

***Manejo Integrado da Bacia Hidrográfica e dos
Recursos Hídricos : Rios e Poços
O caso do estado de Nebraska, nos EUA.***

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Derrel Martin, Biological Systems Engineering



Projected Population Growth

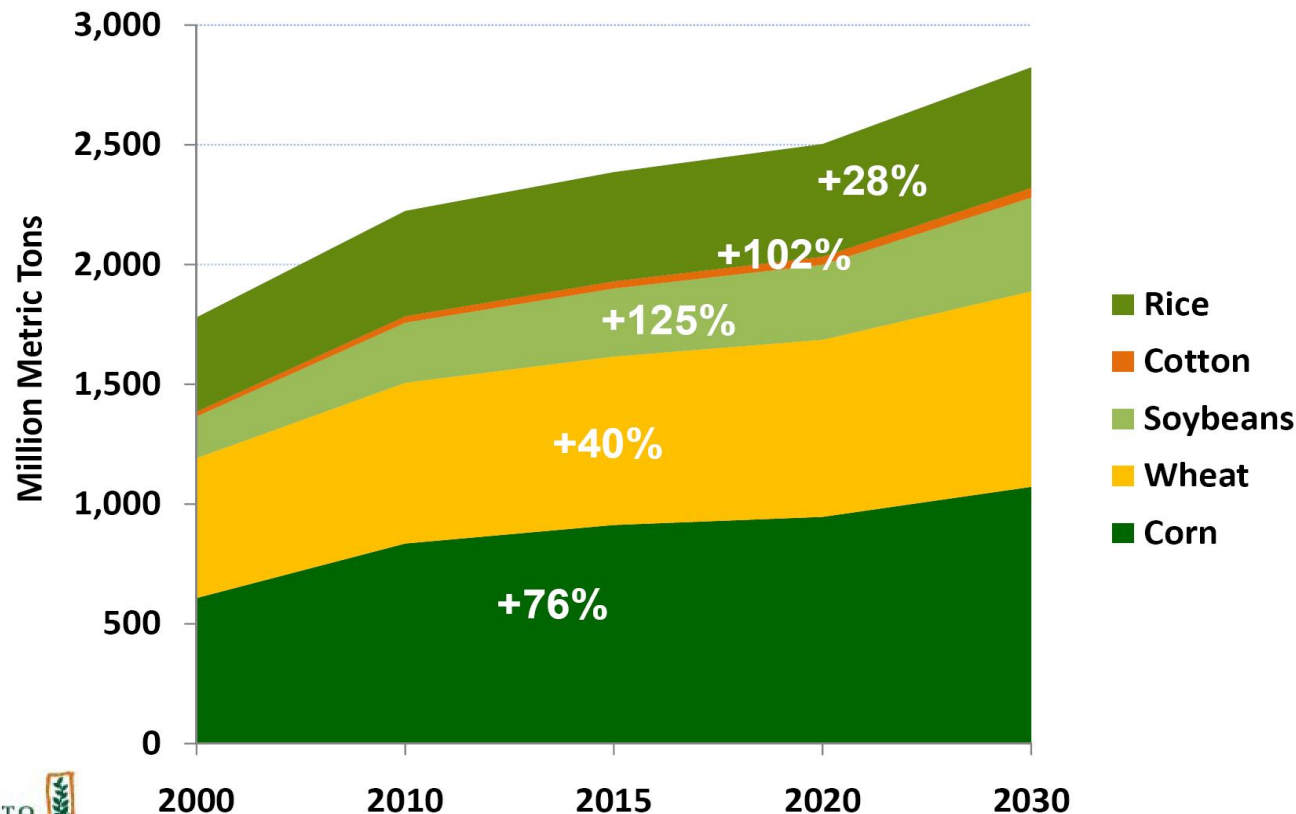
Region	2008	2050	Change	Percent
World	6,705	9,352	+2,647	+ 40
High Income	1,227	1,294	+ 67	+ 6
Low Income	5,479	8,058	+2,579	+ 47
SubSaharan Africa	809	1,698	+ 889	+110
S. Central Asia	1,683	2,605	+ 922	+ 55
Lat. America/Carib	577	778	+ 201	+ 35
N. Af & W. Asia	422	670	+ 248	+ 59



Source: Population Reference Bureau. 2008 World Population Data Sheet, based on U.N. Population Office and U.S. Census Bureau analyses.



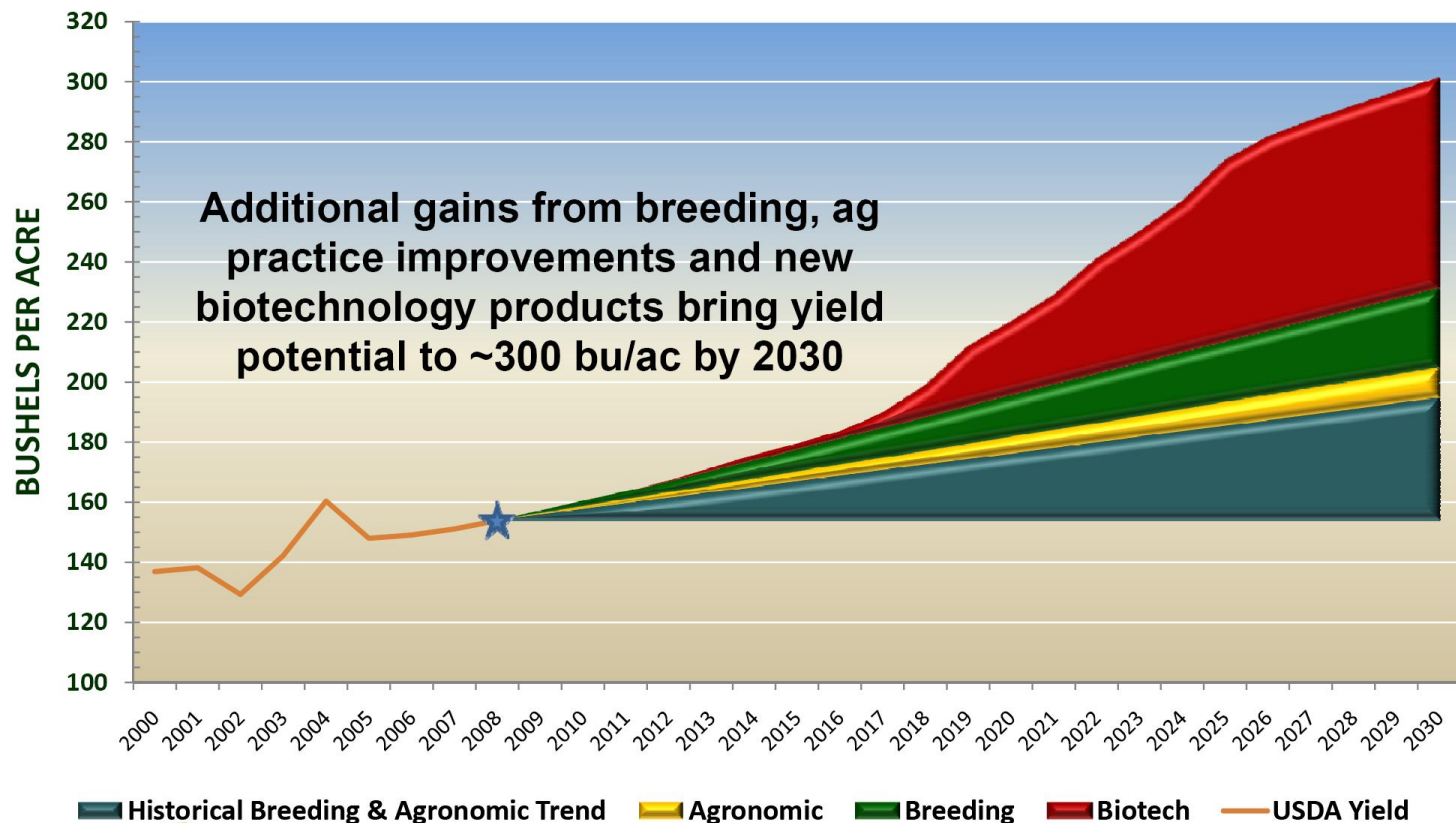
Global demand for crops projected to grow dramatically as population/income continues to rise



Source: IHS Global Insights, Agriculture Division



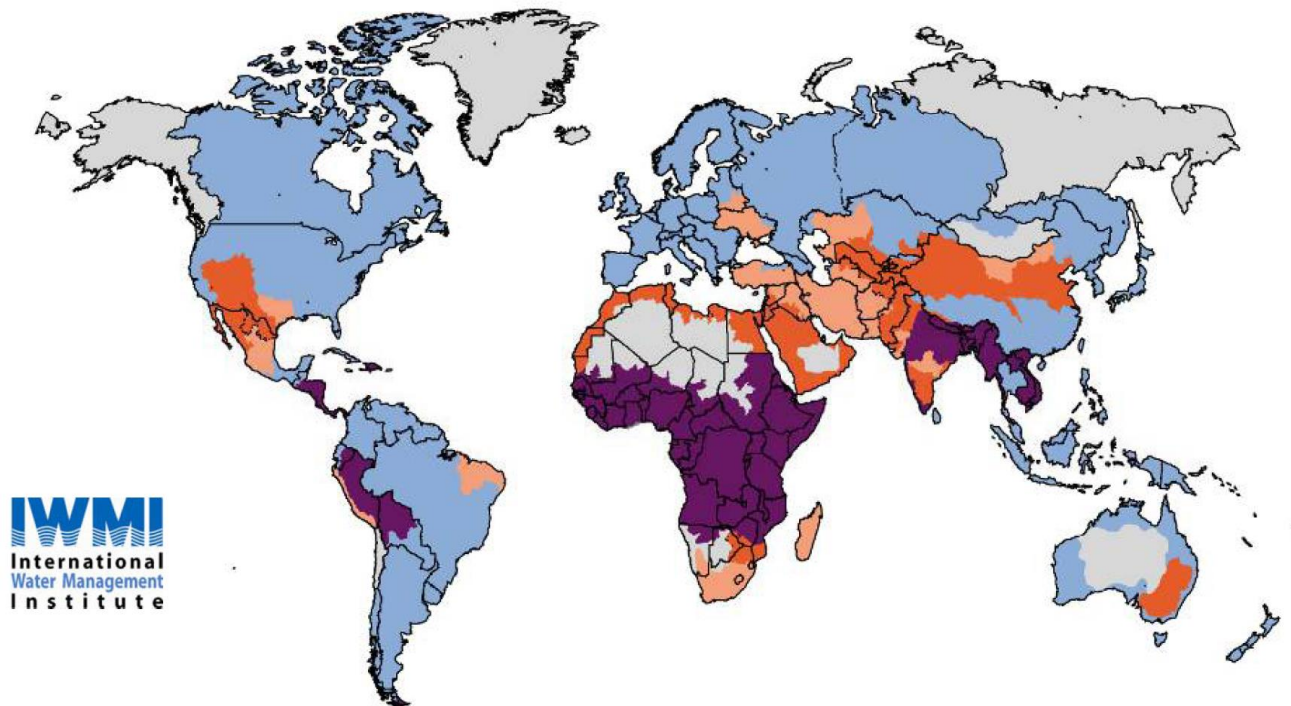
CORN YIELD POTENTIAL TO 2030 IN THE UNITED STATES





1/3 of the world's population living in water basins already dealing with water scarcity issues

- Little or no water scarcity
- Approaching physical water scarcity
- Not estimated
- Physical water scarcity
- Economic water scarcity



IWMI
International
Water Management
Institute



Source: IWMI Comprehensive Assessment, Summary for decision makers, pg 11.

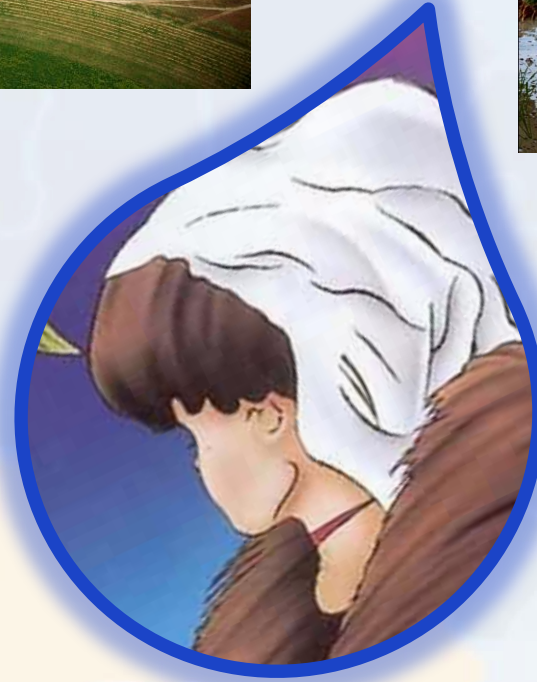
8

O que vês nesta imagem?



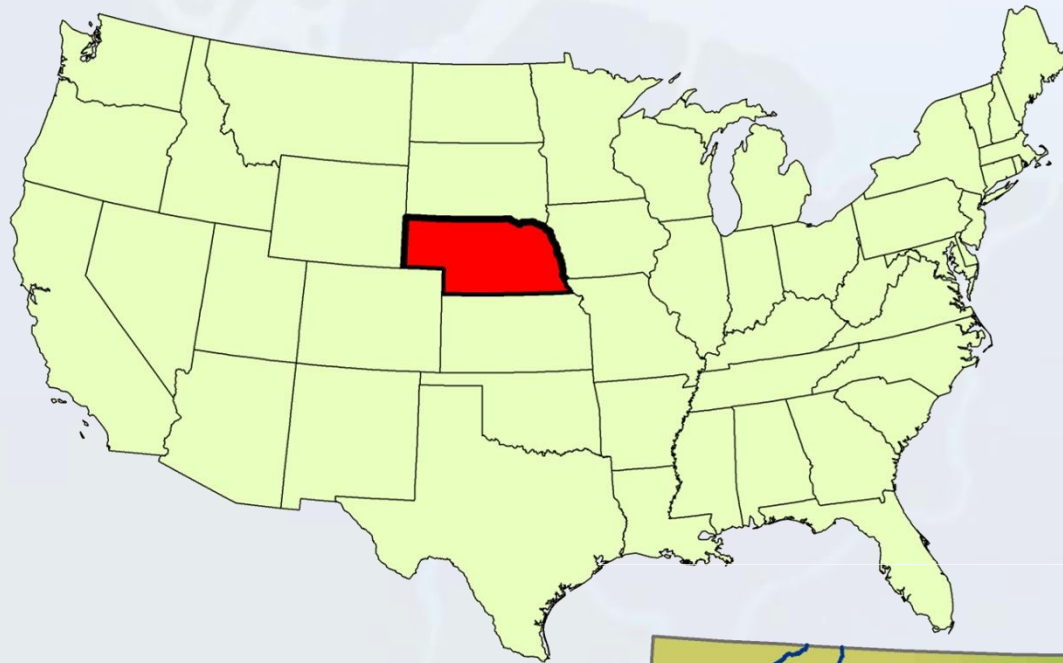


Muitas perspectivas



Tópicos:

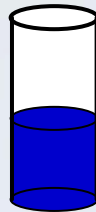
1. Resumo das Condições de Nebraska
2. Sustentabilidade das Bacias Hidrográficas
3. Eficiência e Water footprint : “Uso da Água”
4. Avanço do Manejo da Irrigação em Pivot Central
5. Oportunidades com o Manejo da Irrigação



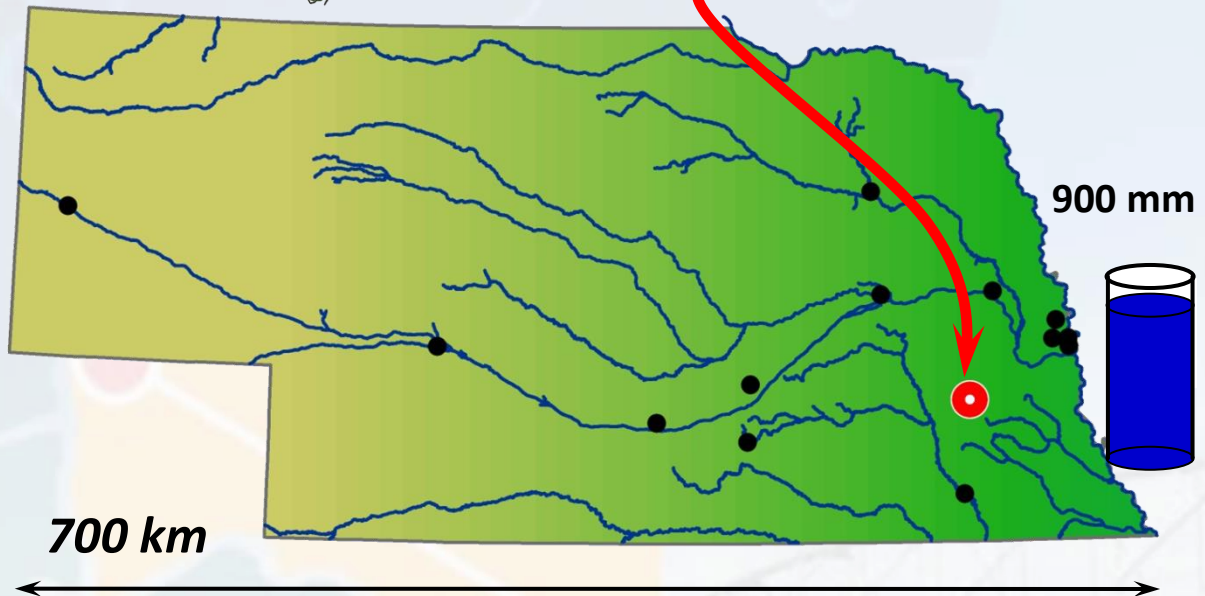
Nebraska

Lincoln

Precipitação:
380 mm



1,7 milhões de pessoas



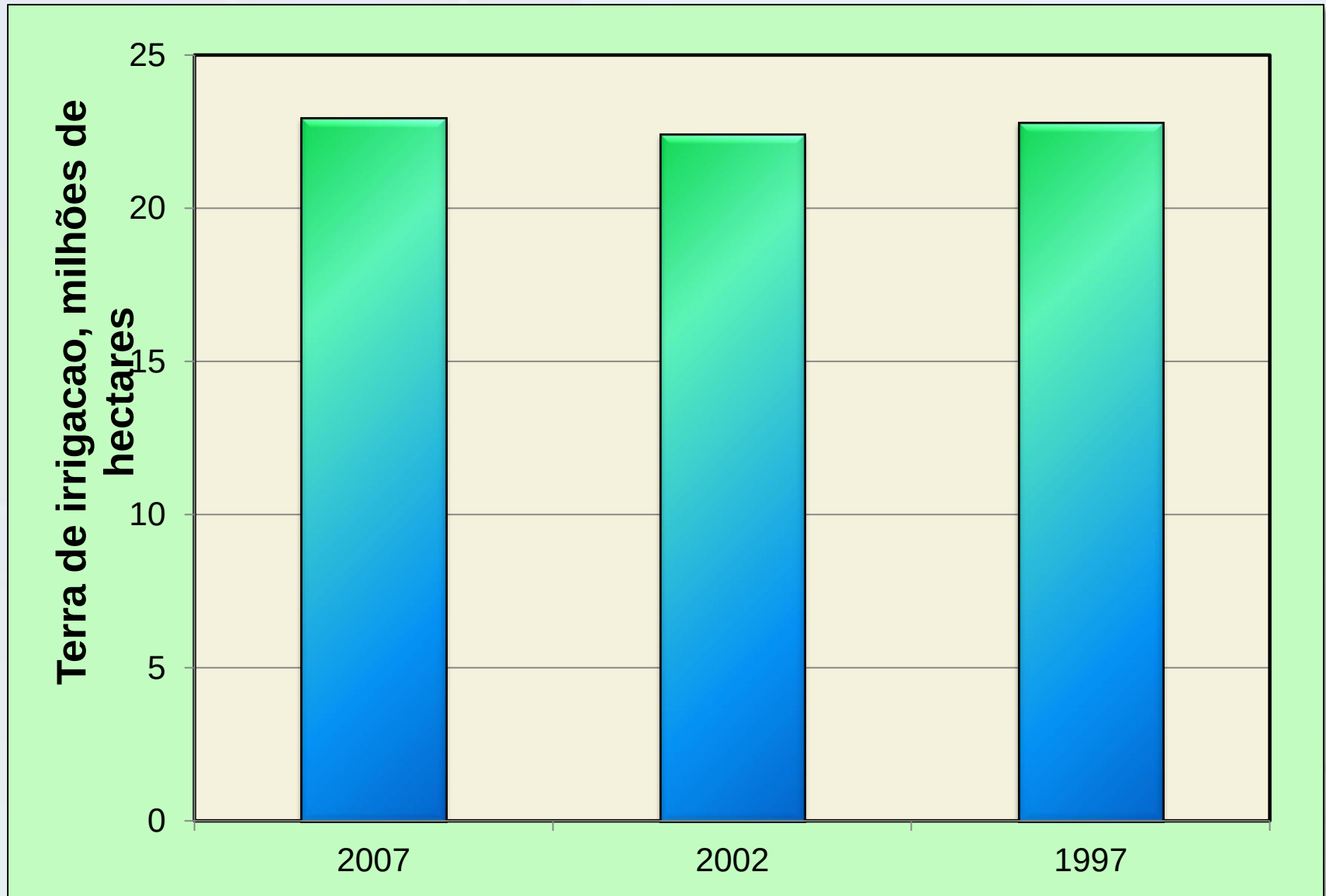
Nebraska

Comparação de tamanho

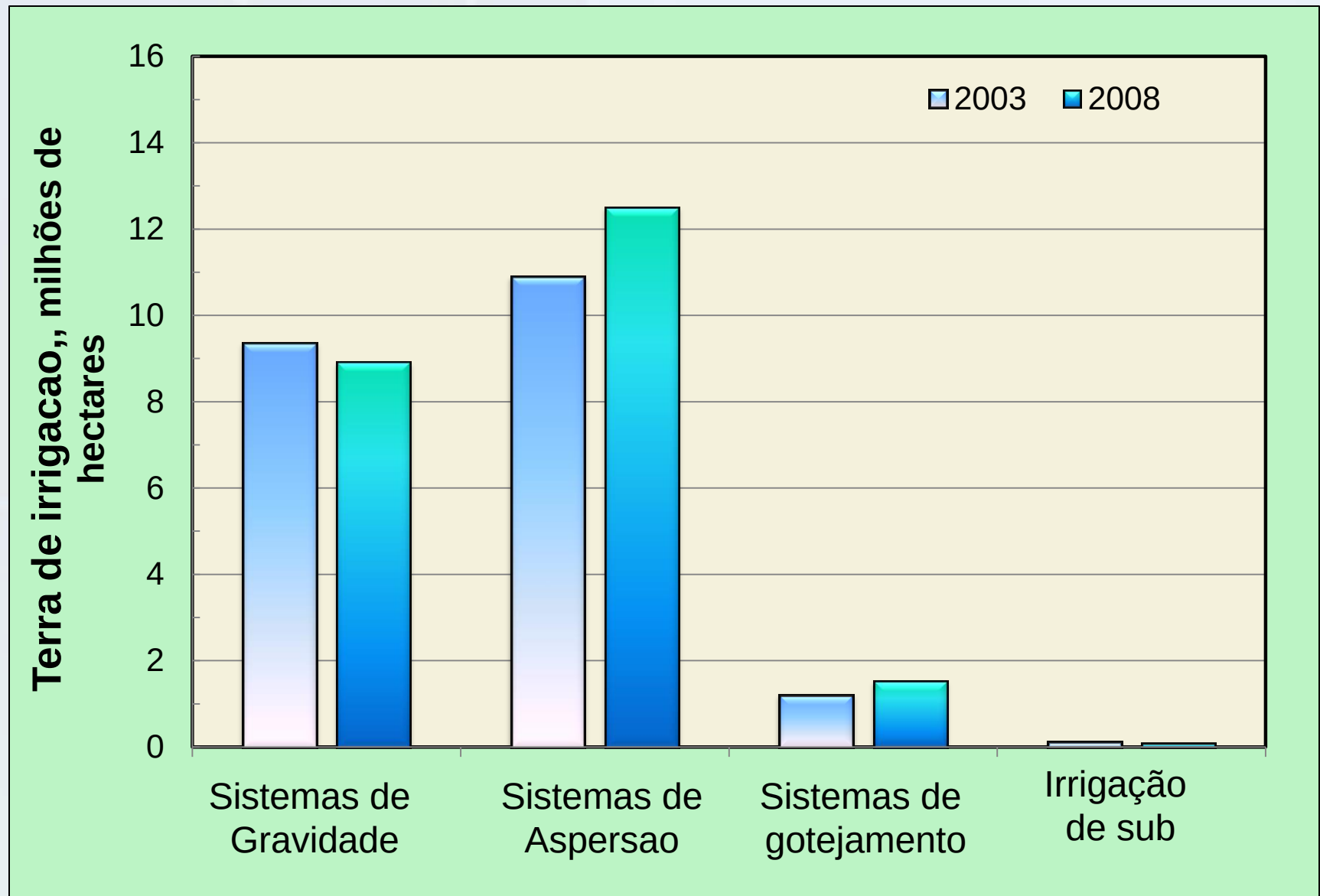
Nebraska → 20 million ha
Bahia → 57 million ha



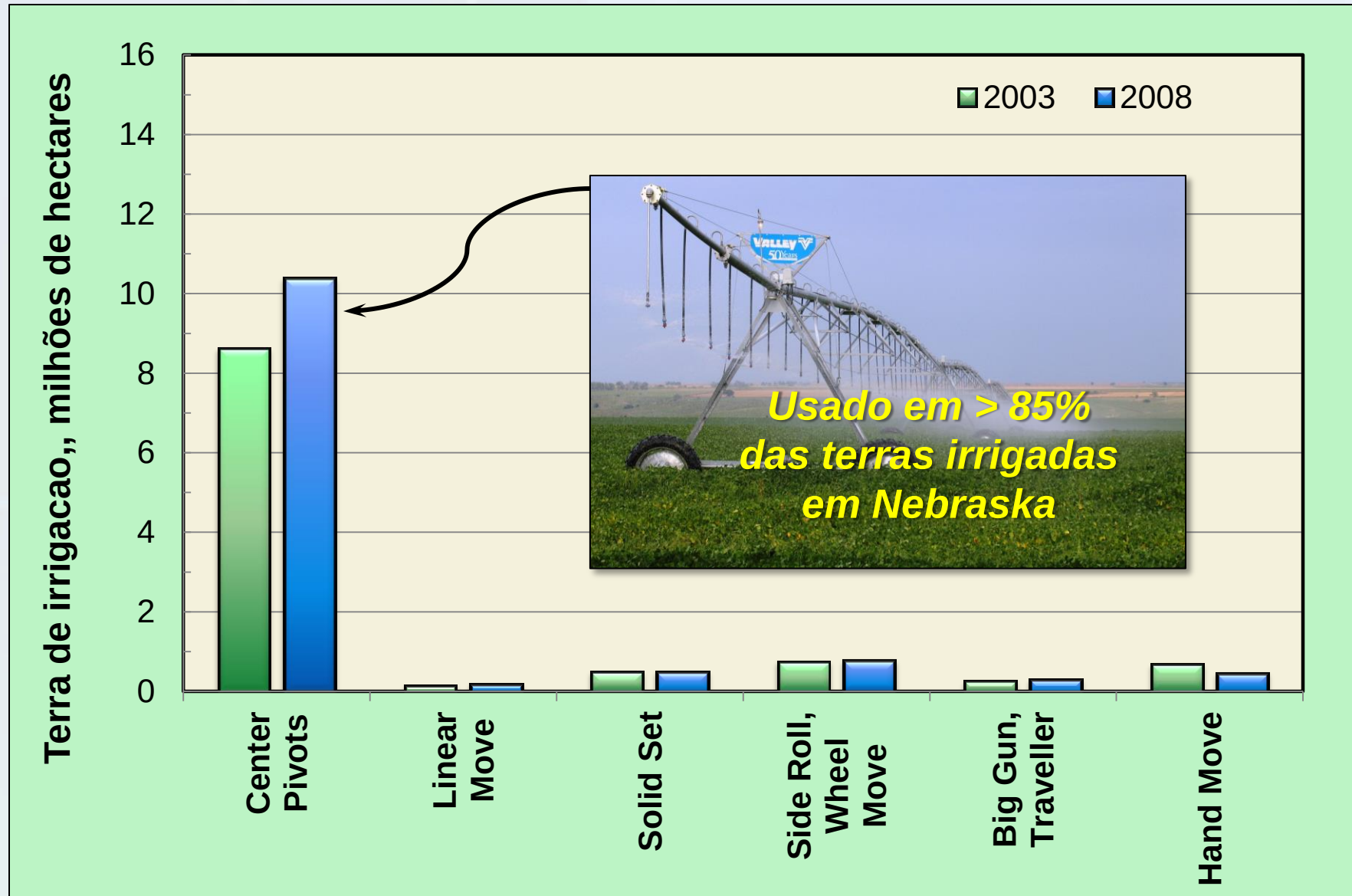
Areas Irrigadas - E.U.A.



Métodos de Irrigação Usado nos Estados Unidos

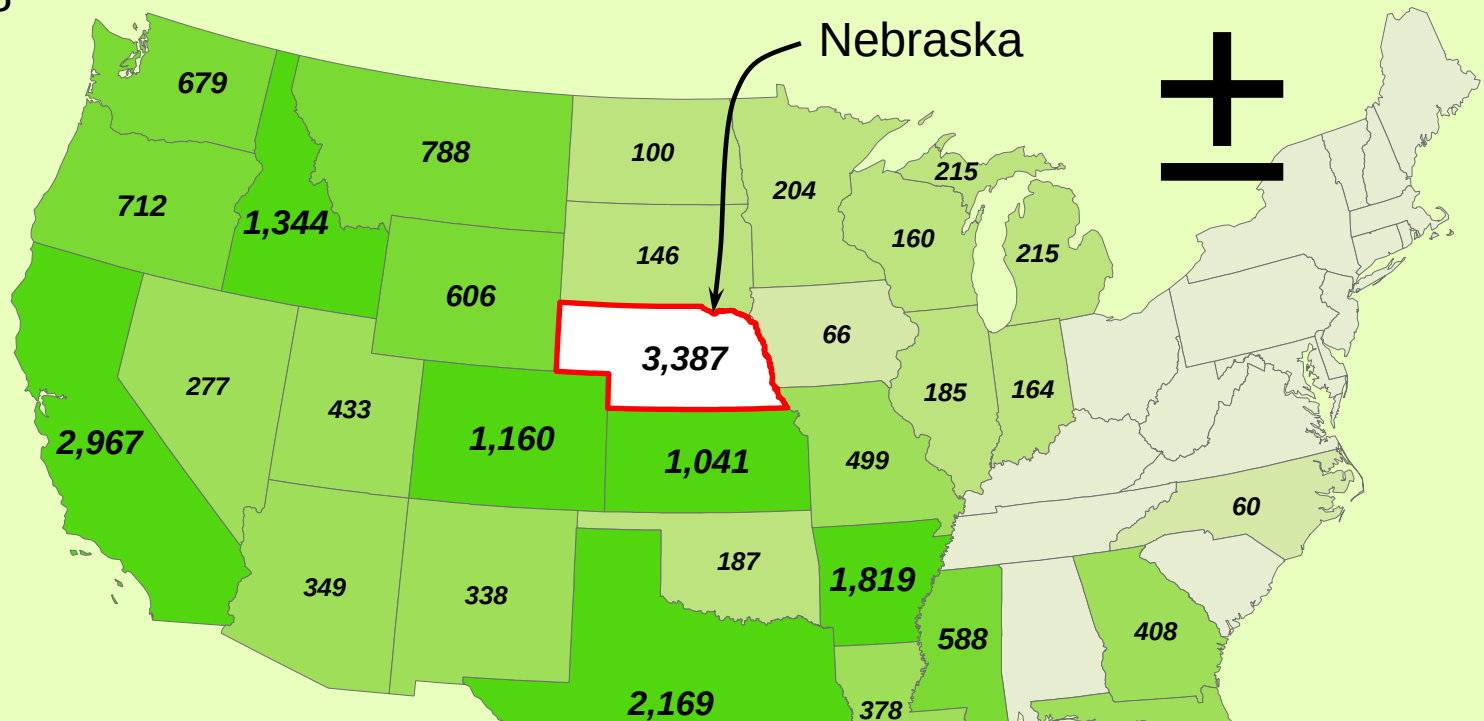


Métodos de Irrigação por aspersão nos EUA



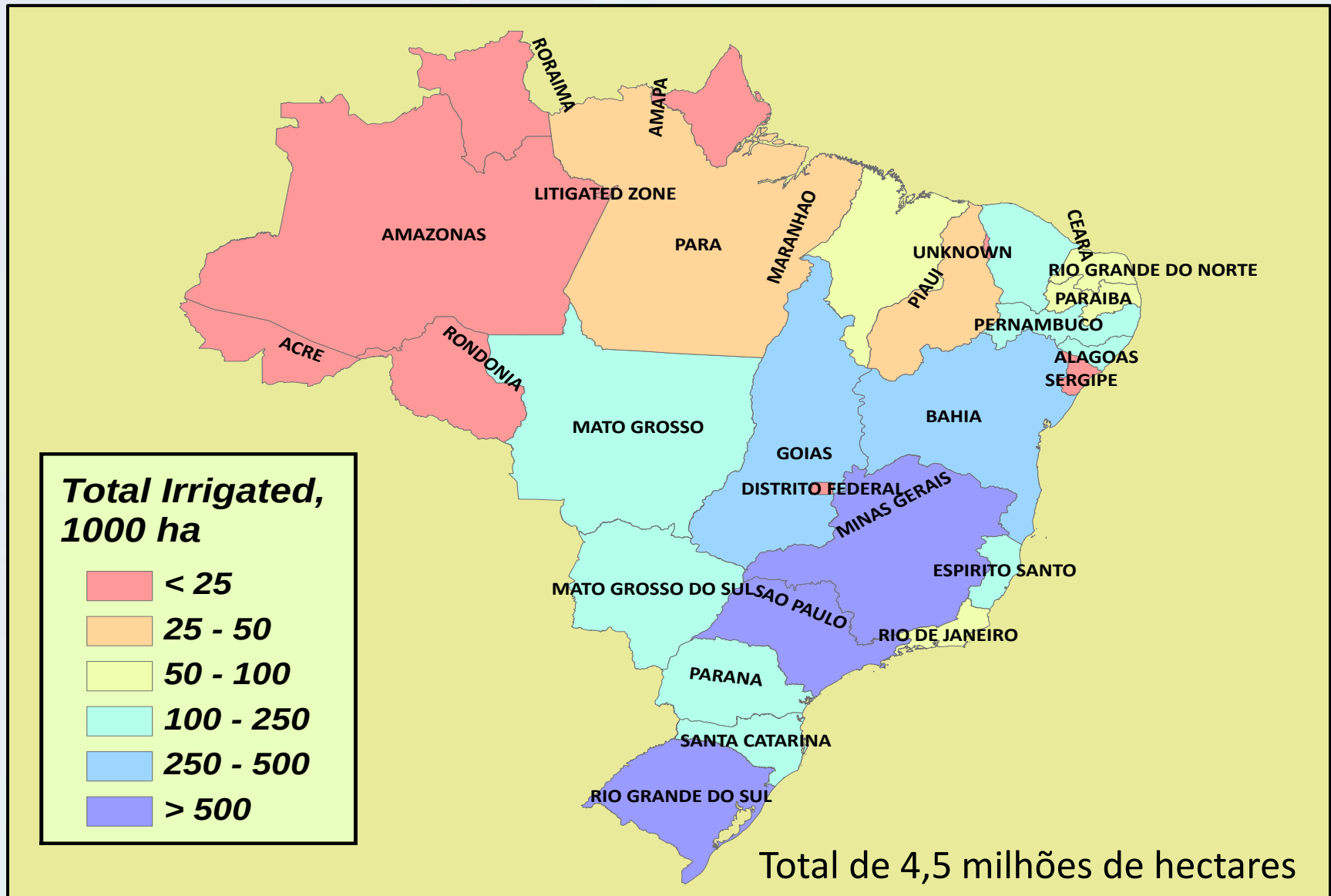
Terra de Irrigacao - E.U.A.

