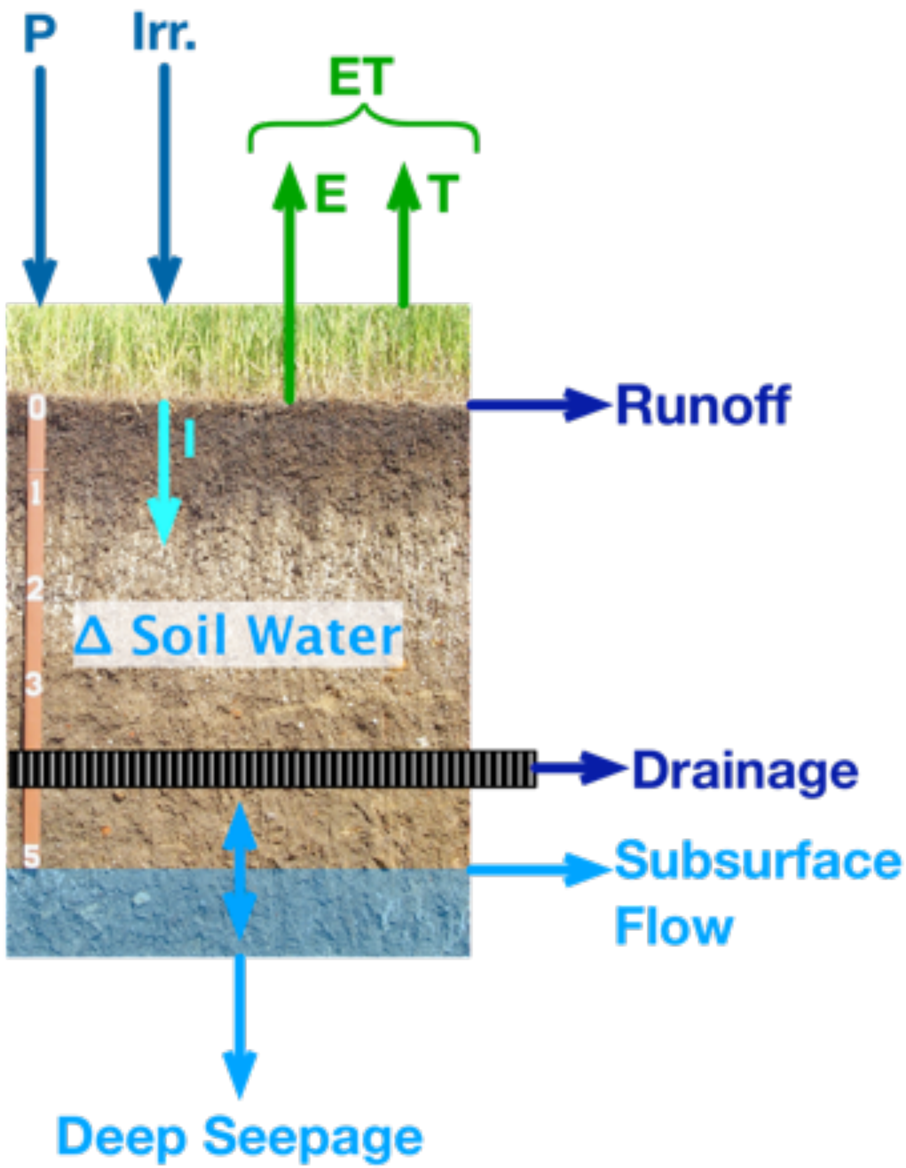


Key factor: Soils



- Soil type (clay, loam, sand)
- Bare, cover, or crop
- Wet, dry, or frozen?

Key factor: Soils



- Clay soils → Drainage generally reduce peak flows
  - Exception: Cracking
- Sandy soils → Drainage tends to increase peak flows
  - Exception: Frequently inundated sands

Source: Robinson and Rycroft (1999)

Key factor: Precipitation intensity—can trump soil

Gentle Rainfall

- Favors infiltration
- Tile drainage system influences flow
- Surface drainage has little impact

Photo: Luc Viatour

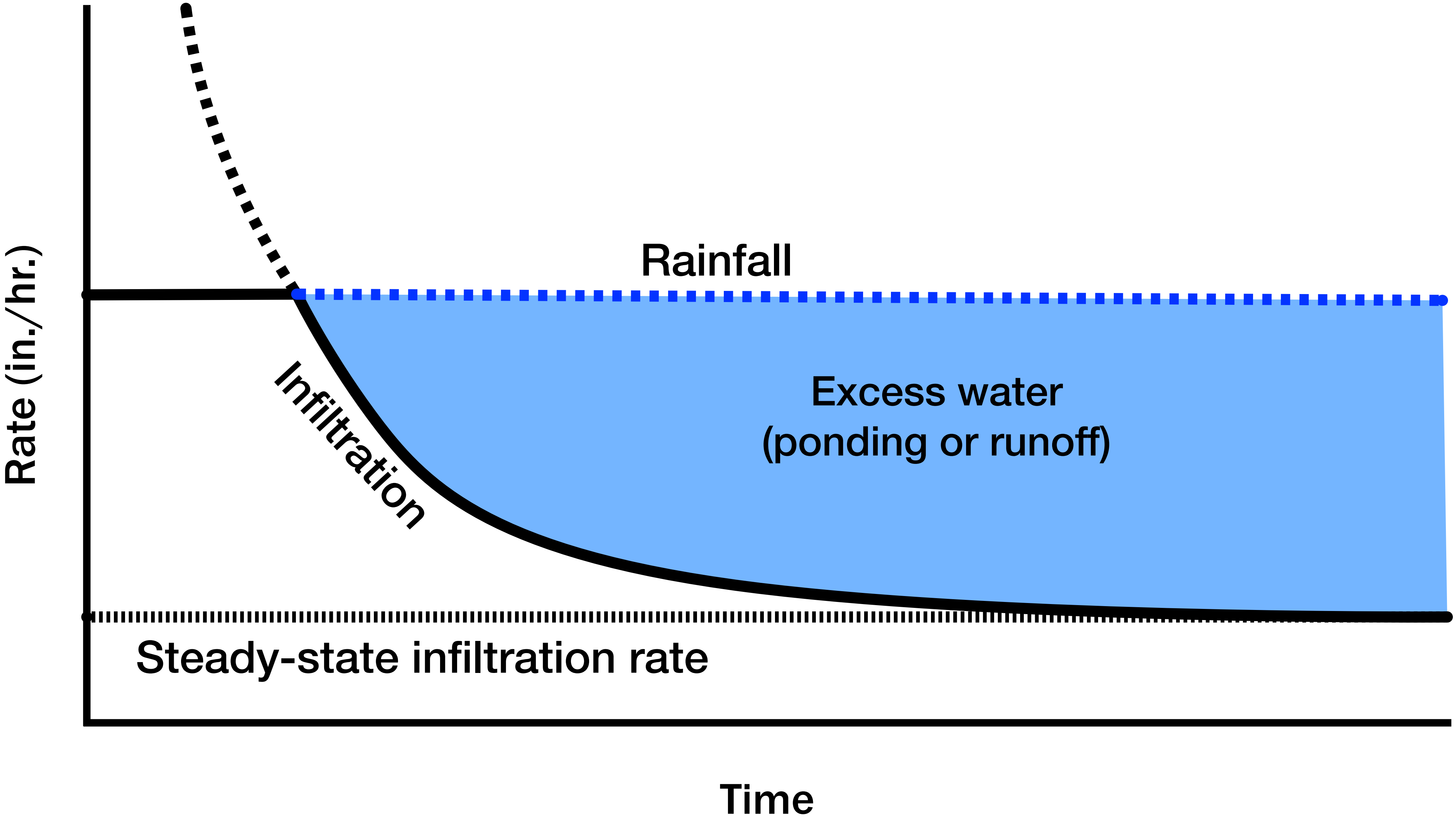
Key factor: Precipitation intensity—can trump soil

High Intensity Rainfall

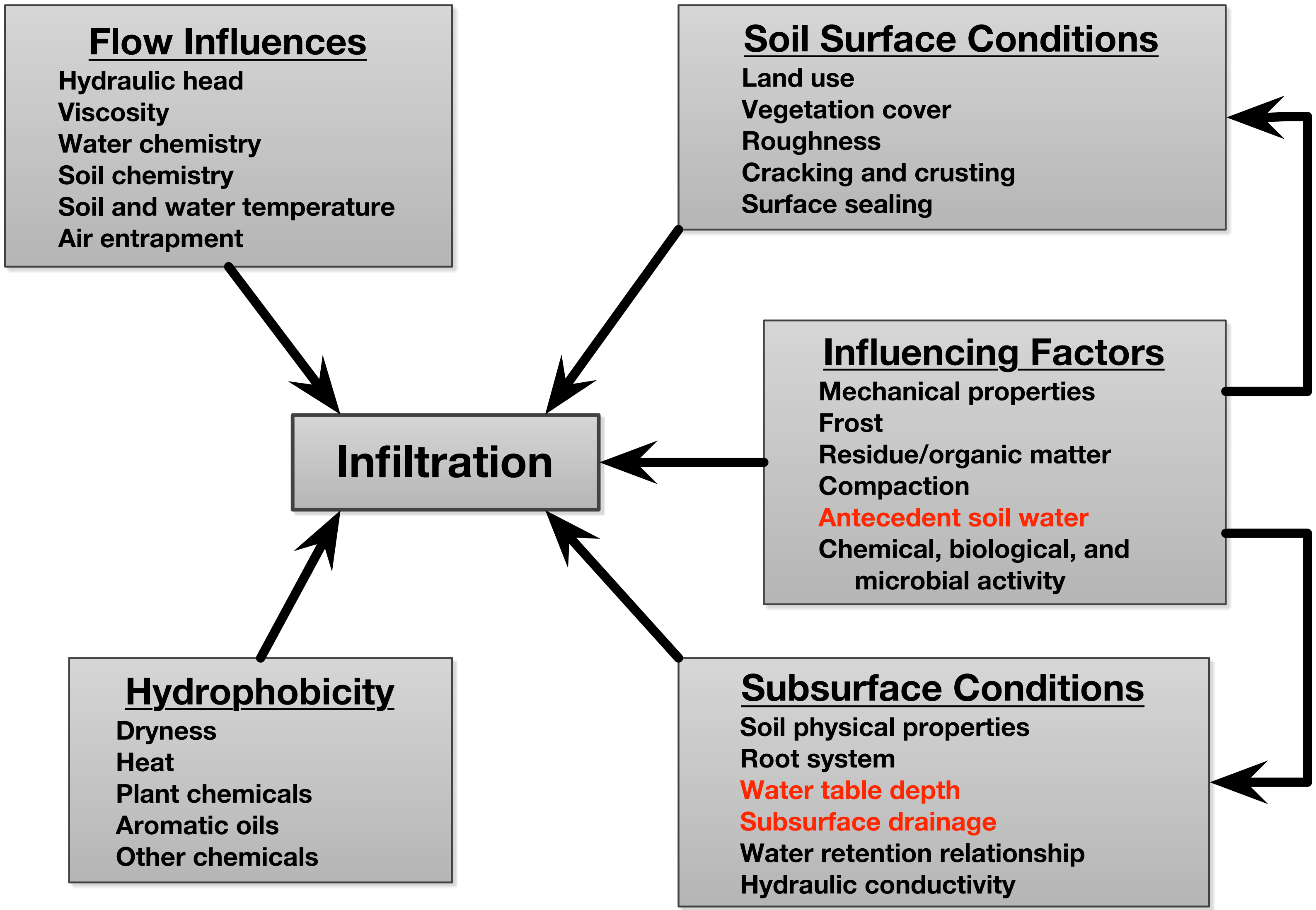
- Favors surface runoff
- Surface drainage system influences flow
- Tile drainage has little impact

