# The Office of Cyber and Infrastructure Analysis
# National Protection and Programs Directorate

SAND2016-9559PE

## National Infrastructure Simulation and Analysis Center

## *High Plains Resource Risk and Economic Impacts in New Mexico, Oklahoma, and Texas*

Online Webinar

June 25, 2016

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# High Plains Resource Risk and Economic Impacts in New Mexico, Oklahoma, and Texas

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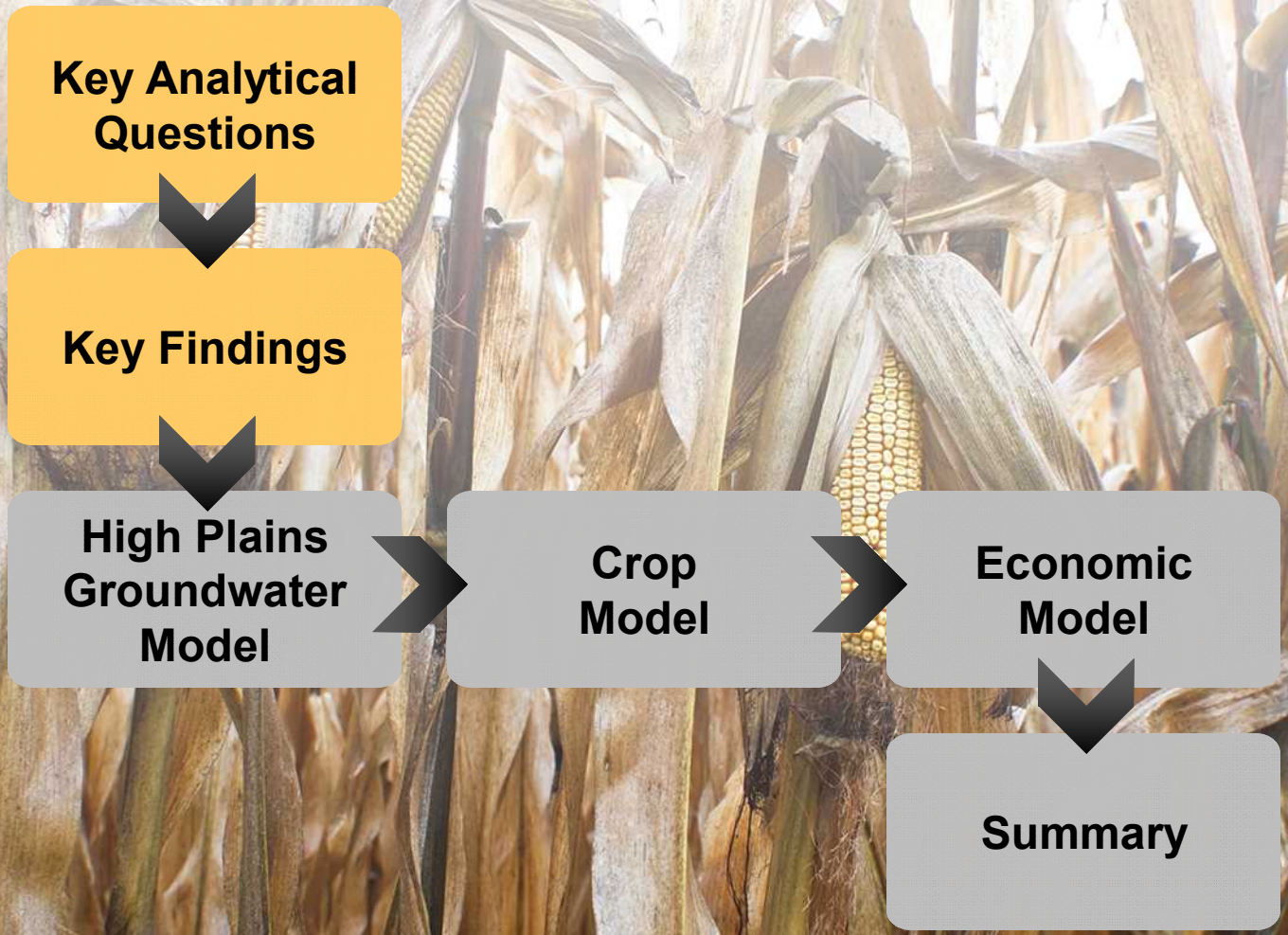
# High Plain Resource Risk Topics