2008

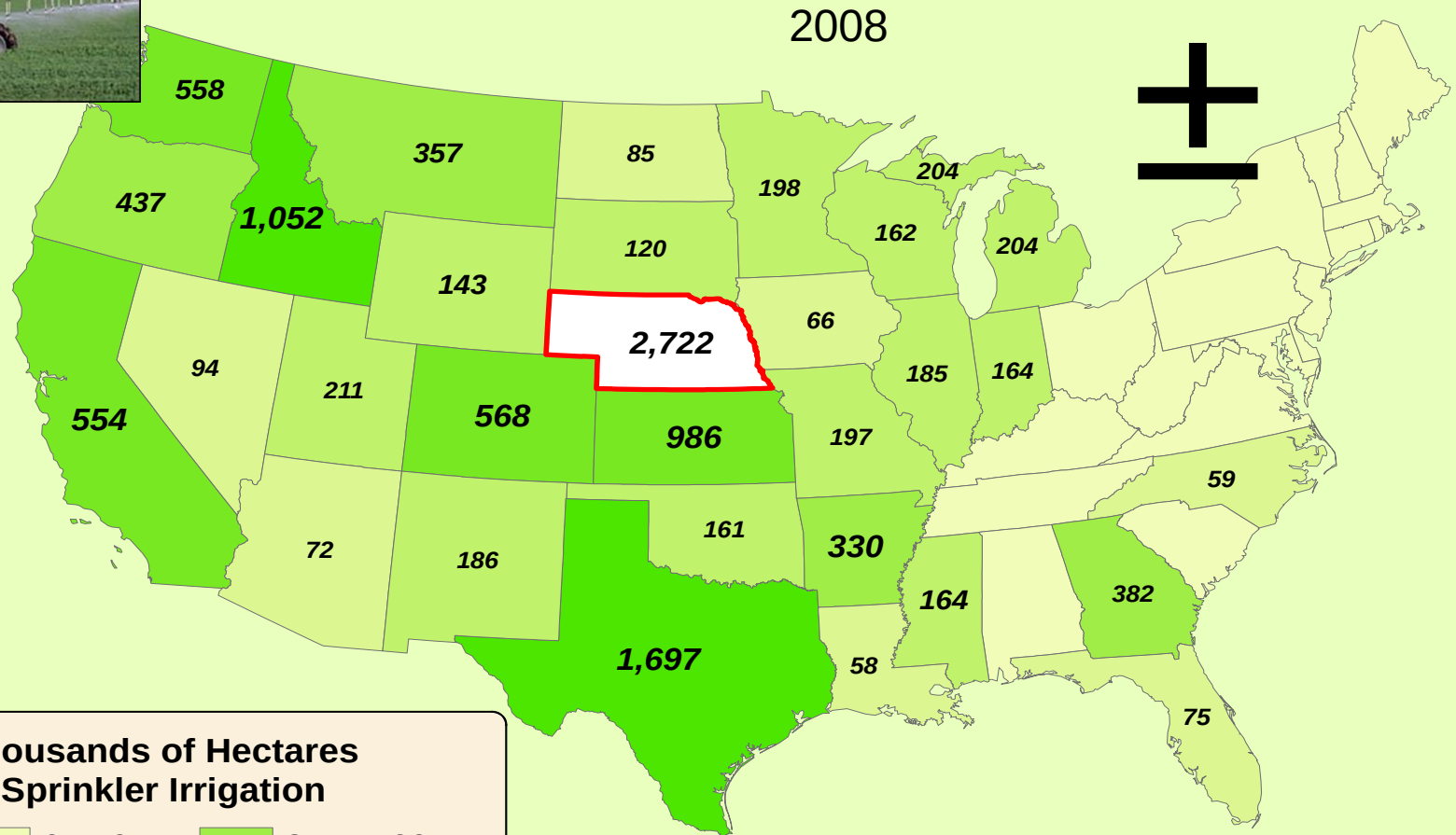


- Hoje 3,65 milhões de hectares
- > 16% das terras de irrigado nacional está em Nebraska
- Maior impacto na economia do estado é de \$ → 11 bilhões \$ em 2012
- 90% de retirada de água para irrigação

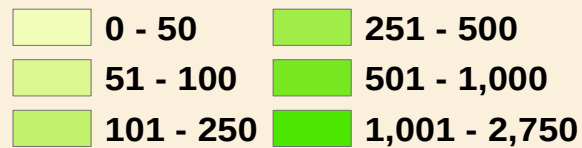
Total irrigada área ← FAO estatísticas



Irrigação por aspersão nos Estados Unidos

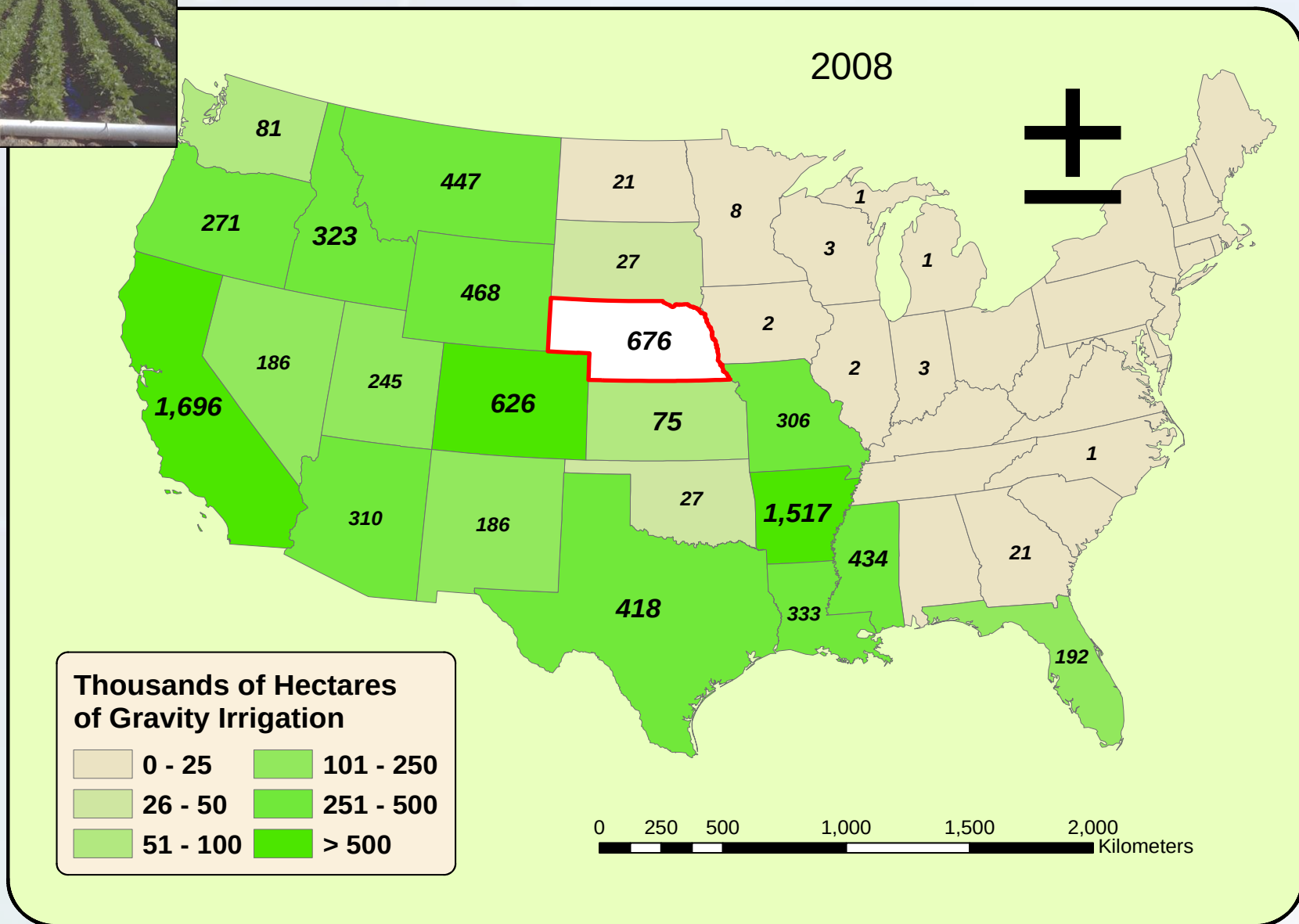


Thousands of Hectares
of Sprinkler Irrigation

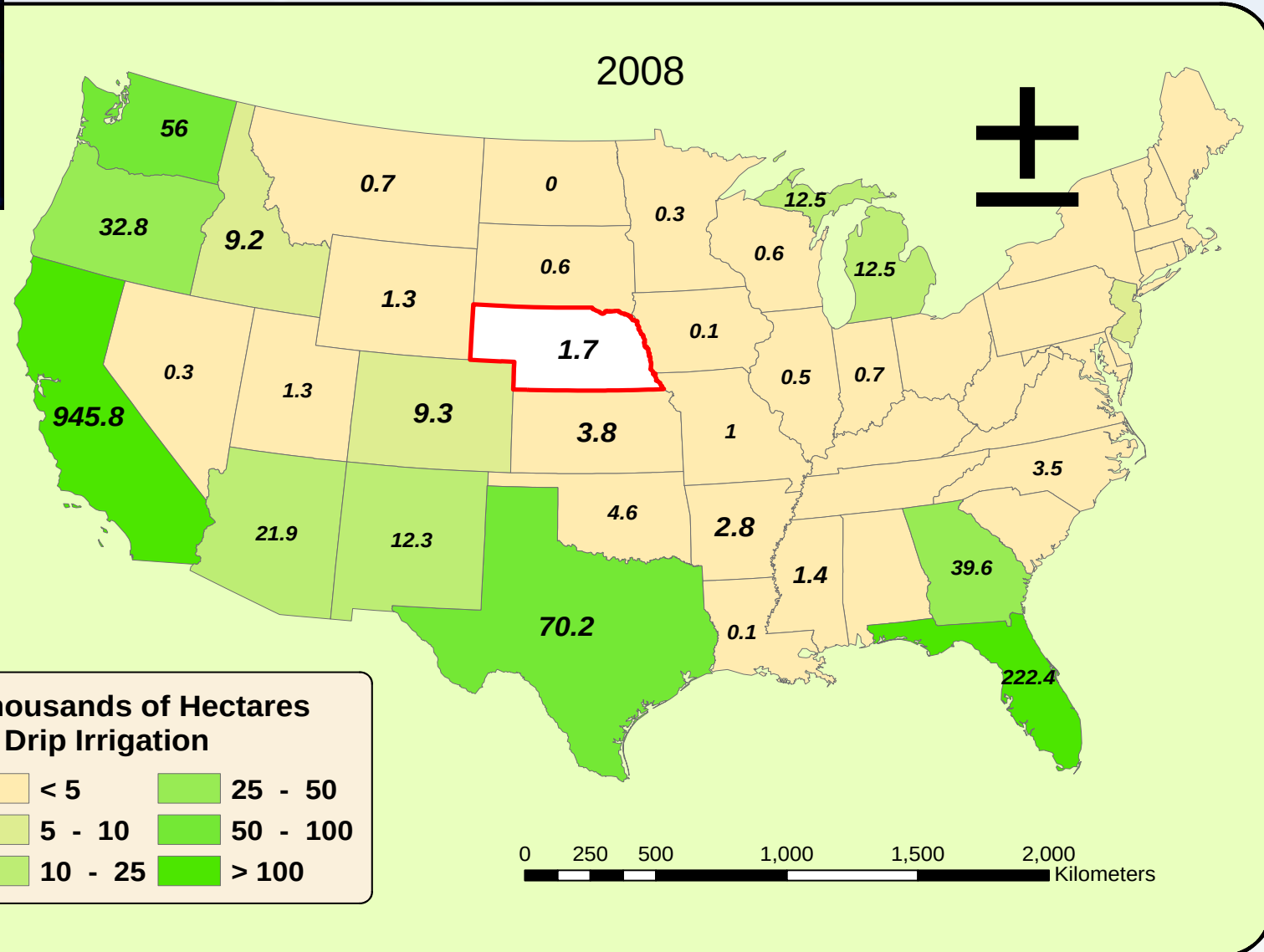


0 250 500 1,000 1,500 2,000 Kilometers

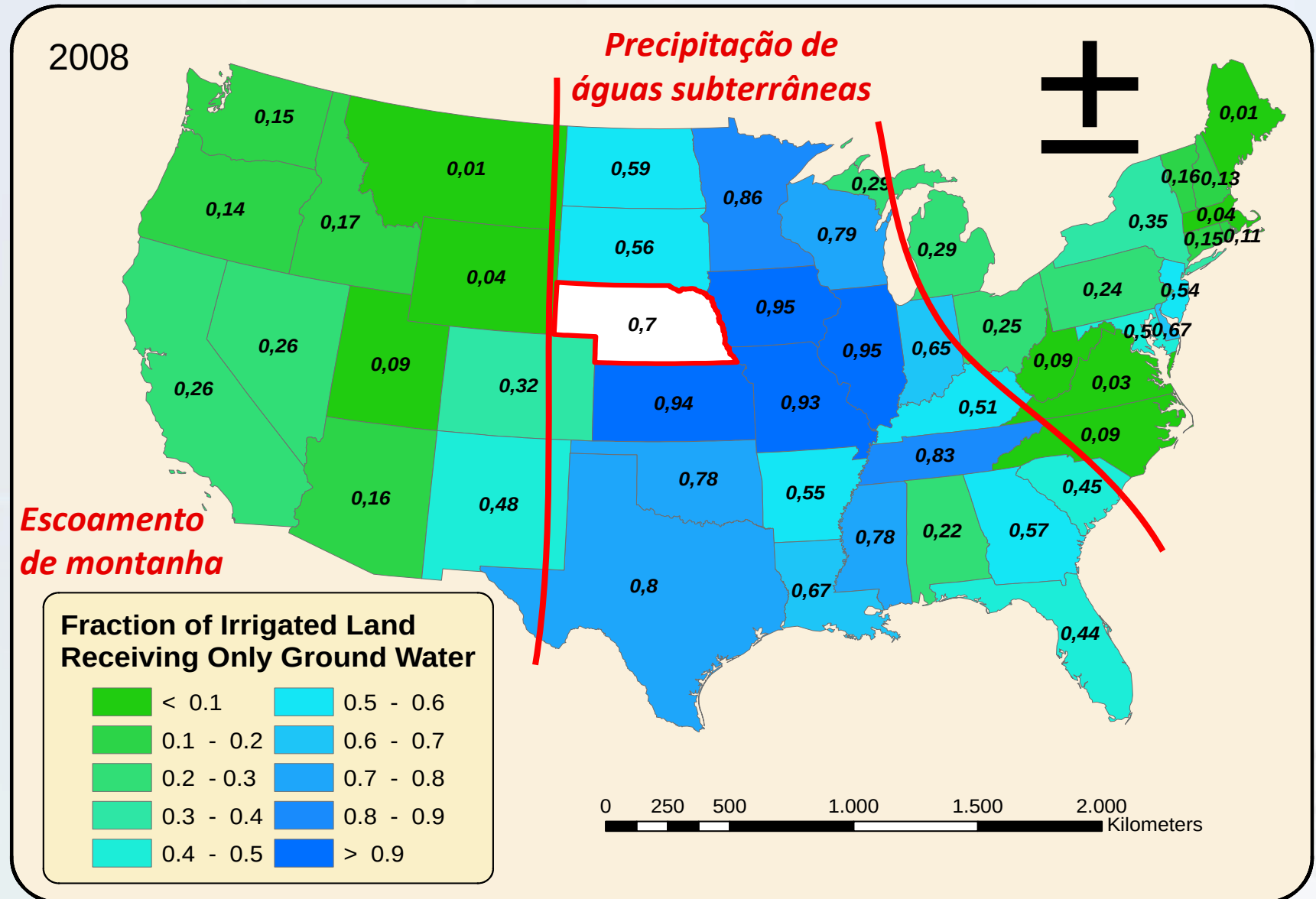
Irrigação de Gravidade nos Estados Unidos

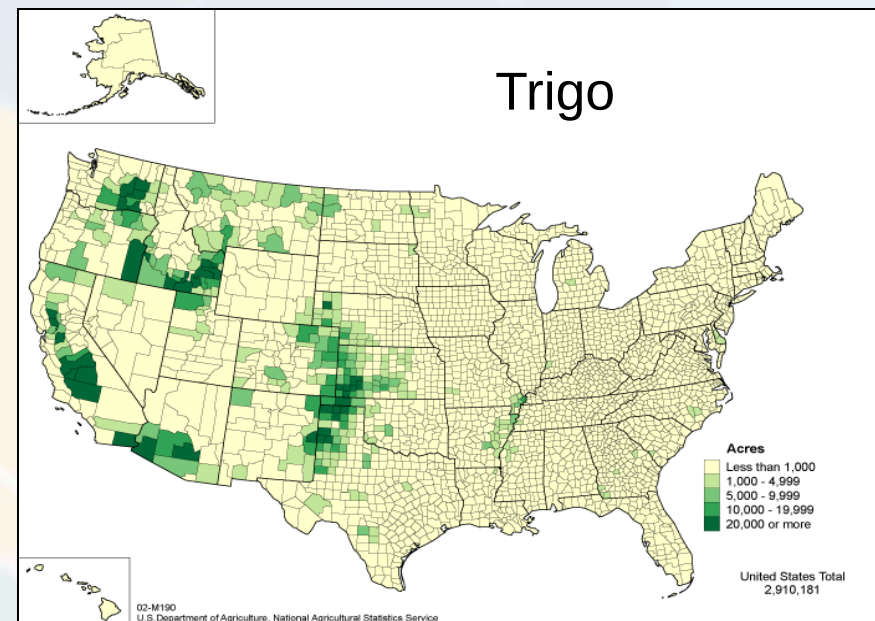
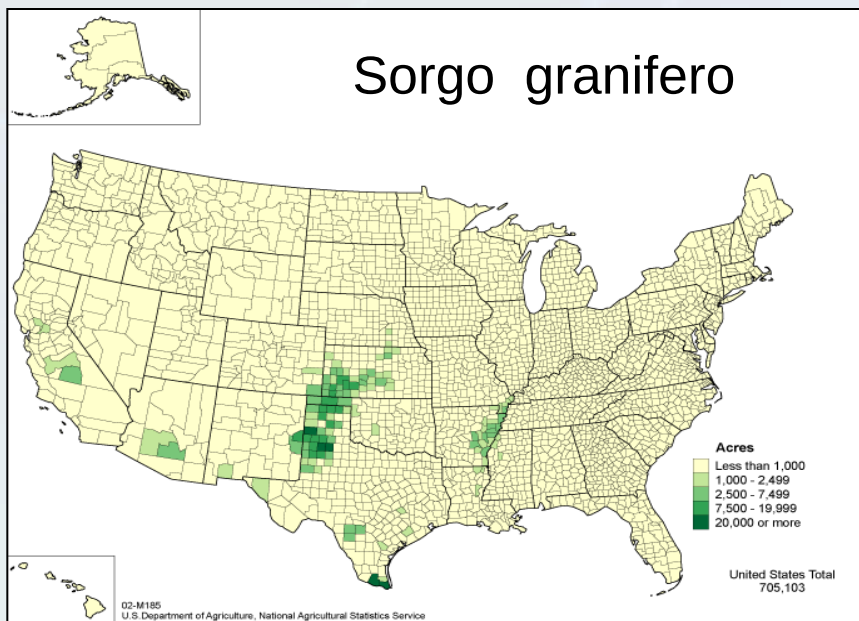
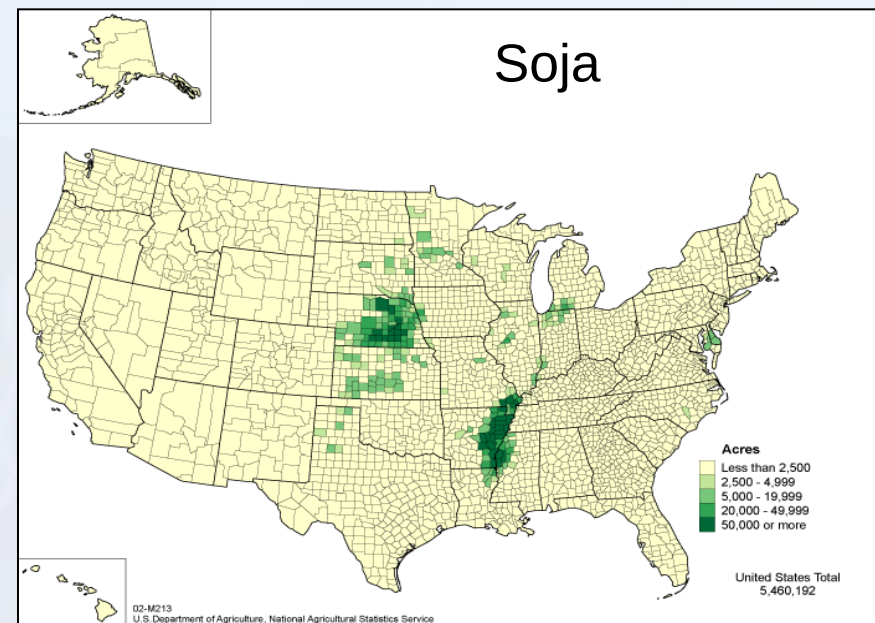
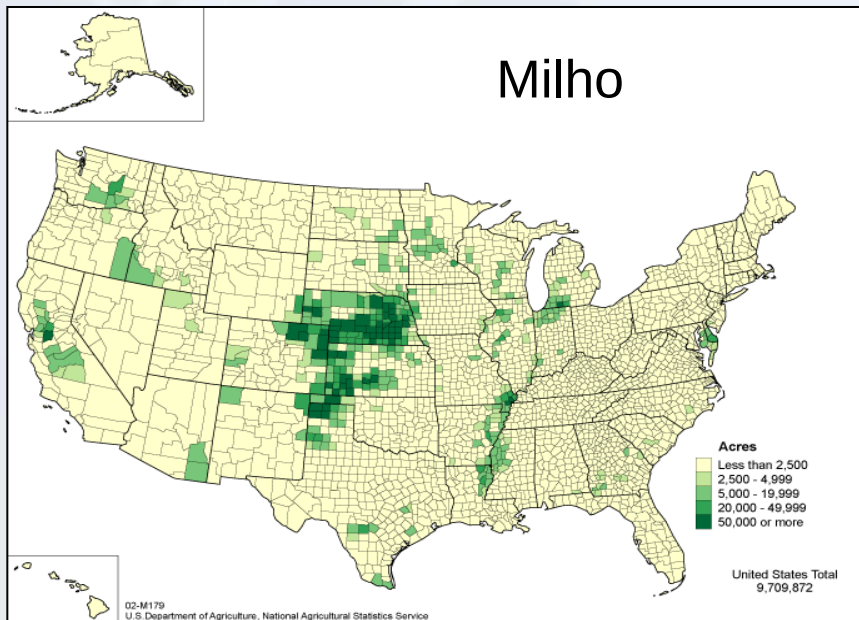


Irrigação de gotejamento nos Estados Unidos

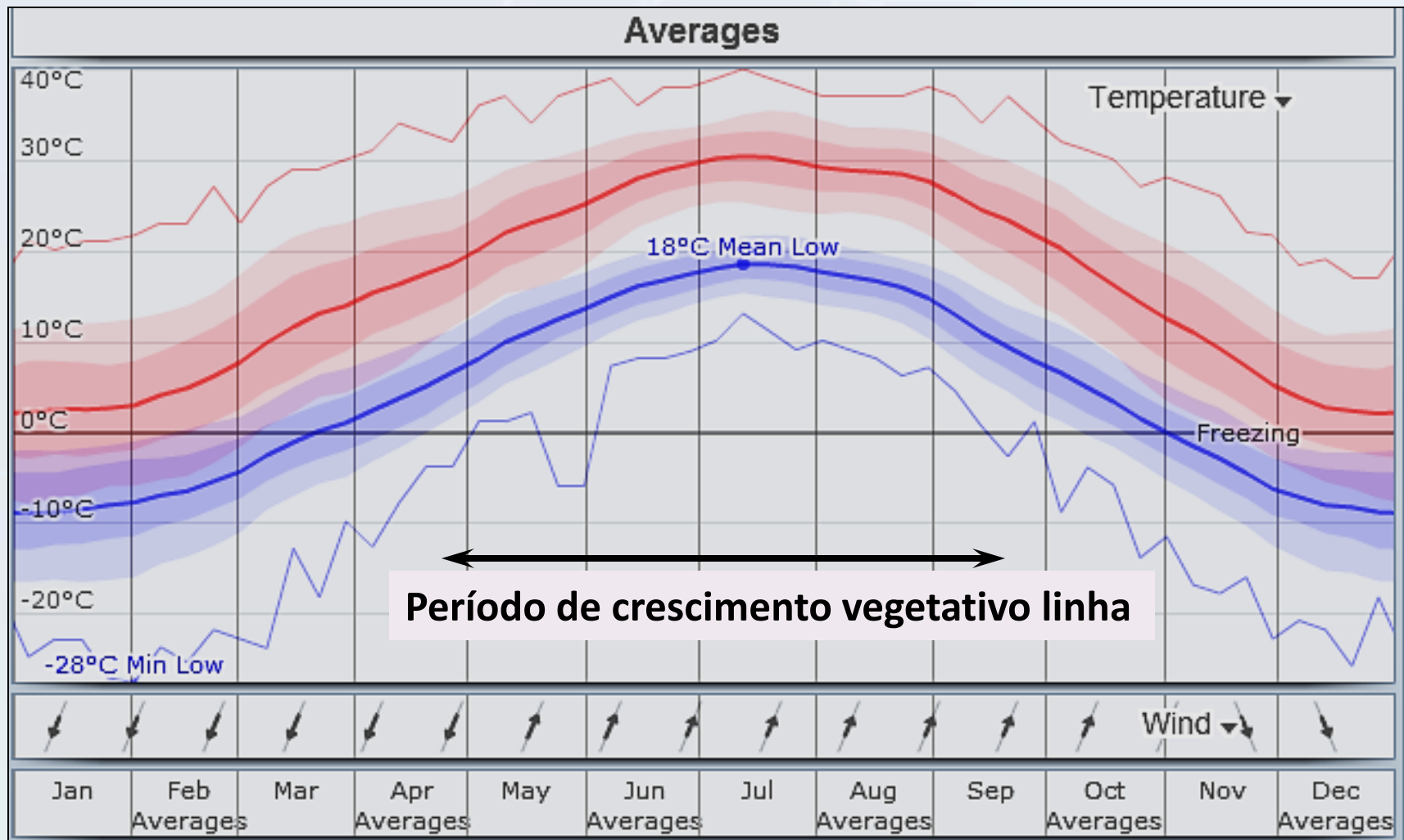


Áreas que recebem apenas água subterrânea



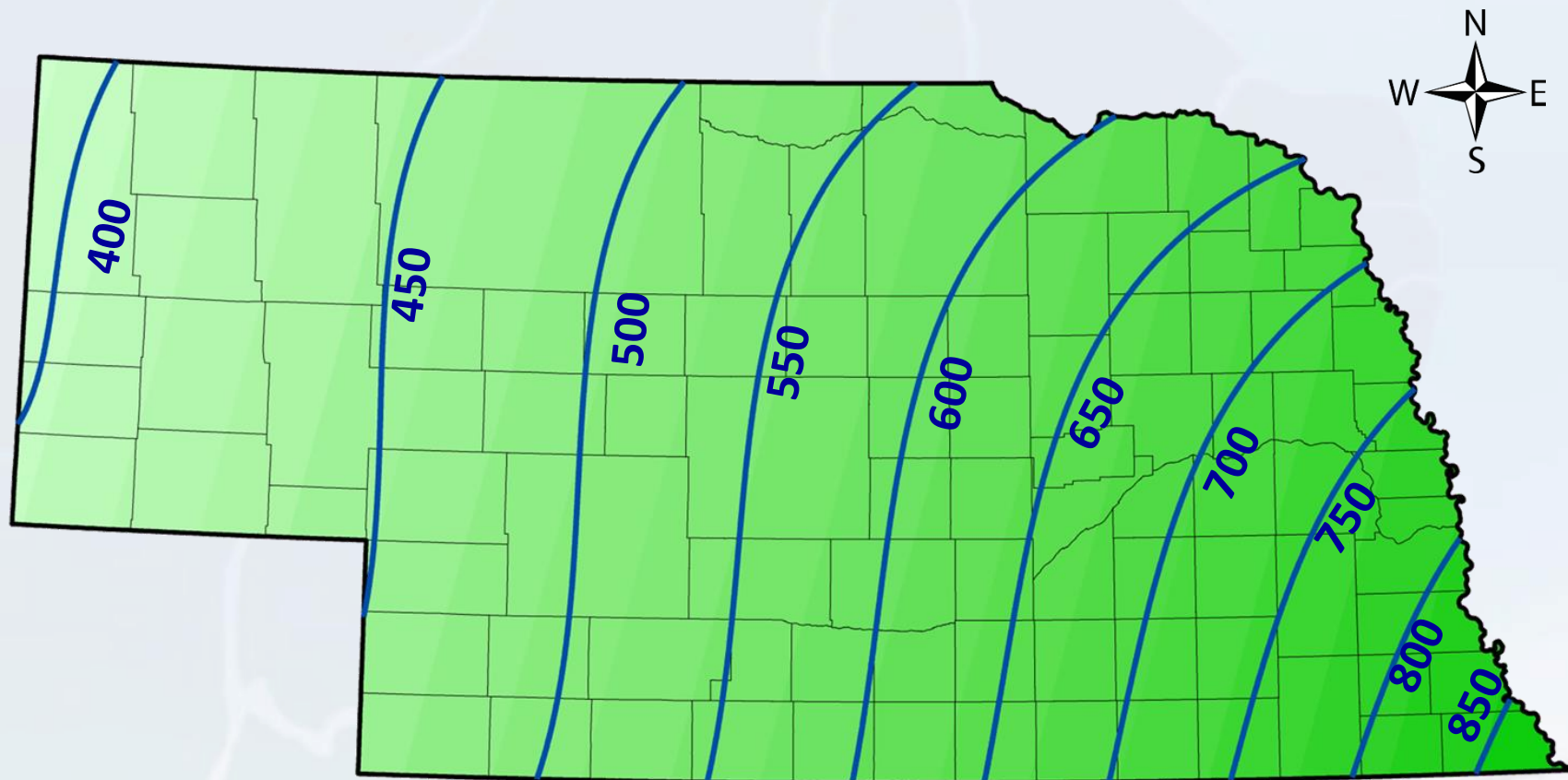


Temperatura do ar no centro de Nebraska



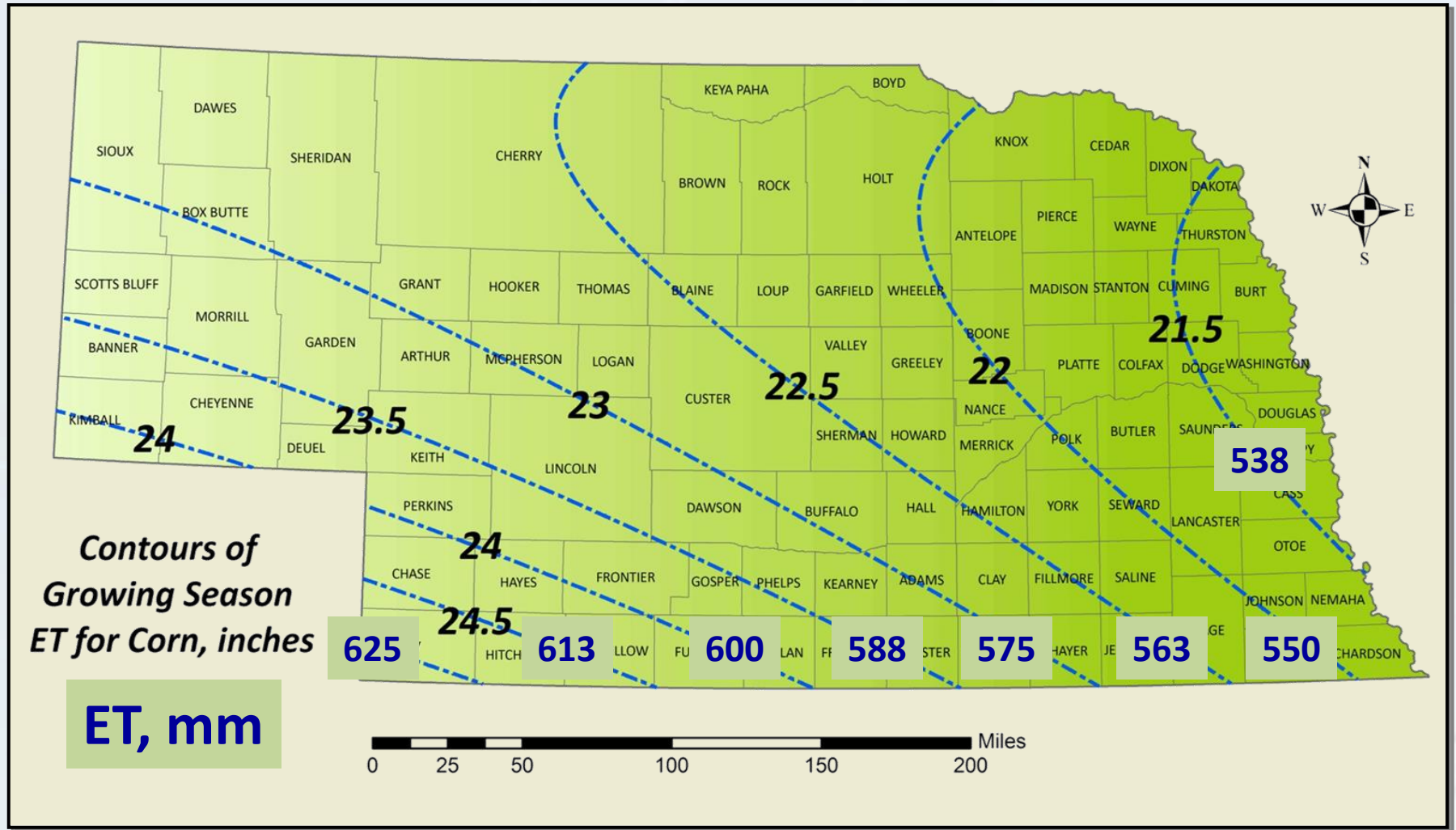
Precipitação média anual

A precipitação varia de cerca de 10 mm para 16 km



Média de precipitação anual, mm

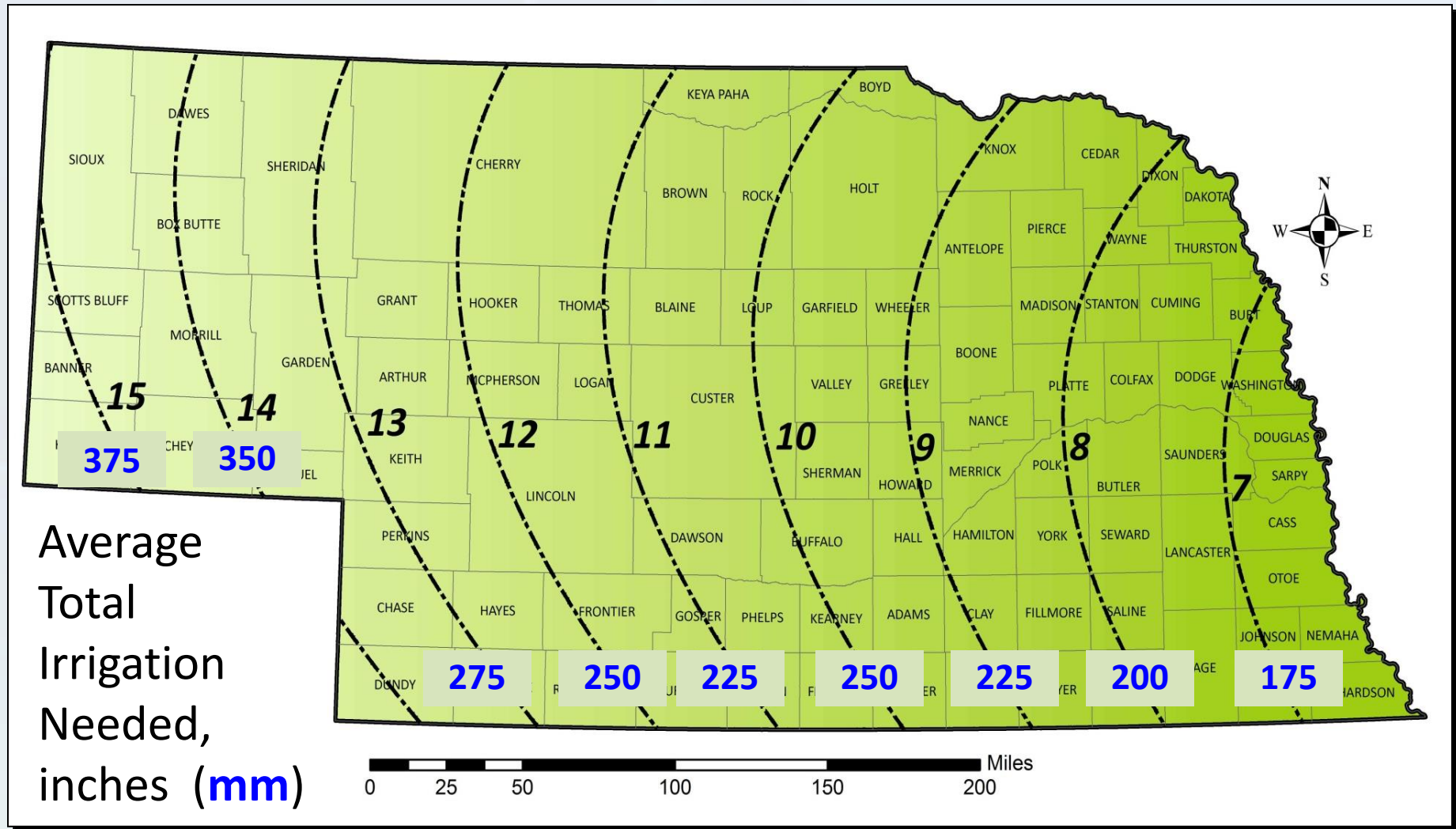
Evapotranspiração é menos variável do que a precipitação