Photo: NOAA

Infiltration: Precipitation and soils

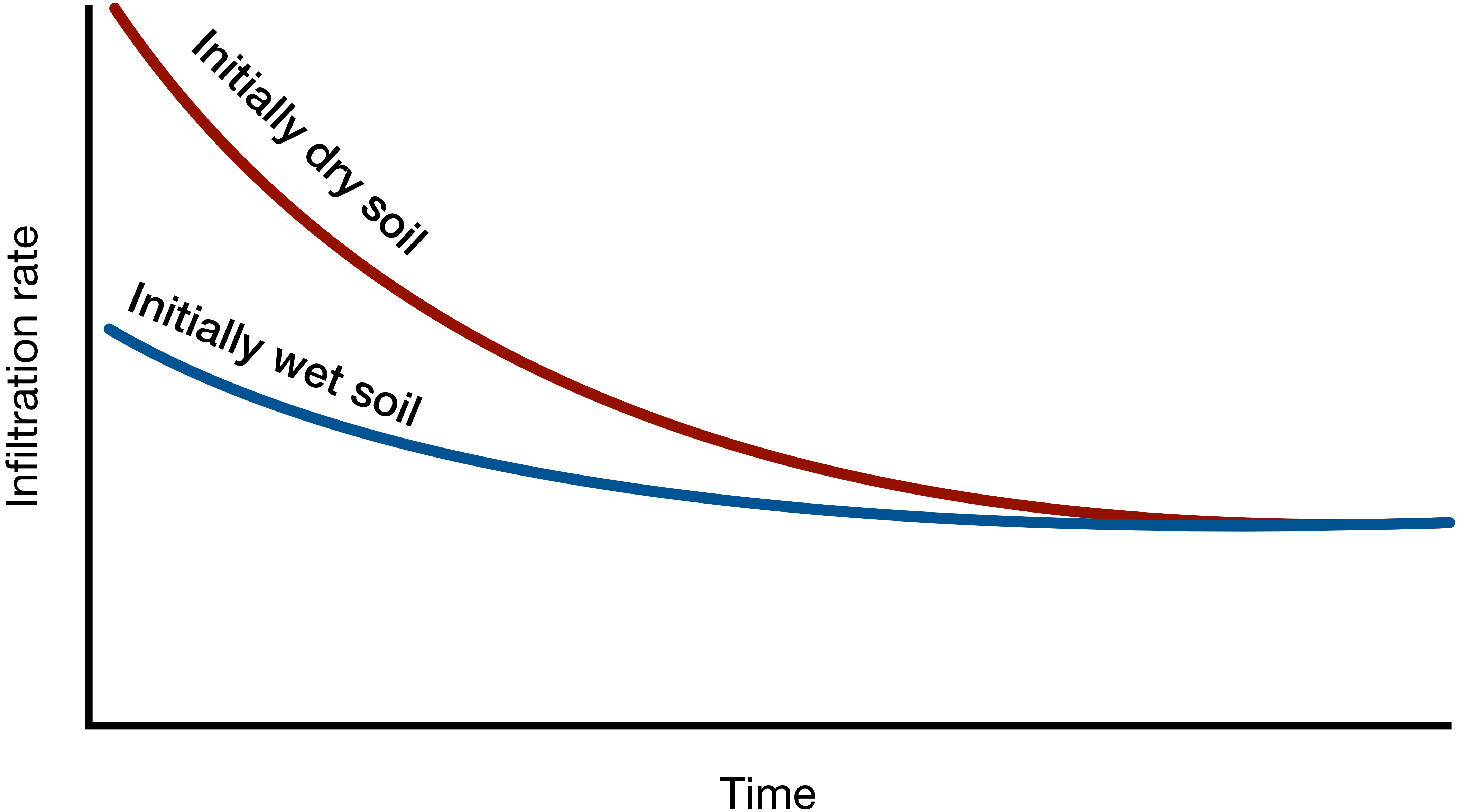


Infiltration is a process influenced by many factors

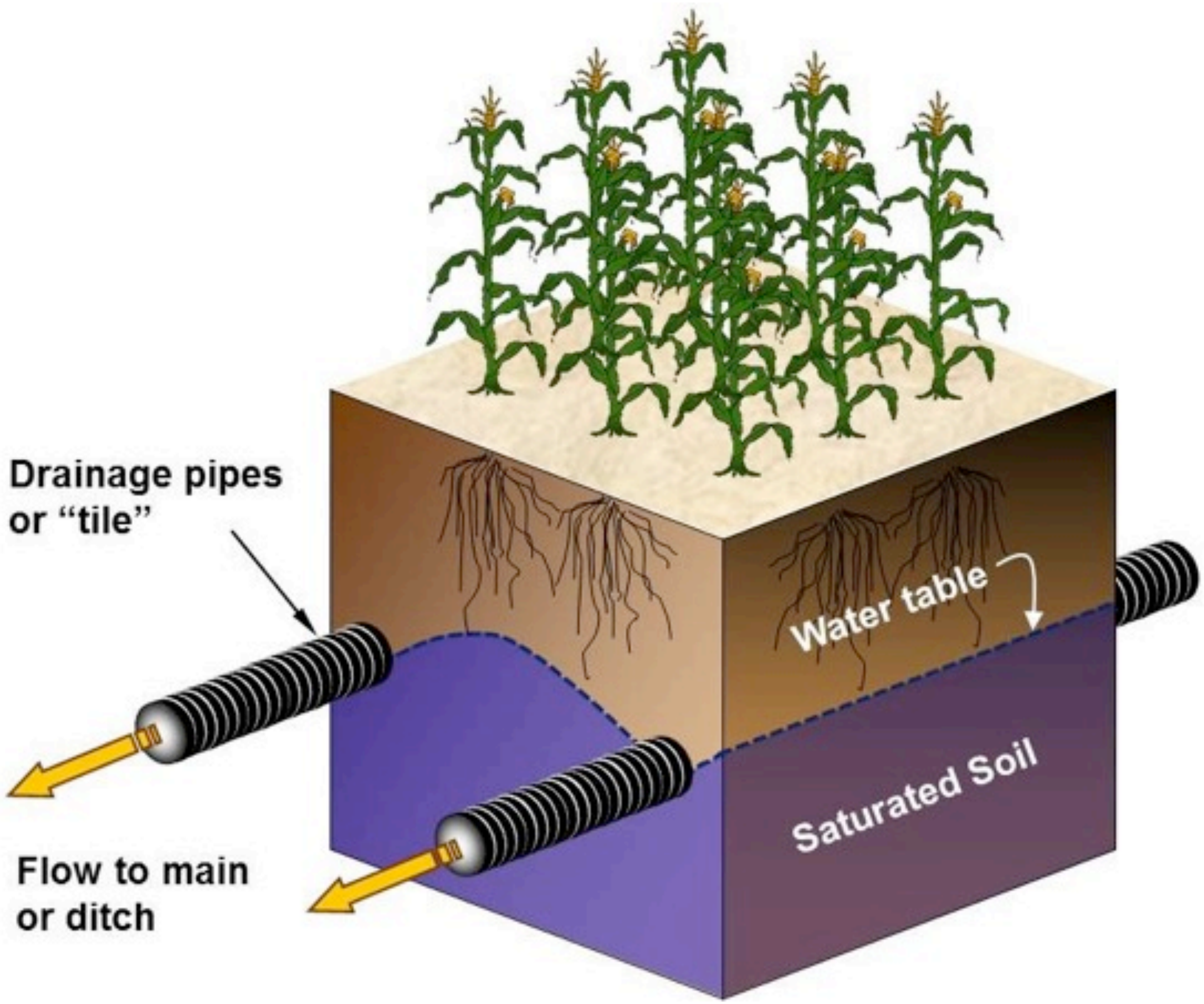


Adapted and redrawn from Ward and Trimble (2004)