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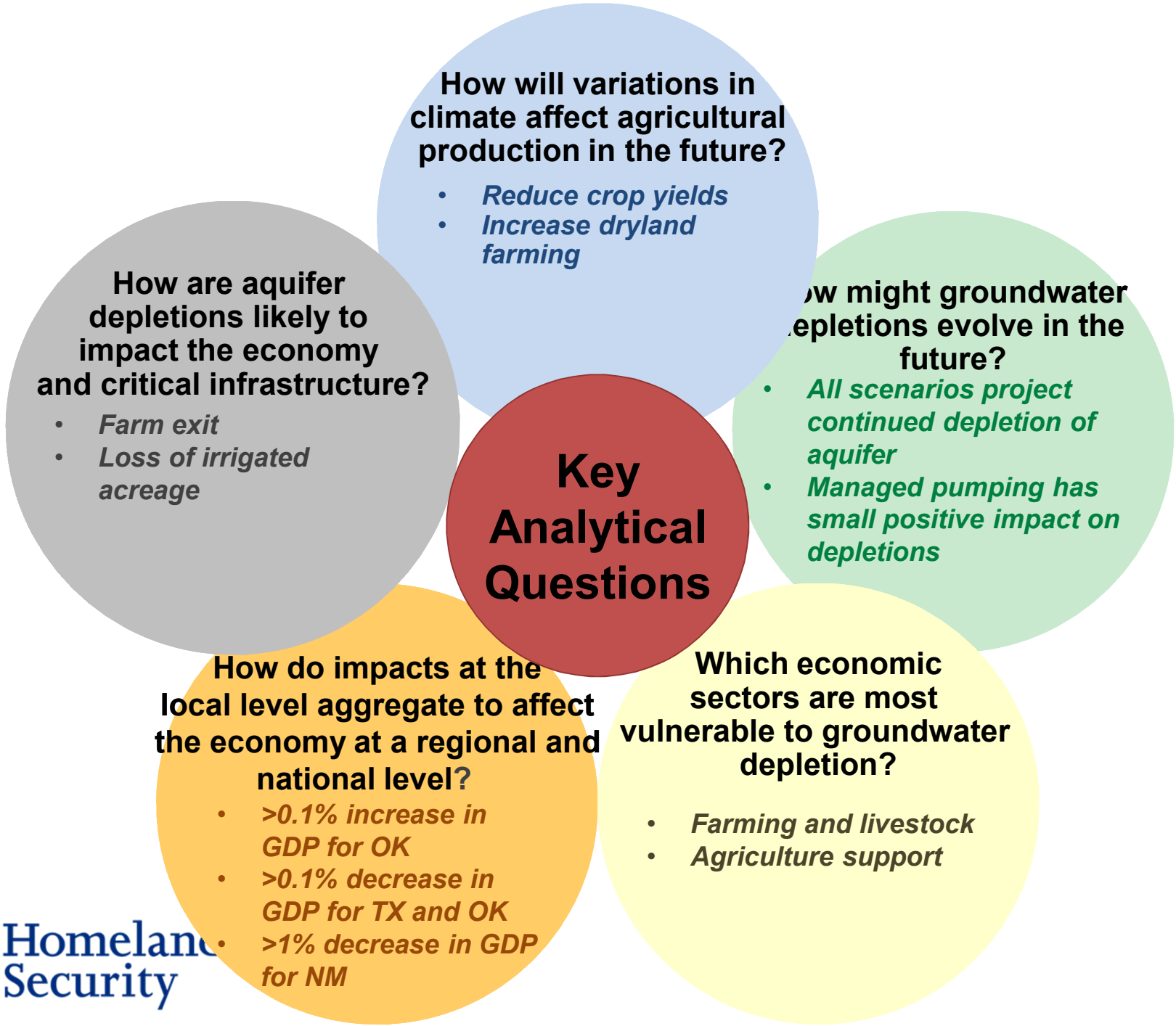


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# Key Findings

- Modeled climate projections suggest irrigated crop yields could decrease by 29 to 37 percent (all other factors assumed constant)
- Groundwater depletions are projected to continue albeit at a lesser extent under the managed groundwater scenario (according to state water plans) relative to business as usual.
- Prolific agricultural and livestock production rely heavily on groundwater pumping from the High Plains Aquifer, putting these sectors at economic risk to groundwater depletions
- Micro-economic analyses indicate that increased temperatures combined with groundwater decline augment the likelihood of farm exits. The likelihood of farm exits is lower for farm operations in Oklahoma than in New Mexico or Texas, due to non-climate related factors
- For each year of the macroeconomic analysis, projections are that Oklahoma experiences a slight increase in state gross domestic product of close to one-tenth of a percent, New Mexico has less than a one-percent decrease, and Texas has less than a tenth of one-percent decrease.