ET amounts from planting (~ 5/1) until physiological maturity (~ 9/20)

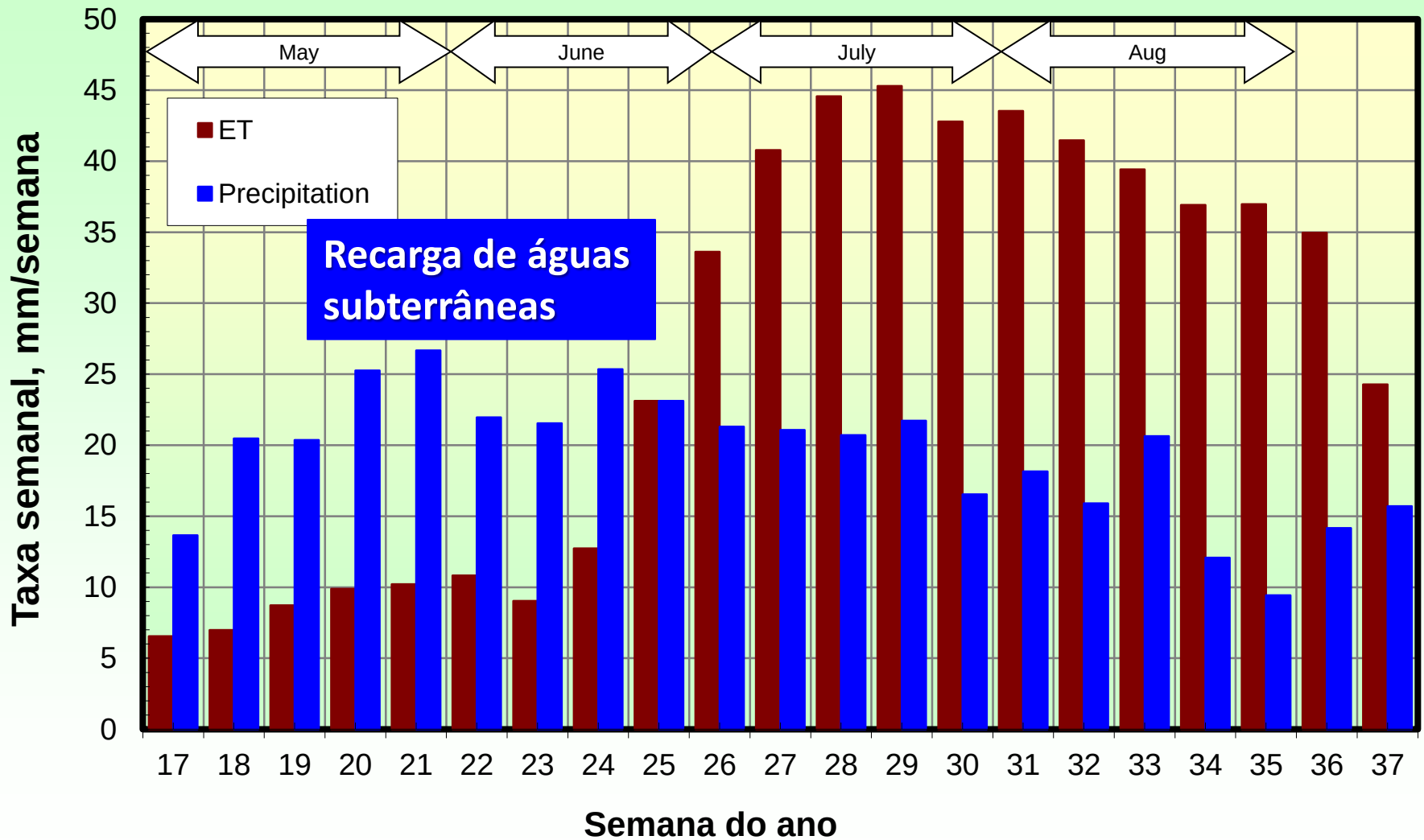
Requisitos De Irrigação Bruta Média Para Milho

(solo arenoso fino, pivô central, com 85% de eficiência de aplicação)



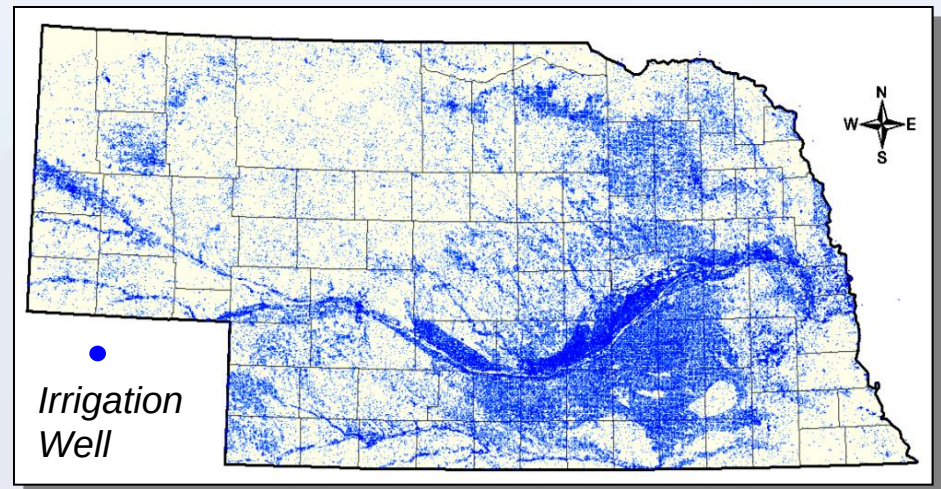
Balanço de água semanal

Kearney

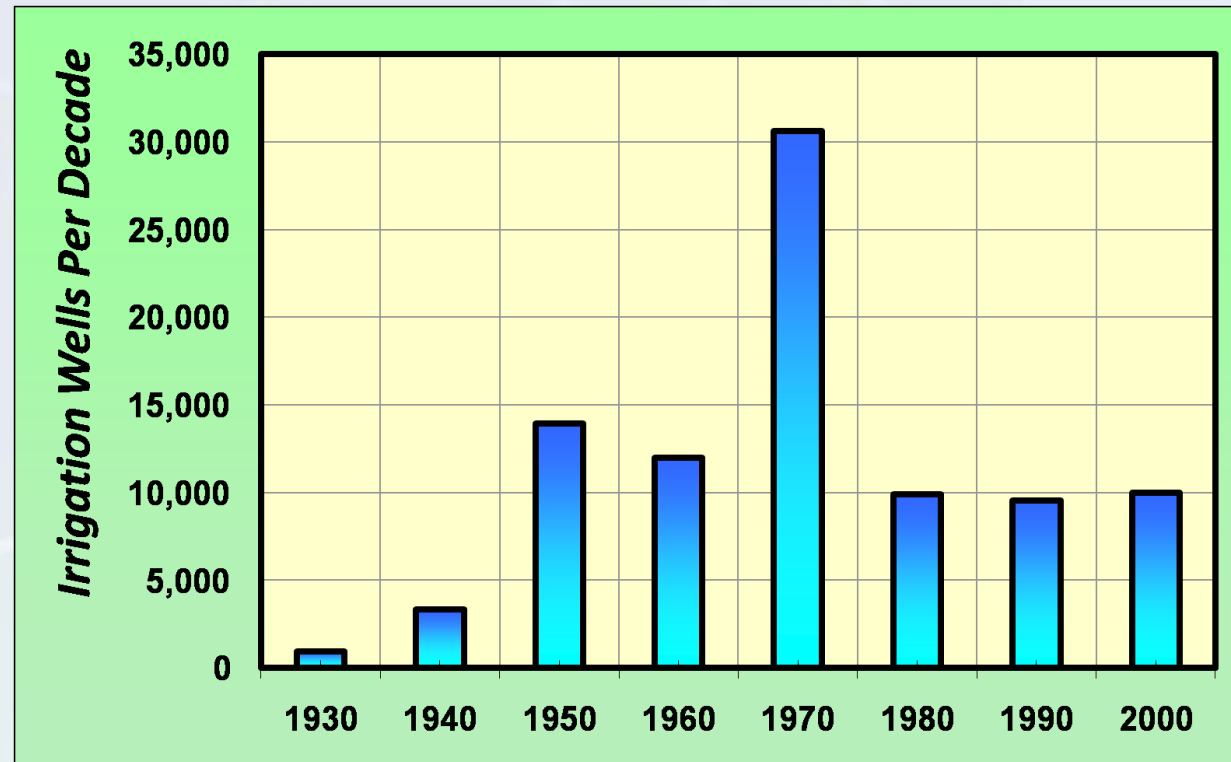


DESENVOLVIMENTO DE IRRIGAÇÃO

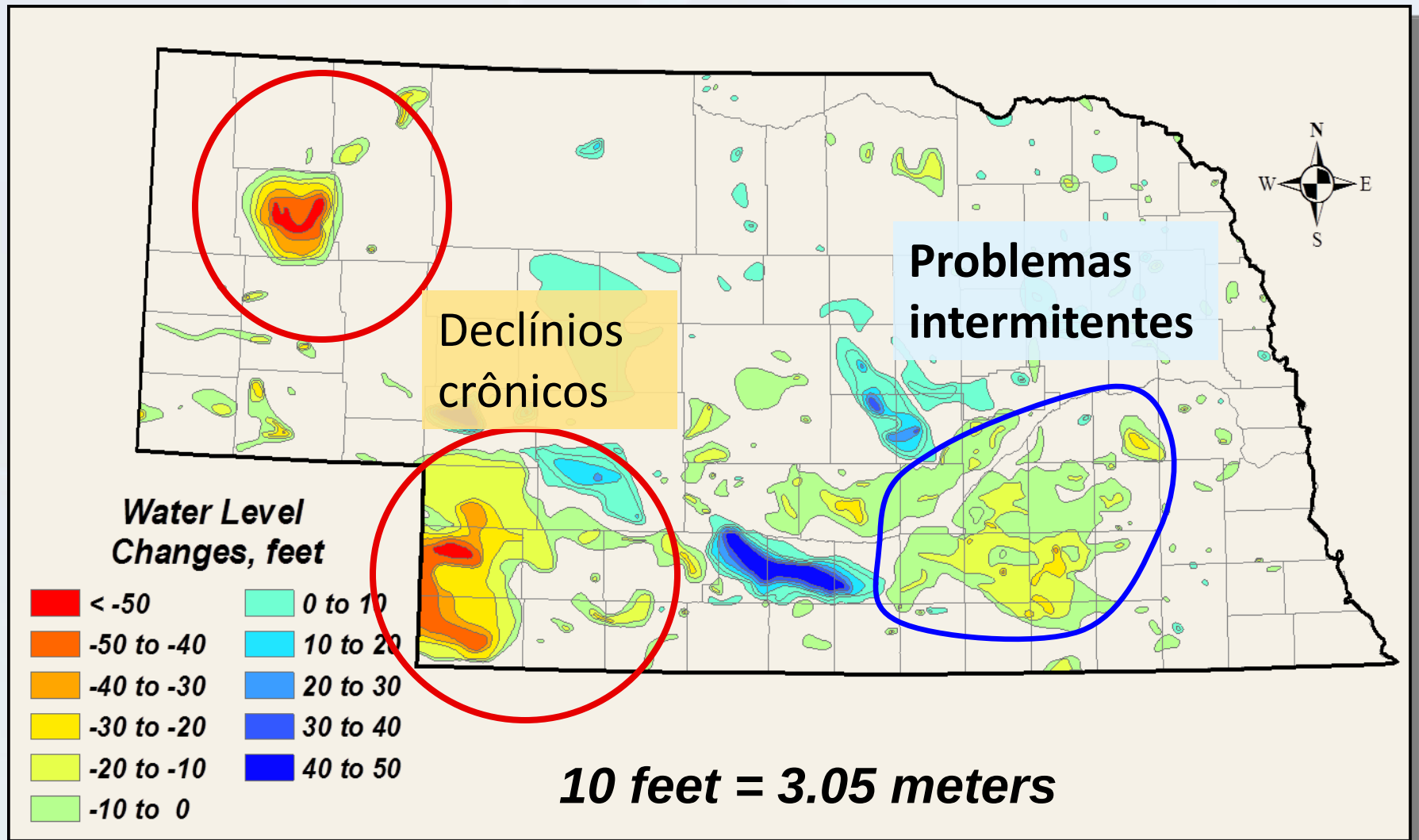
Bombas de Irrigação em
pocos > 93.000



Grande desenvolvimento ocorreu nos anos 70, mas o crescimento continua



Quedas de água subterrânea de 1950 para 2012

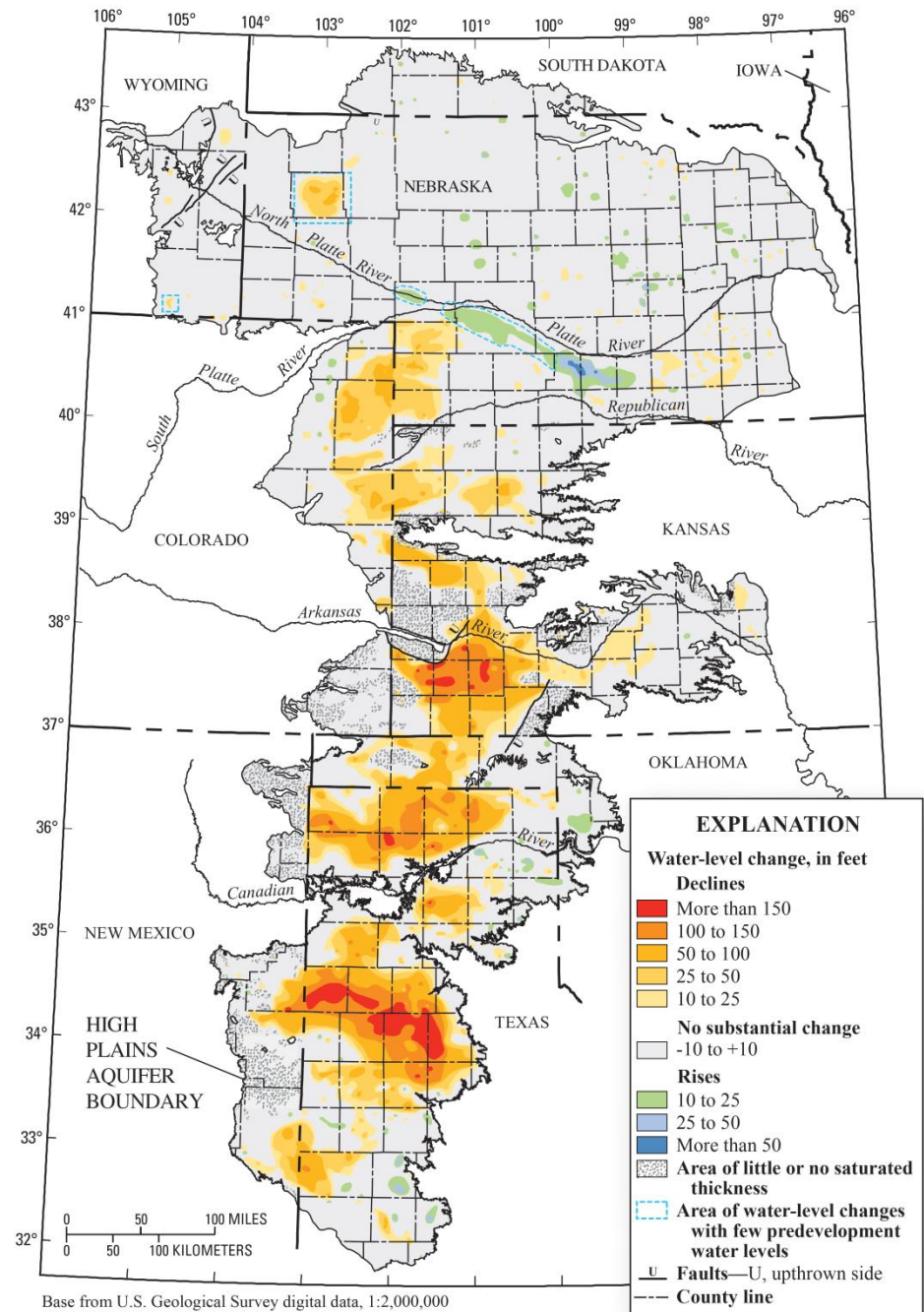


Groundwater:

-Primary source of
Irrigation water

High Plains
Ogallala Aquifer

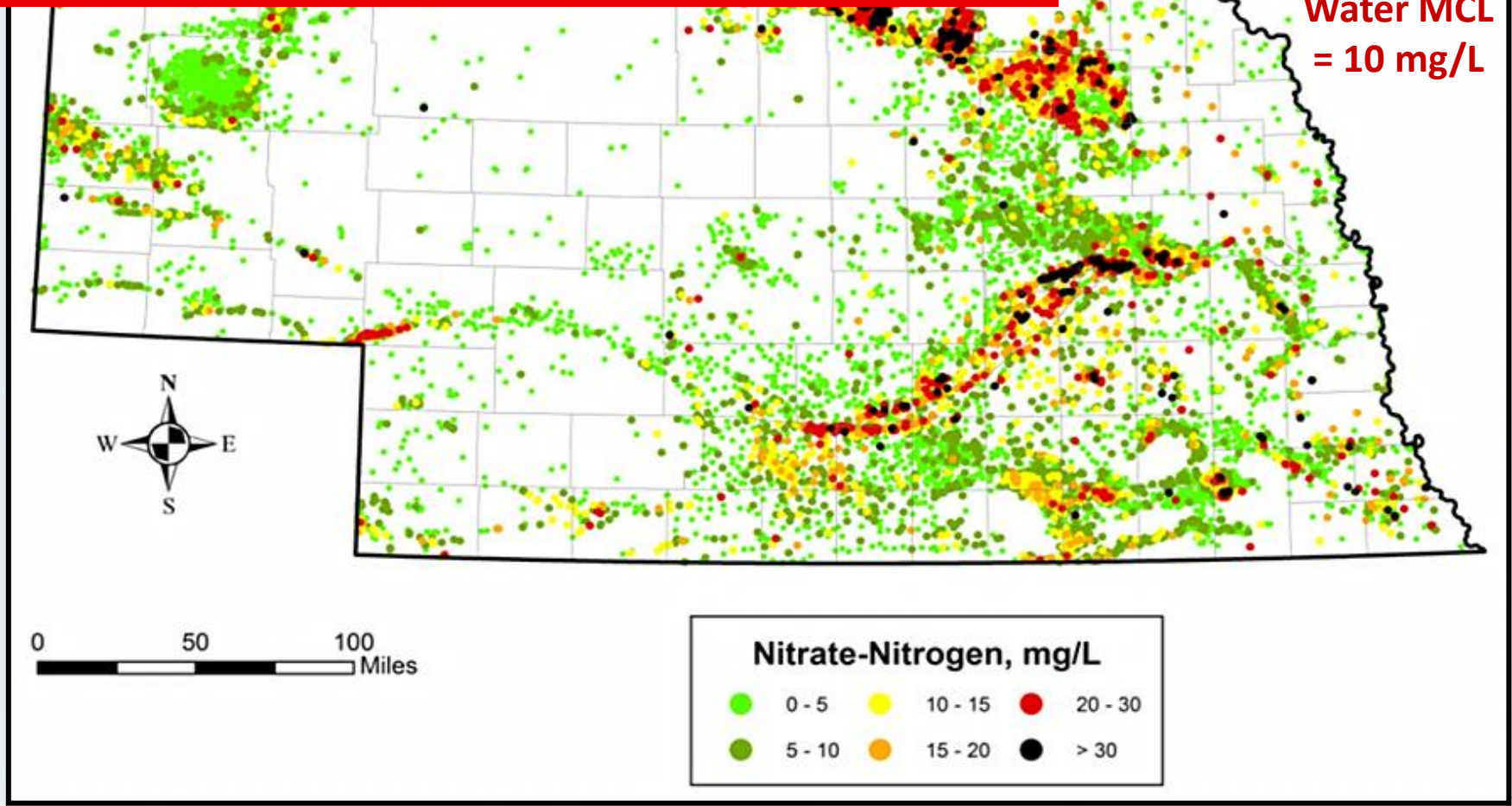
Ground Water Level
Changes
1950 - 2007



Qualidade das águas subterrâneas-azoto nítrico

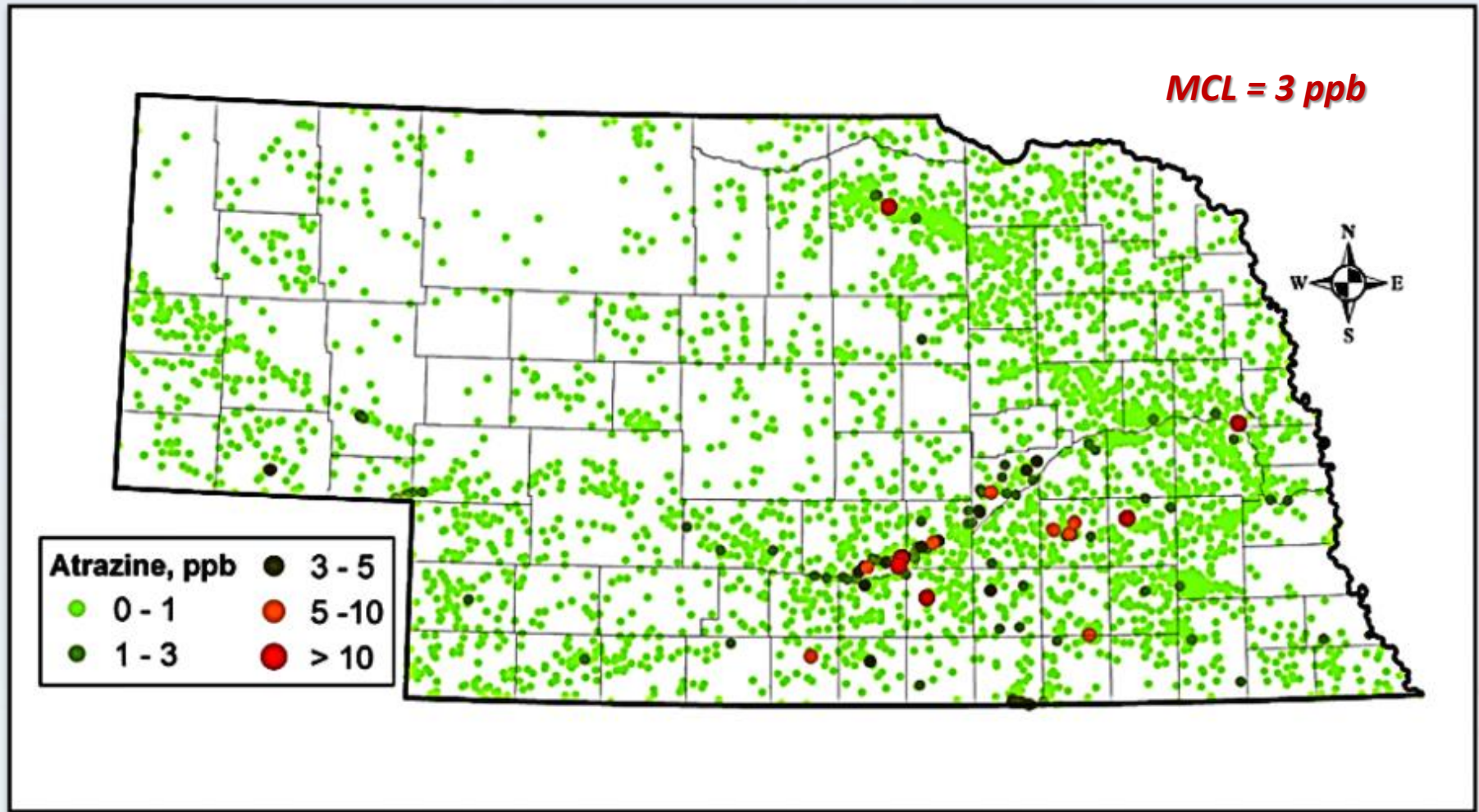
Problemas aparecem primeiro nos vales
Problemas de poluição demoram mais tempo

Safe
Drinking
Water MCL
= 10 mg/L



Qualidade das águas subterrâneas - atrazina

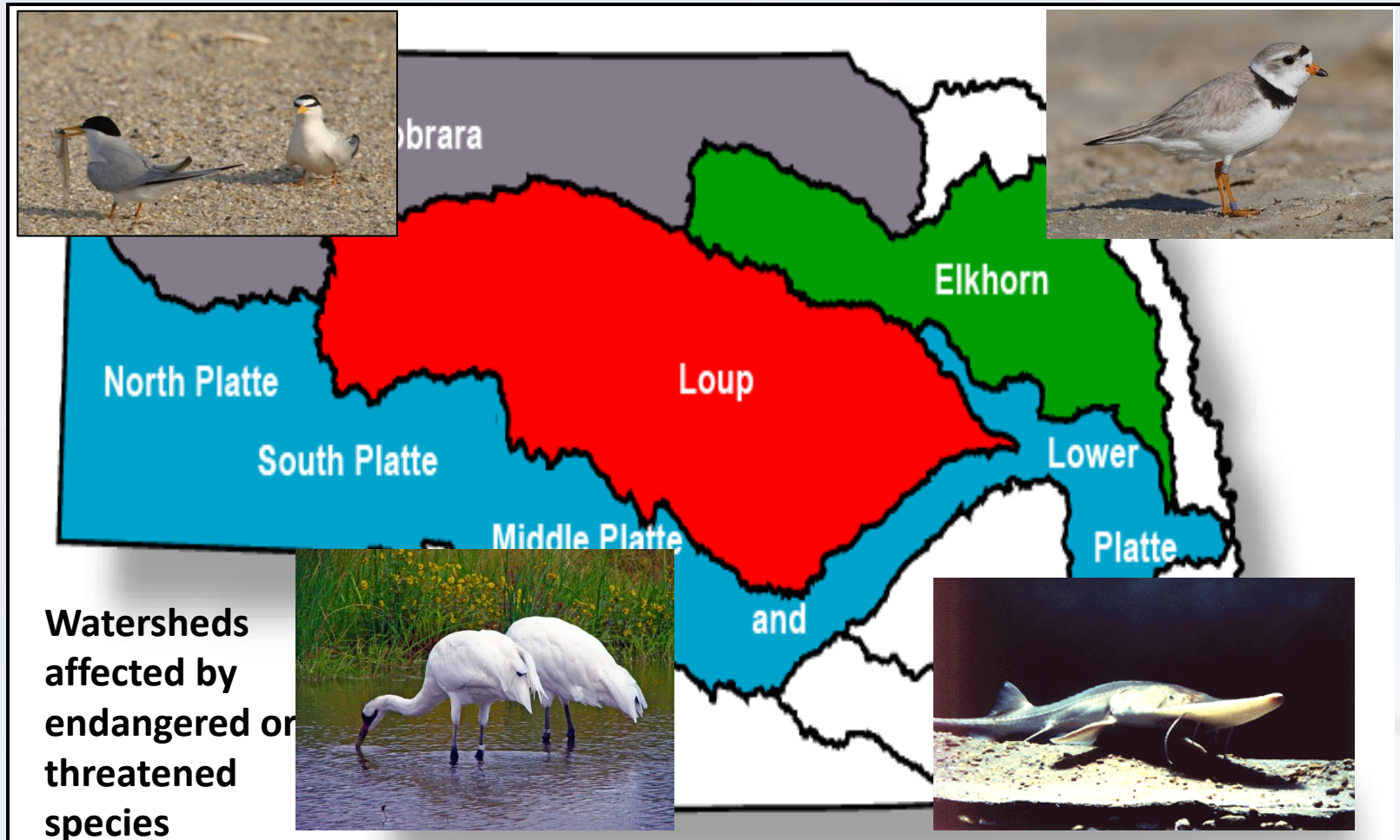
Lixiviação da atrazina é um problema menor.