Initial water content has a large influence on infiltration



Drainage converts wet conditions to drier conditions

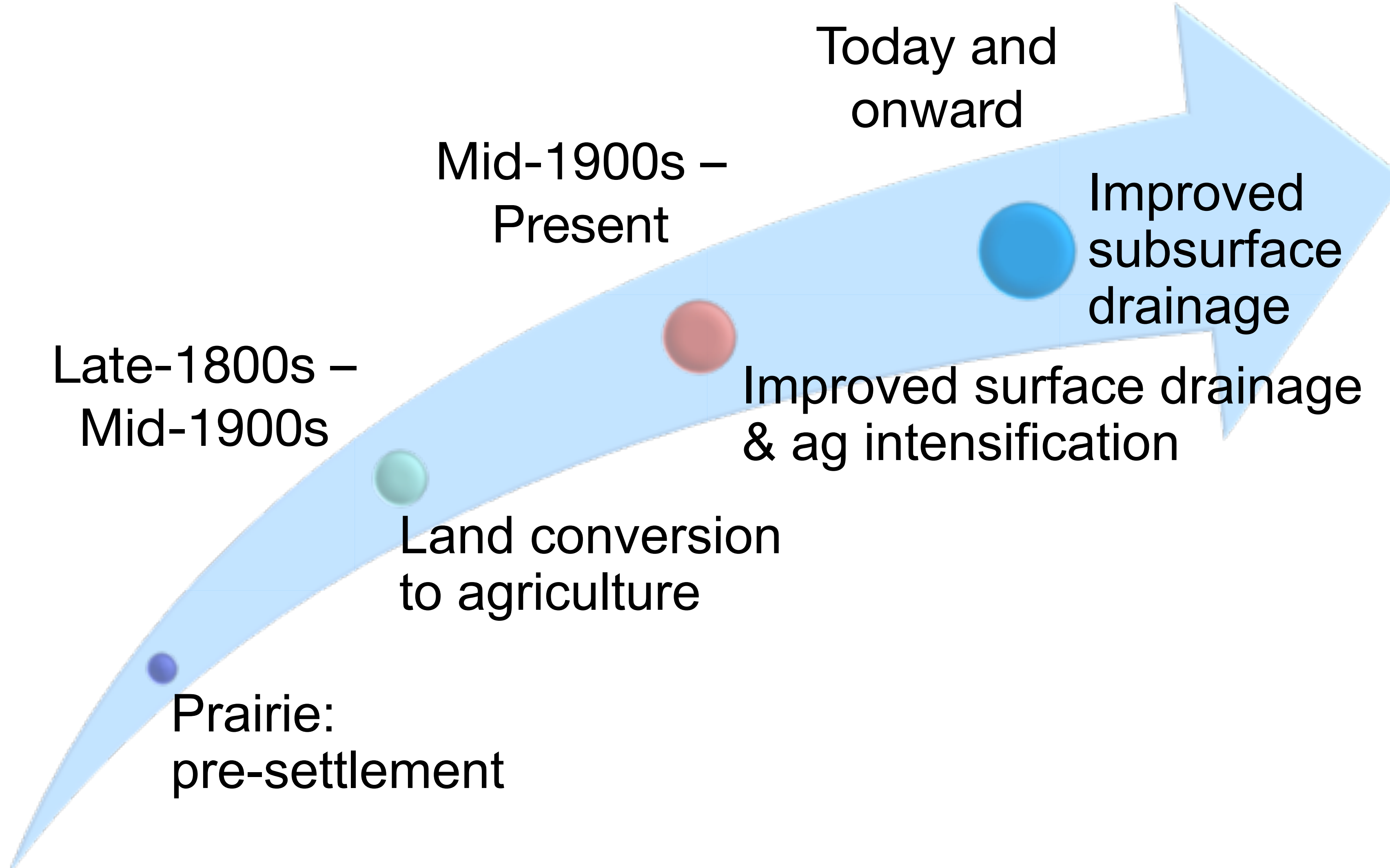


Graphics courtesy of Gary Sands

Key factor: Soil and precipitation factors change with time and season

Photo: simpologist

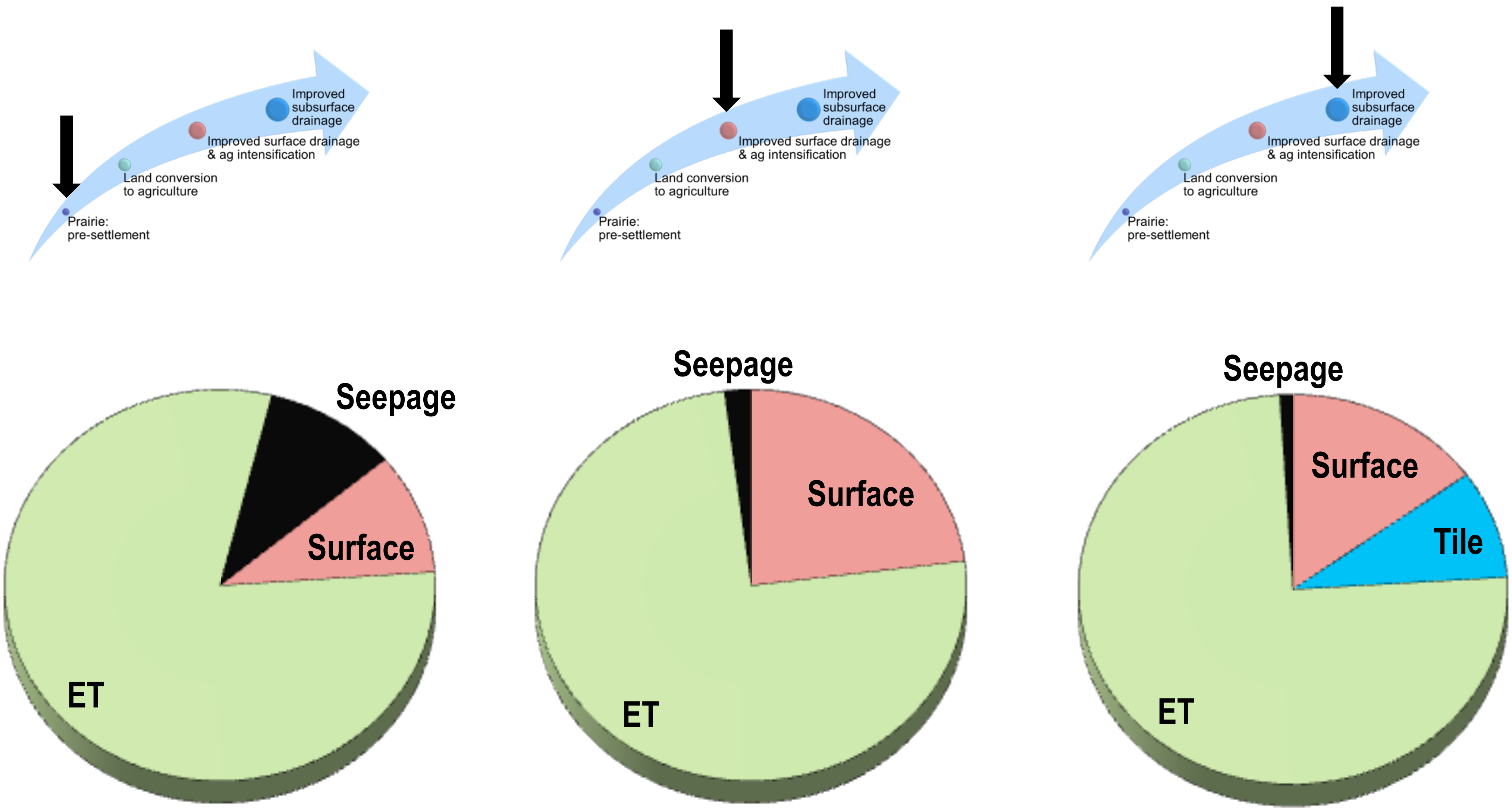
Drainage alterations over time



Graphics courtesy of Gary Sands

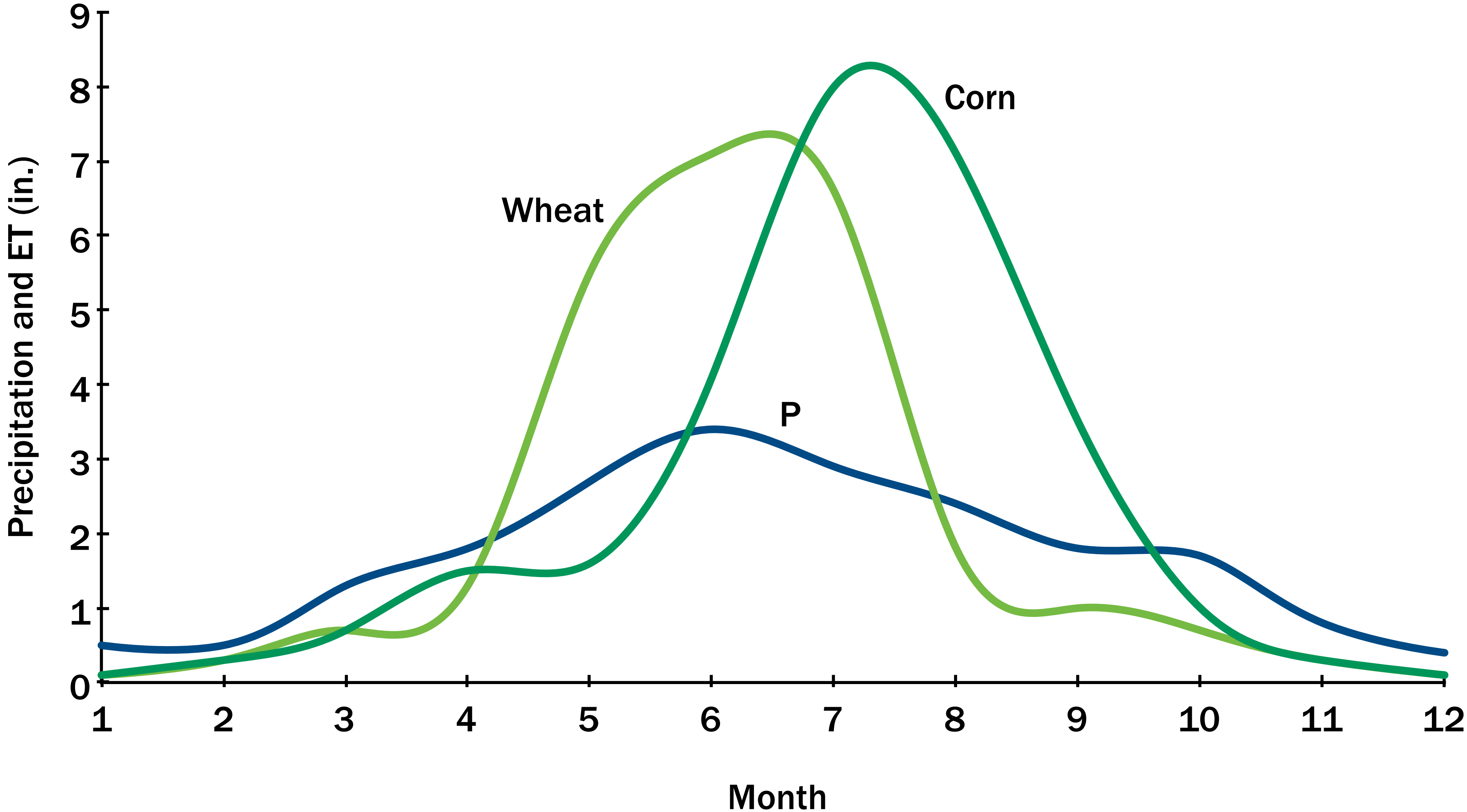
Drainage and the annual water balance

$$P = ET + R + Z + D$$

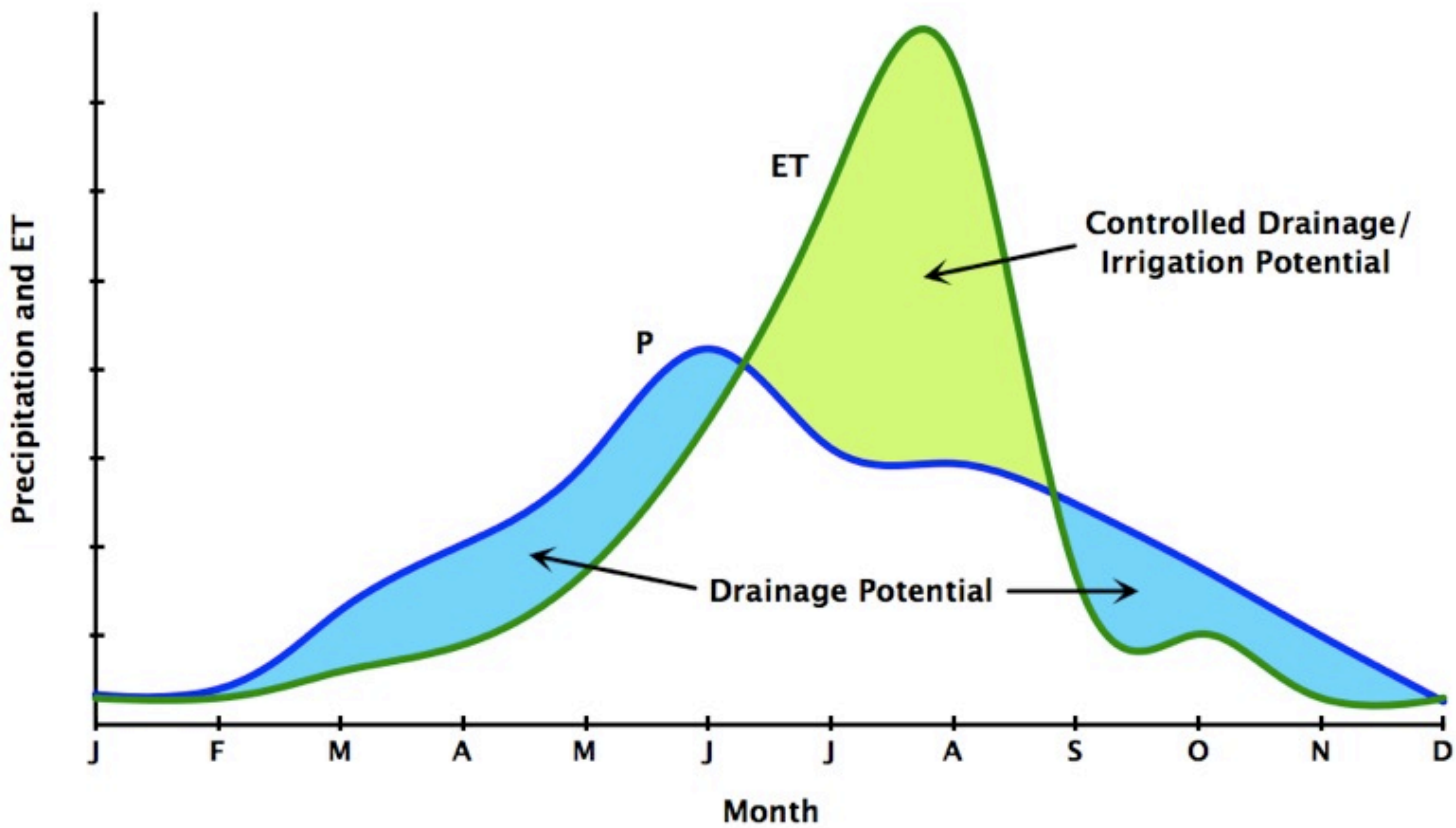


Graphics courtesy of Gary Sands

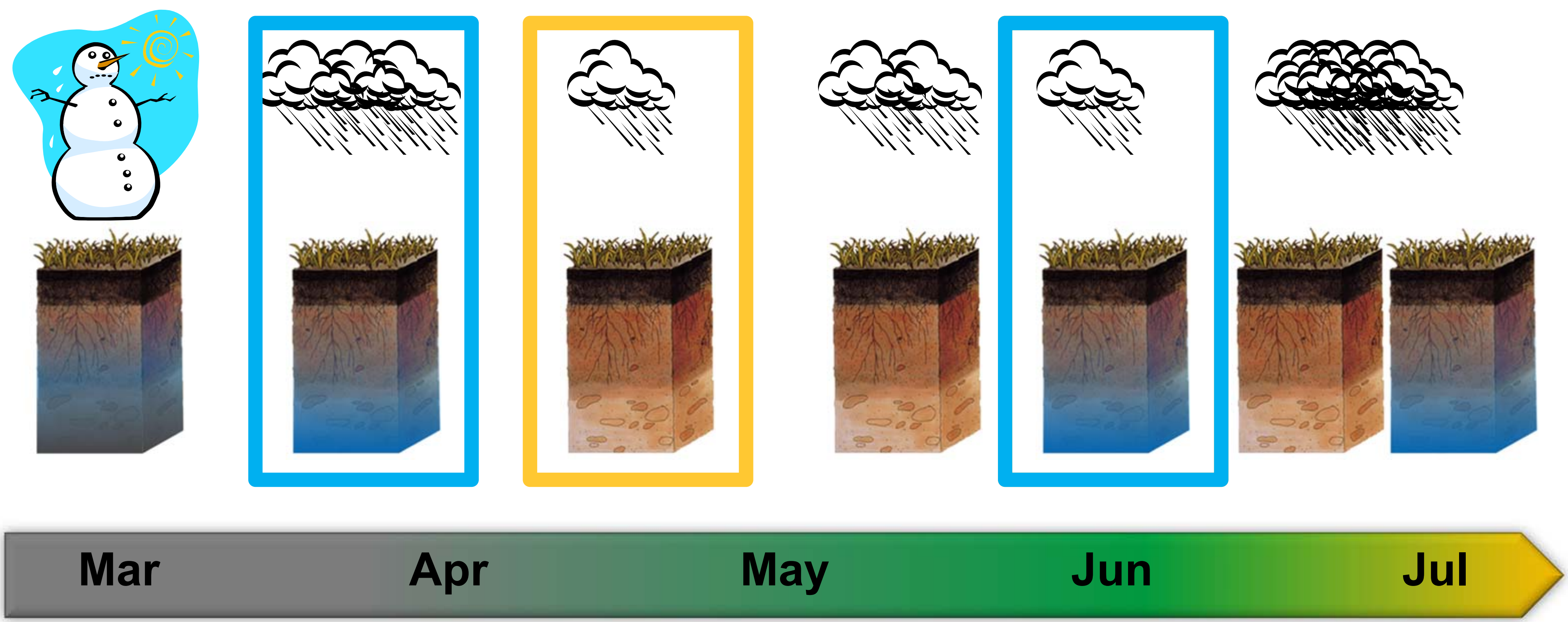
Crop water use and precipitation patterns rarely match