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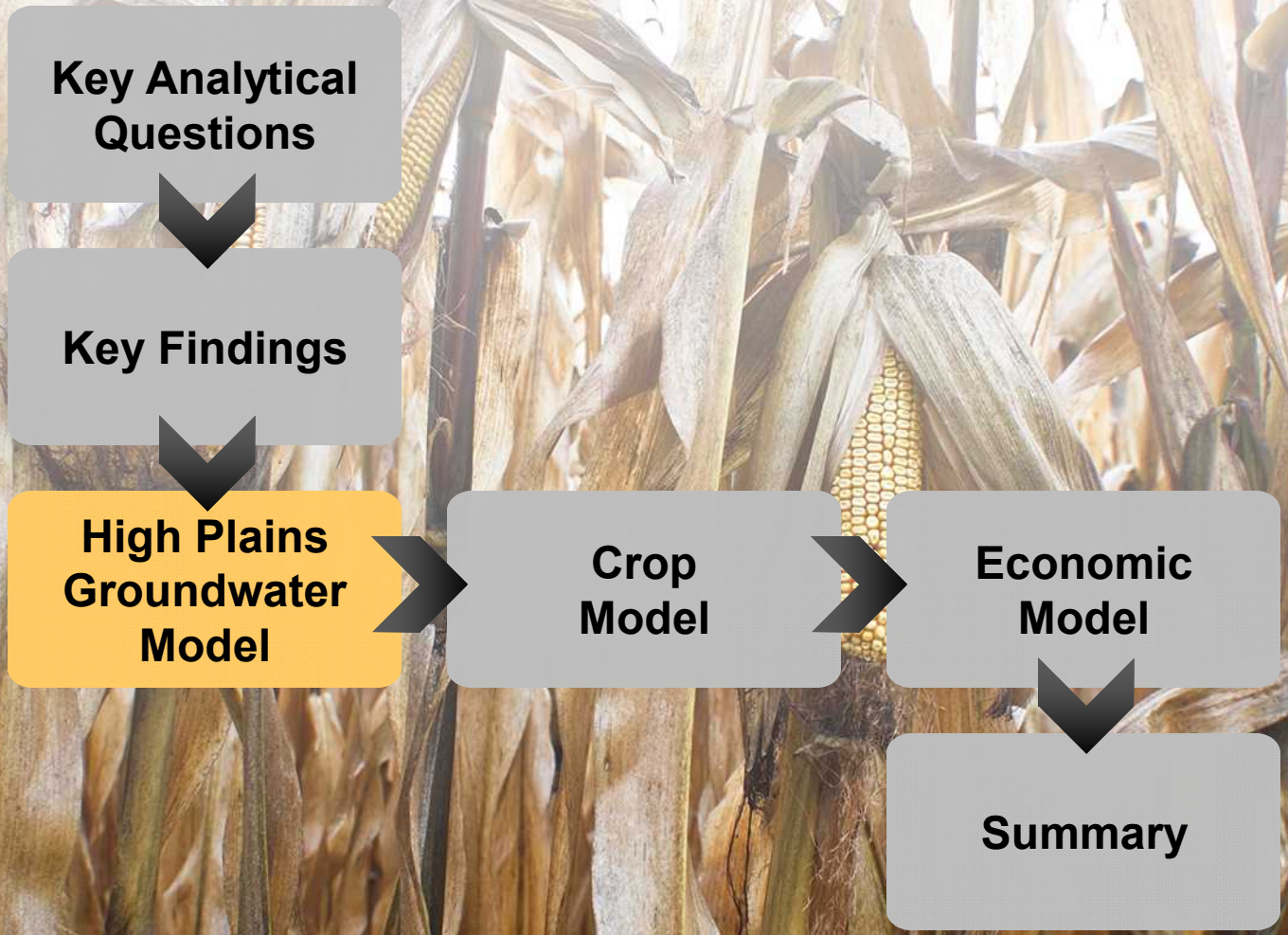
# High Plain Resource Risk Topics