Espécies ameaçadas de extinção e/ou ameaçadas

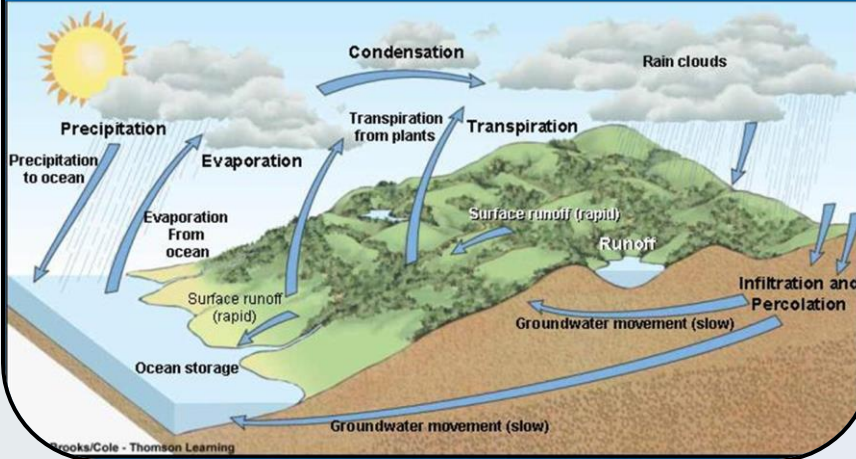
→ InStream demanda

Fluxos de Non-Threatened espécies estão aumentando

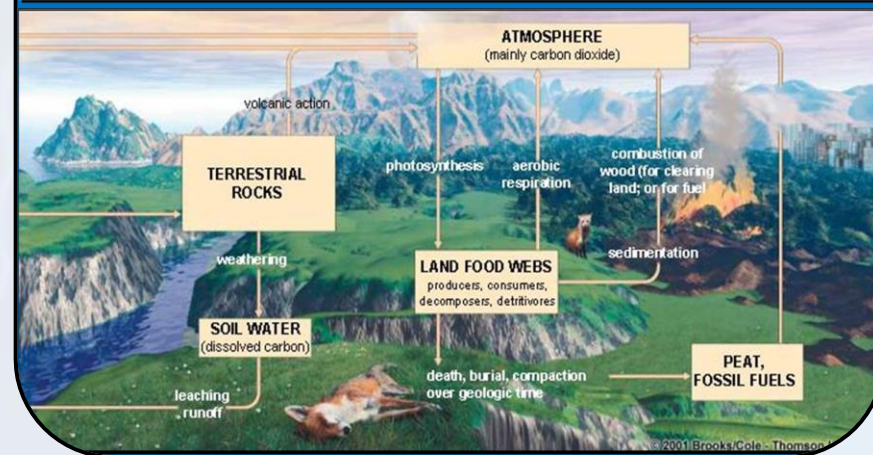


Ecosystem Processes and Functions

Hydrologic (Water) Cycle



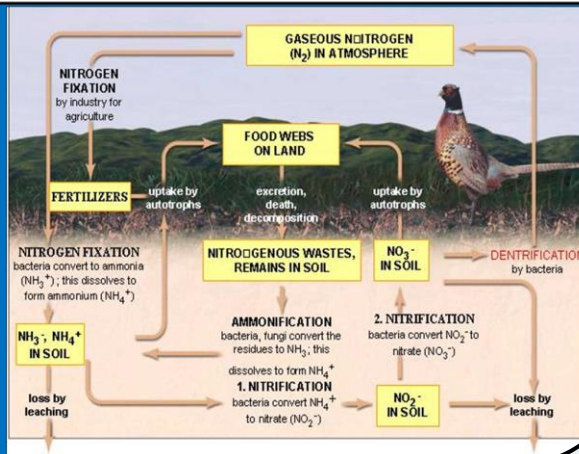
The Carbon Cycle



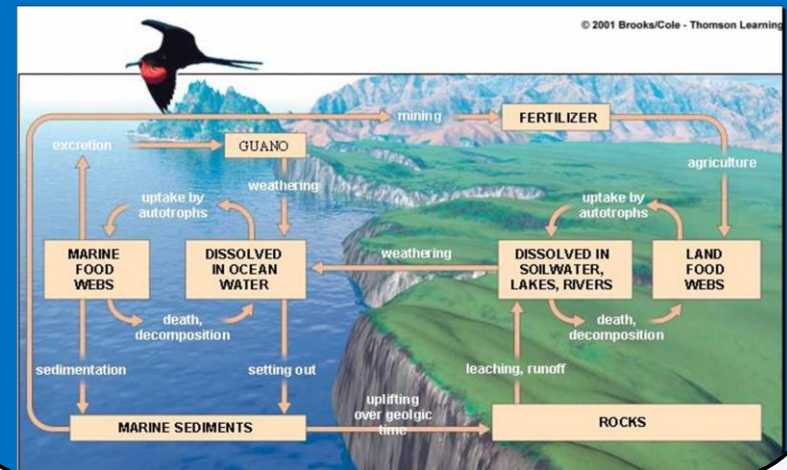
The Nitrogen Cycle

Root nodules
on legumes

Cyanobacteria

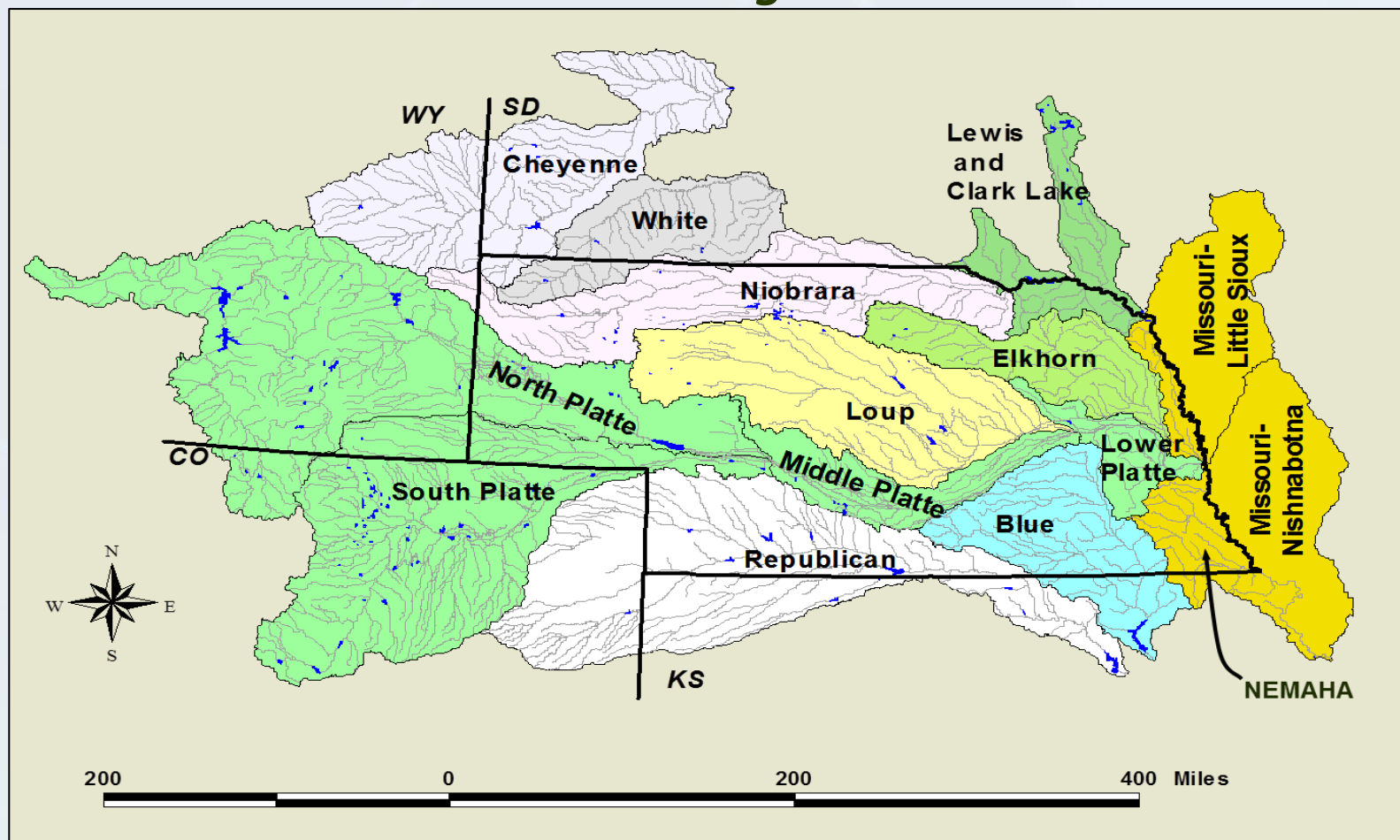


The Phosphorus Cycle



Gestão dos Recursos Hídricos além das Fronteiras da Bacia Hidrográfica

Manejo de Bacias Hidrográficas compartilhadas: Gestão Integrada

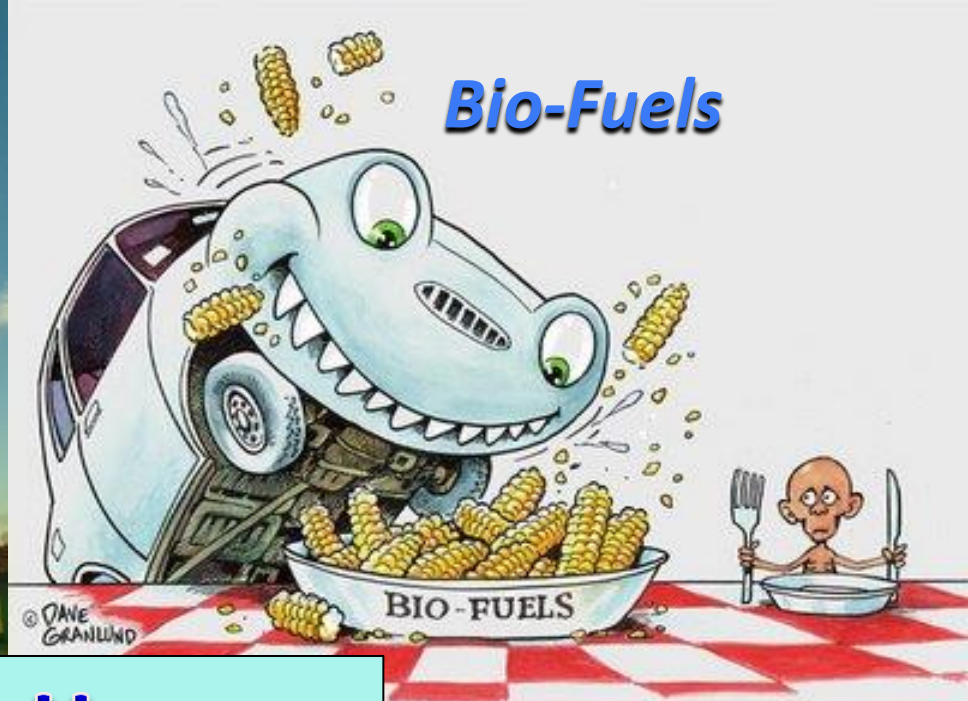


“Fluxo” - Vazão é a questão

Coal Fired

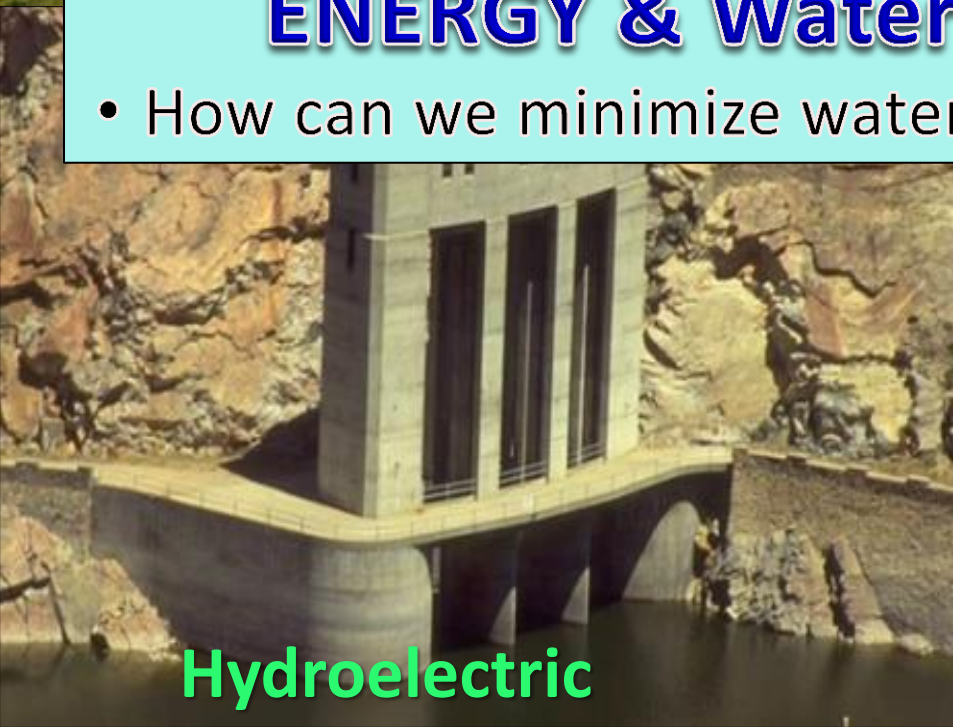


Bio-Fuels



ENERGY & Water Use

- How can we minimize water use

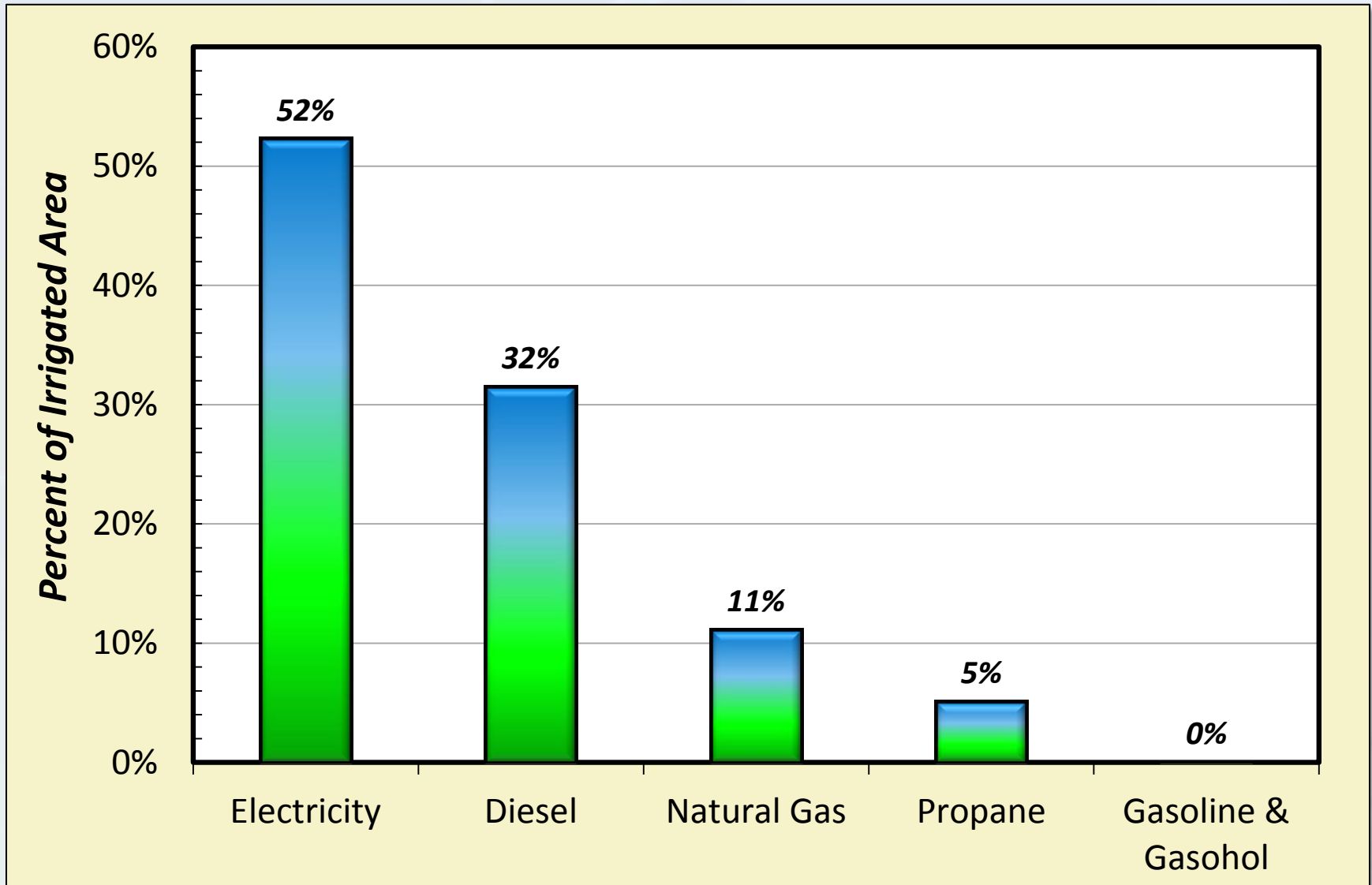


Hydroelectric

Ethanol



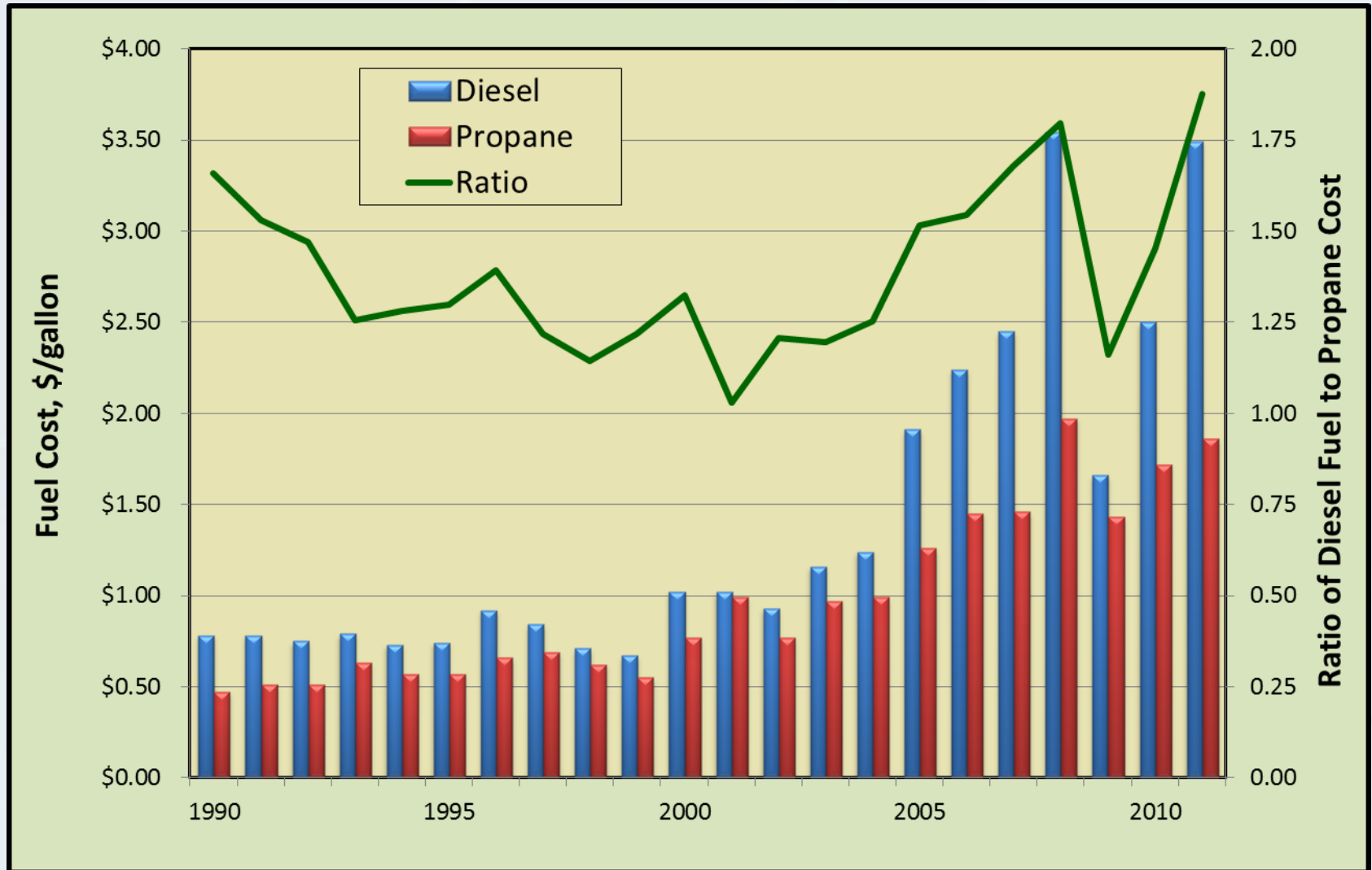
Nebraska Energy Use for Irrigation - 2007



Custo de bombeamento



Preços Médios dos Ag combustíveis nas planícies do Norte



Fatores que afetam a irrigação, os custos de bombeamento

Factors You Can Control

*Irrigation
Scheduling*

*Application
Efficiency*

*Performance of
Pumping Plant*

*Pumping
Pressure*

*Volume of Water
Pumped, acre-inches*

*Cost to Apply
Water, \$/acre-inch*

Field Size
Crop Water Needs
Precipitation

Pumping Lift
Price of Energy

**Factors You
Cannot Control**

Cost to Irrigate Field

Uso de energia de Nebraska para irrigação- 2002

- 1. 3,4 Milhões de hectares de irrigação**
- 2. Usa cerca de 400 litros de diesel por hectare por ano**
- 3. Se todas as terras fossem irrigadas com motores diesel**
 - Cerca de 1,4 bilhão de litros de diesel combustível por ano**
 - US \$ 1 bilhão por ano para combustível diesel**
 - Agricultura : um dos maiores usuarios de energia**

A map of Nebraska is shown in the background. The state is divided into counties. A large black question mark is centered over the northern part of the state. In the southwestern part of the state, there is a red dot with a white outline, and a white line connects it to the letters 'BA' which are written in white. The letters 'BA' are positioned to the right of the red dot.

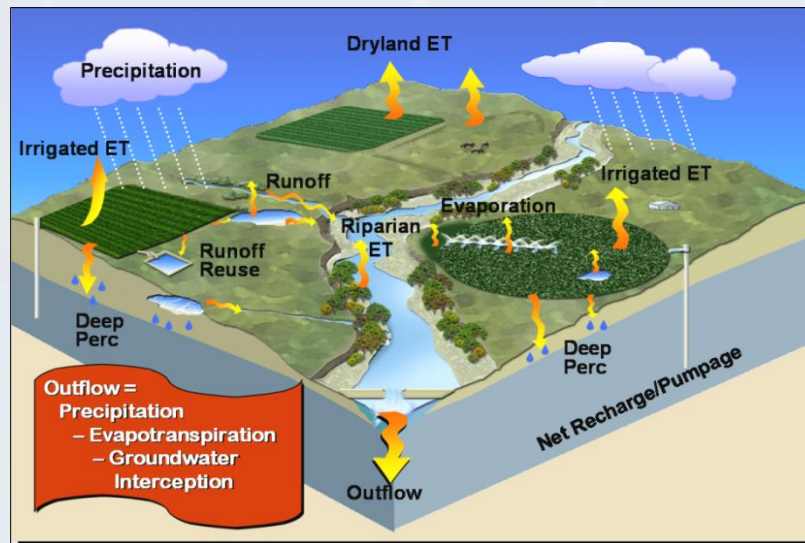
?

BA

Manejo de Irrigação: “Quebrando Paradigmas”

O que mudou nos últimos 5 anos??

Manejo dos Recursos

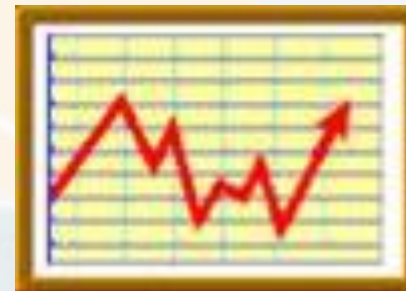


Mudanças na Legislação



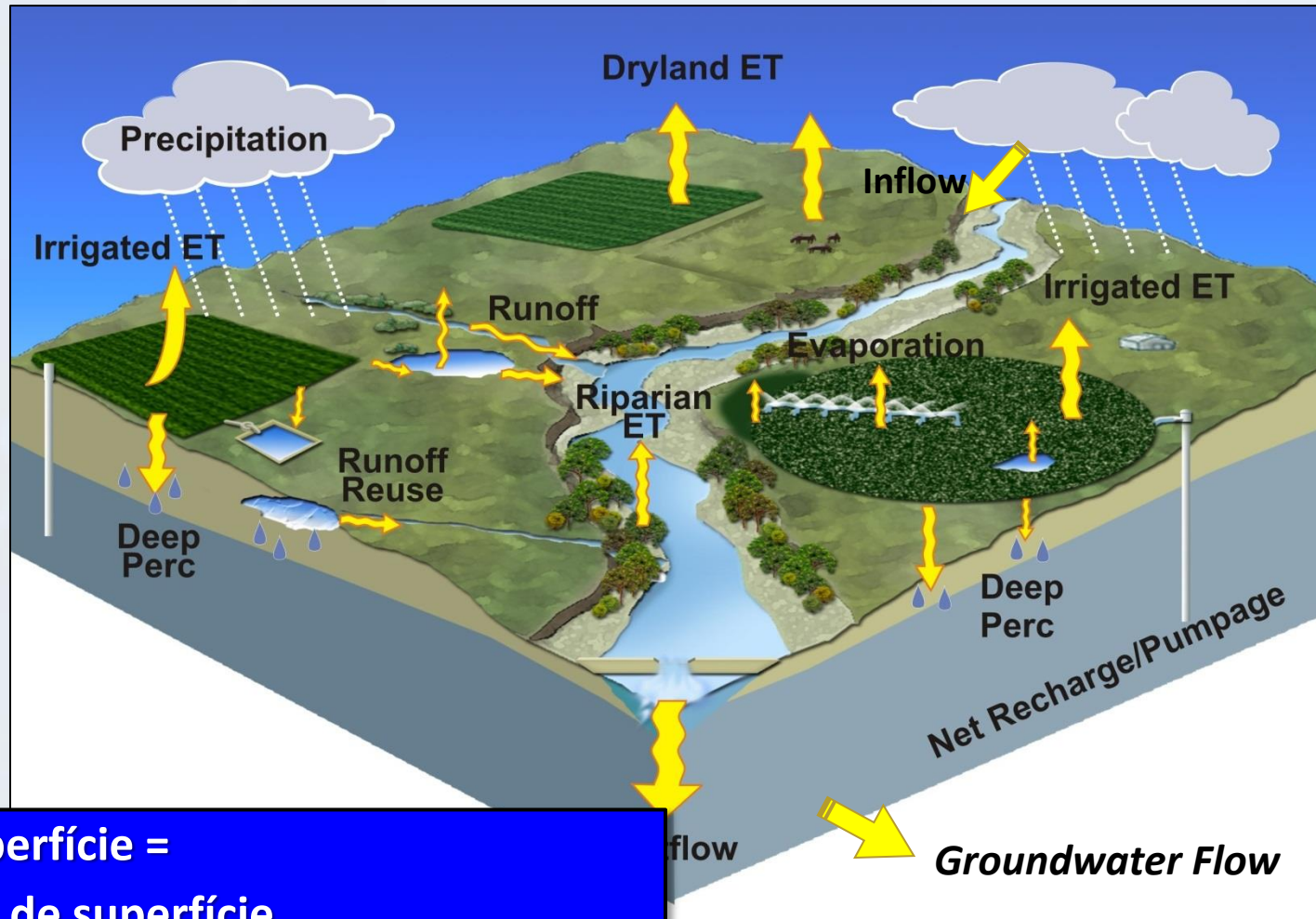
Melhoria dos Sistemas Produtivos

Volatilidade dos Preços / Custos



Balanço hídrico em uma bacia hidrográfica irrigada

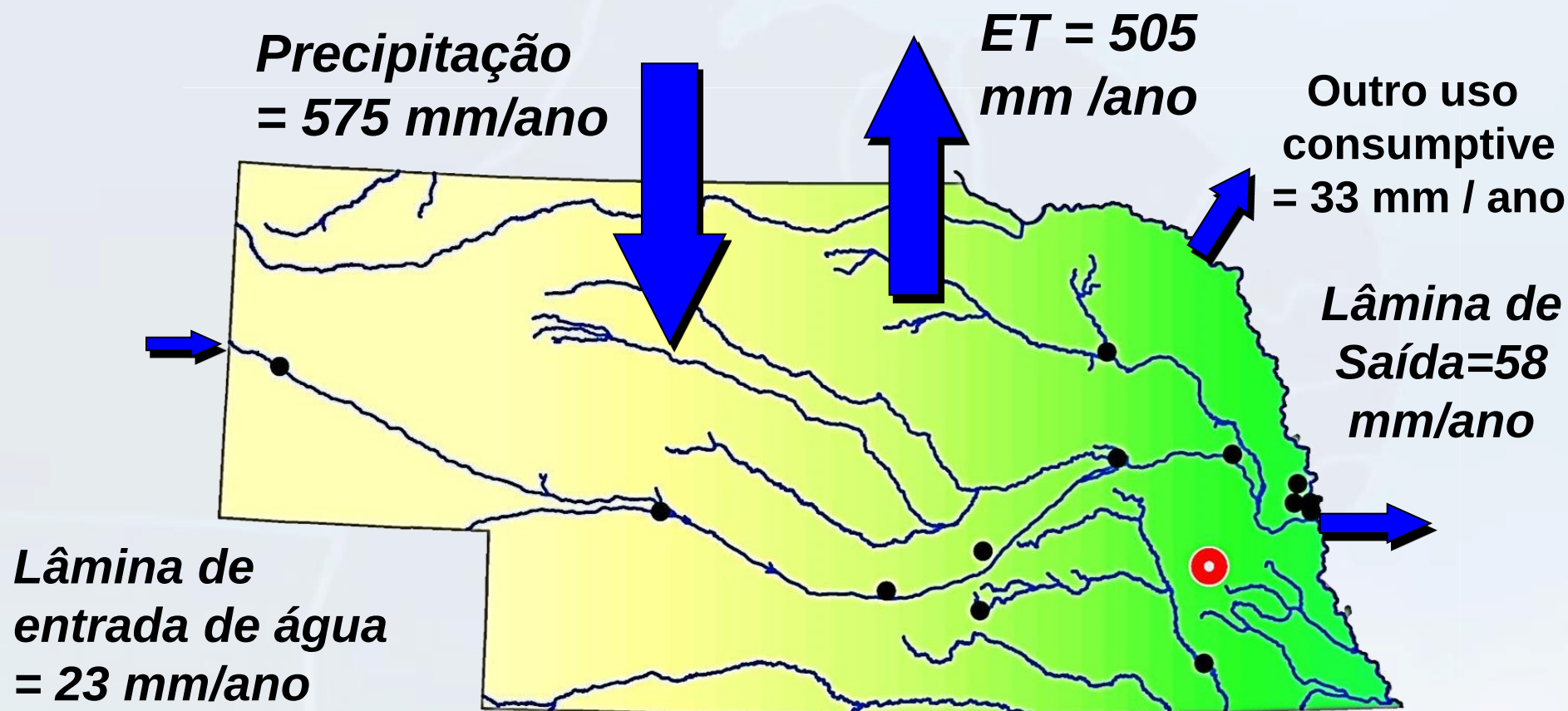
Equilíbrio de longo prazo



Saída de água de superfície =

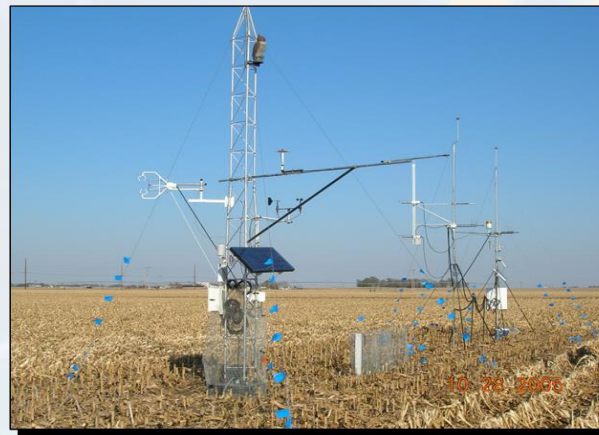
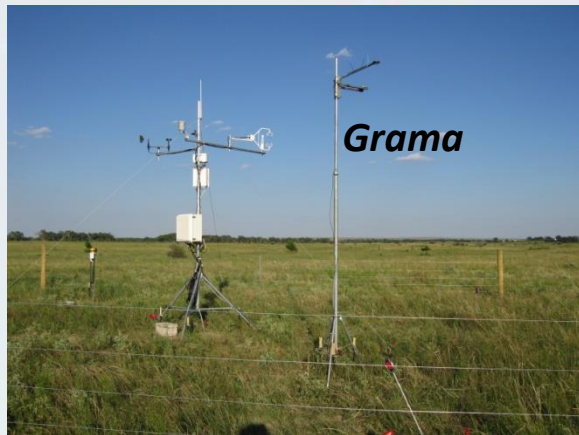
- + Entrada de água de superfície
- + Precipitação
- ET em bacias hidrográficas
- Retirada/recarga de águas subterrâneas líquido
- Saída de líquido das águas subterrâneas

Nebraska's Abastecimento de água (condições médias)



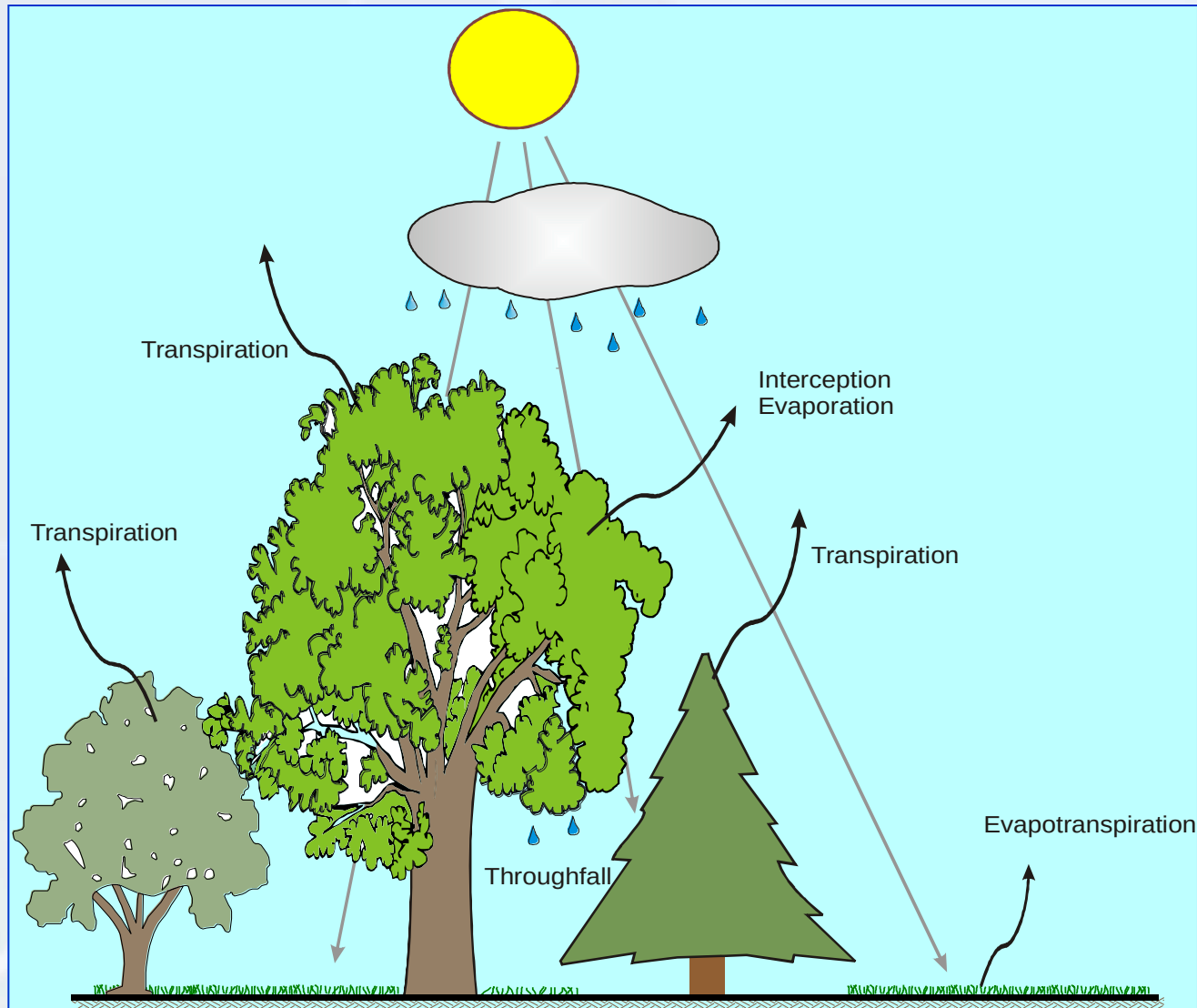
- ~ 88% de precipitação destina-se a evapotranspiração
- ~ 6% de precipitação incrementa o Fluxo
- ~ 8% da evapotranspiração devido à irrigação

Medição da Evapotranspiração



- Research is expensive: equipment, labor, travel, maintenance
- Long-term studies to account for precipitation variation and cropping rotations
- Need long-term funding

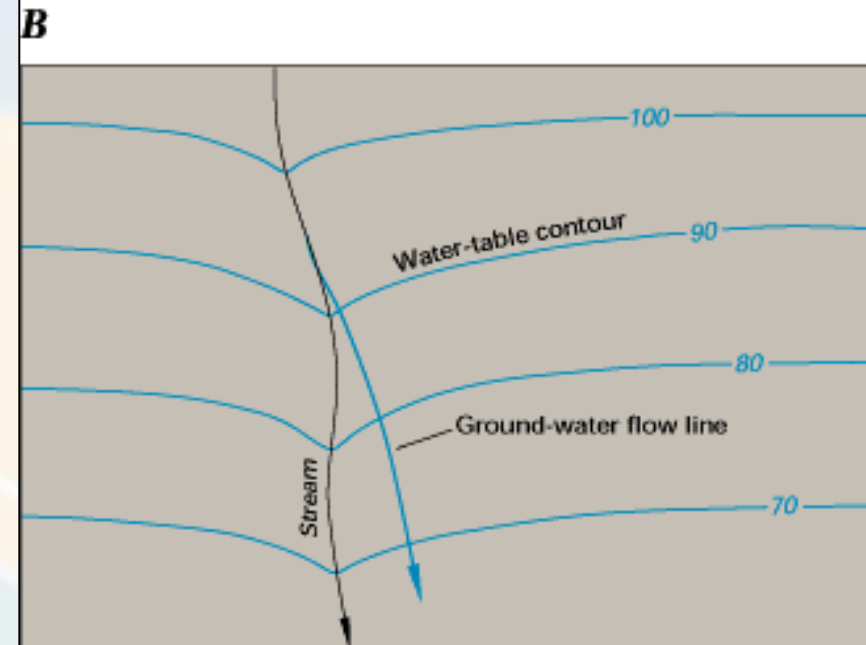
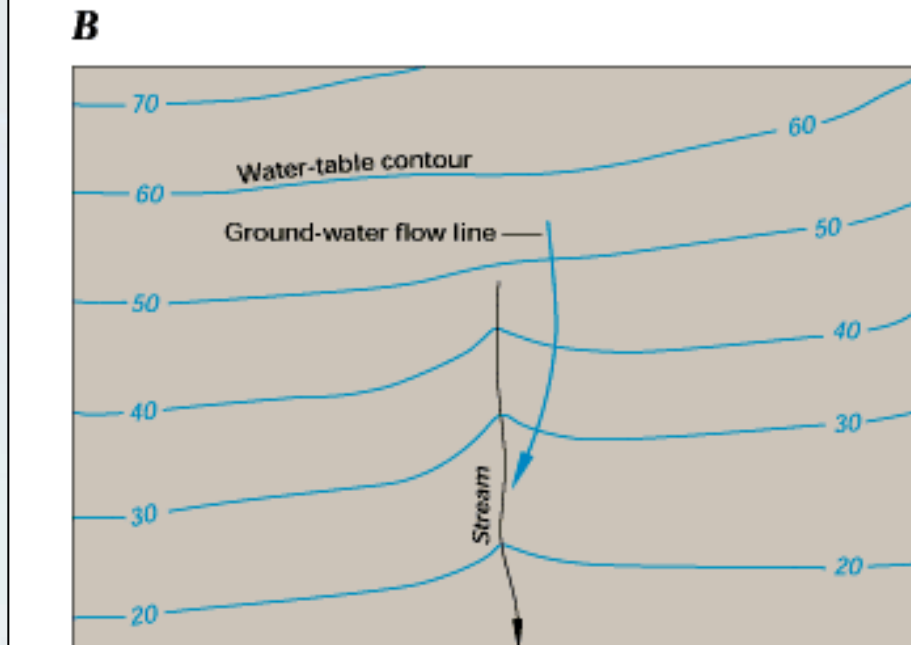
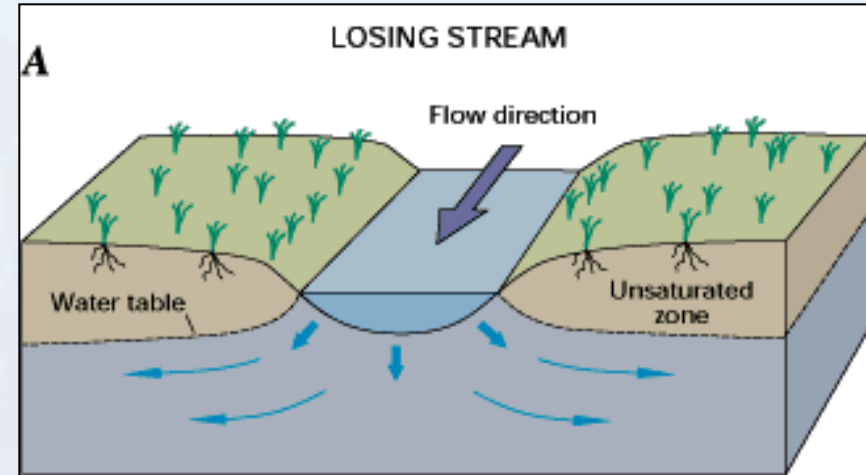
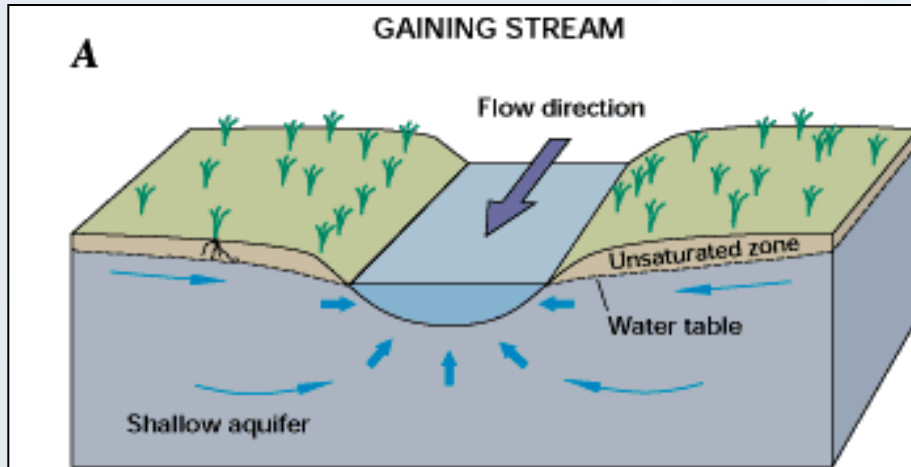
Components of Water Balance in Riparian Zone