This creates water management challenges and opportunities

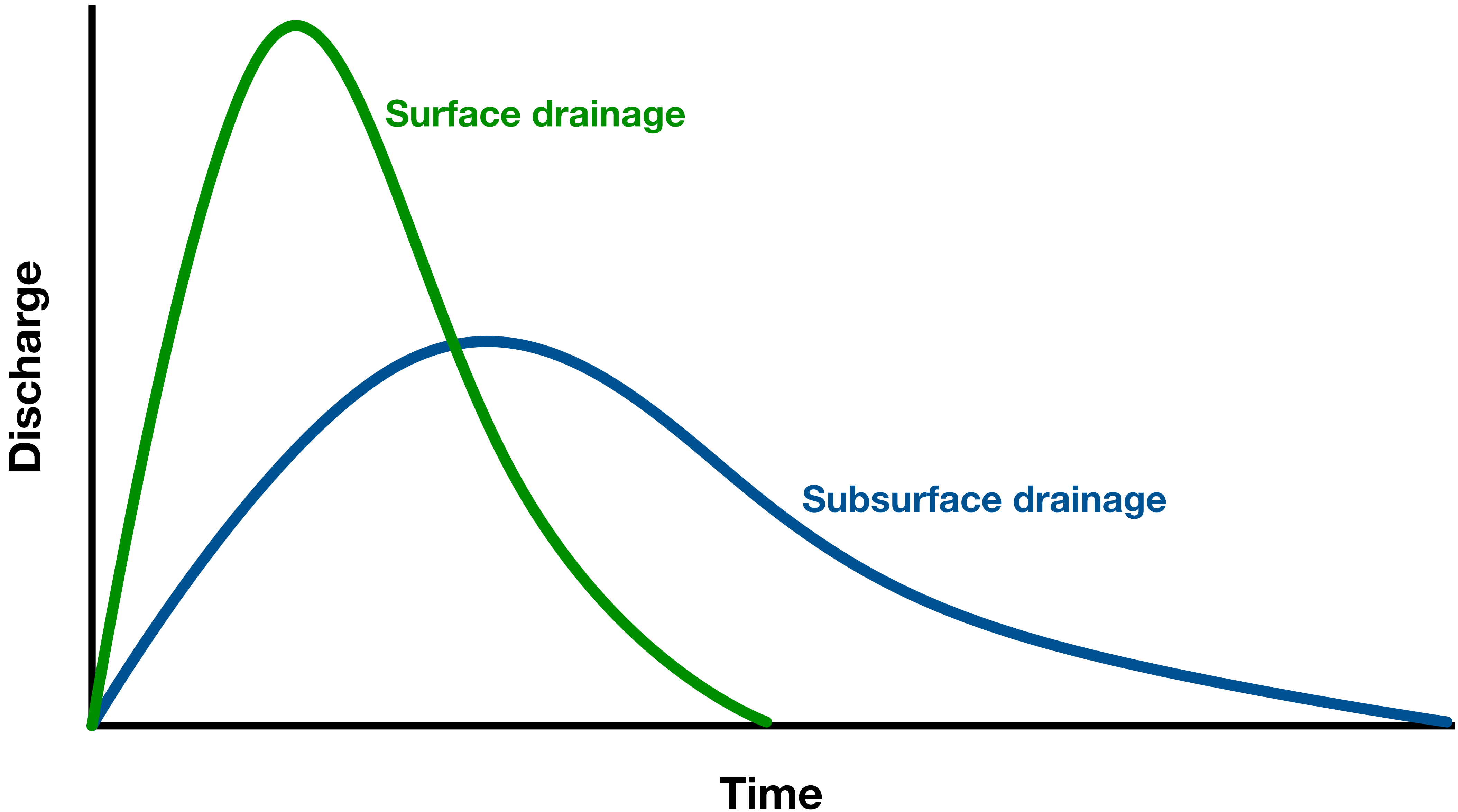


Drainage impacts on hydrology change seasonally



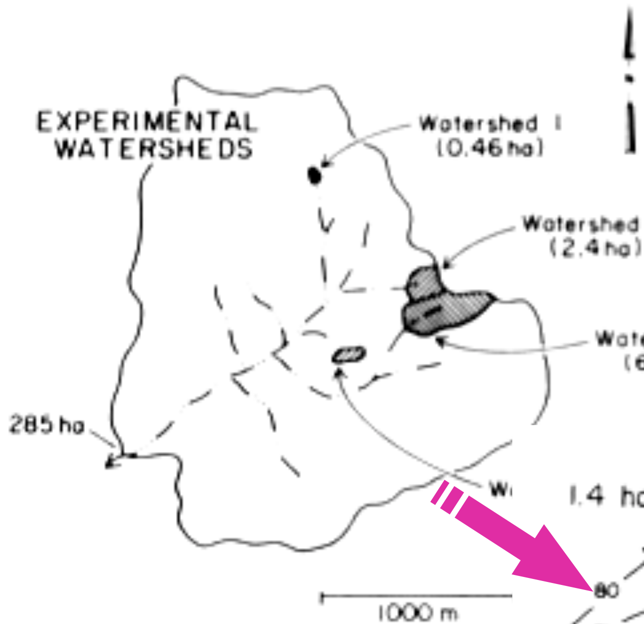
Graphics courtesy of Gary Sands

Single event, field-scale impacts

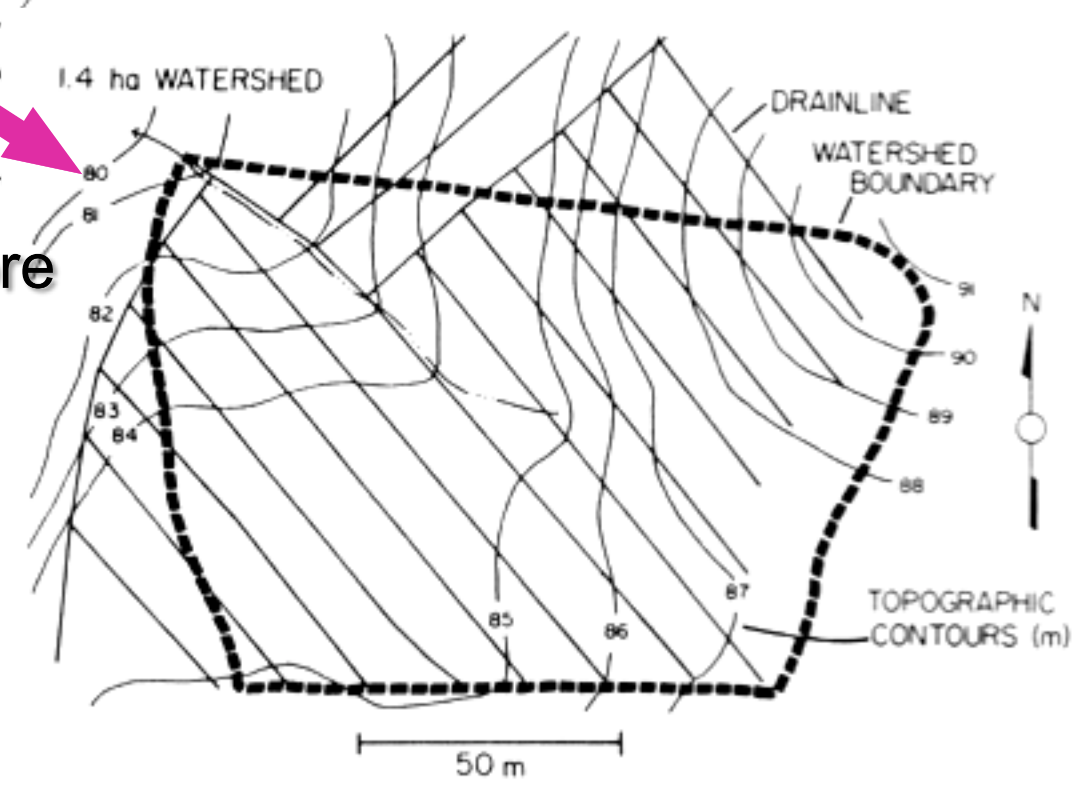


Example: Istok and Kling (1982)