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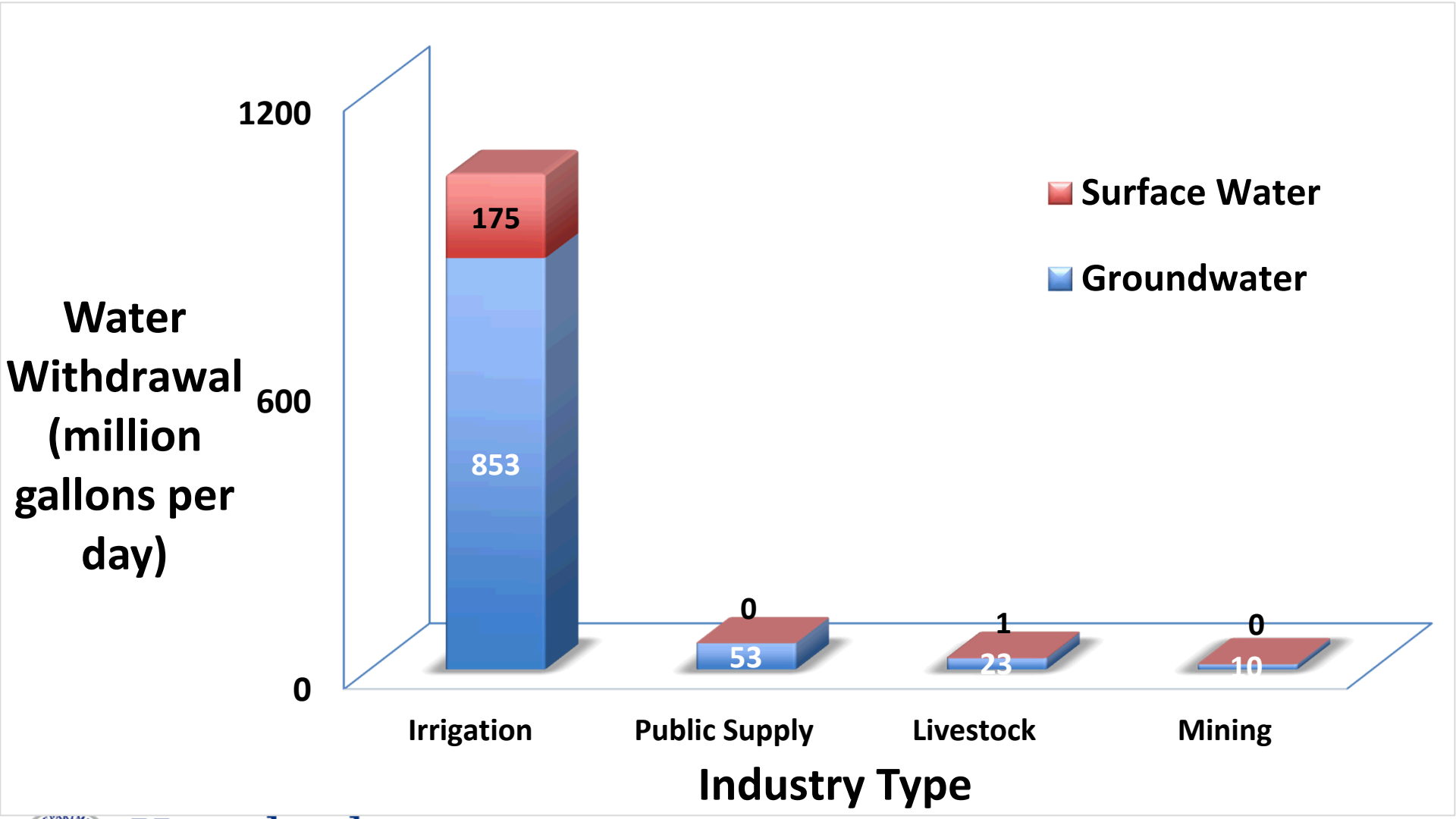
# New Mexico: Agriculture is the Largest Water User