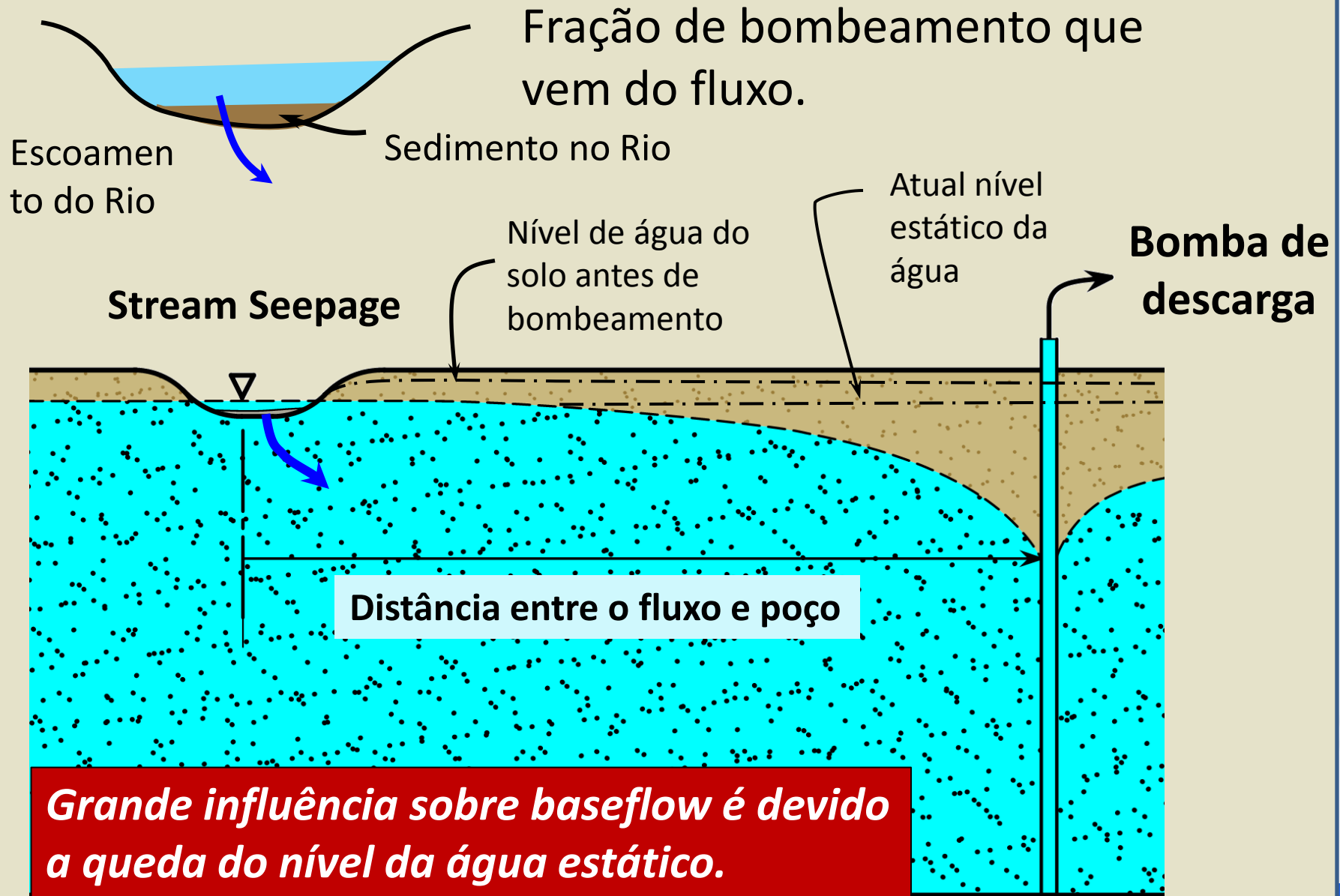
Impacto de terraços e reservatórios no escoamento e recarga



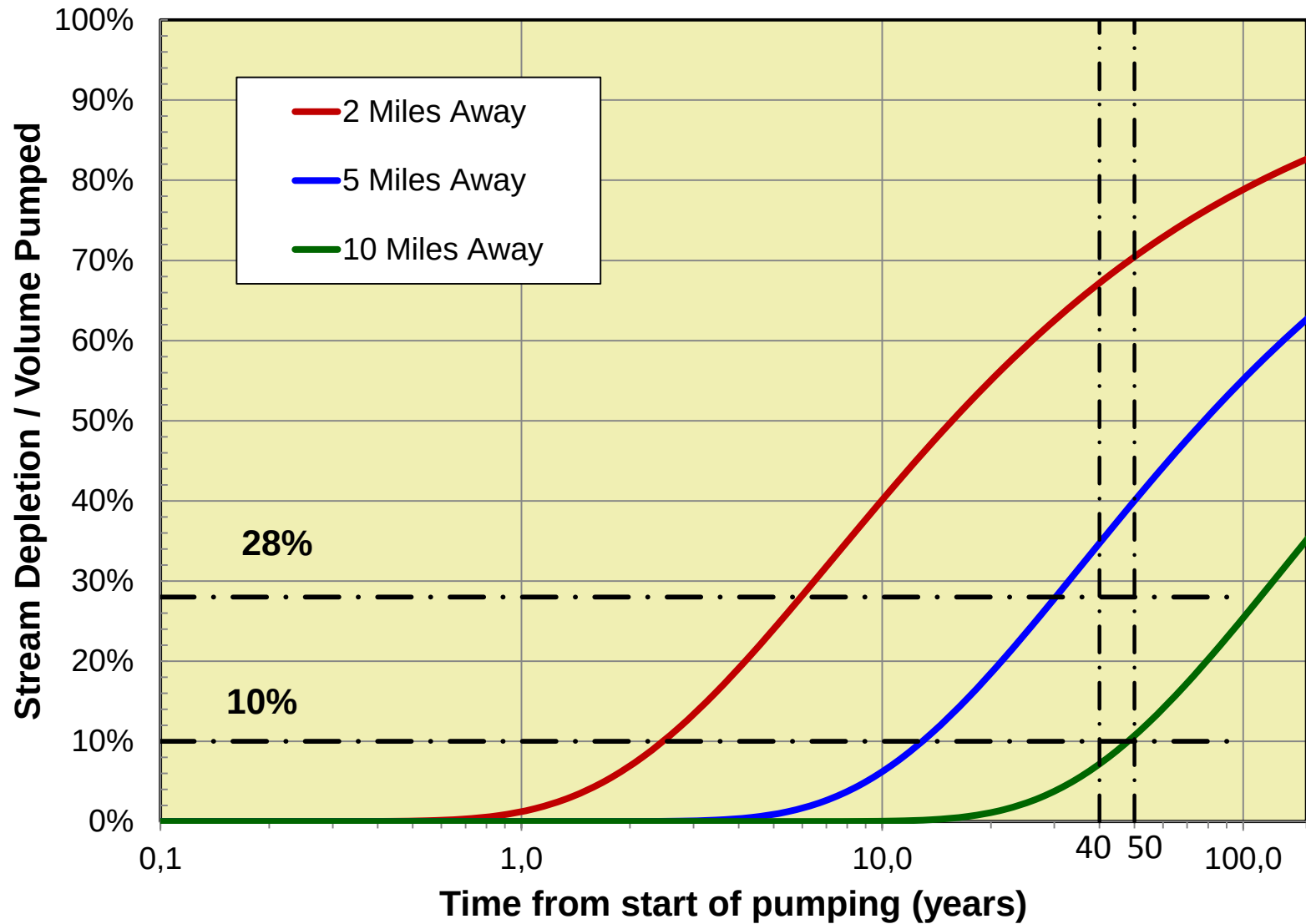
STREAM-AQUIFER INTERACTION



Depleção de fluxo

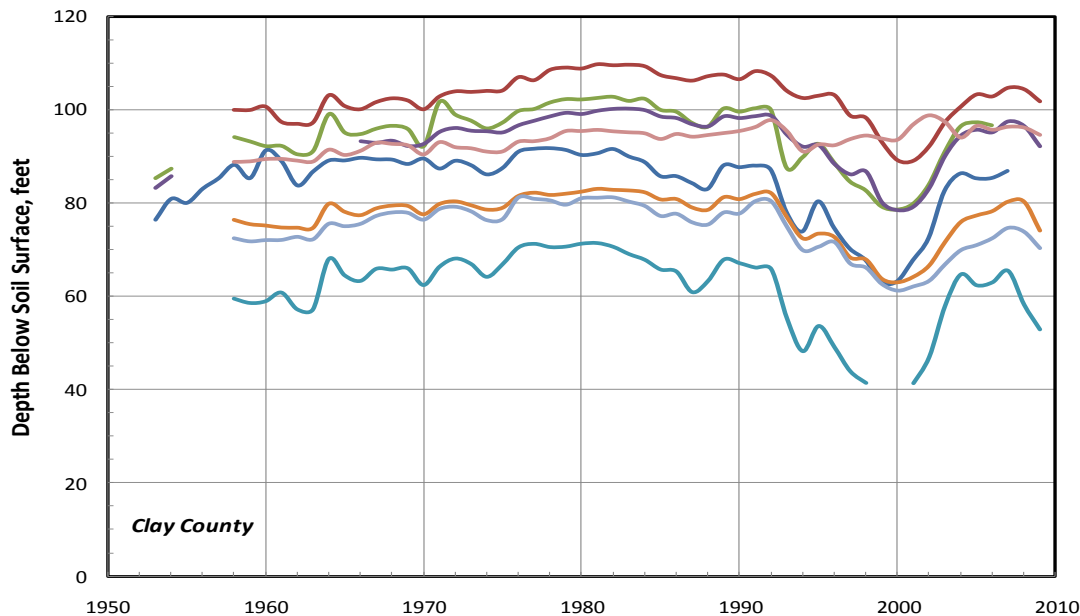
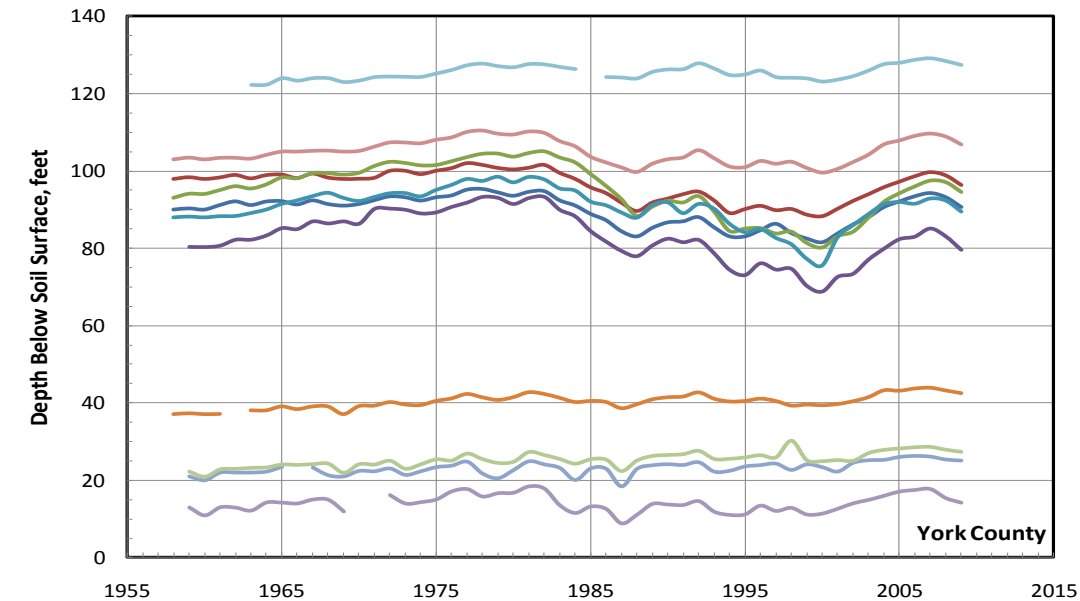


Stream Depletion Factor



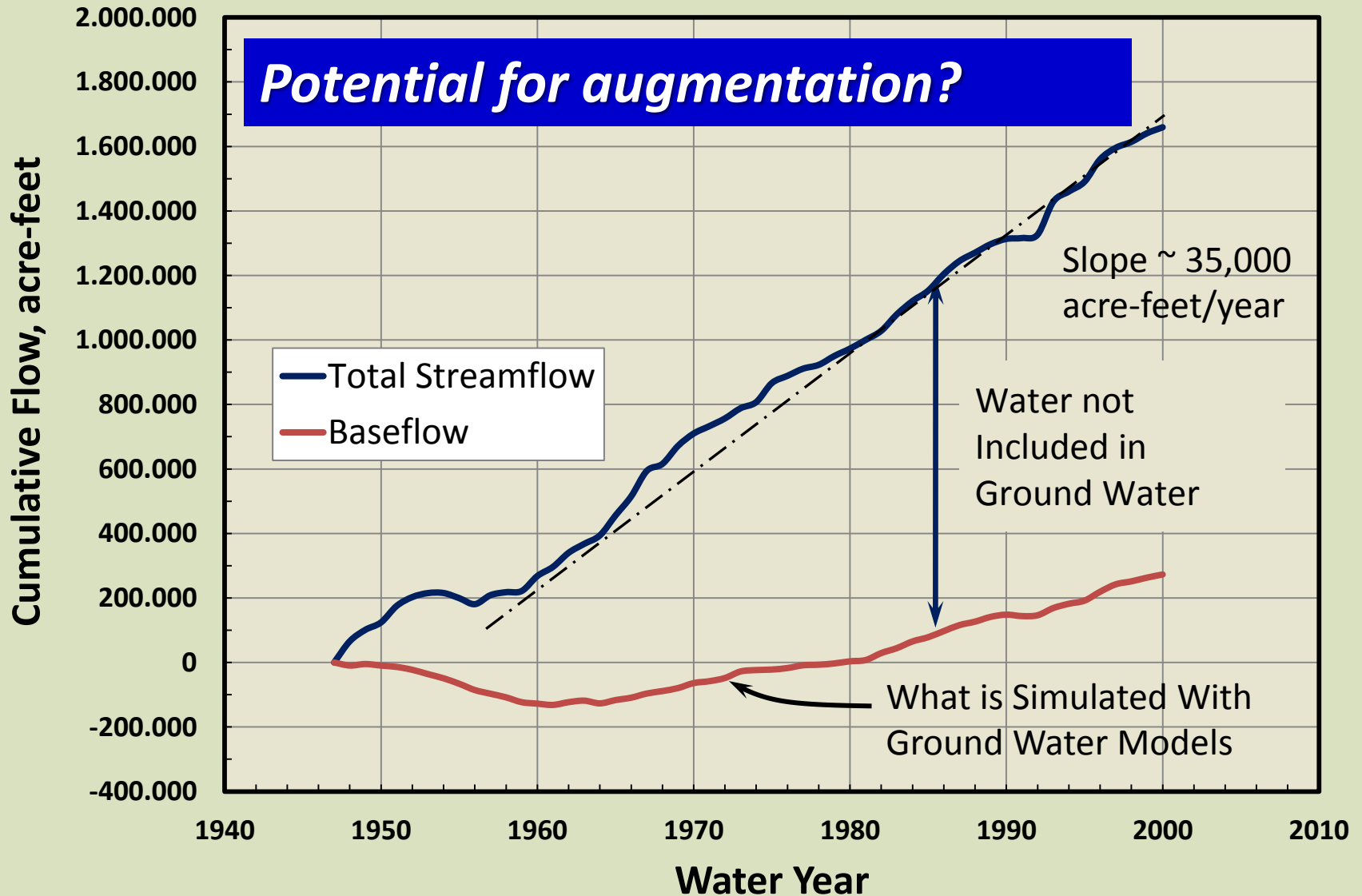
Ground Water Levels in York and Clay Counties

*Use aquifer
like a reservoir*



- Drawdown in dry periods, recharge & reduced pumping in wet periods.
- How often will this happen?
- Streamflow decreased following dry period.
- Groundwater storage was replenished
- Streamflow should recover.
- How does stream depletion factor apply?

Republican River Gain from Cambridge to Orleans

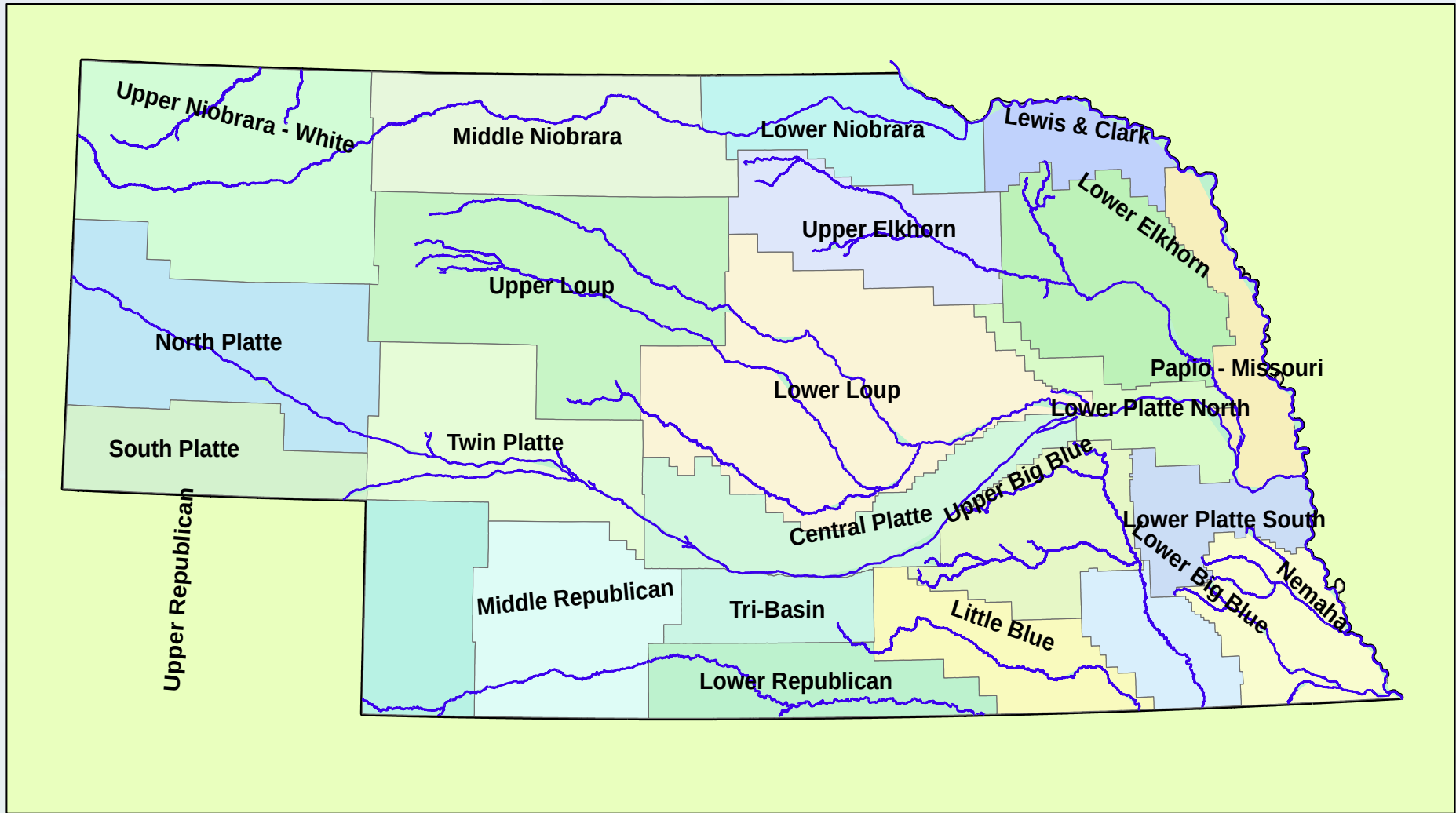


Natural Resource Districts – Since 1972

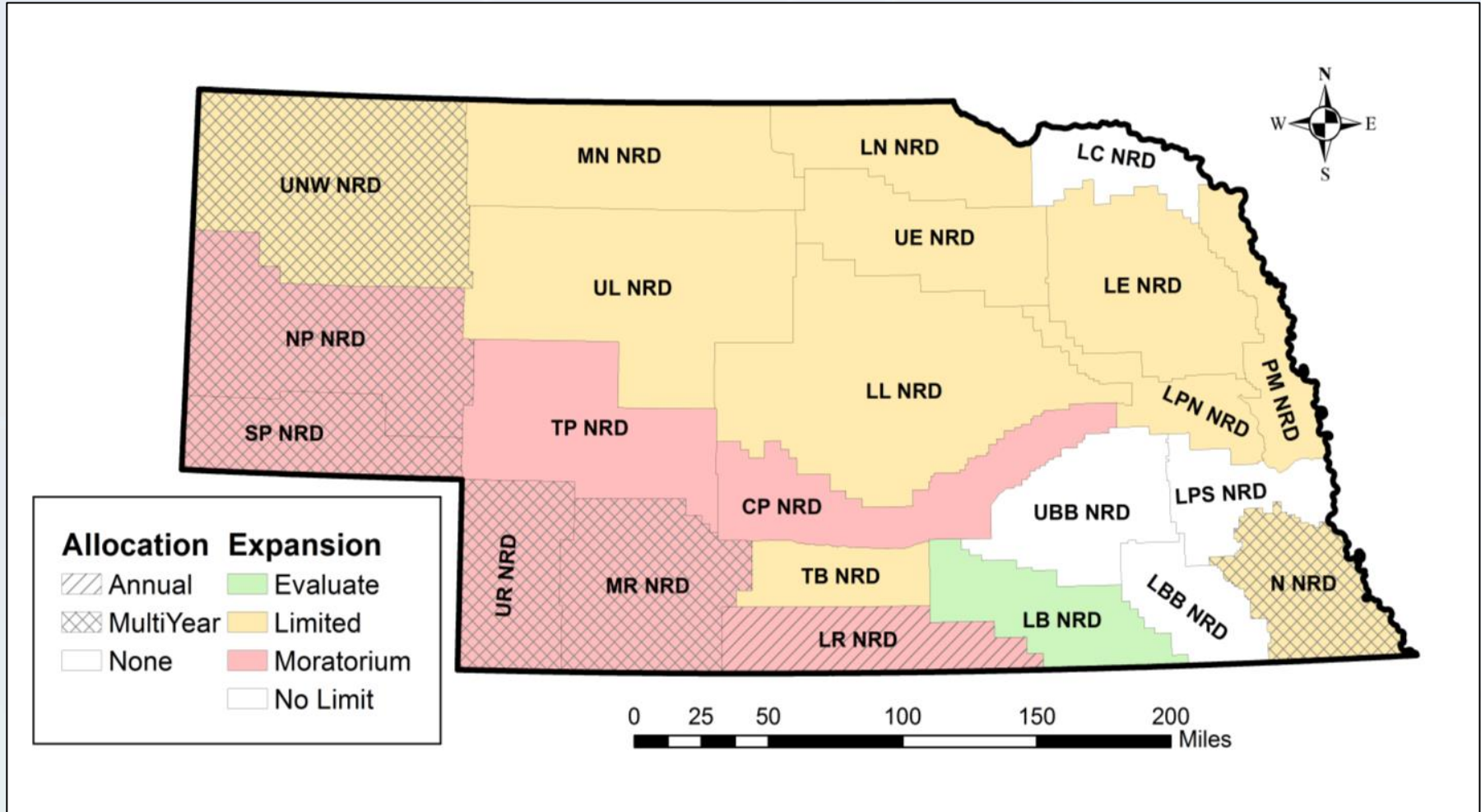
Nebraska's system of local natural resources management

- *23 NRDs are based on river basin boundaries,*
- *Resources management on a watershed basis.*
- *Locally elect Board of Directors.*
- *NRDs share a common responsibilities*
- *Each district sets its own priorities and develops its own programs to best serve local needs*
- *Local taxes stay in NRD, and receive some State \$*
- *Responsible for water quantity and quality*

Distritos de recursos naturais

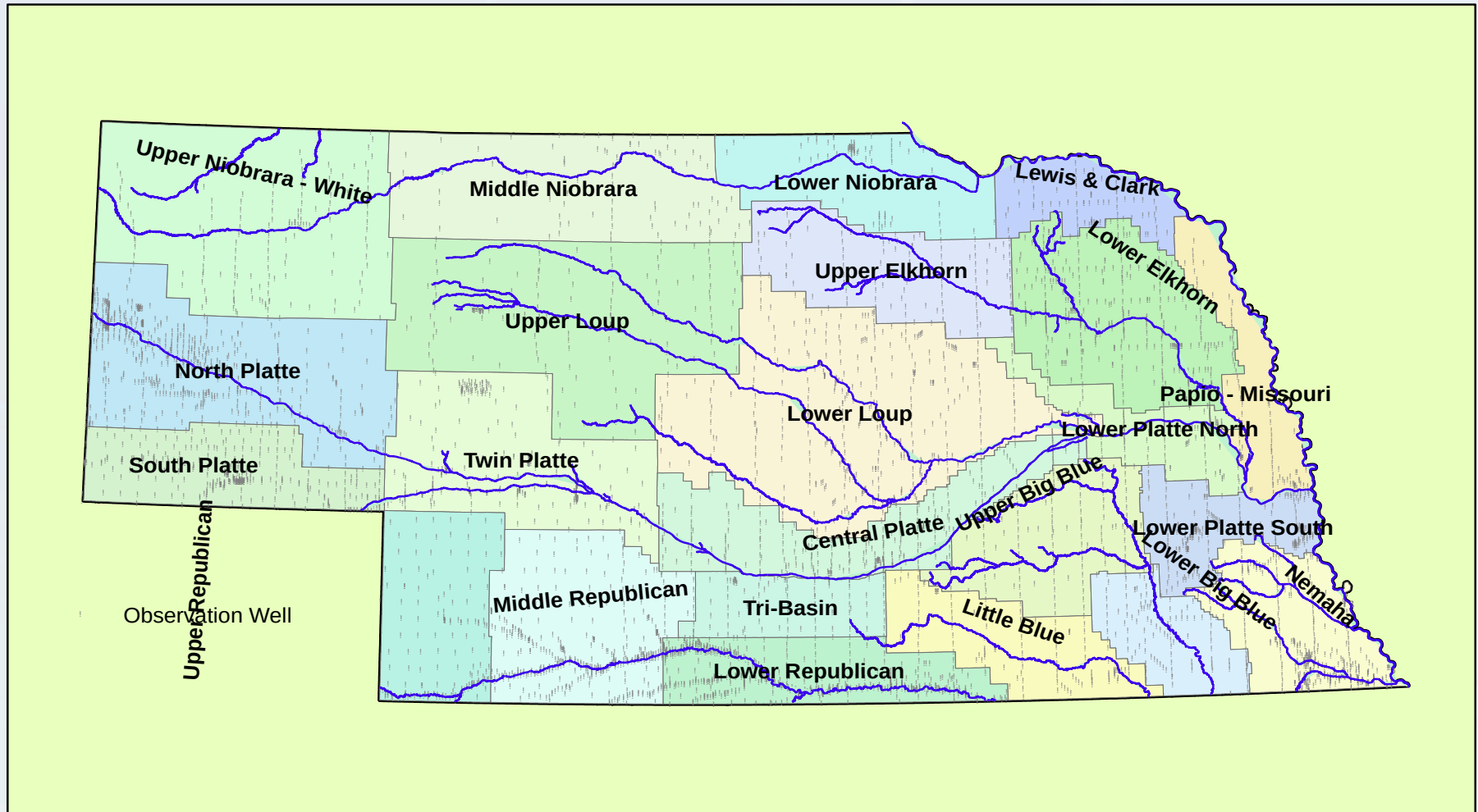


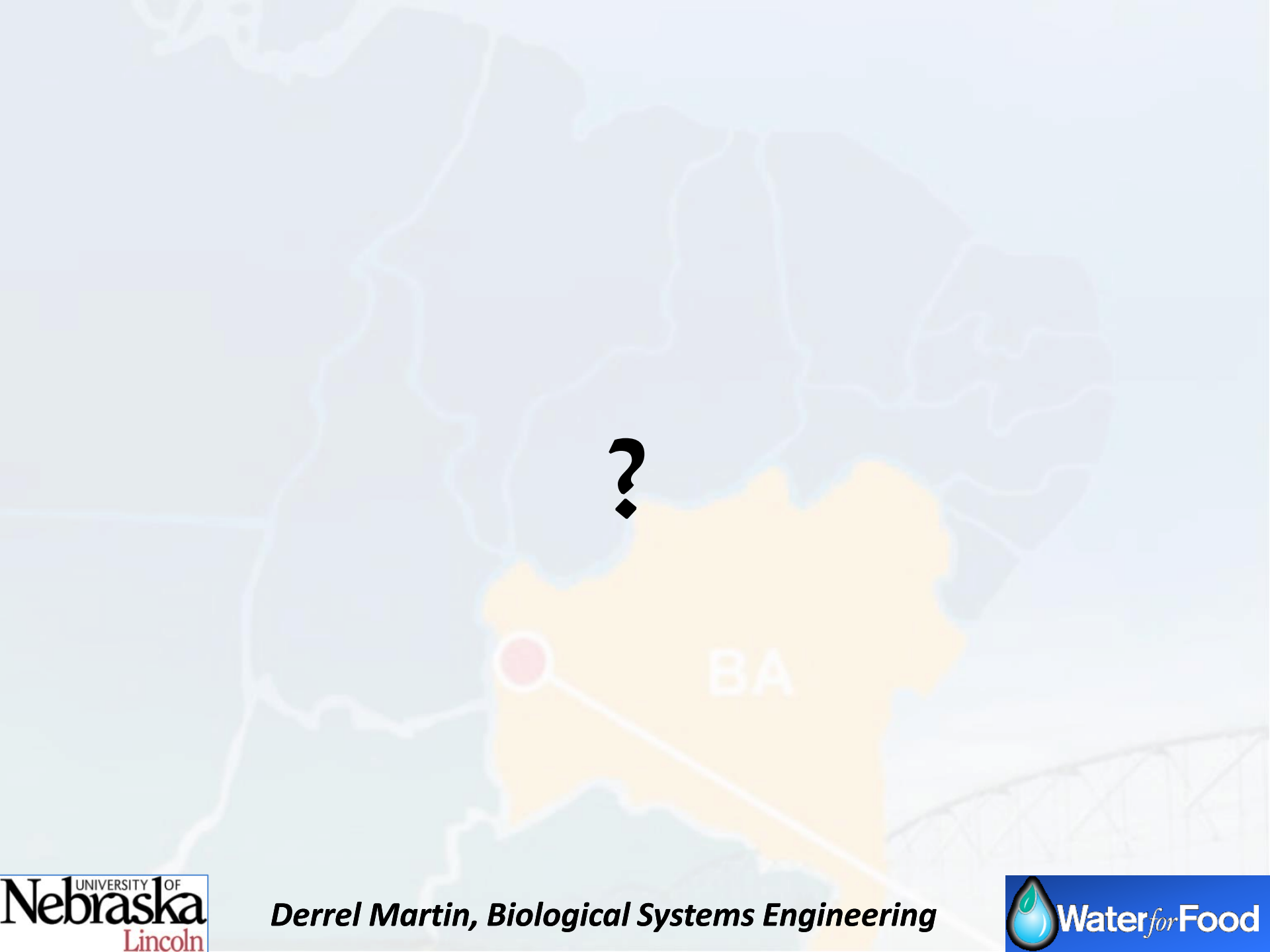
Natural Resource District Management Strategies



Distritos de recursos naturais

Exploração de águas subterrâneas utilizando poços de observação







Crop Water Footprint → Productivity

- Total evapotranspiration from crop (m^3/ha) divided by crop yield (tons/ha).
- Crop water use depends on the crop water requirement and available soil water
- Crop water requirement is the total water needed for evapotranspiration under ideal growth conditions from planting to harvest.
- Soil water is replenished by rainwater or irrigation.

Smaller footprint obviously seems to be good, but...

Water Footprint

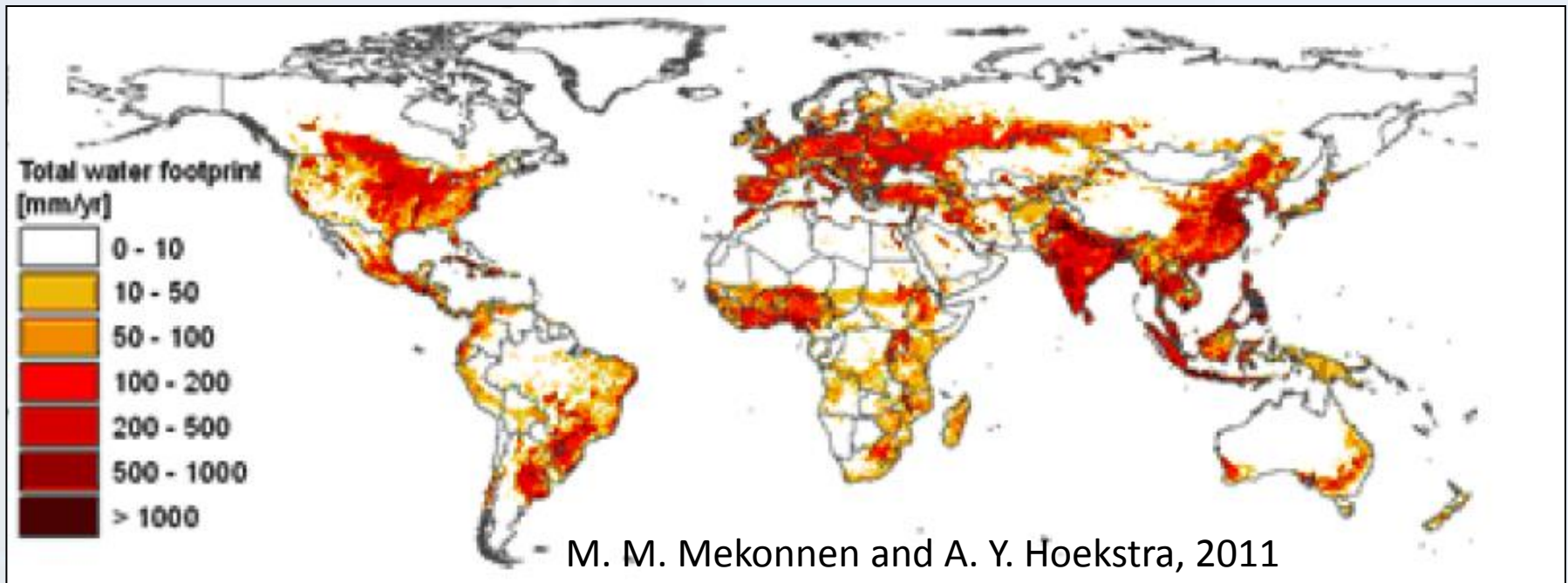


Water footprint is usually high for animal agriculture.

We don't ask what is the alternative use of the land.

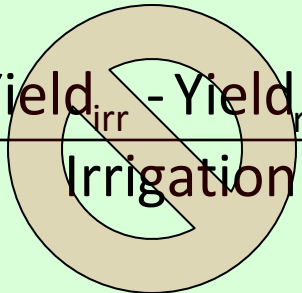
How would the alternative land use affect the watershed?

Worldwide Water Footprint



- Brings attention to water issues but can convey wrong message to stakeholders
- Implies that changing practices would make more water available elsewhere
- Consider the Corn Belt → What would the net water use be if corn and soybeans were not grown?