- Western Oregon
- Winter wheat
- Low-mod intensity storms
- Silt loam soils

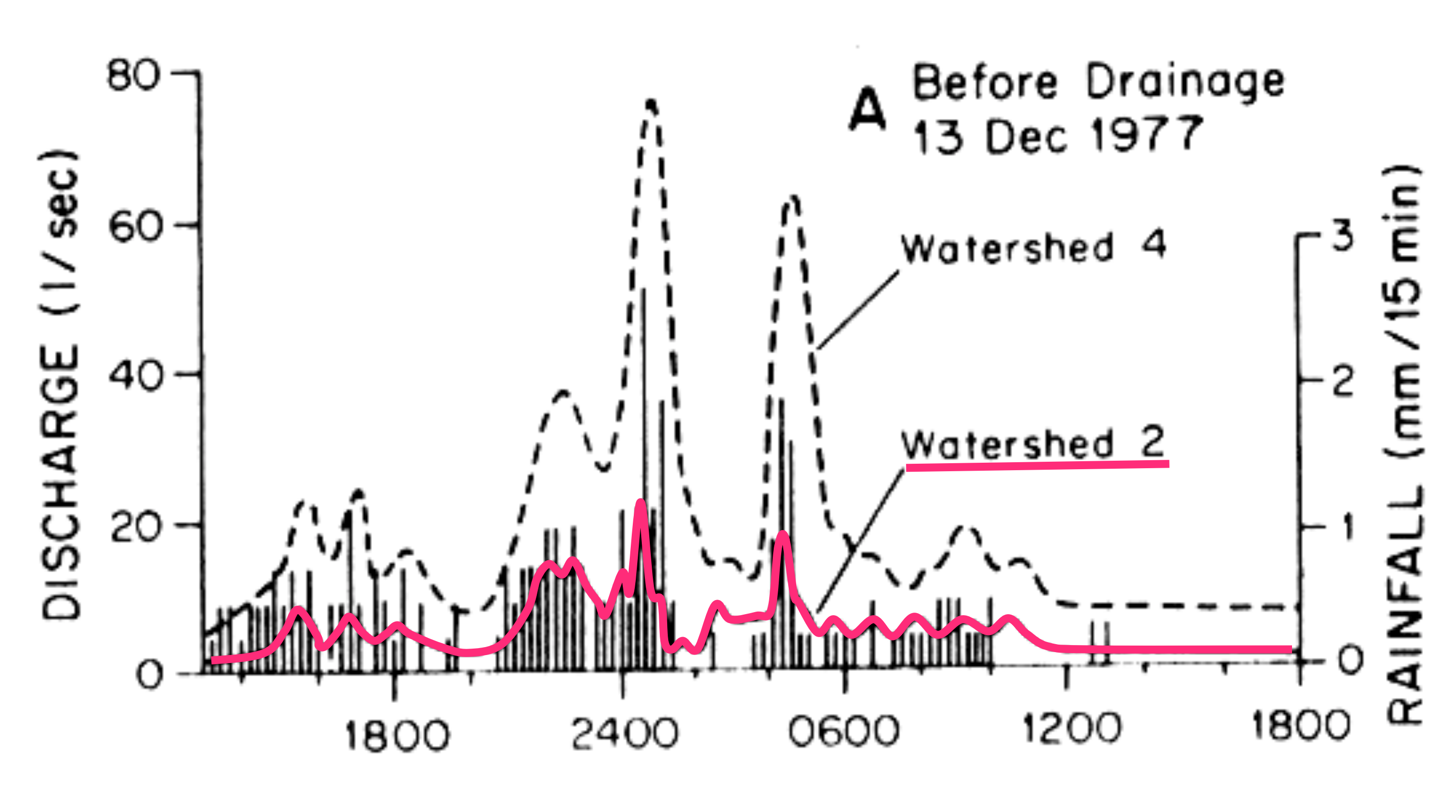


- 2 seasons before drainage
- WS 2 drained
- 3.3-ft depth
- 40-ft spacing

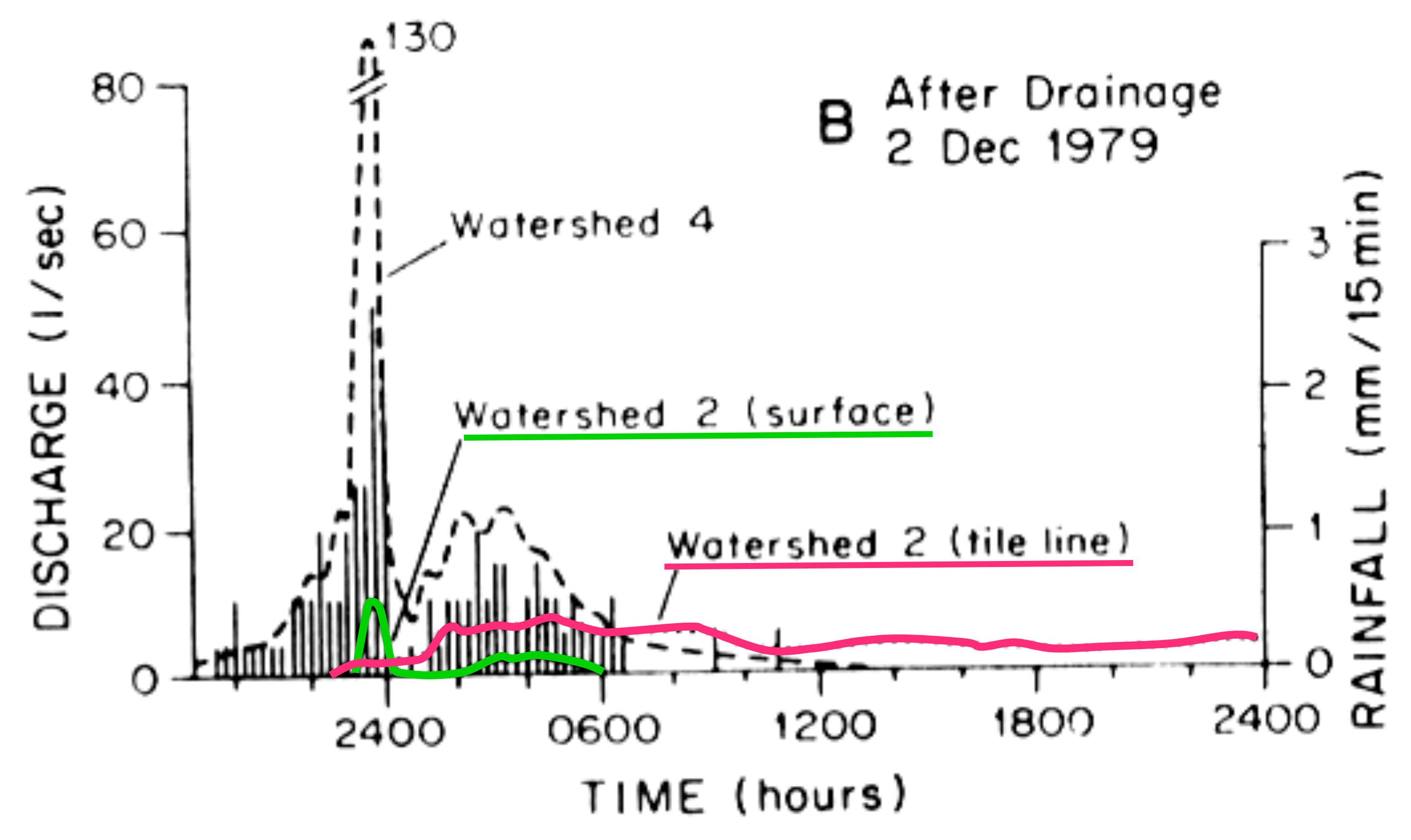


Adapted from Gary Sands

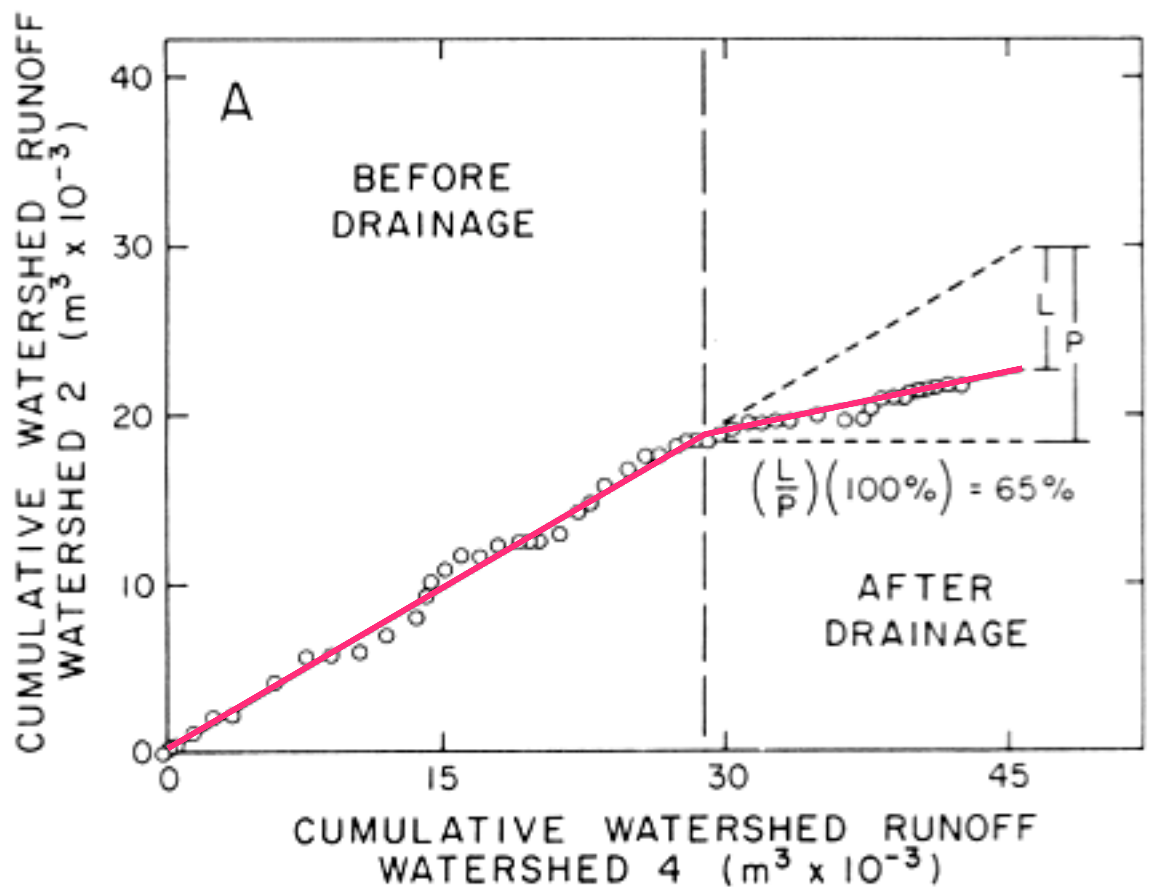
Before drainage hydrographs



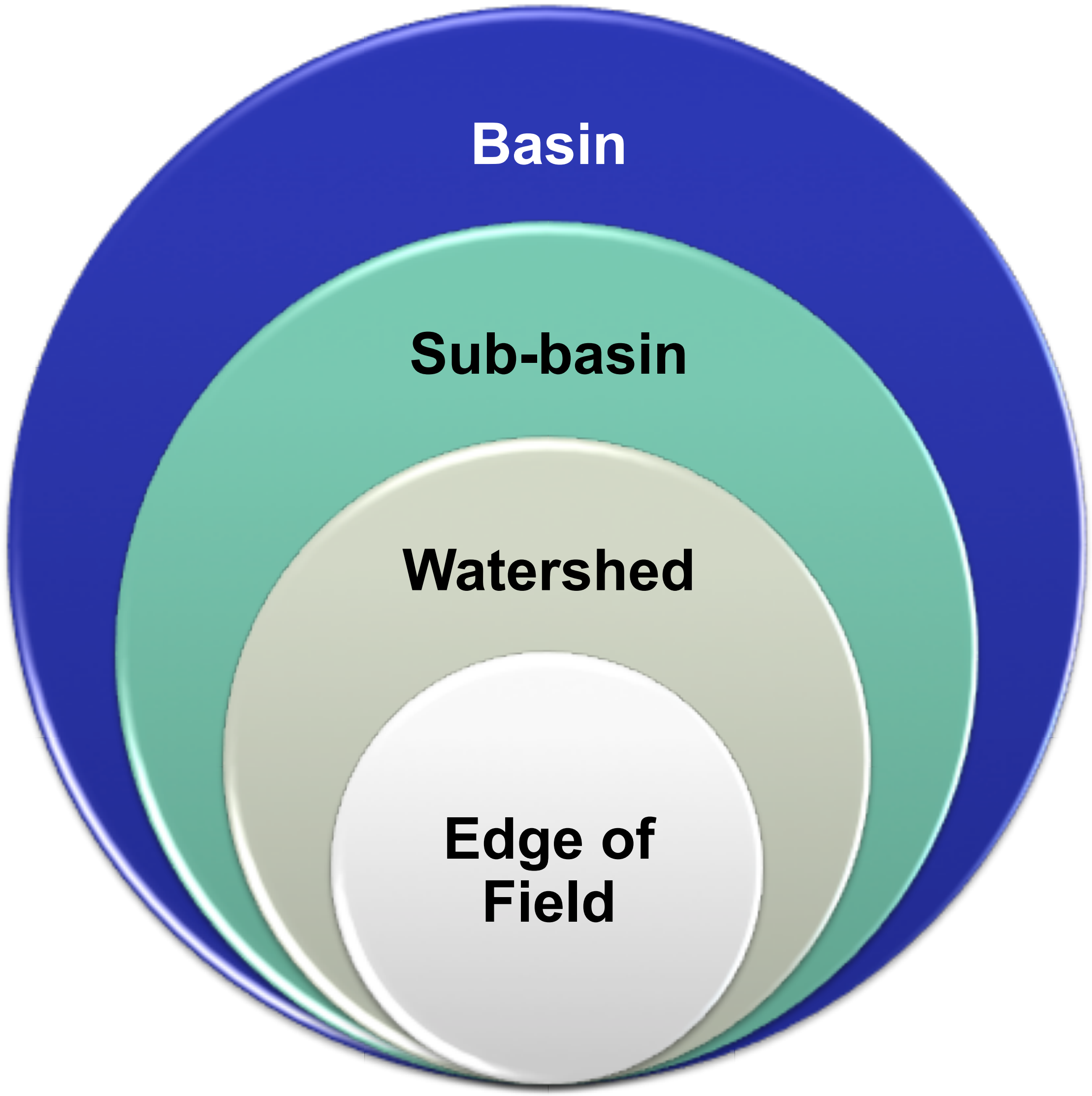
After drainage hydrographs



65% runoff reduction after drainage



Key factor: Spatial scale



Graphics courtesy of Gary Sands

Field scale hydrologic impacts

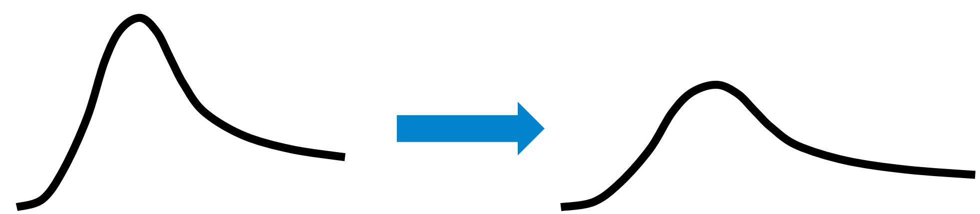
- Surface runoff reduced 29 to 65%
- Peak runoff reduced 15 to 30%
- Total discharge (runoff + drainage) is similar
- Some models suggest runoff may increase 5 to 10%—others show a decrease

Source: Zucker and Brown (1998)

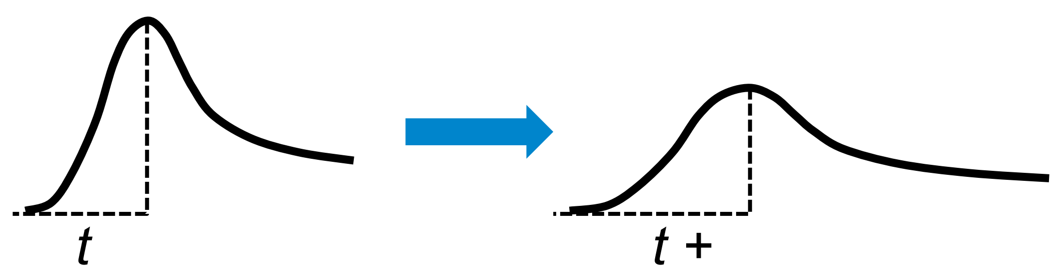
Photo: USDA NRCS

Why spatial scale matters

- ***Complexity*** increases with scale
- ***Dampening*** of field effects with scale



- ***Time lag*** of field effects with scale

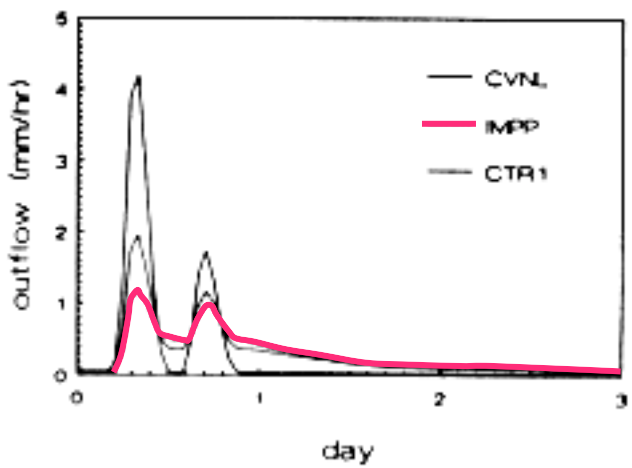


Graphics courtesy
of Gary Sands

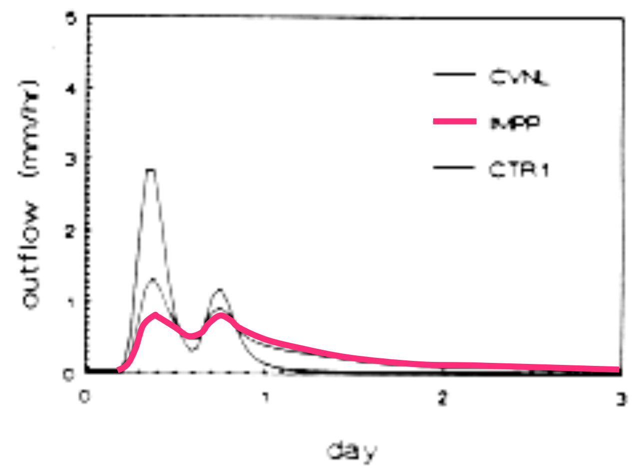
Example of the impact of scale

Konyha et al. (1992), modeling study

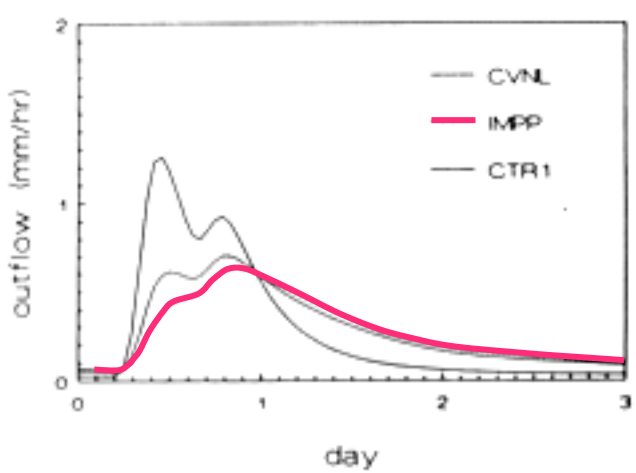
20 ac. field



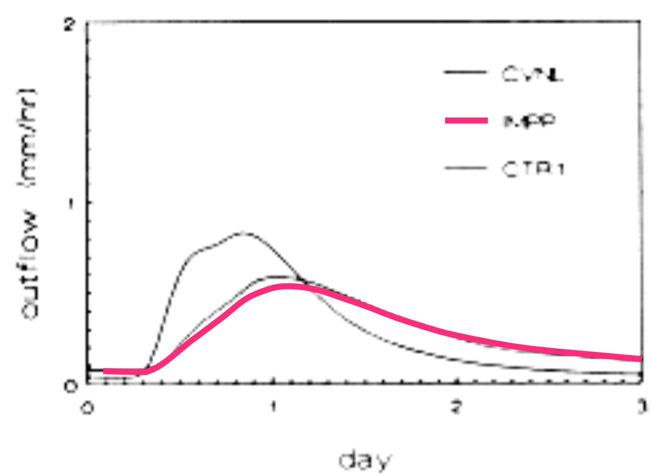
320 ac. watershed



4 mi.^{2} watershed



24 mi.^{2} watershed



Hydrology impacts summary

- Drainage-hydrology relationship is complex and involves many factors
- Factors vary in time and space
- Simple cause-effect statements are unrealistic
- Large scale effects are not well known—most work at the field scale
- Several models suggest increase in water yield—others show a decrease
- Surface flows tend to dominate in major flooding years
- Need to rely on probability basis

Adapted from Gary Sands

Photo: USDA NRCS

What are the water quality impacts of drainage?