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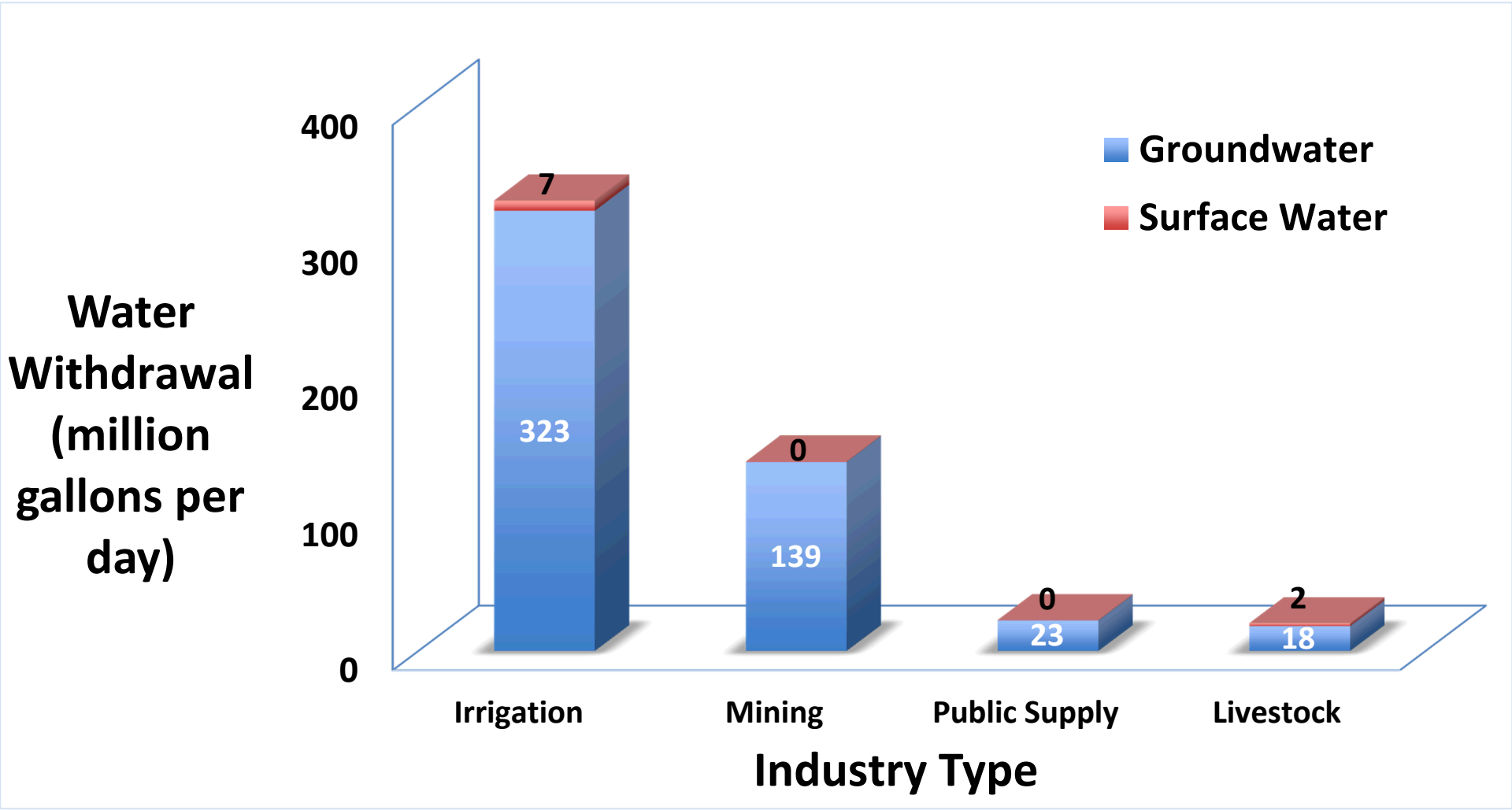
# Oklahoma: Agriculture is the Largest Water User