Breaking Down Water Productivity

$$\text{WUE} = \frac{\text{Yield}_{\text{irr}} - \text{Yield}_{\text{rainfed}}}{\text{Irrigation}}$$


← **Traditional - Misleading**

$$= \frac{\text{Yield}_{\text{irr}} - \text{Yield}_{\text{rainfed}}}{\text{Trans}_{\text{irr}} - \text{Trans}_{\text{rainfed}}} \times \frac{\text{Trans}_{\text{irr}} - \text{Trans}_{\text{rainfed}}}{\text{ET}_{\text{irr}} - \text{ET}_{\text{rainfed}}}$$

**Genetics,
Agronomics**

Field Practices

$$\times \frac{\text{ET}_{\text{irr}} - \text{ET}_{\text{rainfed}}}{\text{Root Zone Stored}} \times \frac{\text{Root Zone Stored}}{\text{Irrigation}} \times \frac{\text{Irrigation}}{\text{Withdrawal}}$$

Scheduling

Application

Conveyance

Breaking Down Water Use Efficiency

$$\frac{\text{Yield}_{\text{irr}} - \text{Yield}_{\text{rainfed}}}{\text{Trans}_{\text{irr}} - \text{Trans}_{\text{rainfed}}}$$



Genetics



Agronomics

Breaking Down Water Use Efficiency

$$\frac{\text{Trans}_{\text{irr}} - \text{Trans}_{\text{rainfed}}}{\text{ET}_{\text{irr}} - \text{ET}_{\text{rainfed}}}$$

Field Practices



- Reduced Tillage
- Residue Management
- Improved Water Application
- Deficit Irrigation

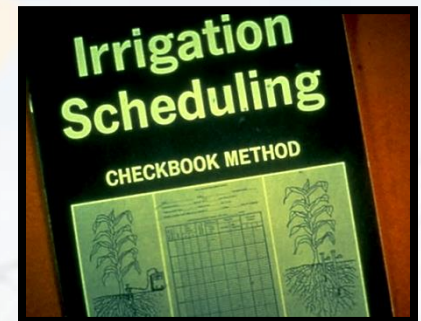


$$\frac{ET_{irr} - ET_{rainfed}}{\text{Root Zone Storage}}$$

Utilize Soil Water
for Beneficial Uses

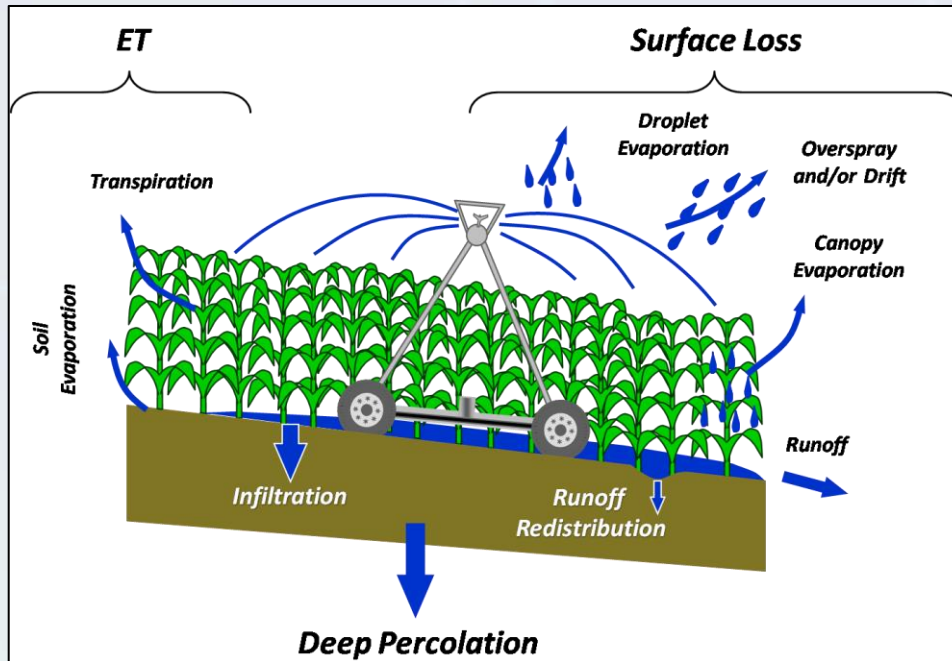


- Measure and Manage Soil Water
- Measure and Predict Evapotranspiration
- Schedule Irrigations



Breaking Down Water Use Efficiency

Root Zone Storage Irrigation Application



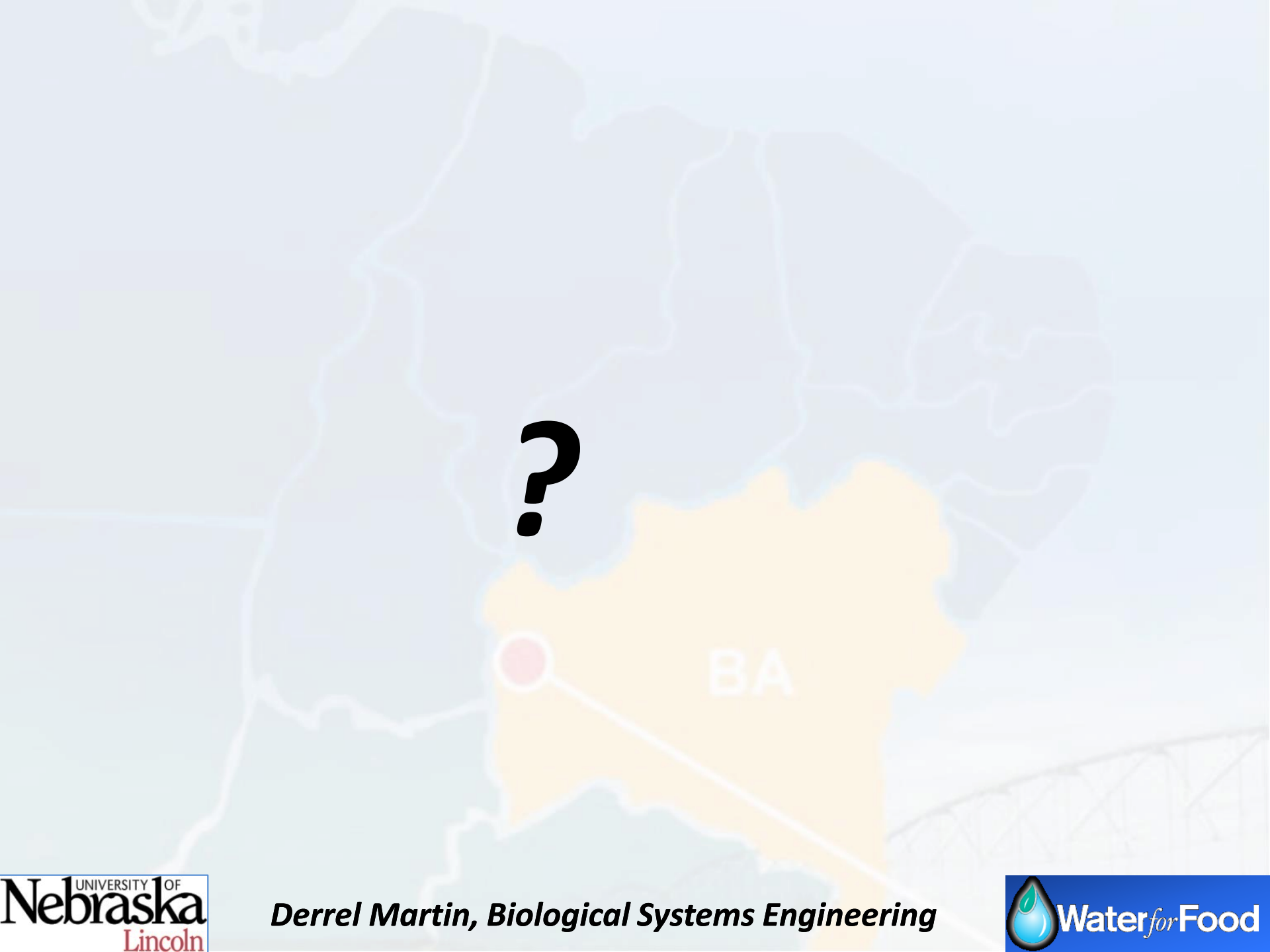
**Better Accounting of Where
the Water Goes**

Maximize Efficiency of Application

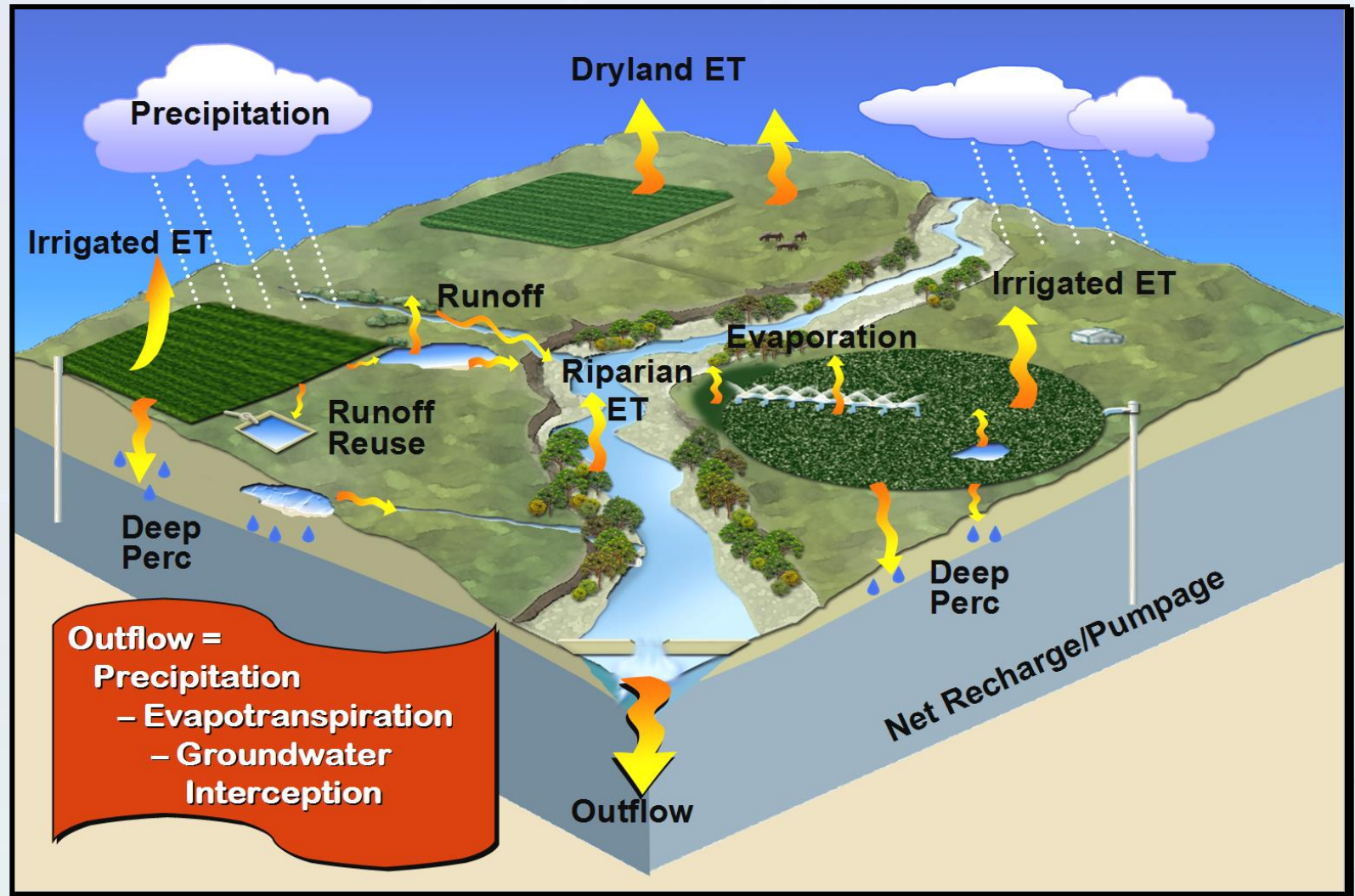


An aerial view of the irrigation system layout. A main canal runs diagonally from the top left towards the bottom right. Several distribution canals branch off from this main canal. Three pivot points are marked with green circles and labeled: PIVOT #1, PIVOT #2, and PIVOT #3. Distances between these points and the main canal are indicated: 13 MILES from the main canal to PIVOT #1, 5 MILES from PIVOT #1 to PIVOT #3, and 11 MILES from the main canal to PIVOT #2. A pump station is located on the main canal, with a distance of 1.5 MILES indicated from the main canal to the pump station. The layout also shows a farm building with a silo and a barn on the left side, and a river or stream on the right side.



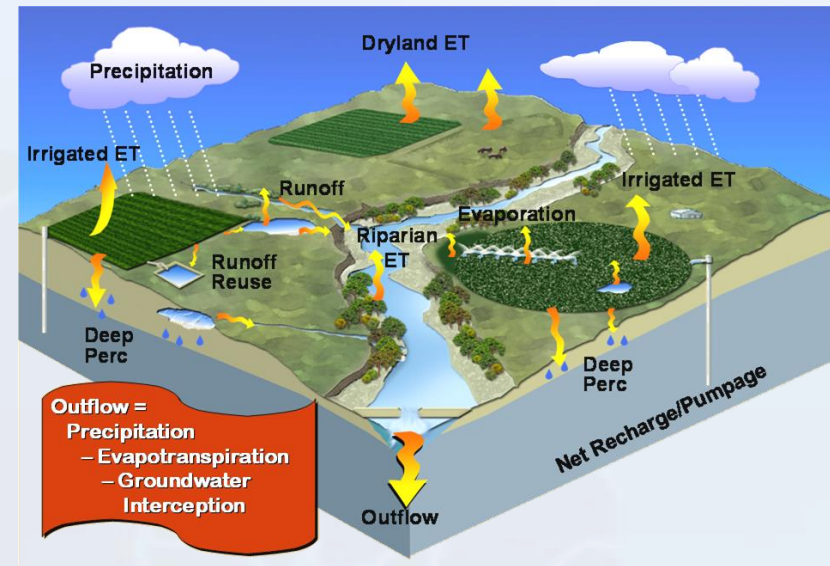


OBJETIVO: Ciclo Hidrológico – Bacias com aproveitamento agrícola



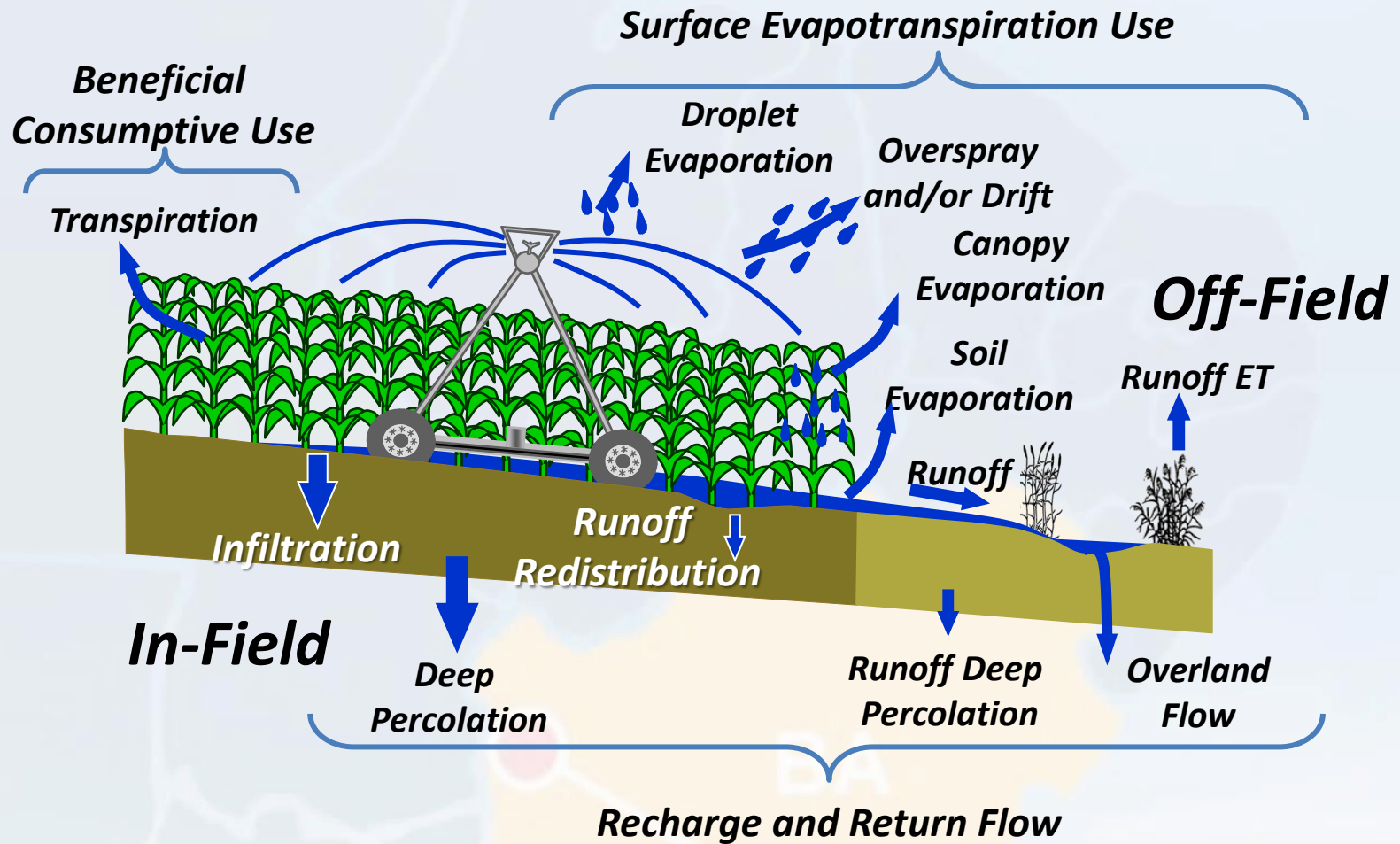
Entabilidade de irrigação

Parece simples, mas há muitas perguntas e consequências indesejáveis.



1. O que sustentar, economia, ecossistemas?
2. Equilibrar consumo agrícola a montante (rural) e a jusante (município ou requisitos ambientais) ?
3. O que fazer com a água do subsolo?
4. Como decidir sobre o prazo de gestão?
5. Equilibrar os direitos de propriedade contra o bem estar da comunidade ?
6. Definir a estratégia de "Gerenciamento adaptável" e objetivos e metas ?
7. Precisamos de uma abordagem sistemática e bem concebida.

Water Balance



- *Manage watersheds by accounting for where the water goes.*
- *Develop tools for water transfer and offsets to meet downstream needs*

Phases of Irrigation Development from a Watershed Perspective

Adapted from Keller (2000)

DEVELOPMENT

CONSERVATION

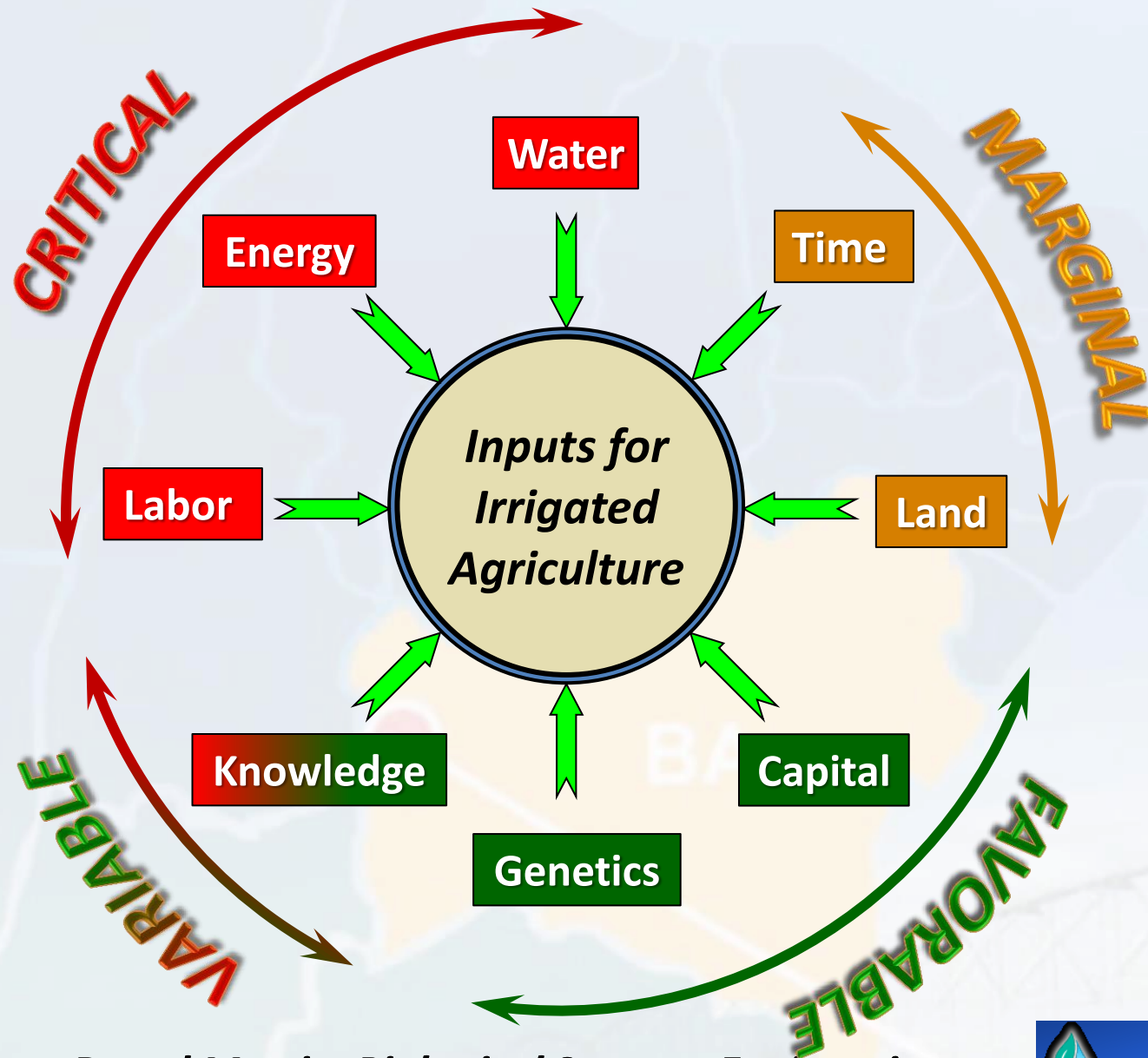
AUGMENTATION

Where are we in the process?

How has irrigation efficiency changed?

What does this mean for the future?

Profitability – Making it Work at the Farm Level



FASES DE DESENVOLVIMENTO DO USO DE ÁGUA

I	II	III	IV	V	VI
DESENVOLVIMENTO		CONSERVAÇÃO		AUMENTO DA	
Derivacao de água e bombeamento de água superficial ou do subsolo – povos rasos	Construir reservatorios e canais Bombeamento de aguas profundas	Inicio de rebaixamento do aquifero e medidas para aumentar a eficiencia	Inicio da utilizacao de agua de reuso	Transfere ncia de agua entre bacias	Medidas extremas – dessaliniza cao da água domar

Phases of Watershed Development

1. DEVELOPMENT PHASE

a

Surface
Water
Diversions
And
Shallow
Ground
Water
Pumping

b

Build
Storage &
Canals
And
Deep
Ground
Water
Pumping

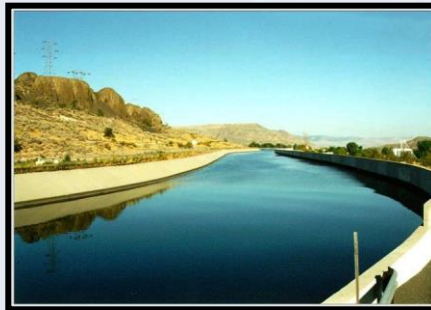
*Surface Water Diversions and
Shallow Ground Water Pumping*



Initially could divert when needed, did not need storage

1. DEVELOPMENT PHASE

BUILT STORAGE & CANALS and GROUND WATER PUMPING



After easy water was captured, turned to sources that were more remote and more difficult to convey

Storage of off-season and flood flows or groundwater became necessary

1. DEVELOPMENT PHASE



- *Did not focus on the impact of development on the watershed*
- *Needed enough water to make it work, legal rights setup to protect previous development*
- *Often a single objective*
 - *Develop the west*
 - *Rain will follow the plow*

***Systems that we have today are an artifact of the past.
Existing systems will drive future decisions.***

Conservation

2a

**Demand
Reduction
&
Efficiency
Increase
& Aquifer
Depletion**

2b

**Water
Treatment
&
Reclam-
ation**

2. CONSERVATION PHASE

CONSERVING WATER:

Mother, god and apple pie

What do we really mean?

Do we really conserve water?

Do we delay the inevitable?

Many activities in the conservation phase have an intended, or unintended, impact on irrigation efficiency

2. CONSERVATION PHASE

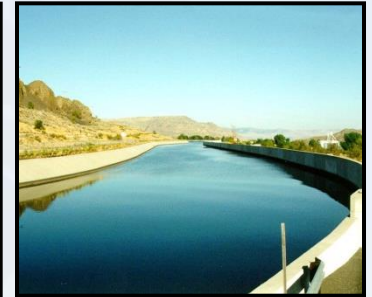
Direct Impact



OLD



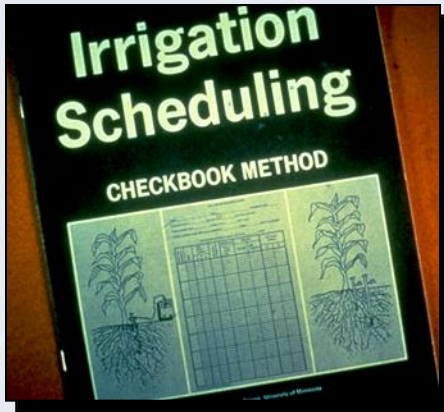
NEW



- 1. Reduced Runoff, Deep Percolation, Applied Smaller Depths When Water Was Needed and Required Less Labor.***
- 2. Allowed Irrigation of More Land Per Farmer and Irrigation That Was Not Feasible Previously***

2. CONSERVATION PHASE

Improved Management In Addition To System

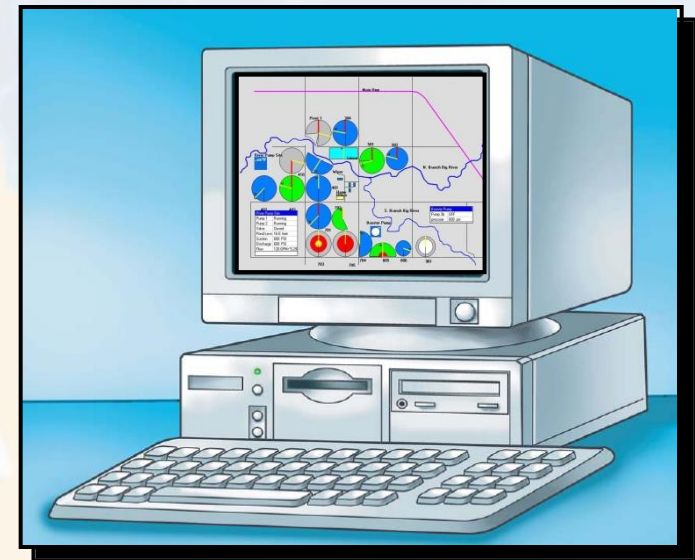


Determine
When To
Irrigate



Improved Monitoring

Computerized Control



Resulted In Increased Irrigation Efficiency

2. CONSERVATION PHASE

Manage Tillage and Residue



- 1. Replaces irrigation water with rainfall to maintain yields → higher efficiency***
- 2. Less water directly to streams***

2. CONSERVATION PHASE

Lining and Automating Canals Improves Conveyance



Less seepage results in less water logged soils

Automation produces smaller spills

More timely delivery to farmers can save water

Less groundwater recharge

Increased Efficiency → More Water to Producer

2. CONSERVATION PHASE

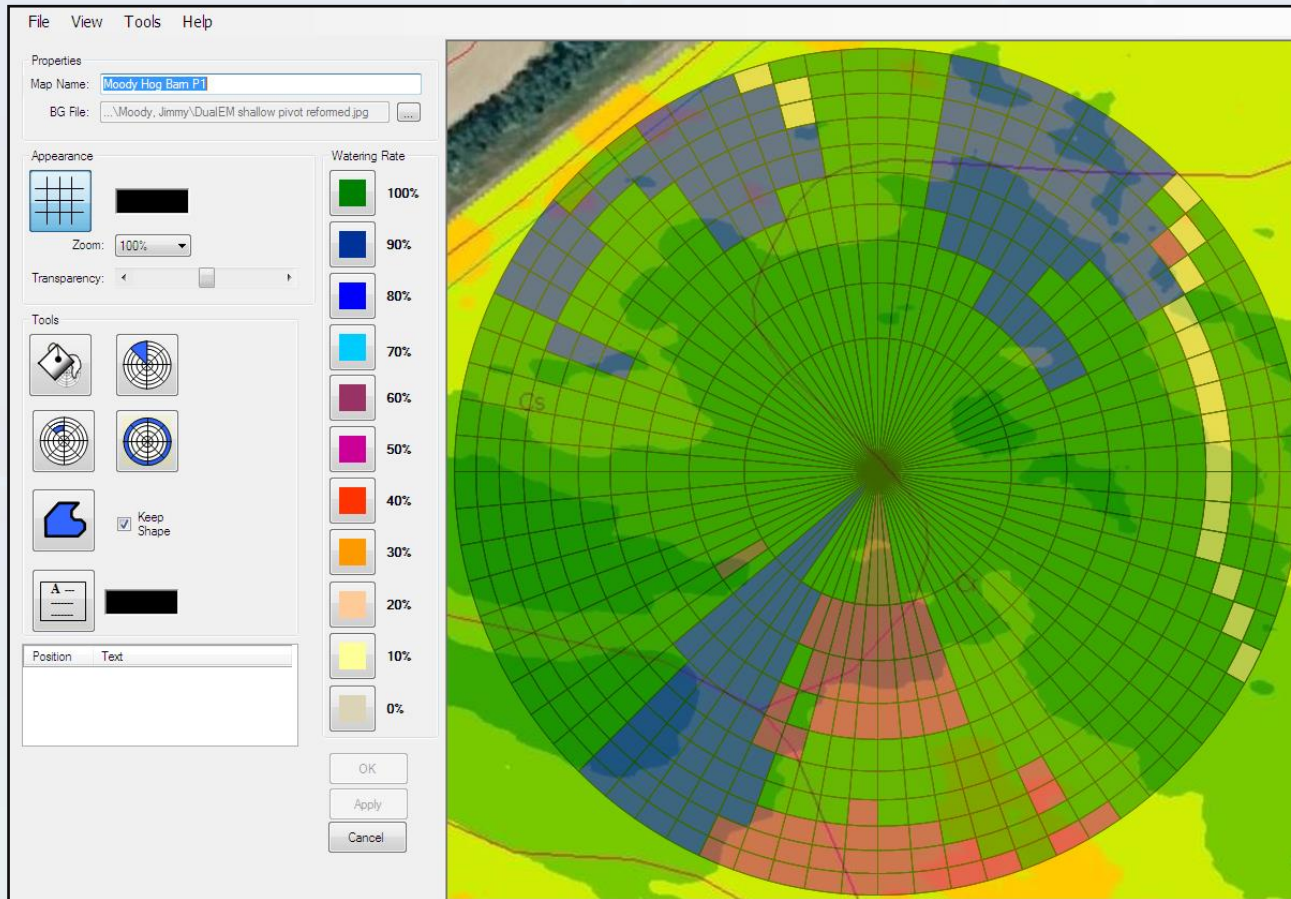
Deficit Irrigation - Intentionally Stressing Crop During Season



1. *How much stress?*
2. *When to stress?*
3. *What will it cost?*
4. *How do crops respond?*

Ultimate Impact is to Increase ET per unit of Irrigation Water

VRI Zone Control



- *May be technology for areas with limited water supplies.*
- *Apply water where it is most productive*
- *May not enhance watershed supplies*

2b. CONSERVATION PHASE

- **More Drastic Conservation Measures:**
 1. Water Treatment
 2. Reclamation of Waste Water
 3. Disposal of Salts
- **Water Harvesting Techniques**
 1. Minimize Evaporation Losses From Small Rains
 2. Secondary Recovery
 3. Cloud Seeding, ...

Techniques often work for small areas, but don't provide for basin-wide quantities that are reliable or economical.

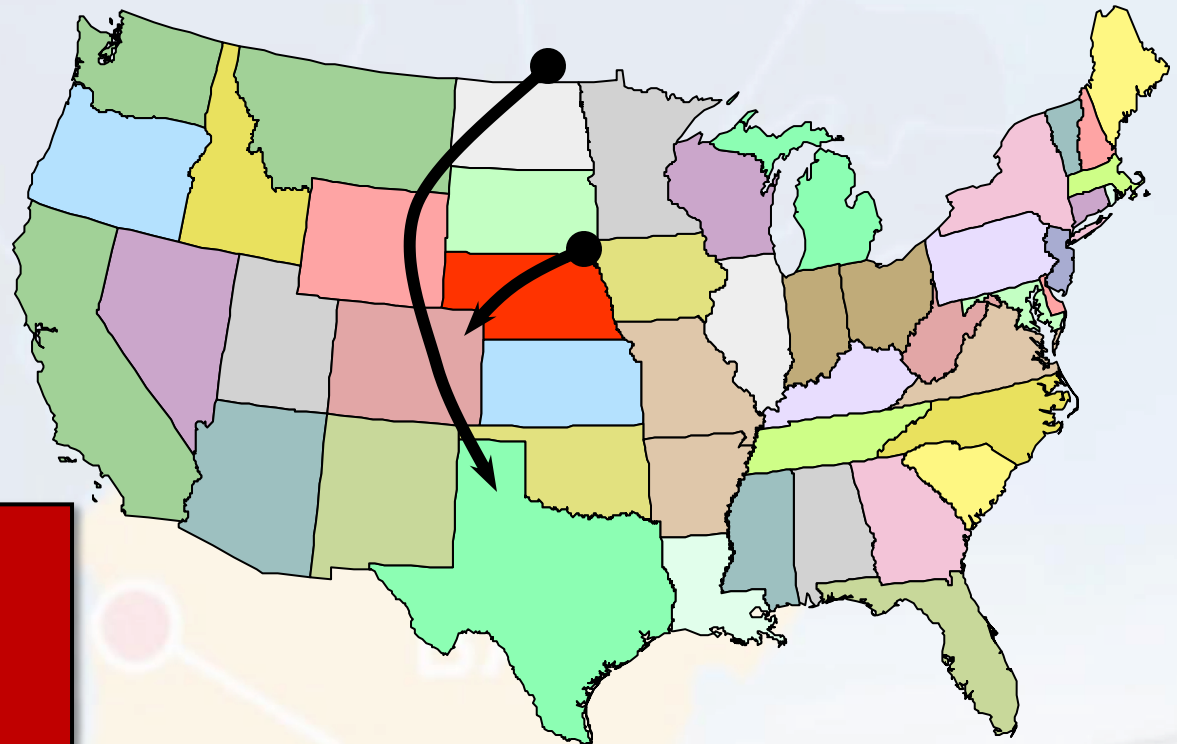
3. AUGMENTATION PHASE

Schemes Of The Seventies

*Pay for Water
with Energy
Revenues*

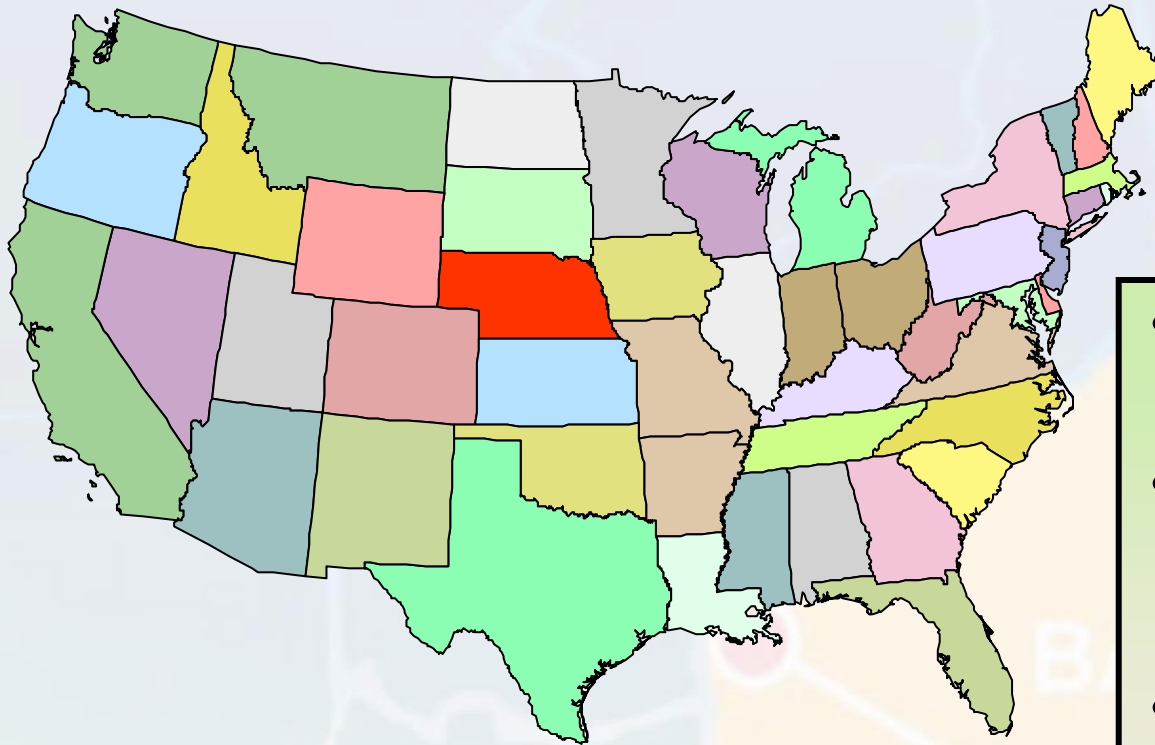
- *High Cost – Infeasible*
- *Who Should Pay*
- *No Willing Providers*
- *Other Higher Bidders*