Photo: Dan Bennett

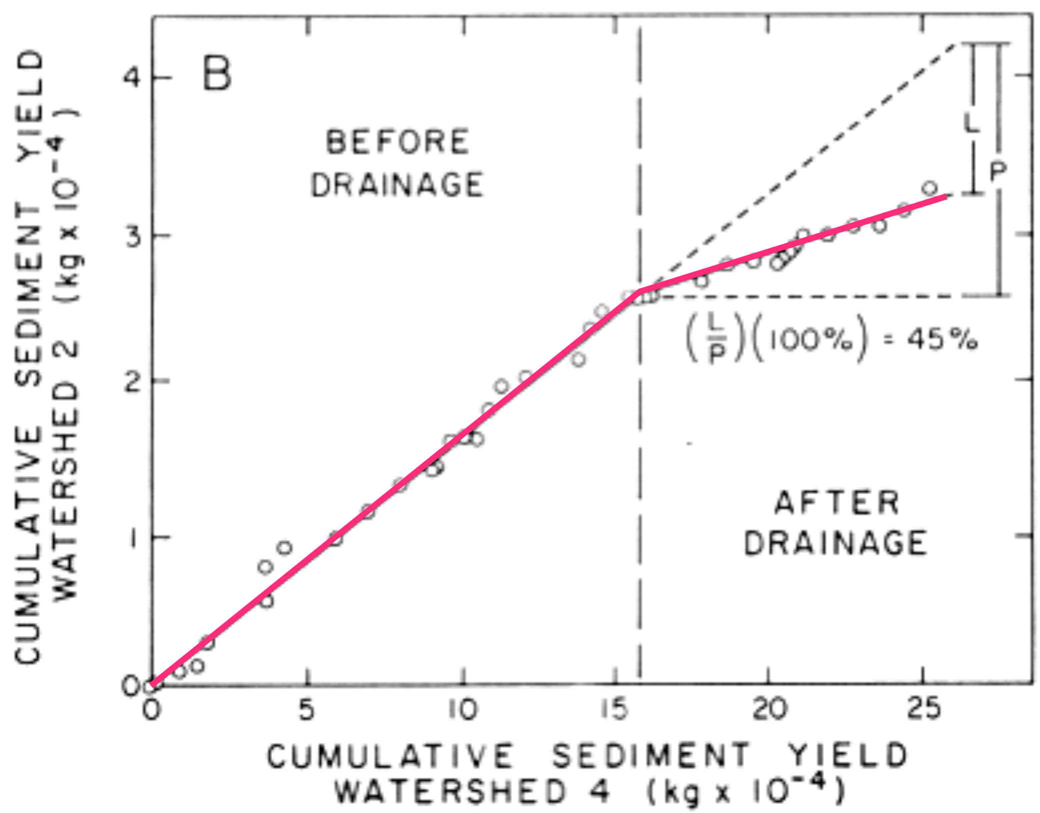
Water quality impacts are a mixed bag

- Soil erosion and sediment loss: 15–30%
- Phosphorous: up to 45%
- Nitrogen (nitrates): varies widely but often exceeds drinking water standard

Source: Zucker and Brown (1998)

Photo: Steve Johnson

Istok and Kling (1982) example: 55% sediment yield reduction following drainage



Drainage impacts on nitrate losses

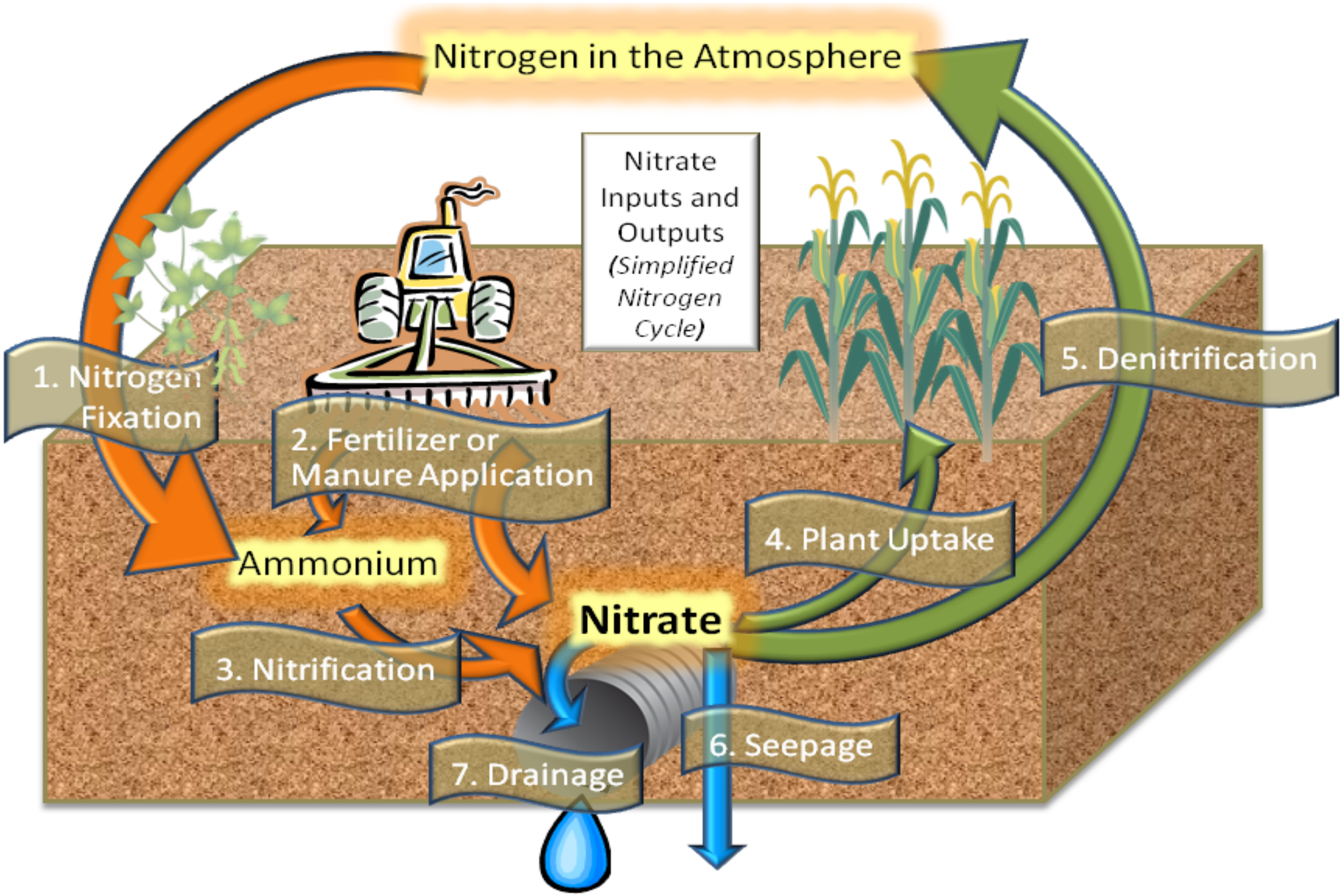
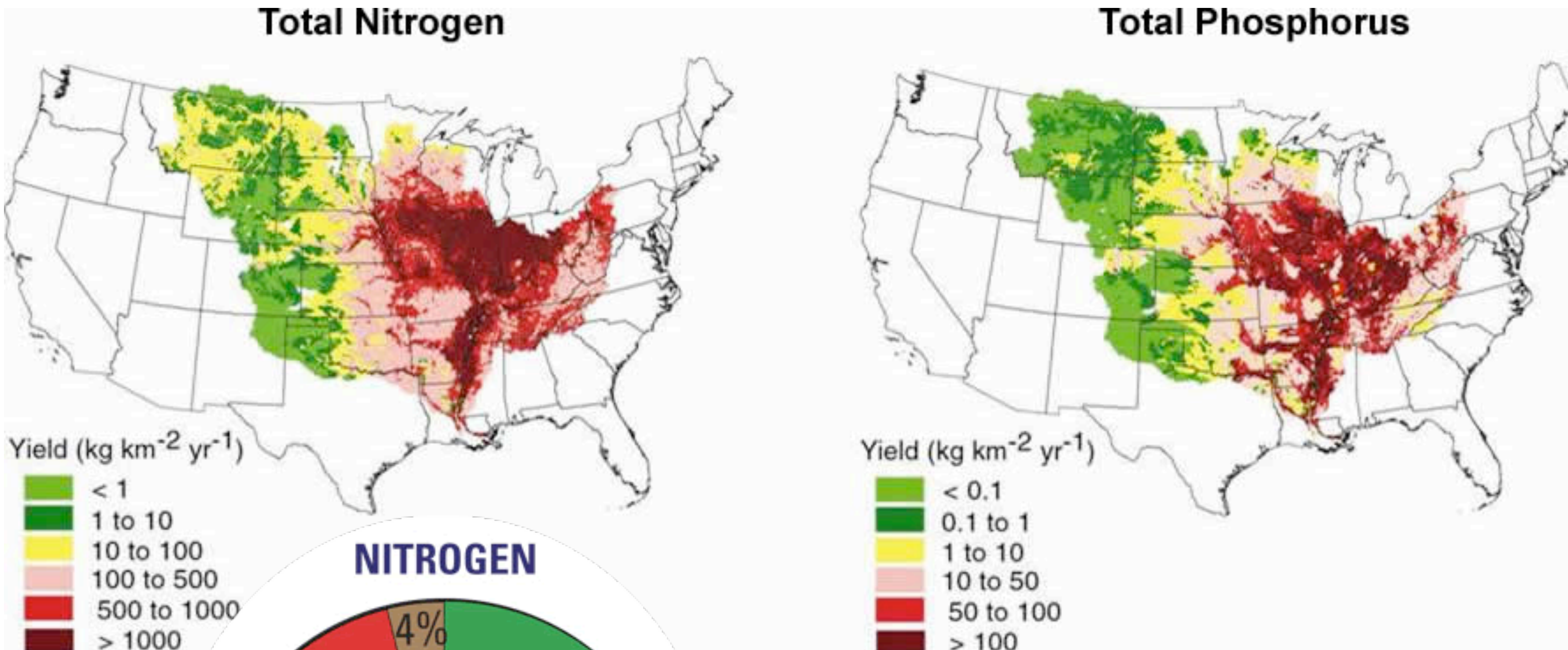
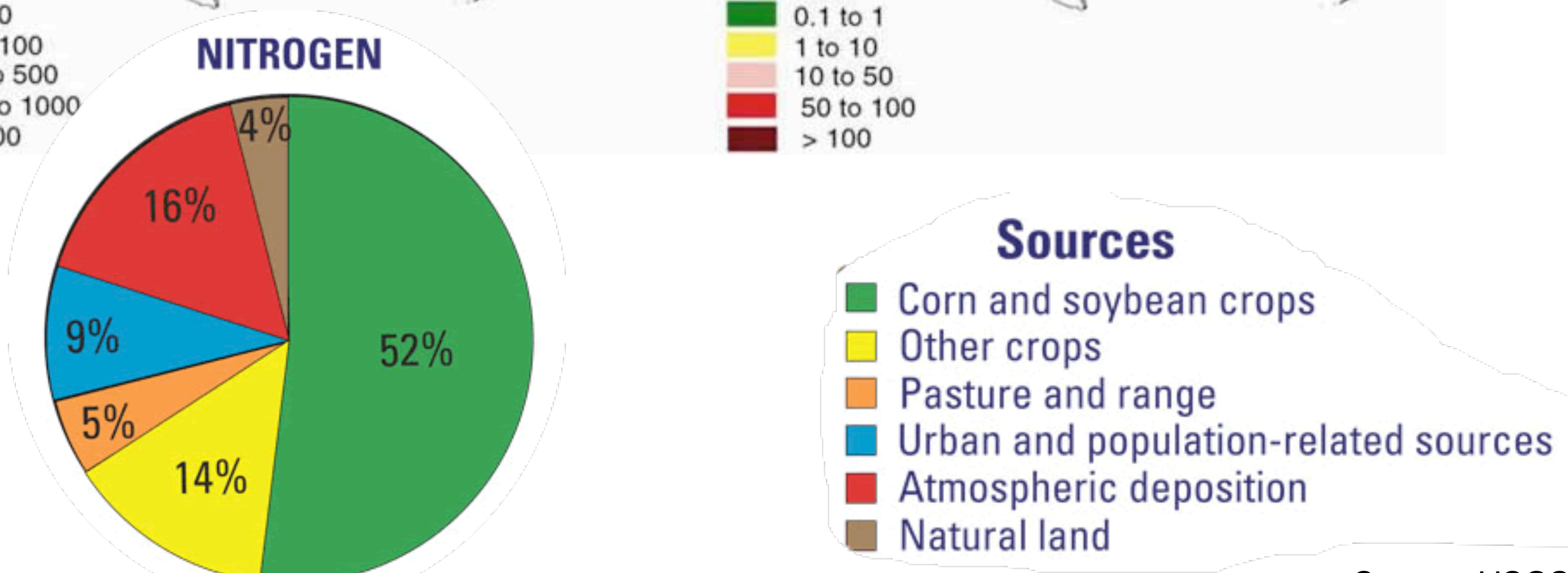


Illustration courtesy of Jane Frankenberger, Purdue Extension

Nutrient deliveries to the Gulf





Source: USGS

Images courtesy of Gary Sands, University of Minnesota Extension

What is conservation drainage?