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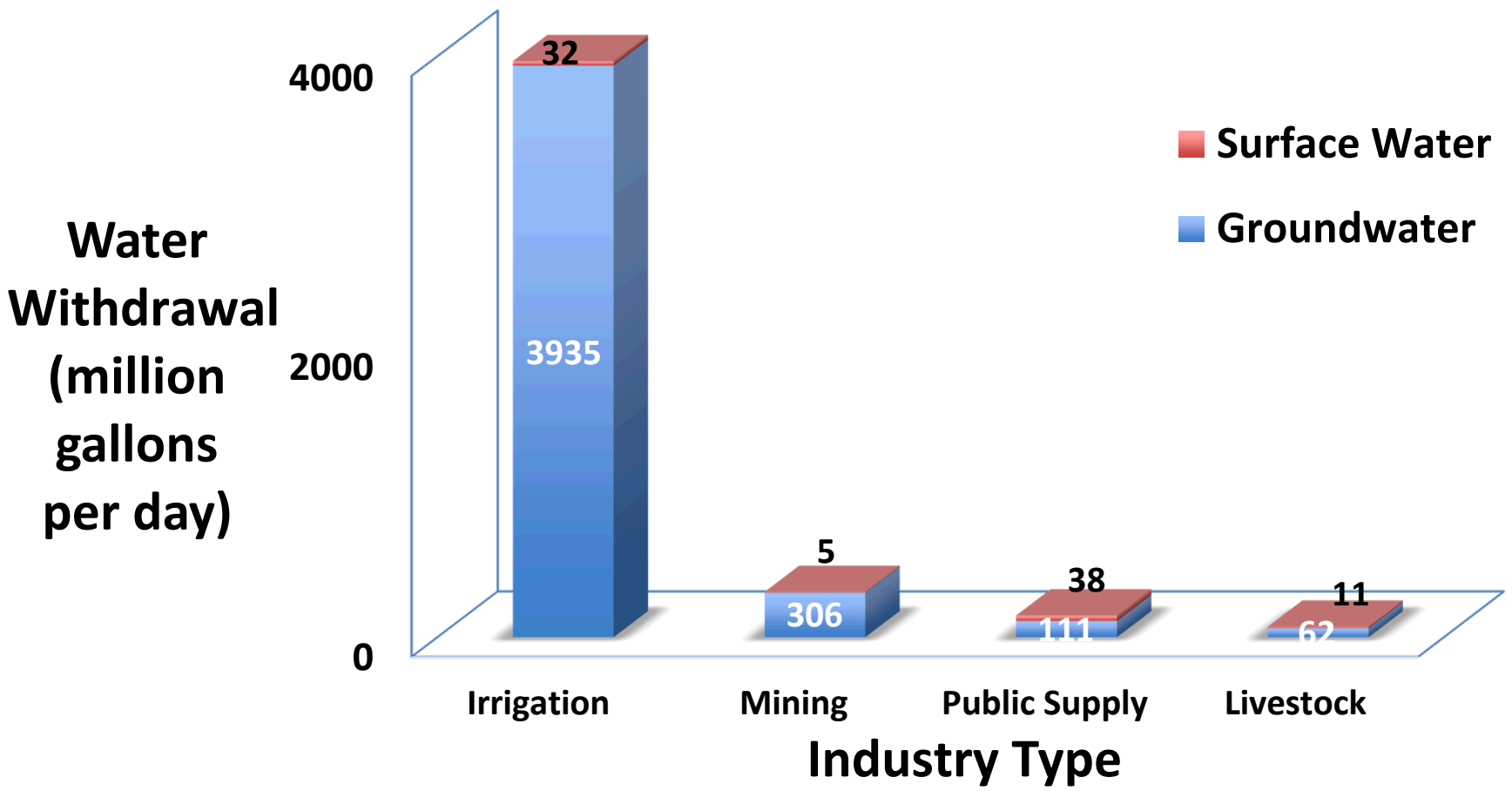
# Texas: Agriculture is the Largest Water User

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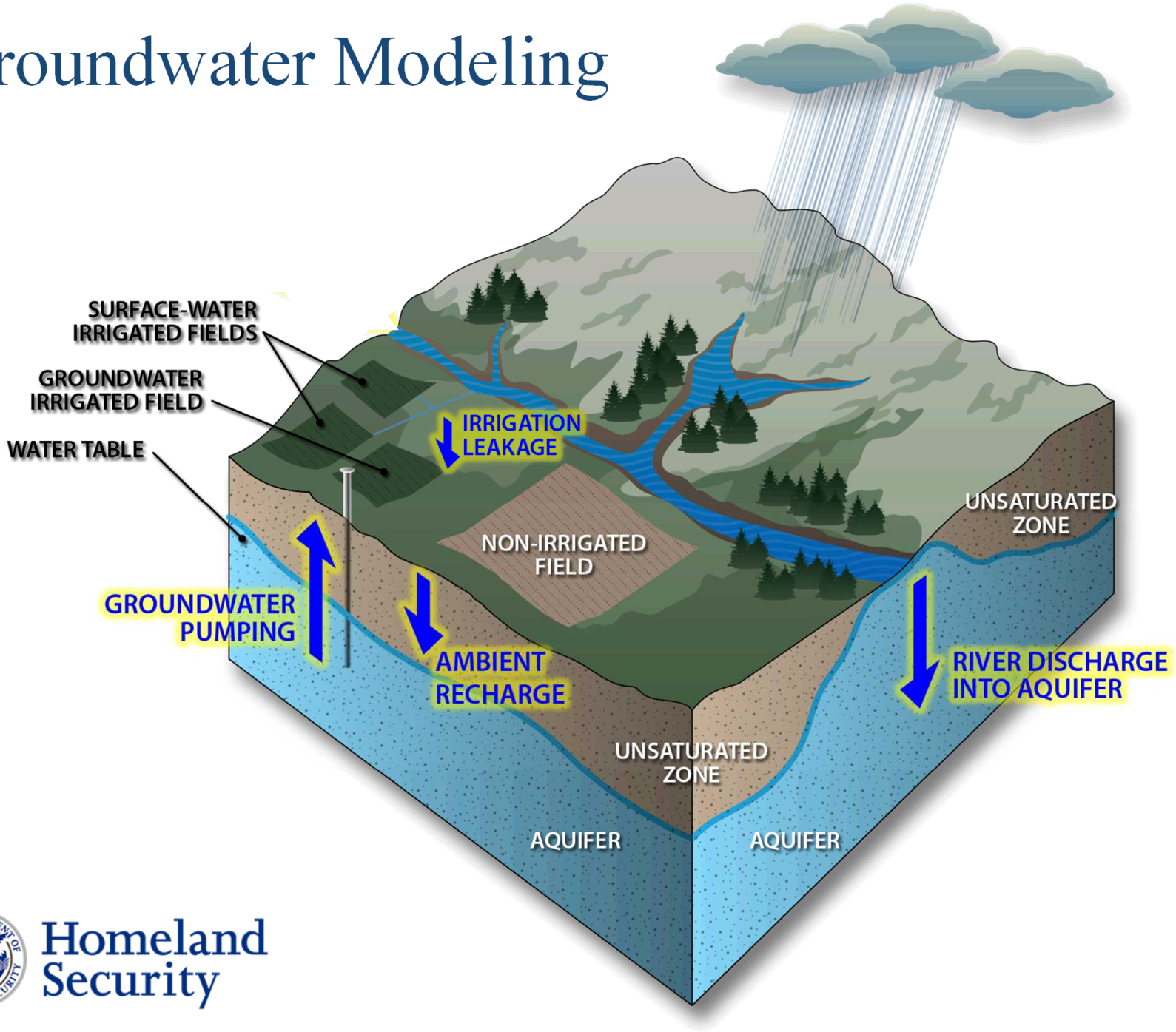
# Groundwater Modeling