TRANSBASIN DIVERSION



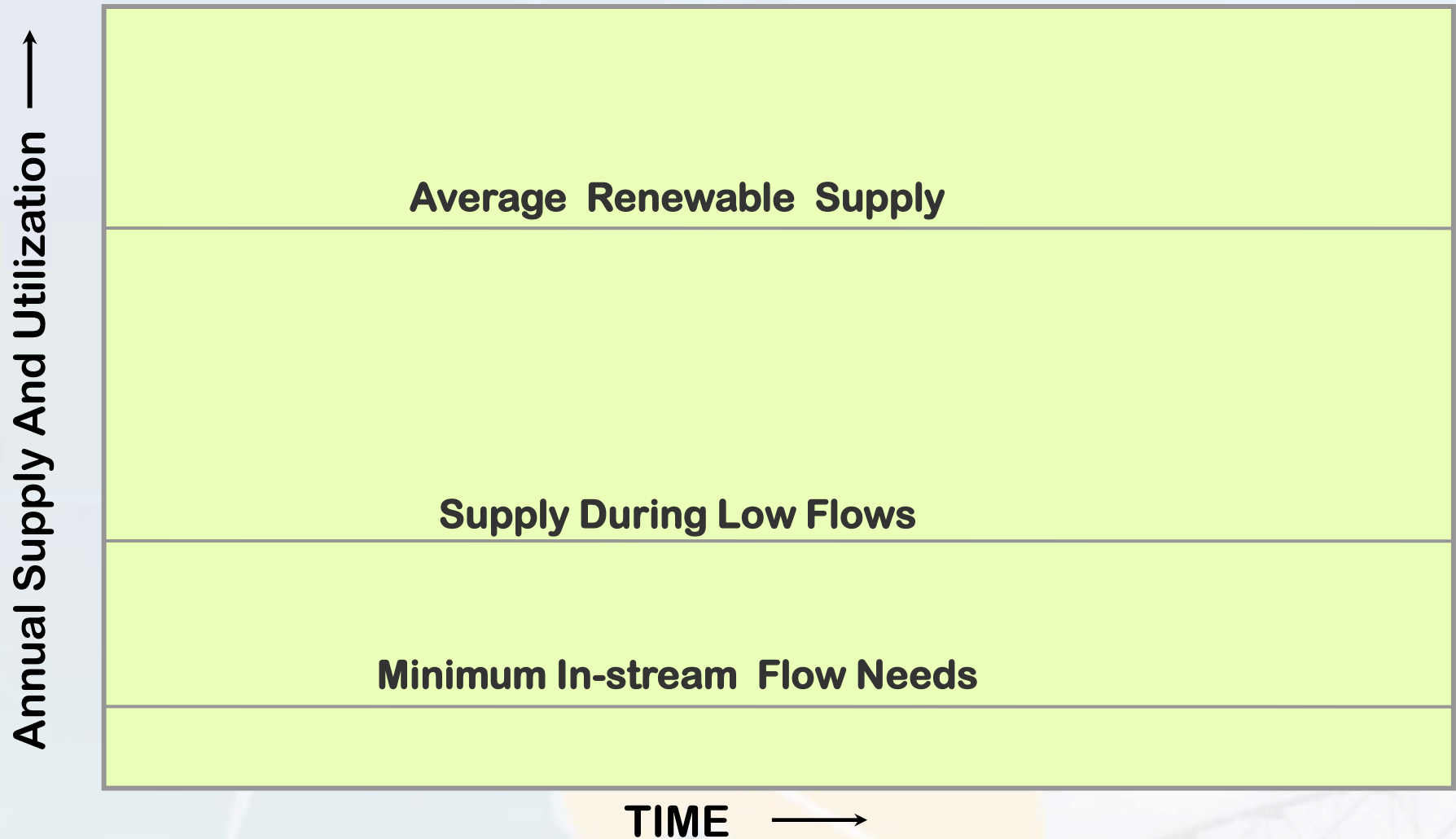
3. AUGMENTATION PHASE

LOCAL WATER TRANSFERS

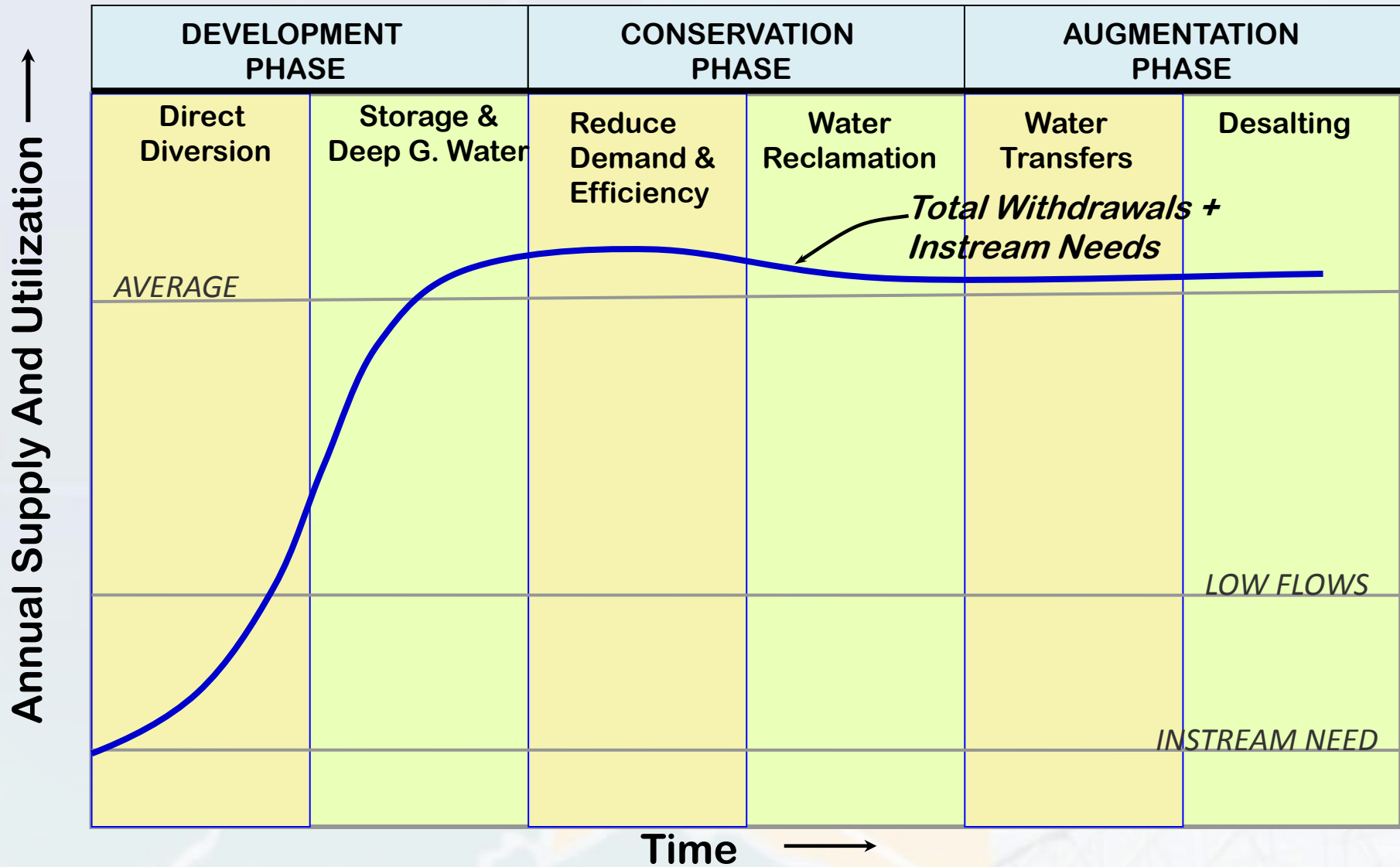


- *Transfers are common in the West.*
- *Usually irrigated agriculture is the seller not the buyer*
- *Transfers will surely increase in Nebraska*

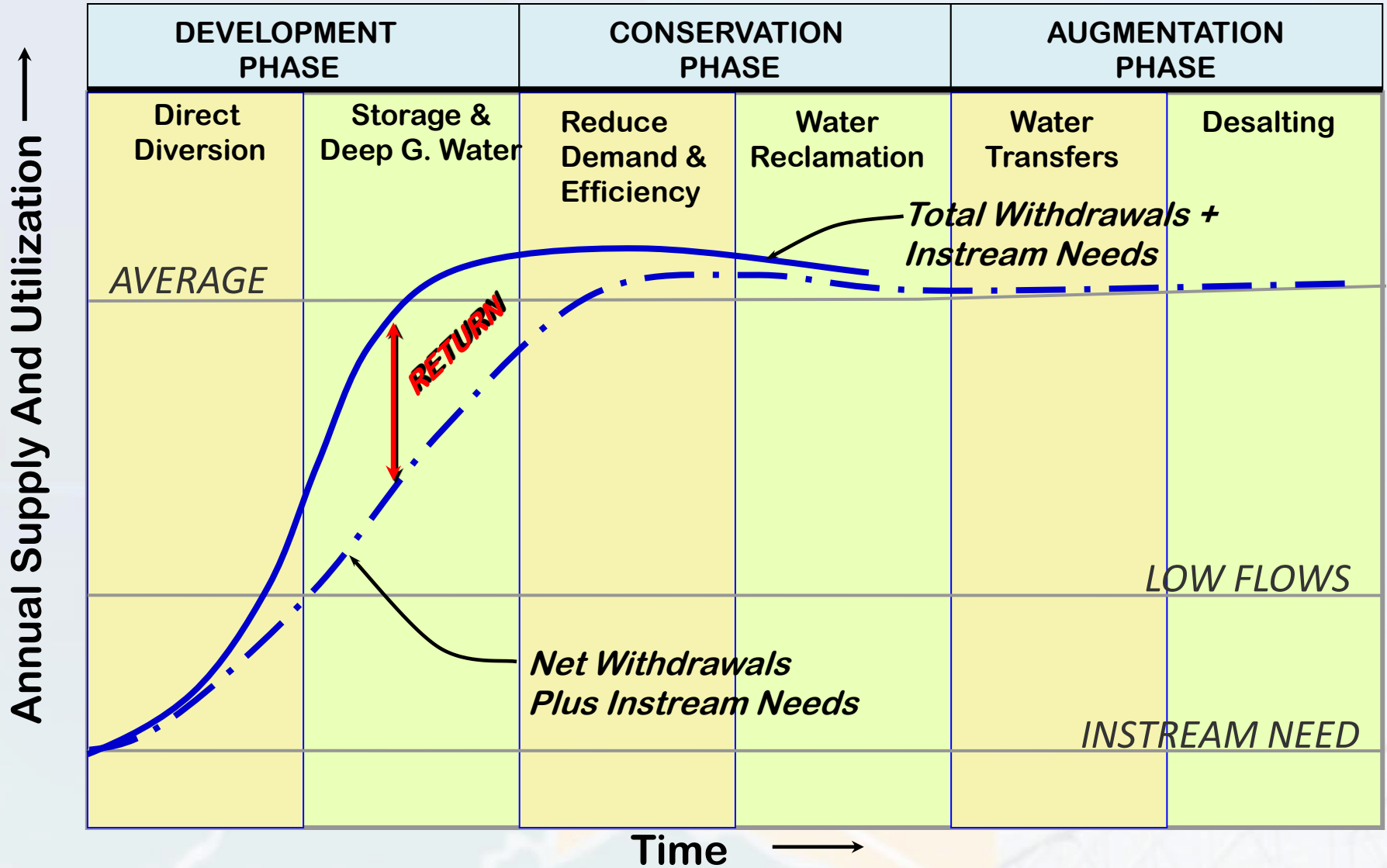
Basin Water Supply (from Keller , 2000)



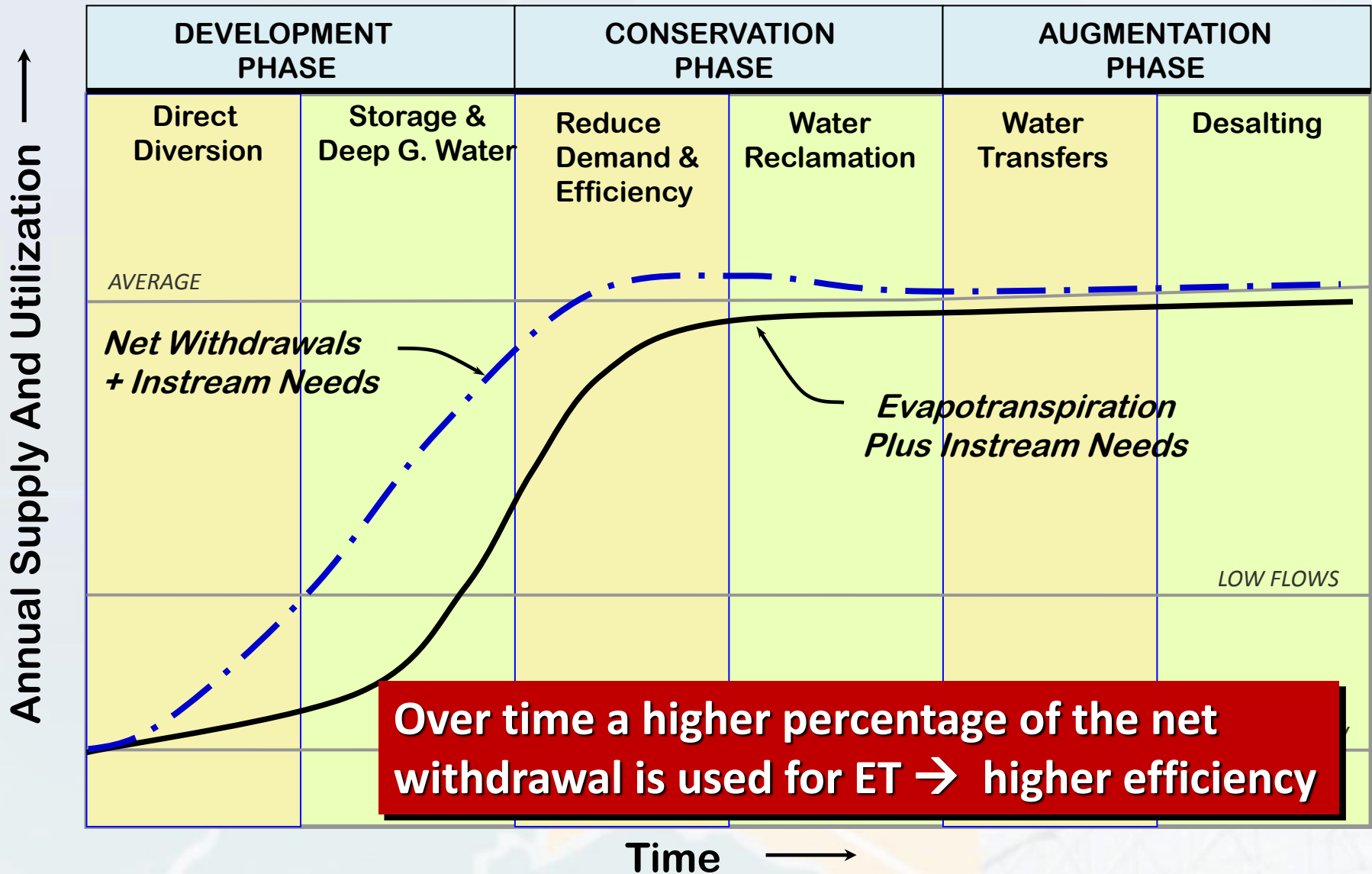
BASIN WATER SUPPLY



BASIN WATER SUPPLY



BASIN WATER SUPPLY



Changing Expectations

- ***Historical focus on local needs and protection of water supply.***
- ***Evolving to a shared watershed***
 - *Other demands becoming important, if not paramount.*
 - *Needs not well defined and continue to emerge*
 - *Comprehensive plans essential for future*
 - *93% private land ownership*

Technology Trends

- ***Historically efficiency improved as technology became economical***
 - *Trend will surely continue*
 - *Impossible to predict technology improvements*
 - *Innovation will happen*
 - *However, there is less to gain now than in the past based on past improvements*
 - *Improvements in strategically applying varying depths to maximize the value of the water*

Technology Trends

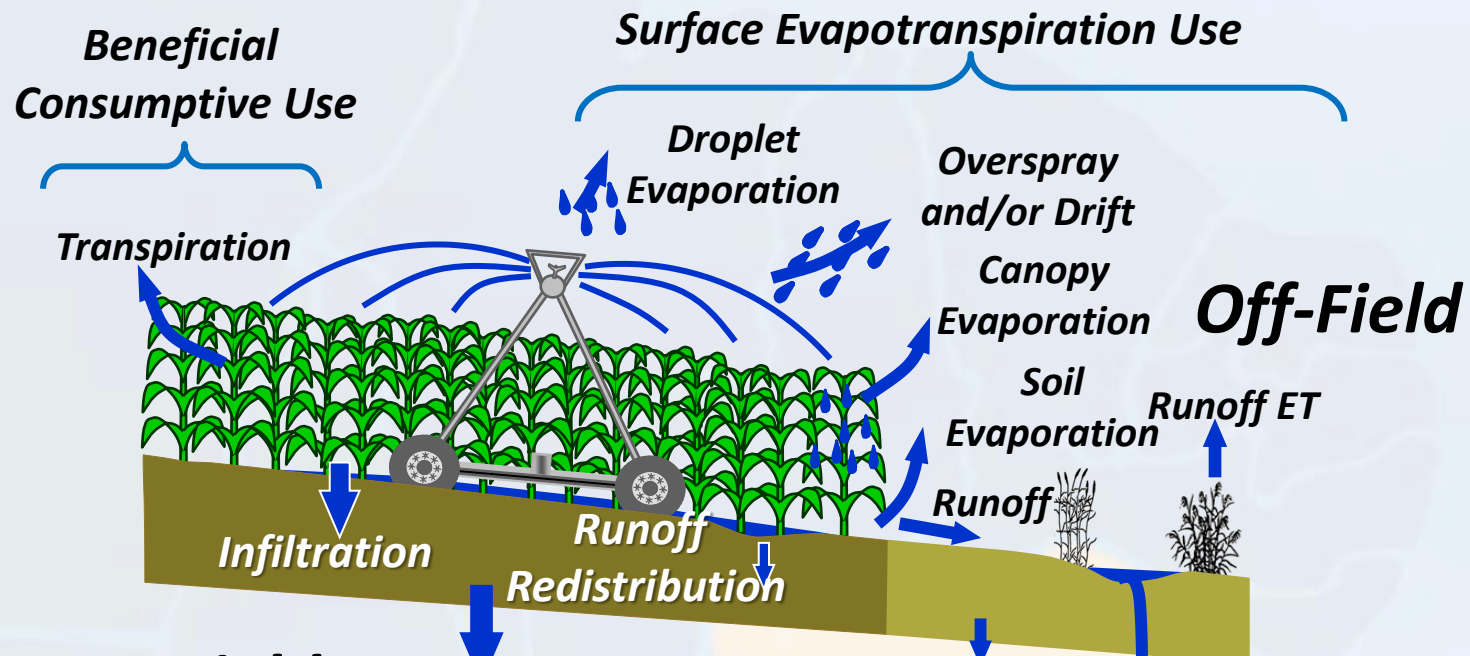
- *Past improvements focused on irrigator, not the watershed*
 - *Improvements not always beneficial to watershed*
 - *Innovation for watershed enhancement is possible*
 - *Hopefully win-win advancements*
 - *Who will pay for watershed technology?*

Future Directions

- 💧 Cost/availability of water will remain principal determinants of irrigation
- 💧 Irrigated acreage will likely decline
- 💧 Shifts to more valuable crops likely
- 💧 Amount of water dedicated to agriculture will likely decline
- 💧 Economic viability will depend on global competition

from NATIONAL RESEARCH COUNCIL 1996 - A New Era for Irrigation

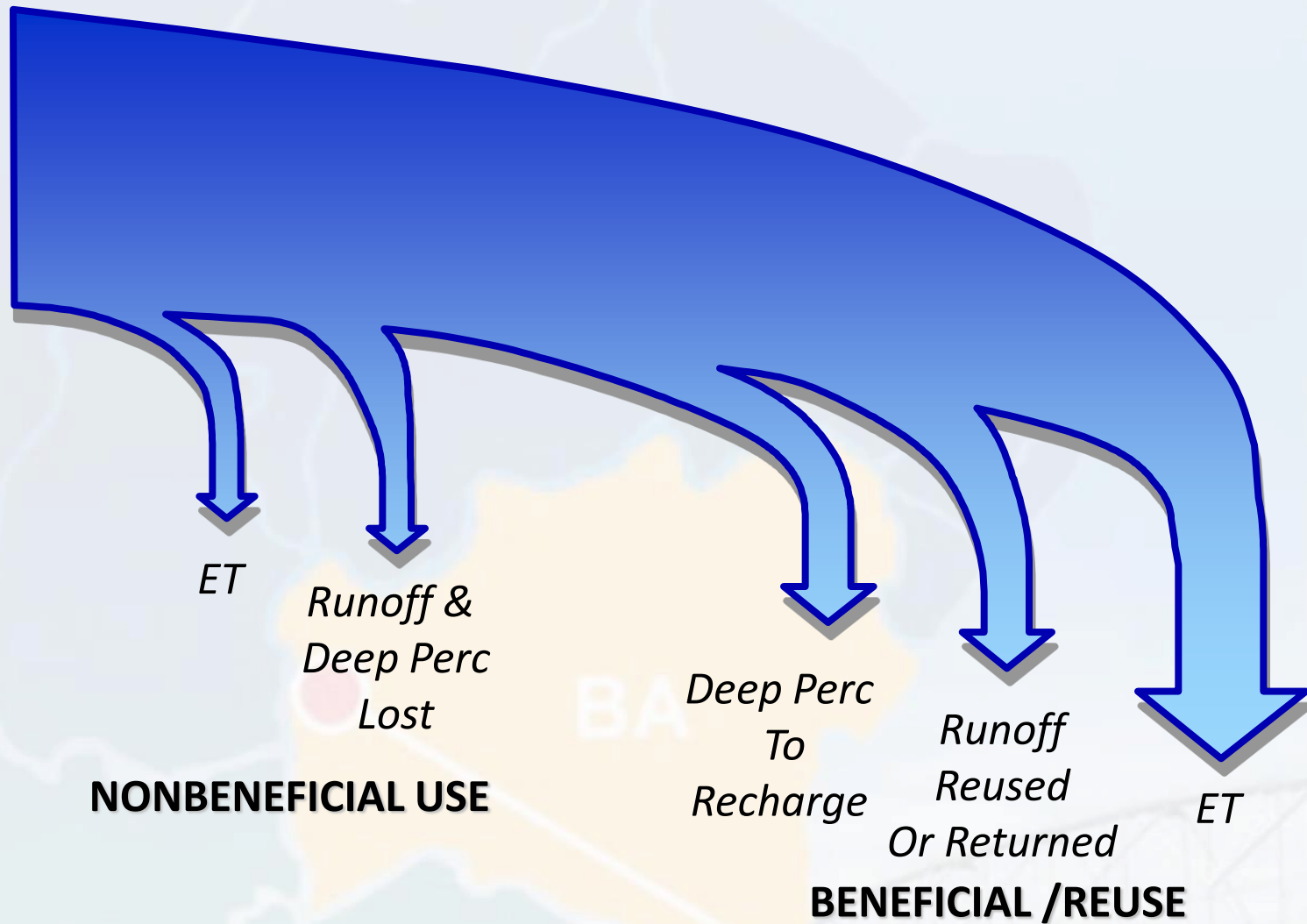
Effect of Irrigation Efficiency on Water Balance



- Farmer Benefits vs Watershed Impacts
- *Where does the water go that leaves the field?*
- *Is that water recoverable?*
- *Manage watersheds by accounting for where the water goes.*
- *Get better at predicting the impact of irrigation.*
- *Develop tools for water transfers and offsets to meet instream flow needs.*

Where Water Goes

*Irrigation
Diversion,
Pumpage, or
Precipitation*



Agricultural Water Use Efficiency Program from Keller, 2000

Develop Quantifiable Objectives For The Watershed

TARGETED FLOW PATH CHANGES				
Flow Paths & Water Balances	Quantity		Quality	
	Base	Target	Base	Target
Total Supply: Diversions, Rainfall				
Total Water Inflow: Net Surface Water Releases, Internal GW Extractions				
Total Manageable Water: Habitat Needs, Channel Seepage, Farm Deliveries,				
Total Evaporative Depletion:				
Total Water Outflow from Area				

Water Conservation Perspectives

Circular Process

1. *NRDs reduce withdrawals*
2. *Producers become more efficient*
3. *Improves value of the water used*
4. *Consumptive use may not drop much*
5. *So, NRDs reduce withdrawals,*

What about the \$

1. *What impact on regional economy?*
2. *What makes sense for producers?*
3. *What if we cap consumptive use?*
4. *Who should pay? Who should be reimbursed?*

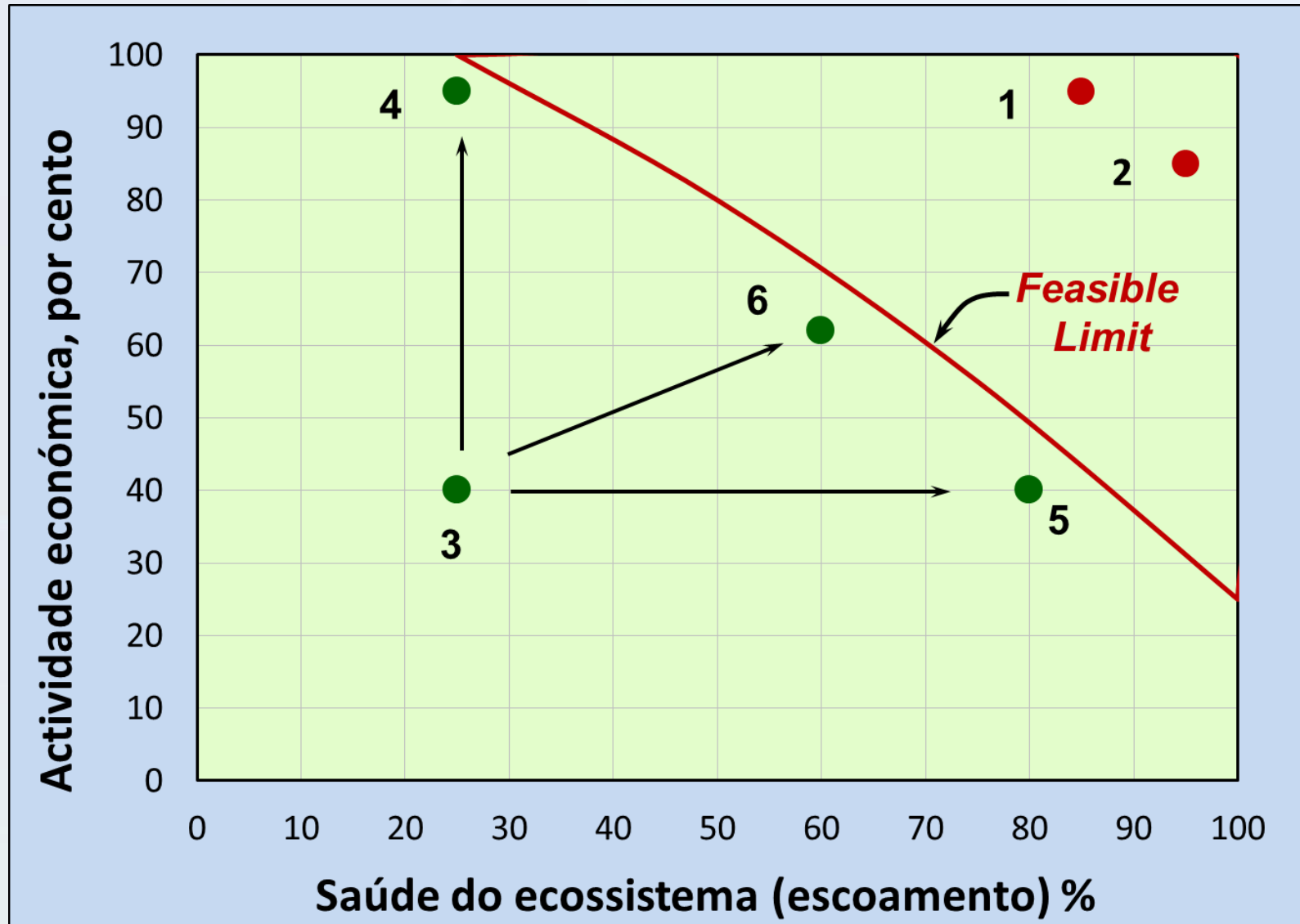
Conflicts

1. *Upstream $\leftrightarrow$ Downstream*
2. *Groundwater Irrigator $\leftrightarrow$ Surface Water Irrigator*
3. *Property Rights $\leftrightarrow$ Public Good*
4. *Economy $\leftrightarrow$ Environment*

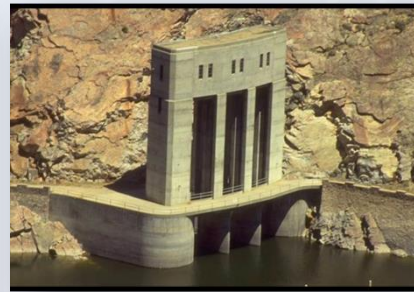


***Have we
really thought
these through??***

Análise de troca



Where Changes Can Be Made



River and Watershed Systems and Management



On-Farm Systems & Management



Plant Productivity & Water Use



Real-time Soil Water Monitoring

Sensors

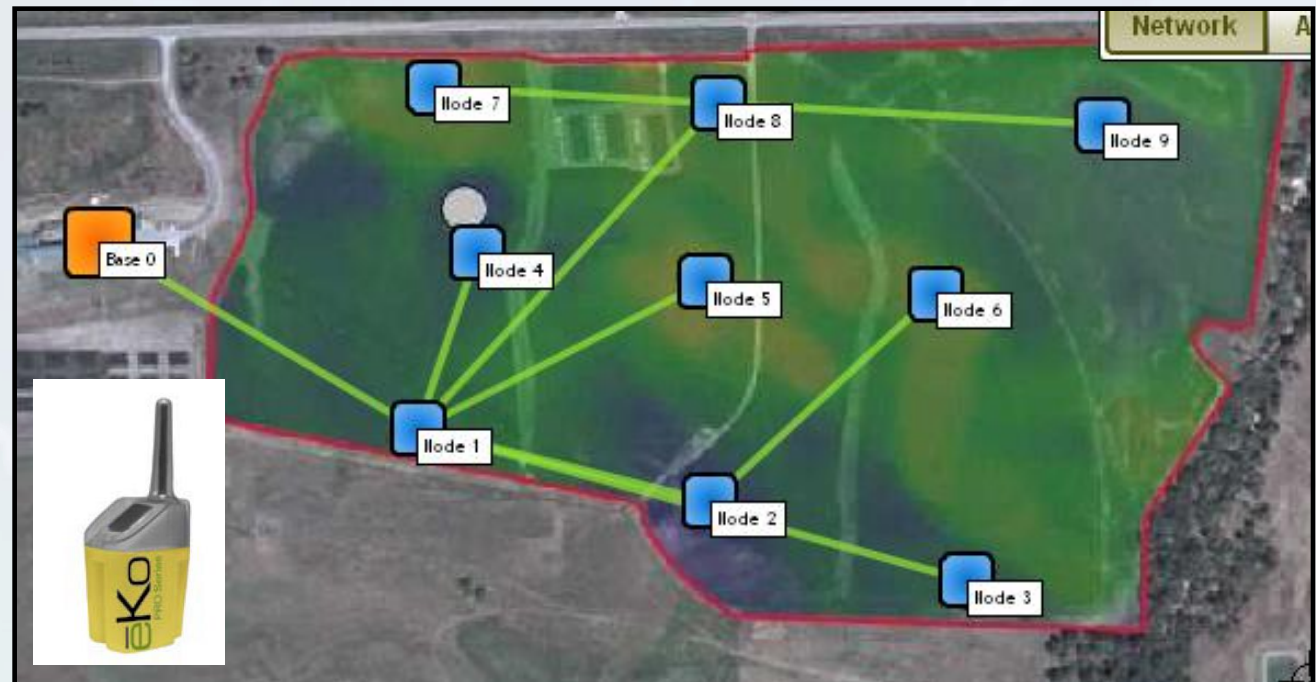


Satellite

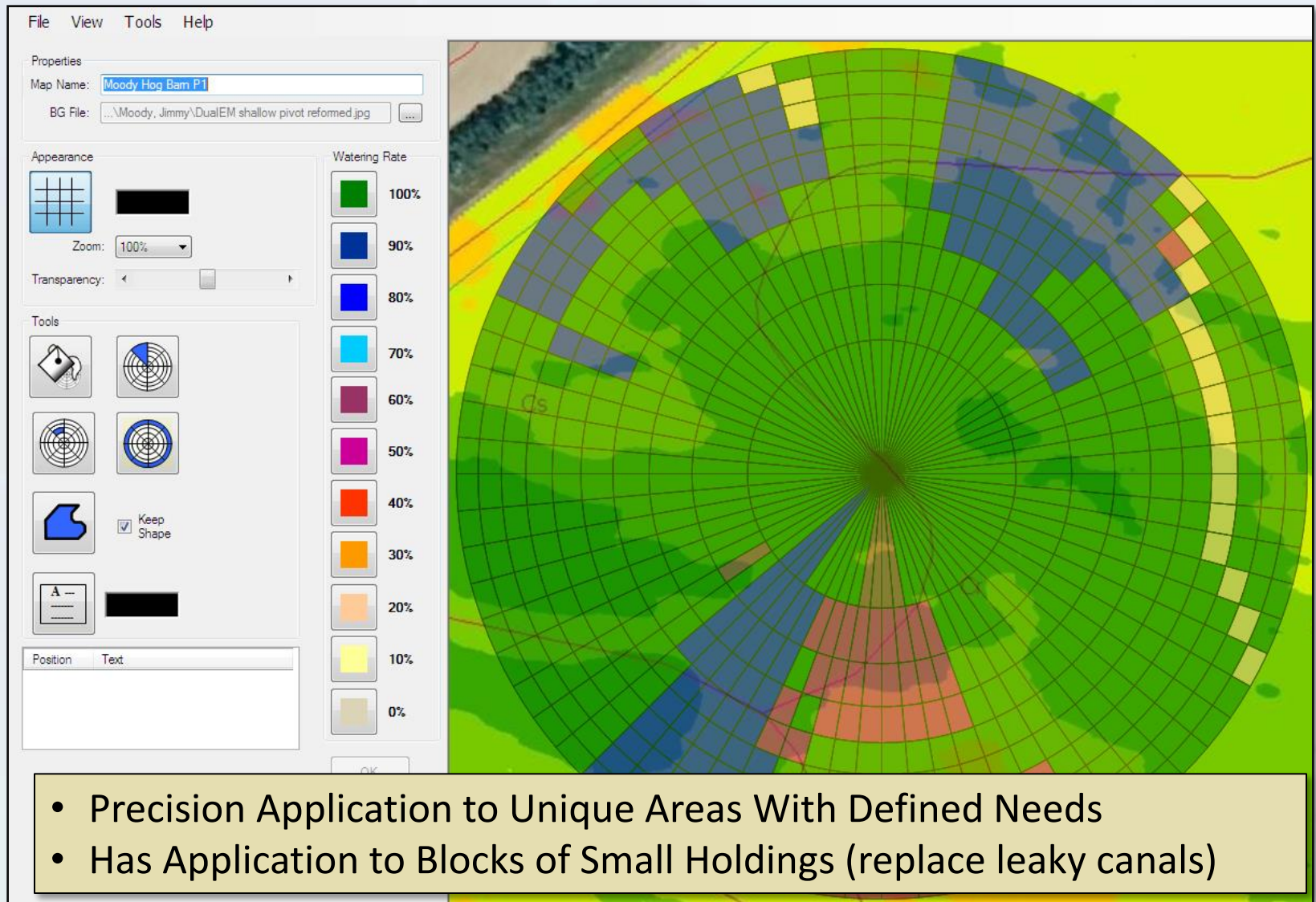


Wireless Node

Data Logger



Valley VRI Zone Control Prescription



Integração de monitoramento de água do solo e controle dinâmico



**Watermark
Sensores de
água do solo**

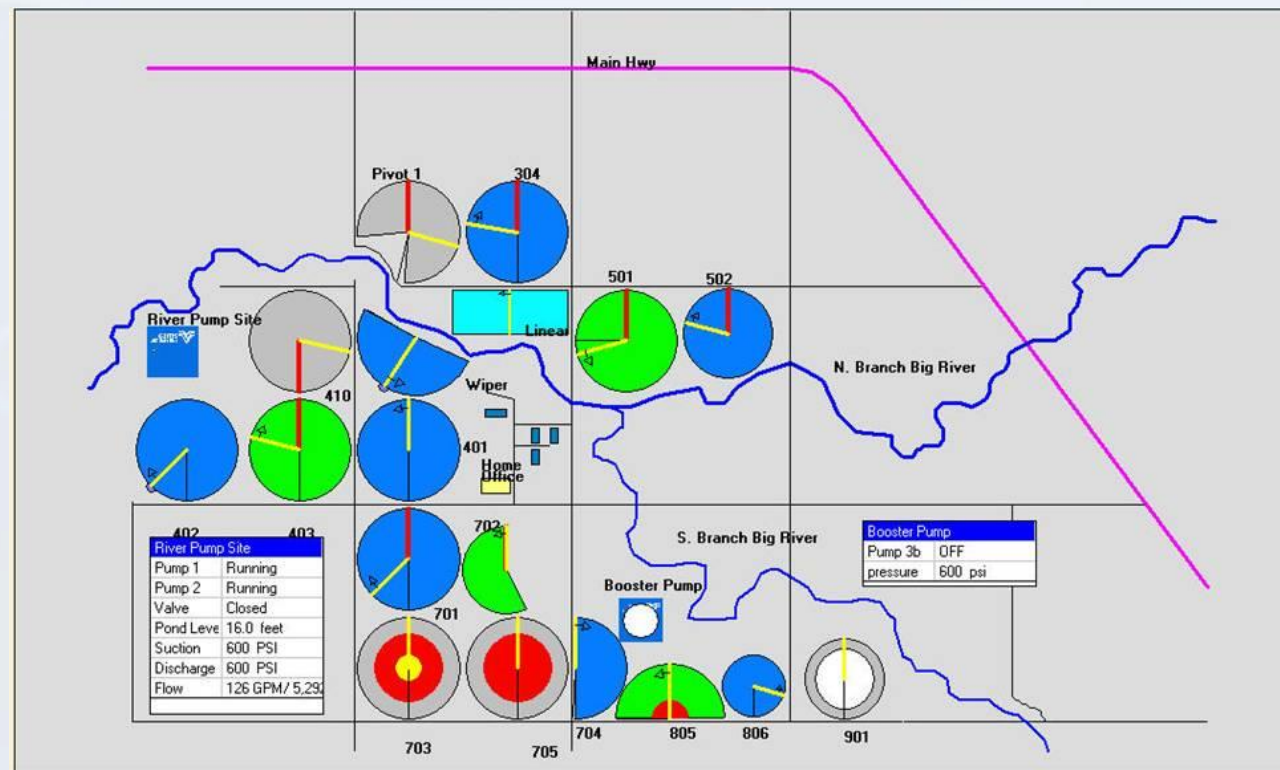


Controle remoto de sistemas de irrigação

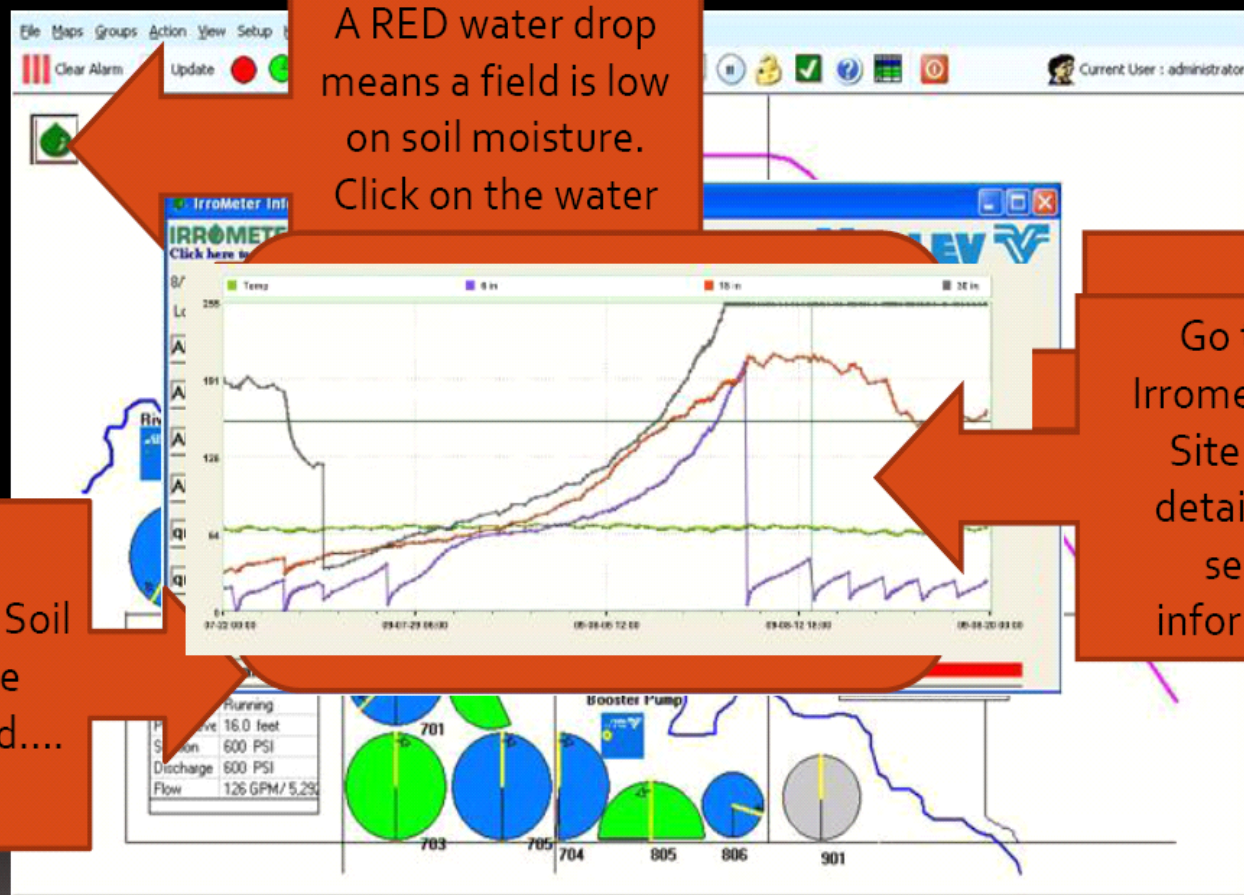


Imagens cortesia da indústrias de Valmont

Tela de mapa



- A tela mapa fornece informações de relance
- O status de máquina é codificado por cores
 - Azul está aplicando água
 - Verde está desligado
 - Cinza está desativado
 - Vermelho está irrigando e aplicando produtos químicos



A RED water drop means a field is low on soil moisture. Click on the water

Go to the Irrrometer Web Site to see detailed soil sensor information

Select any Soil Moisture Sensor and....