Emerging set of designs and practices designed to maintain the benefits of conventional agricultural drainage while addressing water quality and flow issues

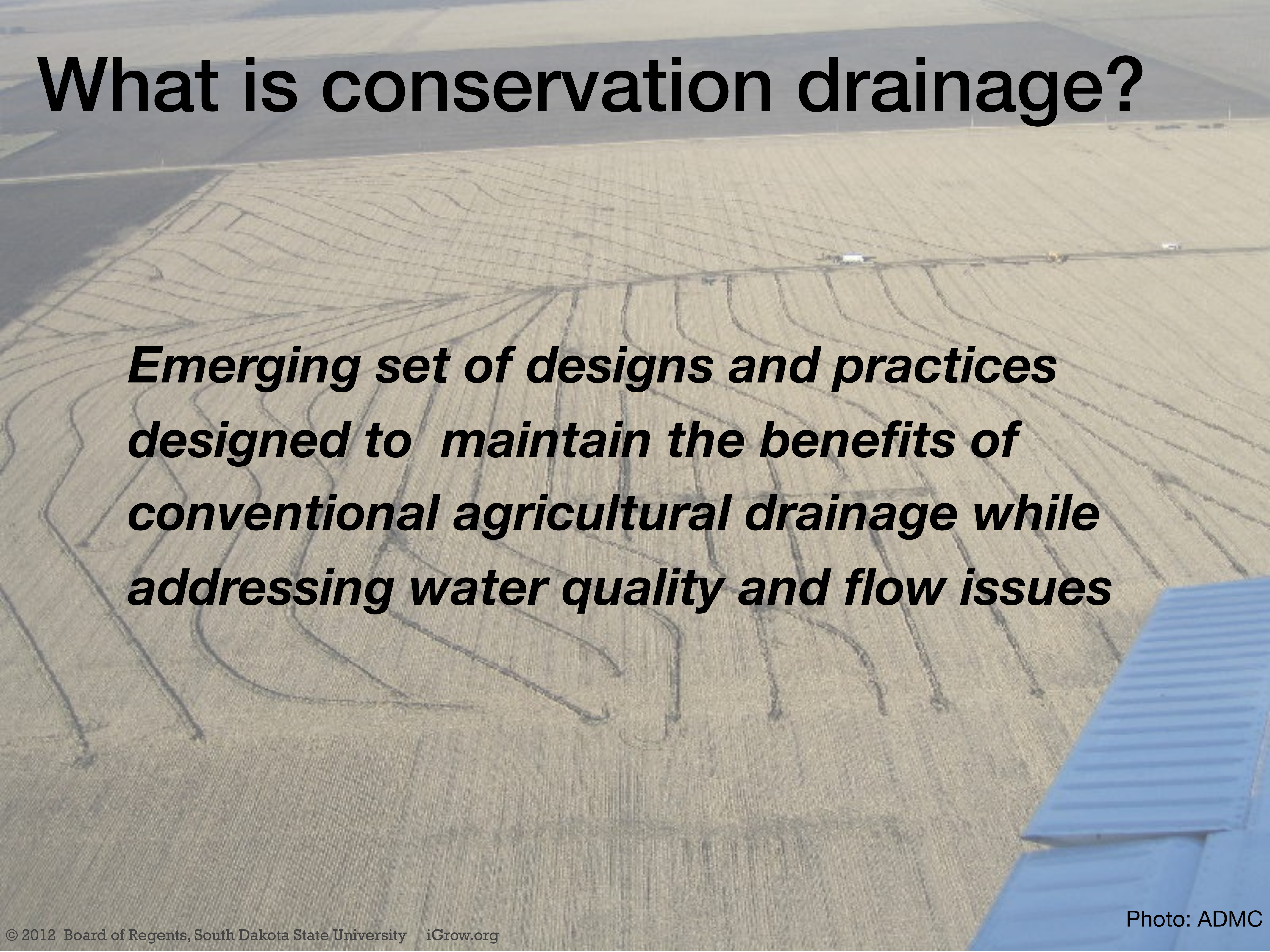


Photo: ADMC

Conservation drainage toolkit

Nutrient and crop practices

- Nutrient, crop, and tillage management
- Alternative crops, cover crops, scavenger crops

Subsurface drainage practices

- Improved drainage design
- Drainage water management

Ditch, impoundment, and treatment practices

- Alternative surface inlets
- Bioreactors, buffers, treatment wetlands, and retention
- Two-stage ditches
- Culvert sizing