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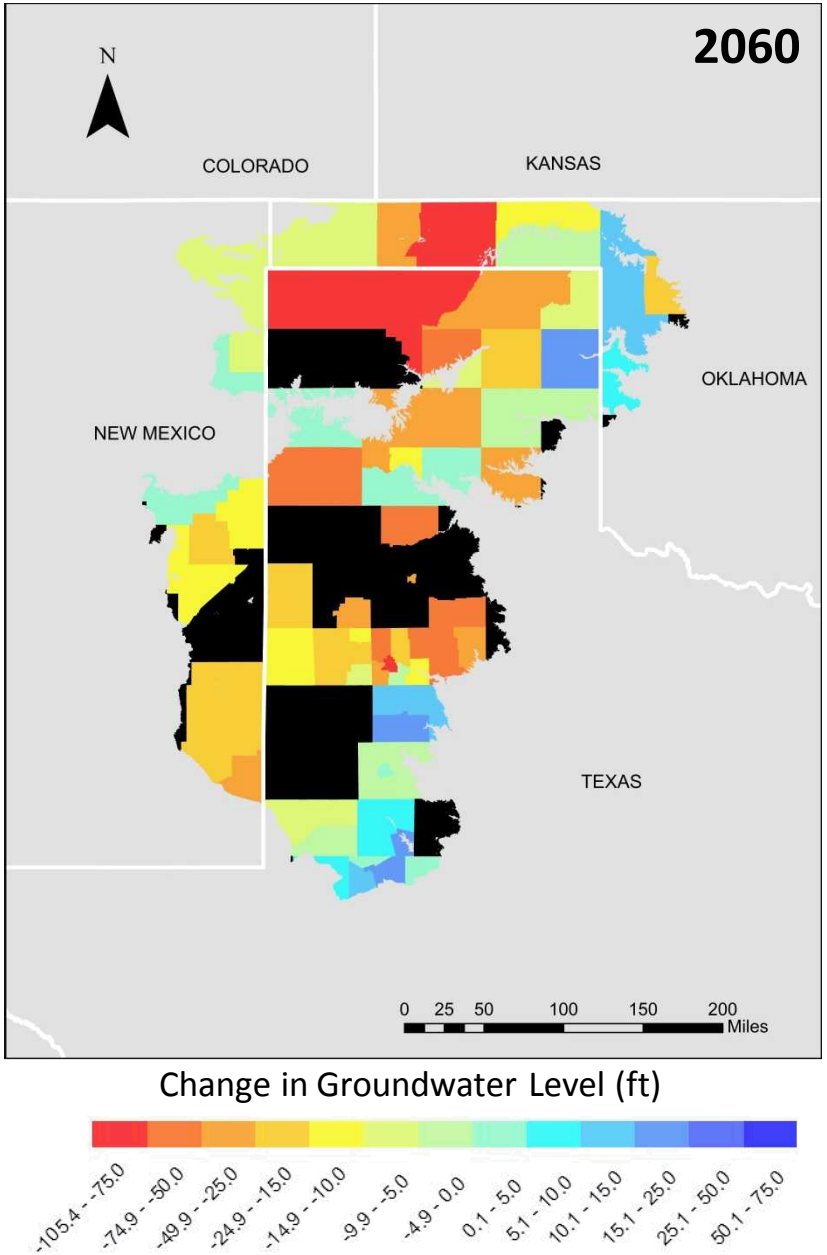
# Projected Groundwater Depletions 2010-2060