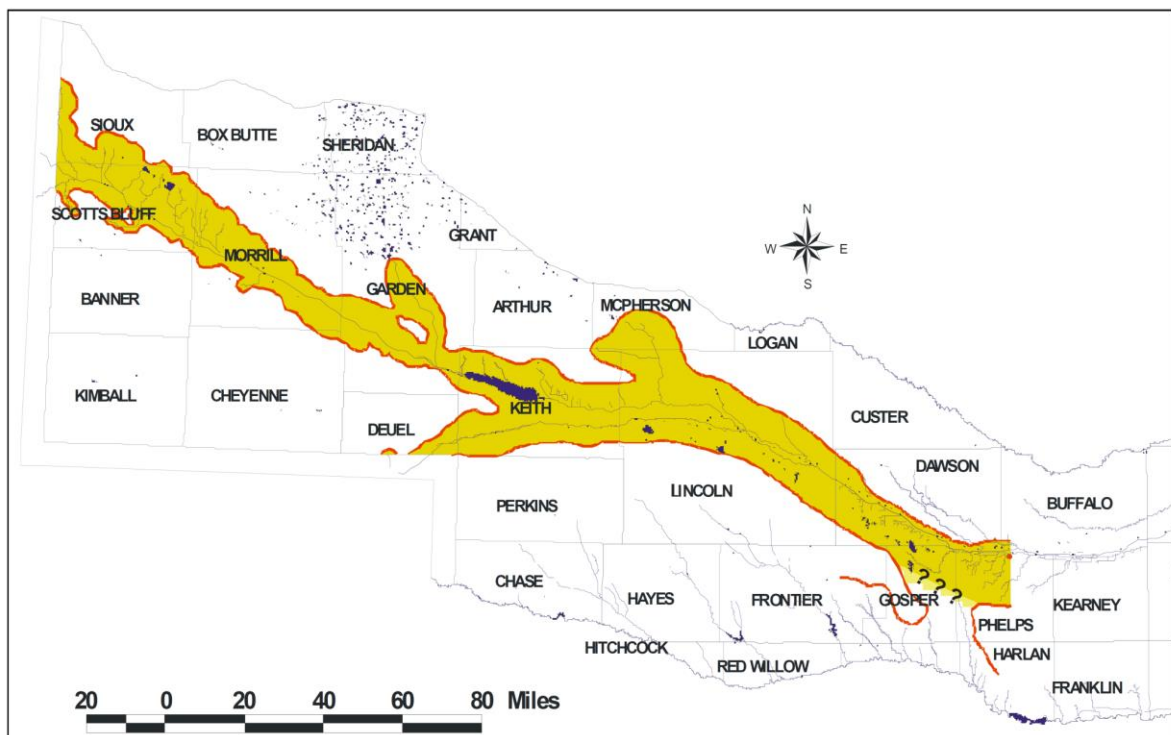
Irrigação de precisão

- 💧 *Não é proposta economicamente mais vantajosa para todas as culturas em todos os locais.*
- 💧 *Podem ser ecologicamente vantajosas em muitas circunstâncias.*
- 💧 *Maiores vantagens podem ser com aplicações de agroquímicos.*
- 💧 *Grande potencial para maximizar o impacto nas condições de água limitada*



Streamflow Depletion & Ground Water Models

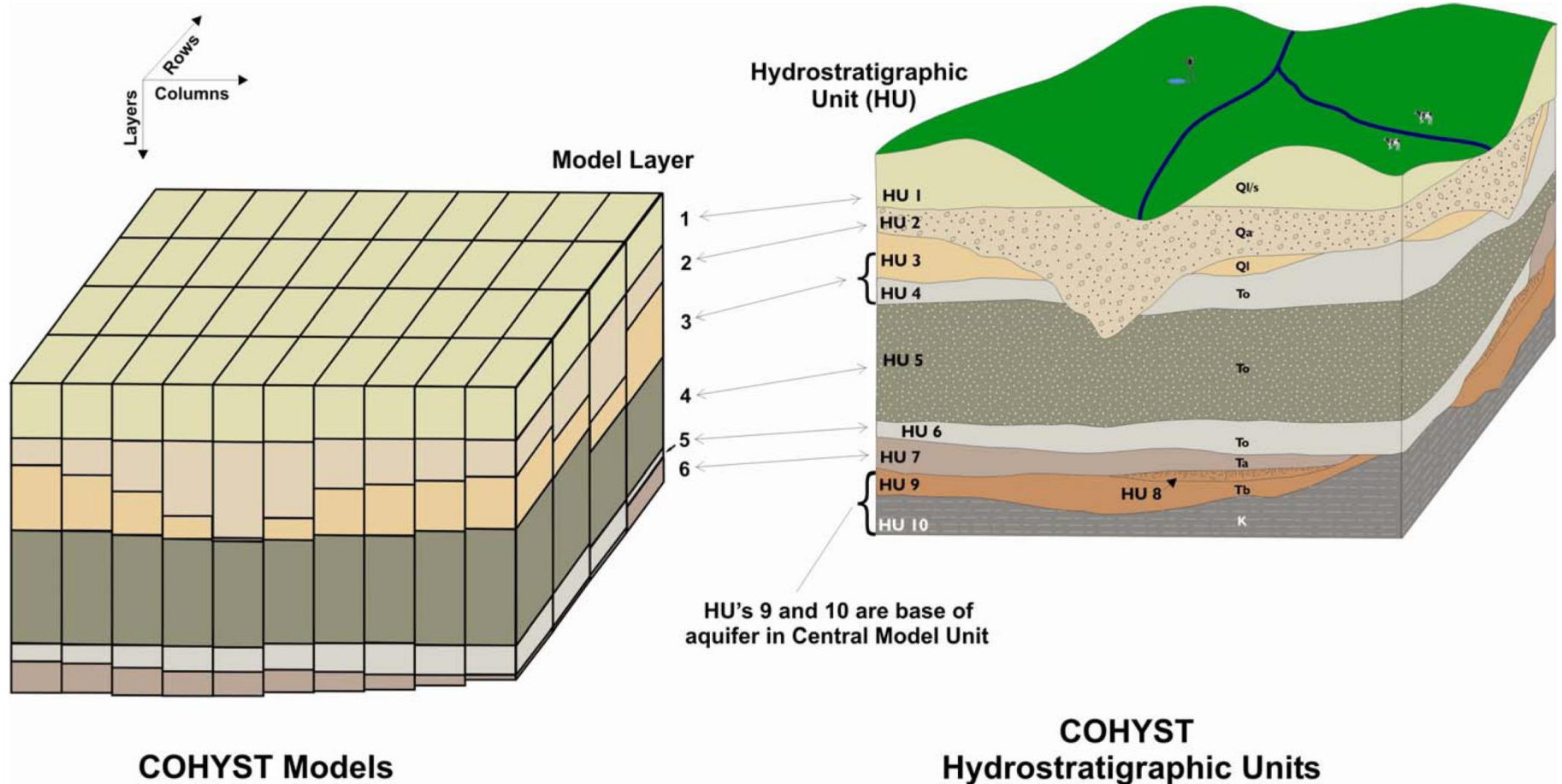
- Depletion of stream flow due to pumping cannot be measured.
- Ground water models can simulate impact of pumping on streams.
- A calibrated groundwater model is run with and without pumping
- Difference in baseflow is referred to as stream depletion.
- Model can be run for future using similar scenarios



Lines of 40-year, 28-percent stream depletion in the Platte River basin west of Elm Creek, Nebraska.

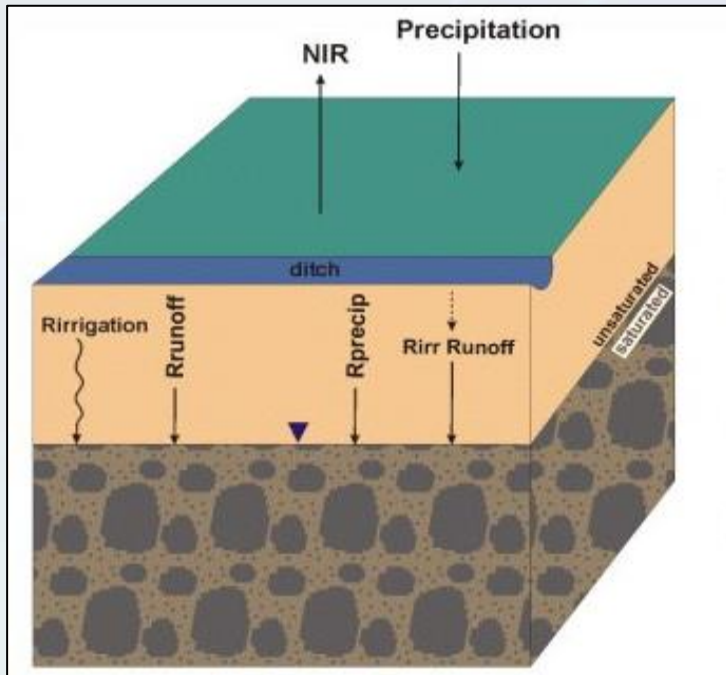
Ground Water Modeling

- Divide the land and subsoil/aquifer into a grid or set of columns.
- The discretion introduces errors.
- Seems that smaller cells would improve accuracy, BUT maybe not.



Need Inputs and Aquifer Properties for Each Cell

Need to know land area, cropping patterns, precipitation, net irrigation pumped, precipitation recharge, maybe upward flow, characteristics of the unsaturated zone.

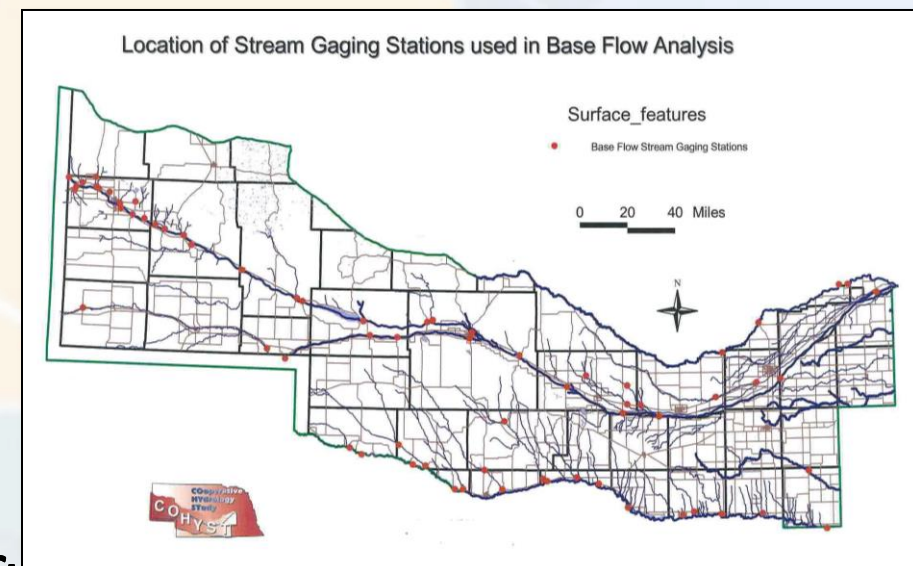
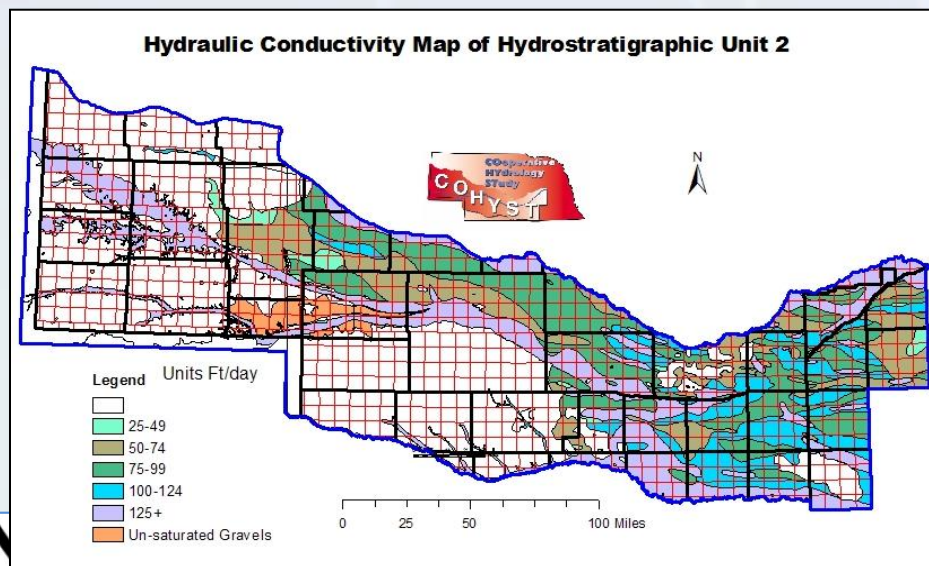
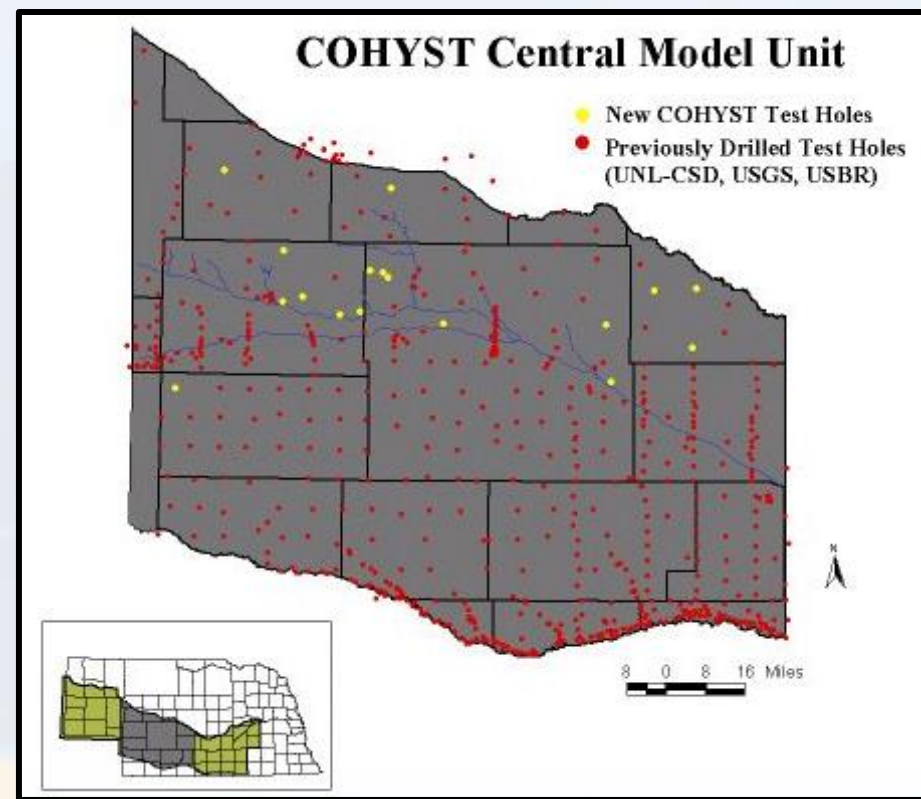


Aquifer Properties Include:

- Hydraulic Conductivity
- Specific Yield Or Storage Coefficient
- Saturated Thickness
- Elevation Of Soil Surface
- Elevation Of Streambed
- Stream Interaction – Conductance
- Other Boundary Conditions

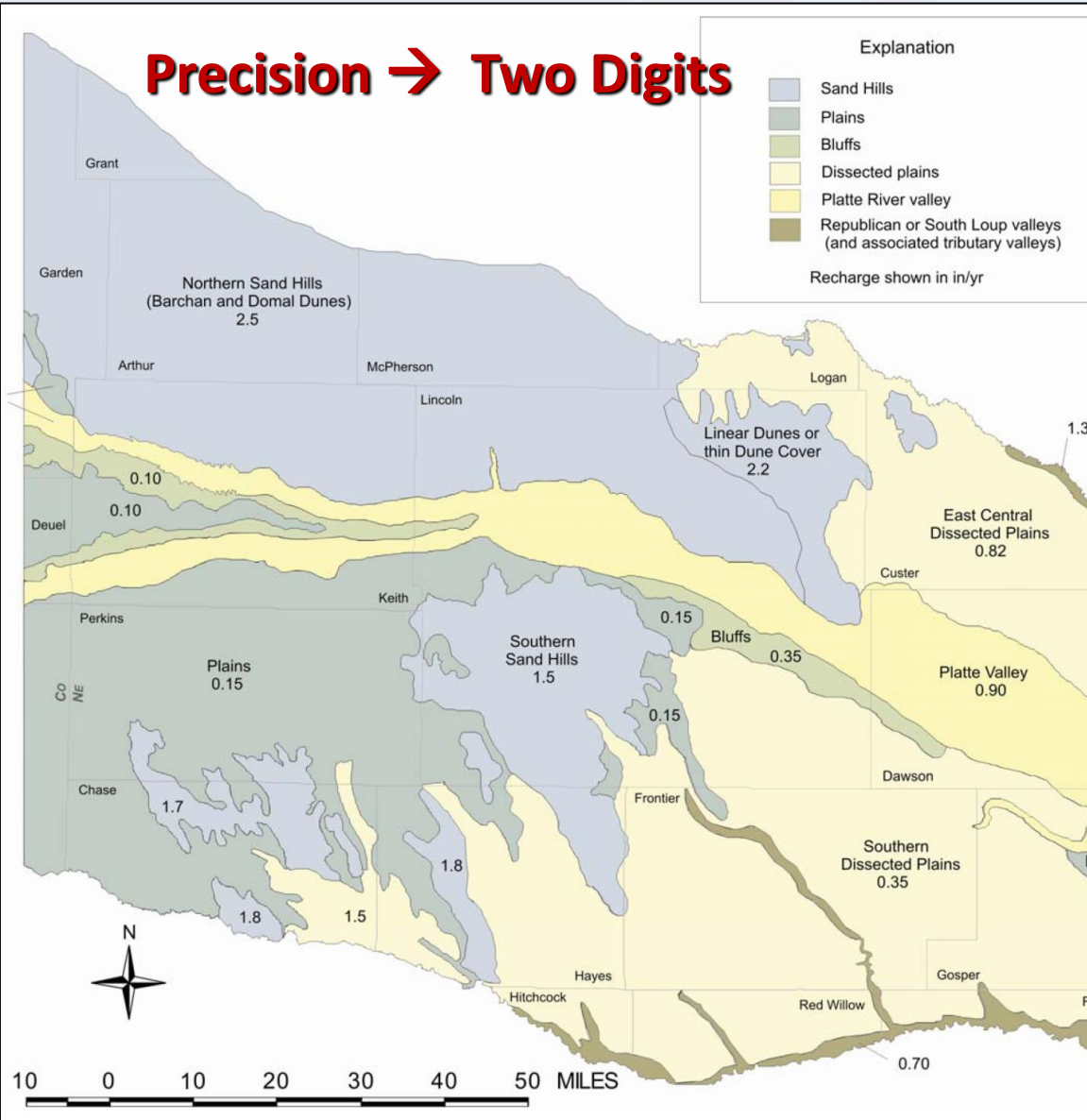
Calibration and Validation of Groundwater Model

Calibration is when you measure the system output and adjust input parameter values to provide a close fit to historical baseflow and depths of the saturated zone (i.e., the hydraulic head) at relatively few locations.



Recharge from Rangeland for COHYST

Precision → Two Digits



- Recharge is often a calibration parameter, **but**
- Recharge from rangeland may not change materially over time, although range management has an impact.
- Recharge from rainfed areas have changed materially with land use changes, tillage changes, and construction of water conservation structures (terraces and reservoirs)
- Involves so much area that it can drive model calibration

Non-Unique Solutions

Rule of Mathematics:

Unique solution requires one equation for each parameter.

We have about 10 parameters per equation

So do not get a unique solution

→ Can't really CALIBRATE → really match history

Get the same answer for a range of parameter values
Right Answer → Wrong Reason.

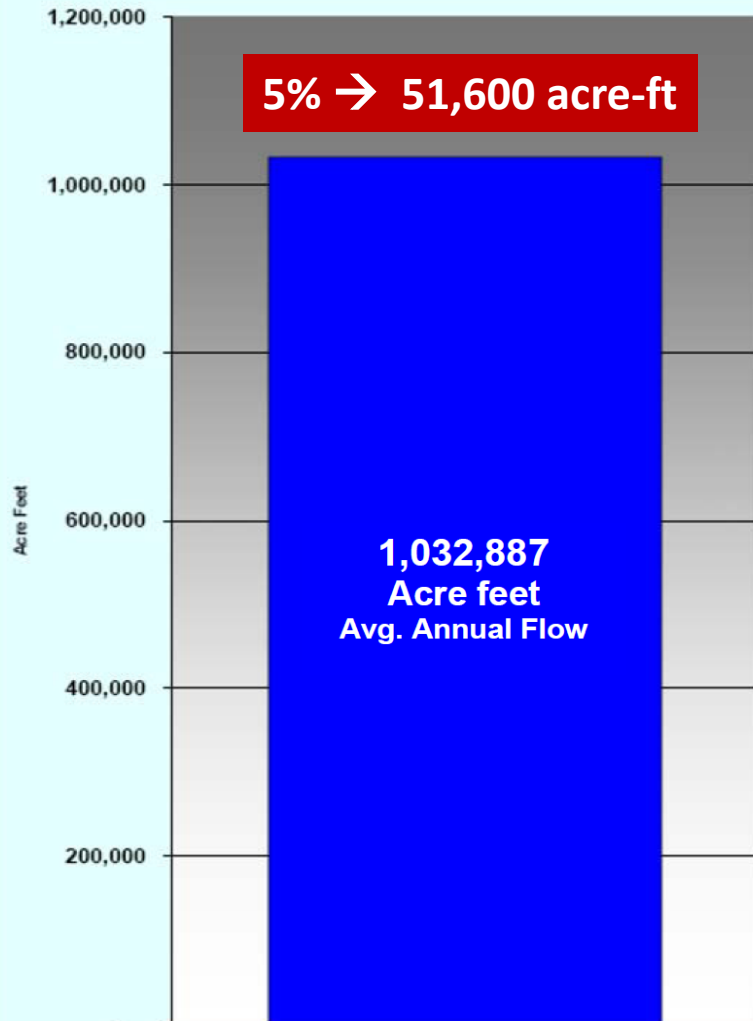
Can “calibrate” for certain conditions , and then run the model for other conditions. Two concerns:

1. Do we assign impact to variables that are irrelevant,
2. Do we miss representing a process because did not “use” that variable in calibration.

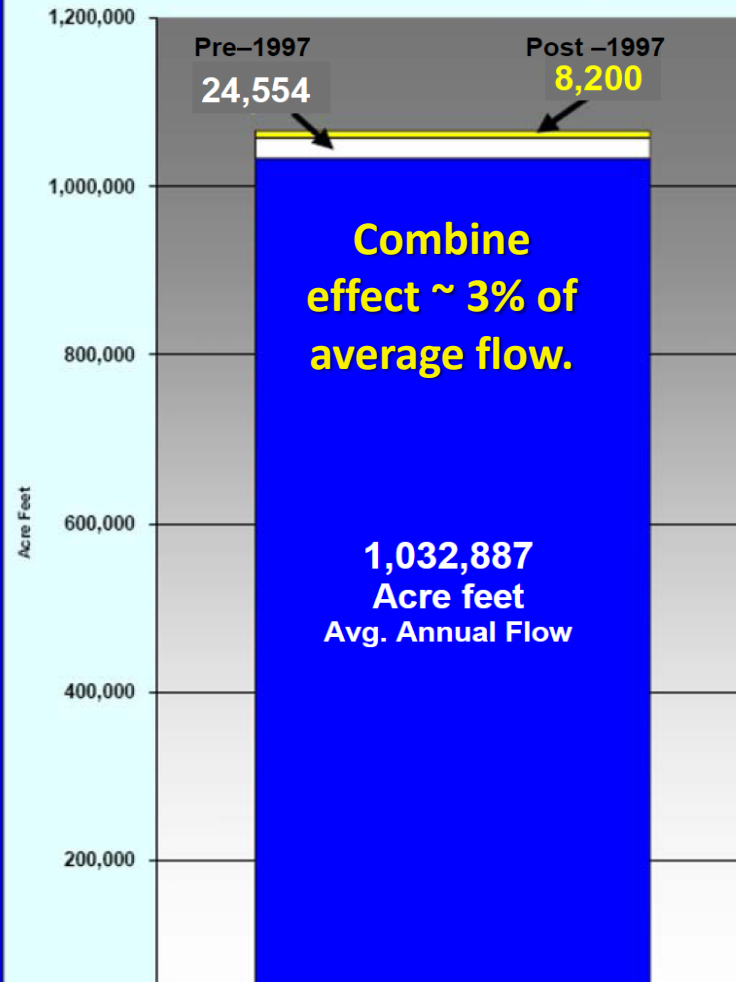
Can't expect to model closer than can measure.

Guard Against Unrealistic Expectations for Model

North Platte River at Lewellen
Historical Record: 1941-2004



North Platte River at Lewellen
If all 144,100 Acres of Ground Water
Irrigated Land Went Back to Dryland

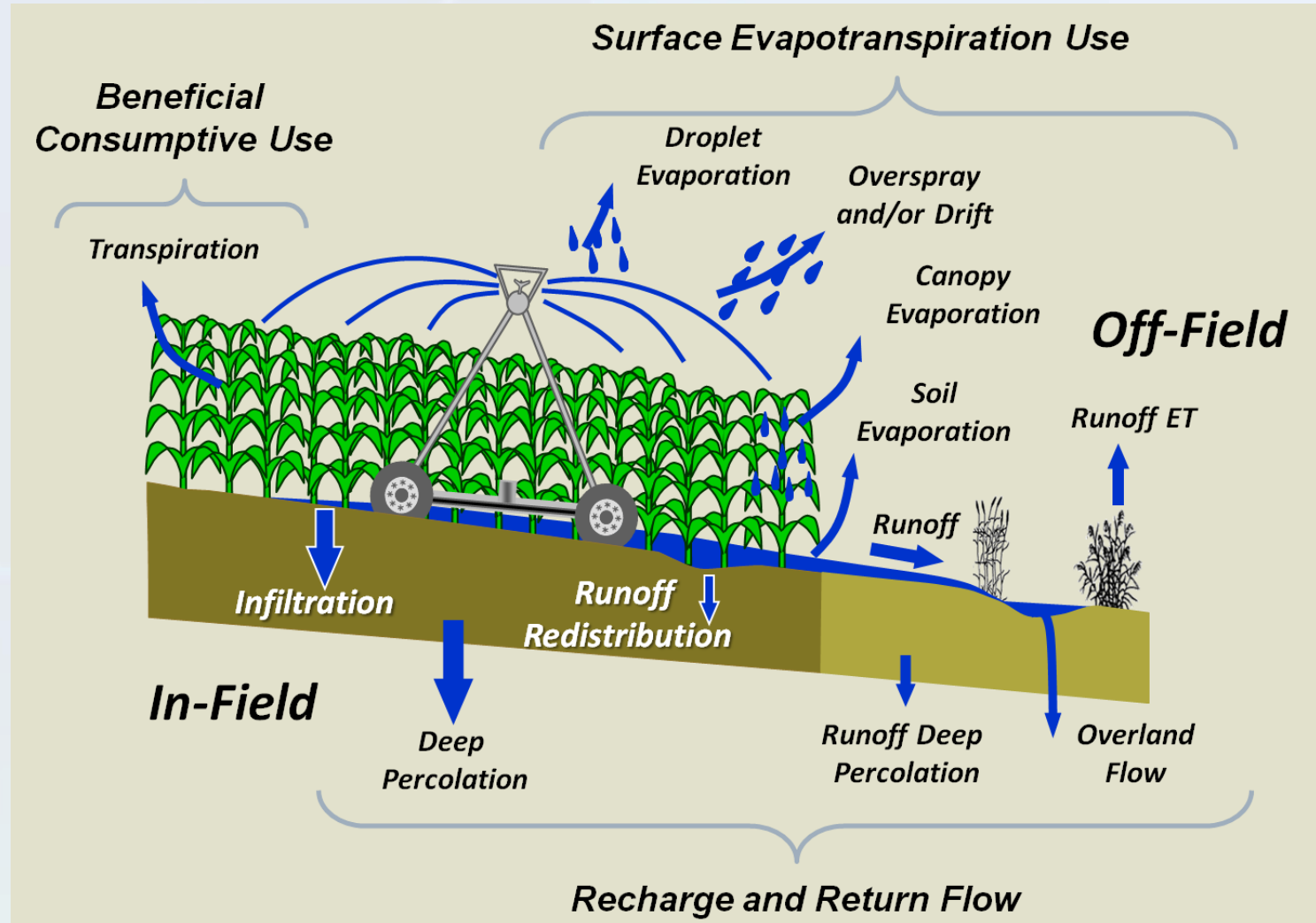


Ground Water Models Don't Do Everything

1. *Remember, are only simulating the interaction of the aquifer and the stream, and that interaction is often over simplified (i.e., one-mile grids, monthly time steps, ...).*
2. *Do not predict storm flow, only baseflow.*
3. *Often lack adequate description of the impact of land use practices in the model to truly simulate management changes over fifty years (e.g., conversion to no-till, ecofallow, different irrigation methods, canal lining, ...).*
4. *Recharge changes are all have to reflect these impacts yet it is often a calibration parameter.*
5. *Often assume instantaneous transport through the unsaturated zone while it may take a decade in some settings.*
6. *Pumpage is often defined externally rather than related to aquifer conditions.*
7. *Water use of riparian systems is overly simplified.*

Ground water model could be excellent but are still missing much of the picture

Need Better Models for Irrigated and Rainfed Fields



Where does rain and irrigation water go?

Biological Systems Engineer

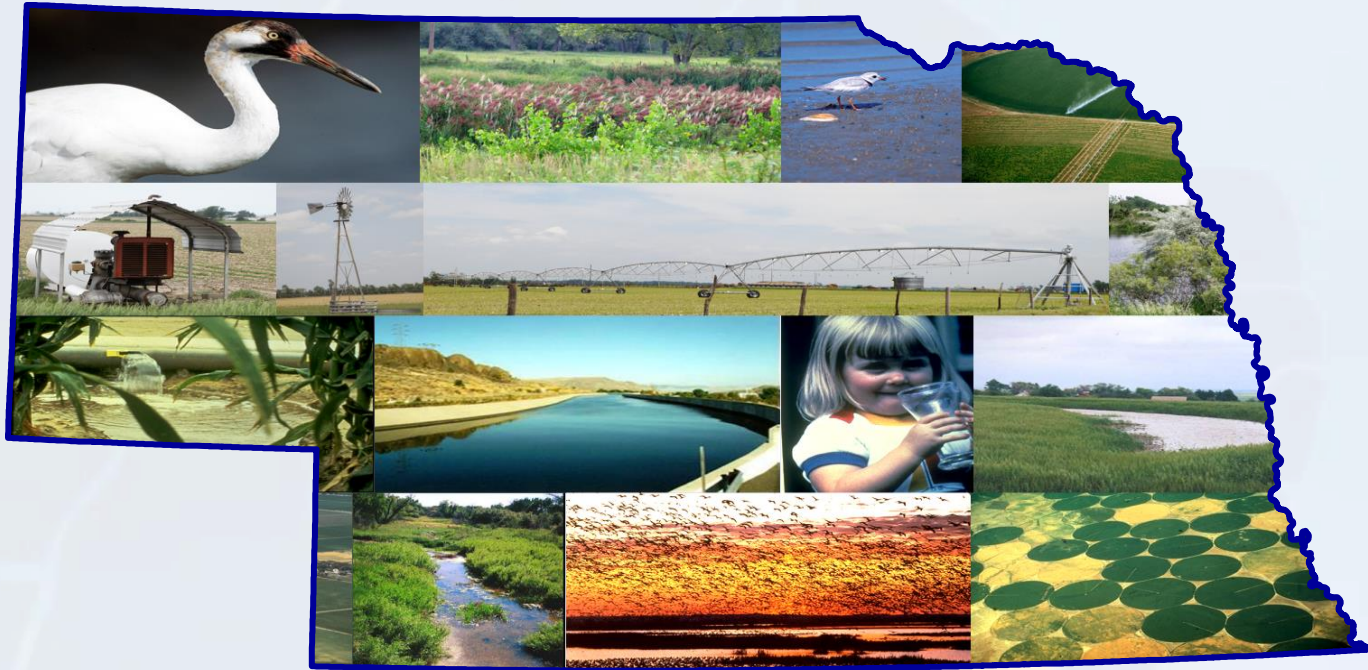
How producers manage?

Education and Management Play Key Roles

- Even with all of our science and technology, we are falling way short of our current potential.
- How do we improve adoption of BMPs?
- How can we attain potential efficiency of irrigation and water management systems.



Water Management : becoming very complex



- ***Need Adaptive Management and Systems***
- ***Can't do the same thing & expect different results***



OBRIGADO