Drainage Water Management

Photo: ADMC

Winter conservation mode

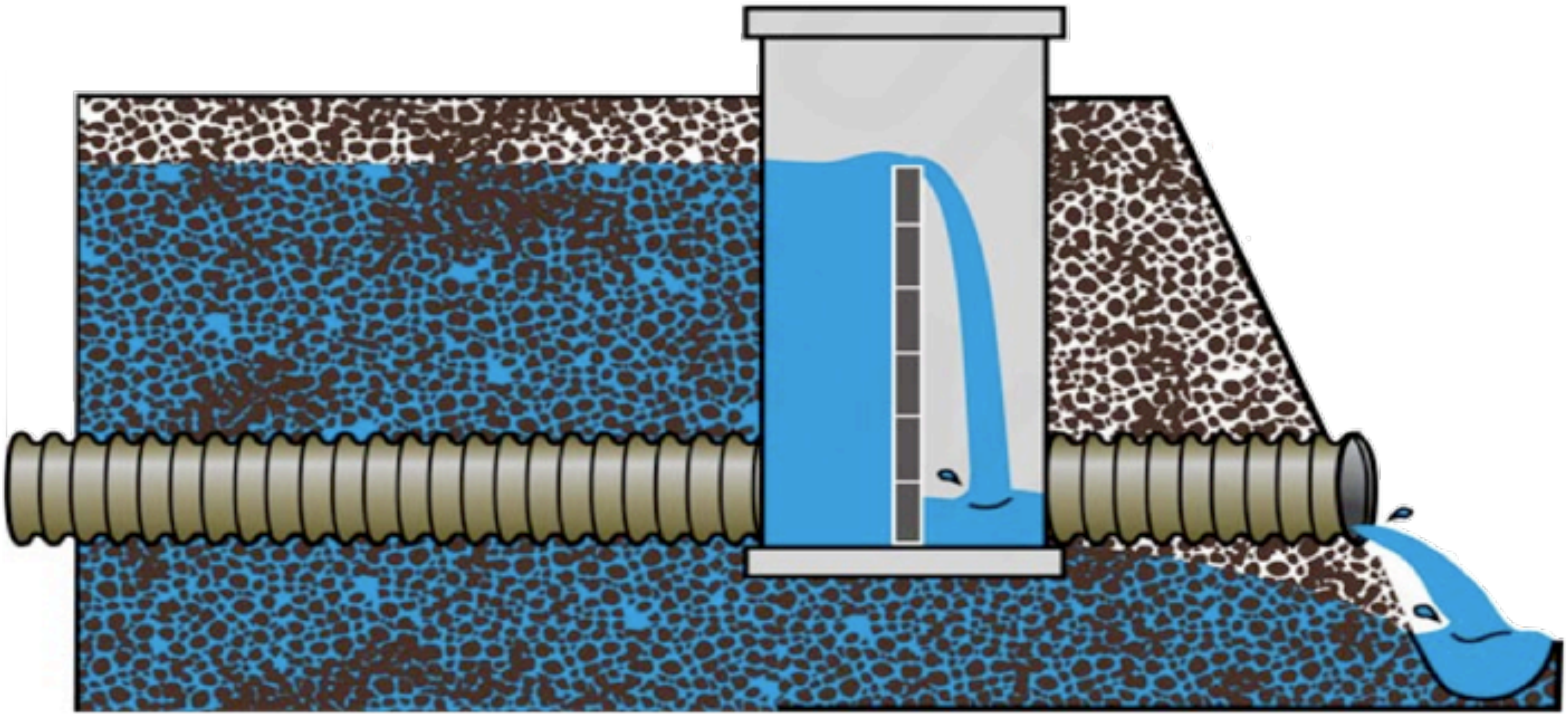


Illustration courtesy of Jane Frankenberger, Purdue Extension

Conventional drainage mode

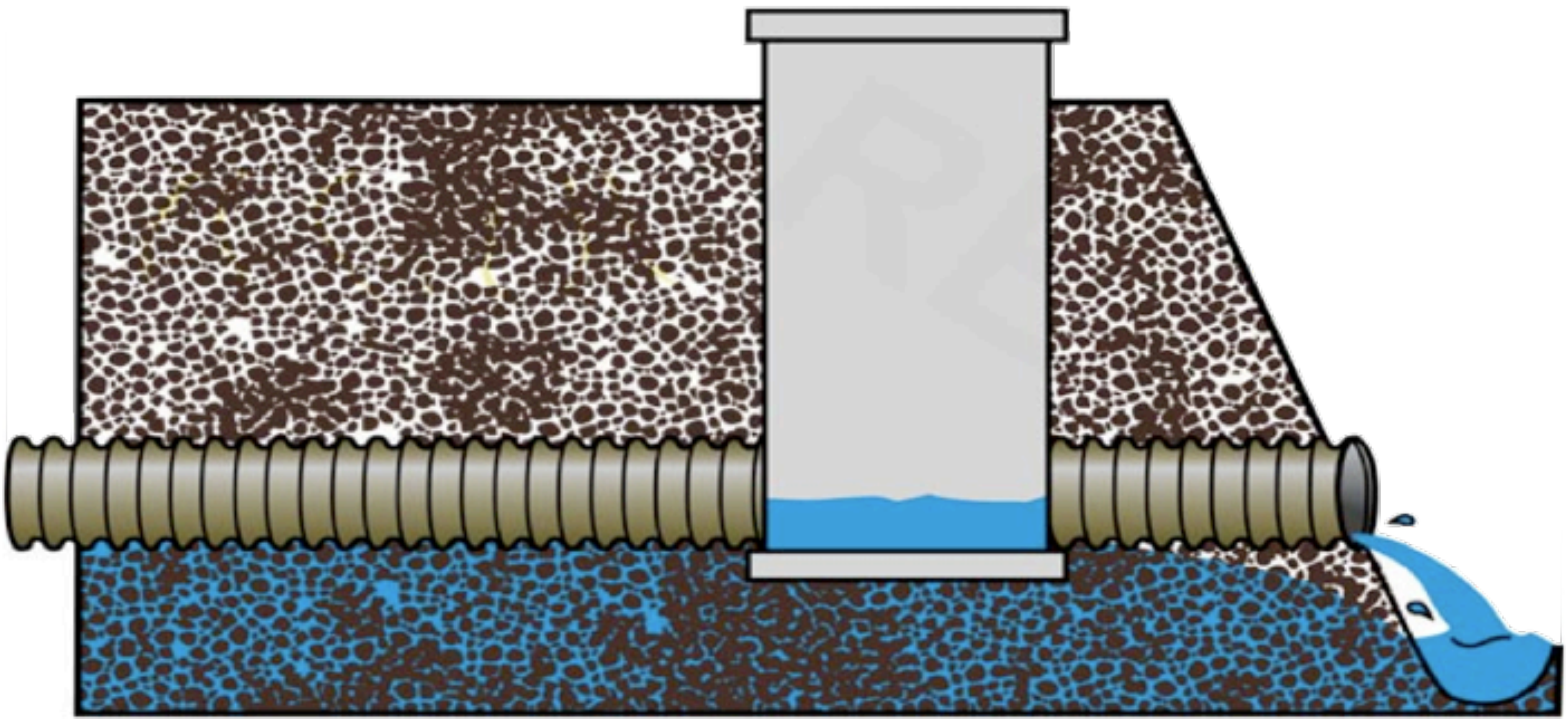


Illustration courtesy of Jane Frankenberger, Purdue Extension

Summer conservation mode

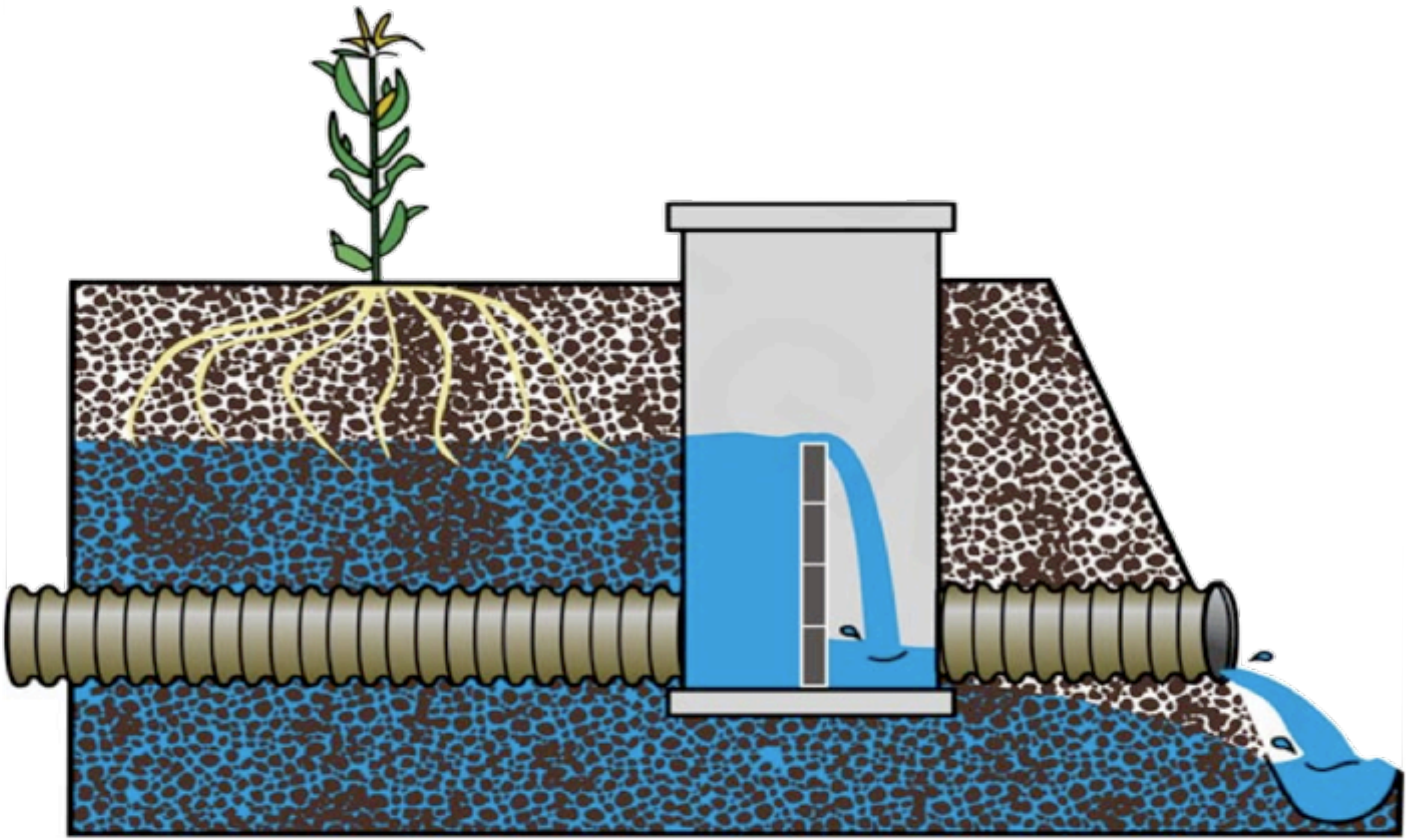


Illustration courtesy of Jane Frankenberger, Purdue Extension

Woodchip drainage bioreactors

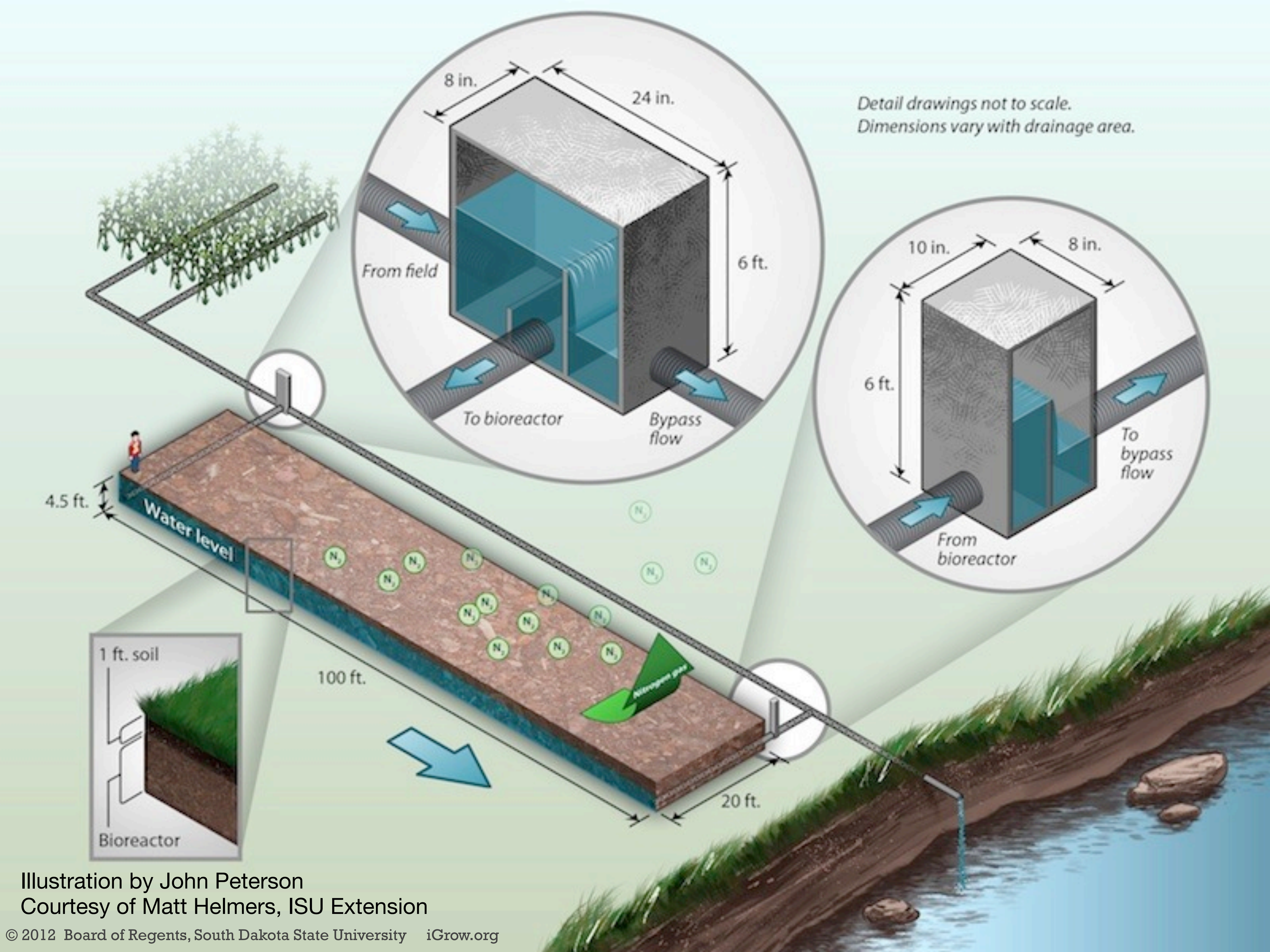
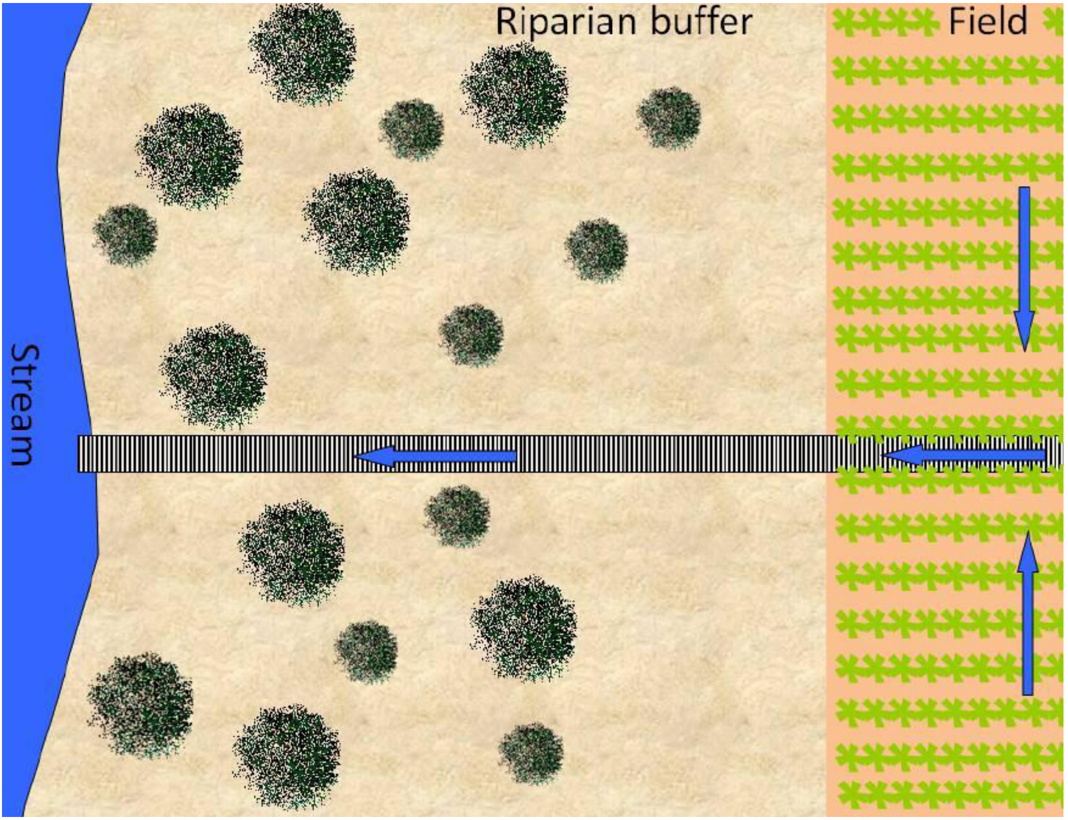
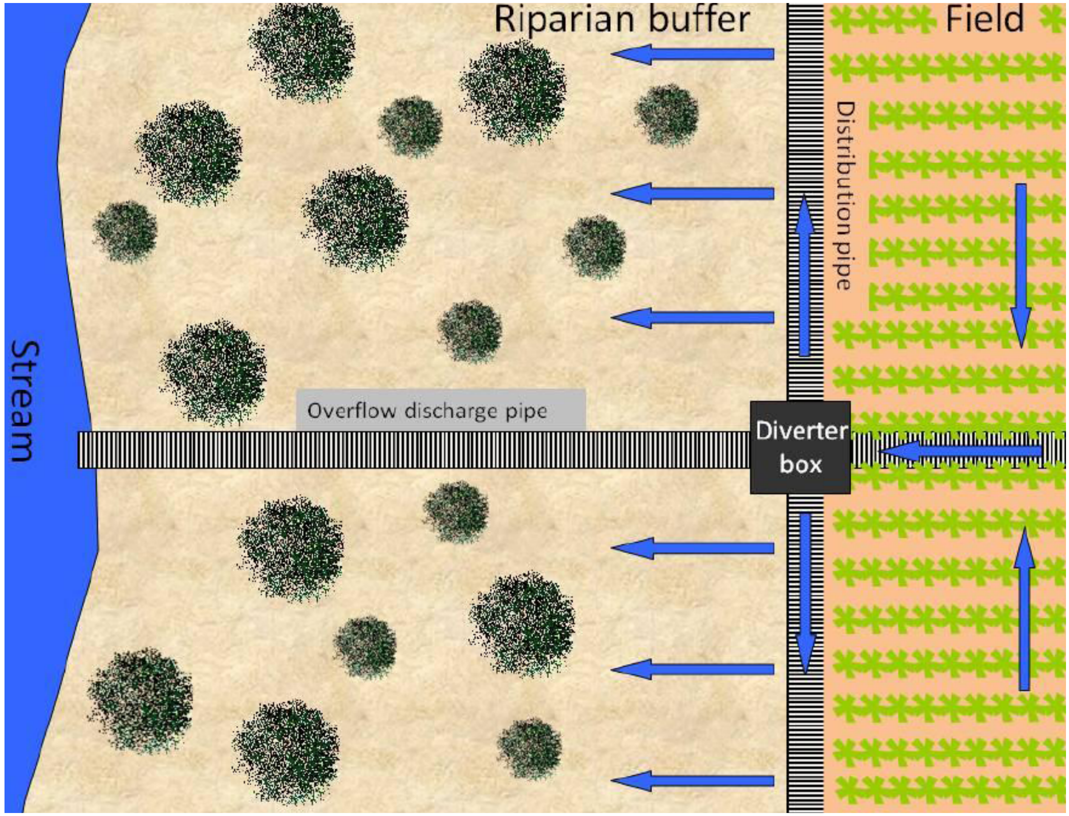


Illustration by John Peterson
Courtesy of Matt Helmers, ISU Extension

Saturated buffers





Illustrations courtesy of Dan Jaynes

In summary, there are many benefits to drainage but some impacts that must be balanced

- There are no simple answers for drainage impacts on hydrology and streamflow, but an understanding of fundamentals and models can help guide us
- There are positive and negative water quality impacts of drainage, and work continues on methods to reduce the negative impacts

SDSU Extension

Questions?

Photo: ADMC