- 16 census tract regions, mostly located around the margins of the aquifer, experience groundwater supply exhaustion by 2060 (areas marked in black)
- 57 of the remaining 82 census tracts experience continued groundwater level declines, averaging over 18 feet (maximum of 61 feet)

## Scenario 1: Pumping Rates Maintained at 2010 Withdrawals

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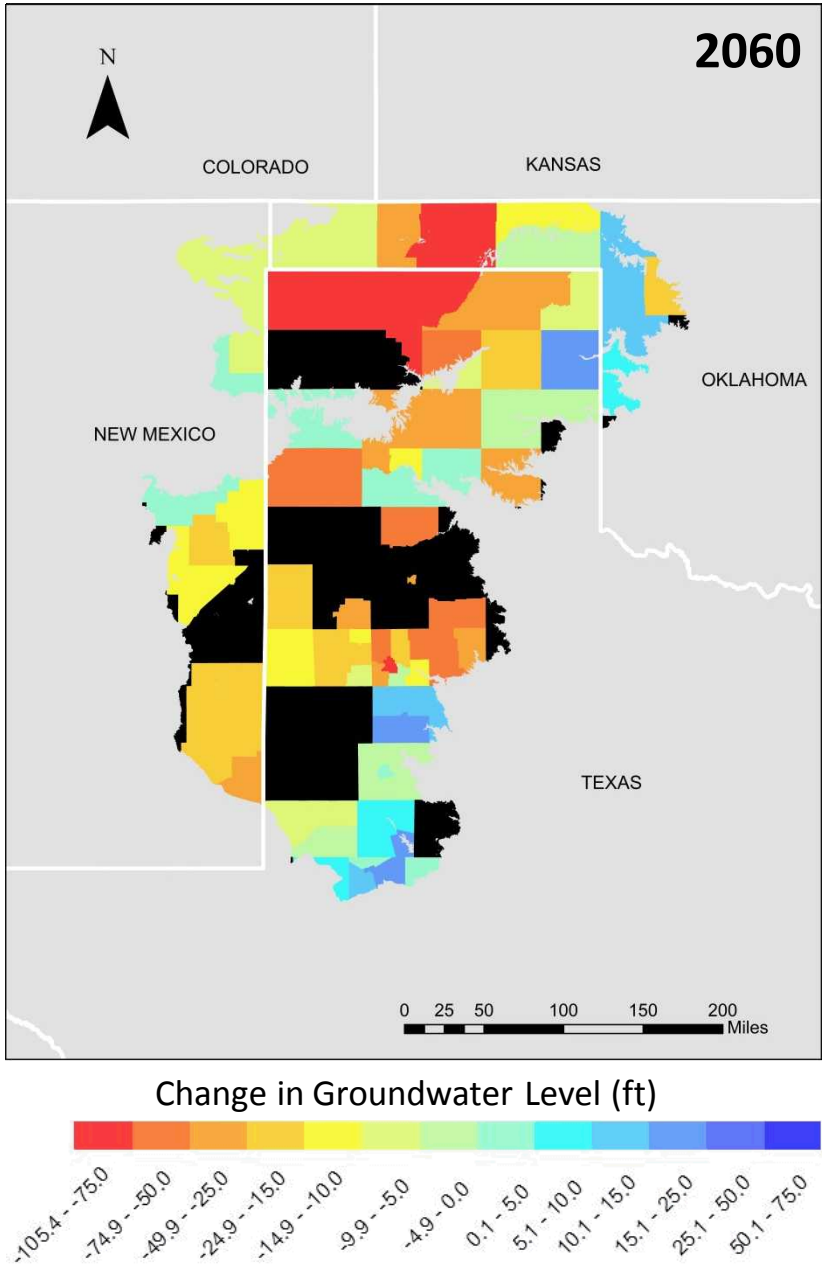
# Projected Groundwater Depletions 2010-2060

- 16 census tracts experience groundwater supply exhaustion by 2060 (areas marked in black)
- 41 of the remaining 82 census tracts experience continued groundwater level declines, averaging 19 feet (maximum of 56 feet)

## Scenario 2: Pumping According to Each State's Water Management Plan

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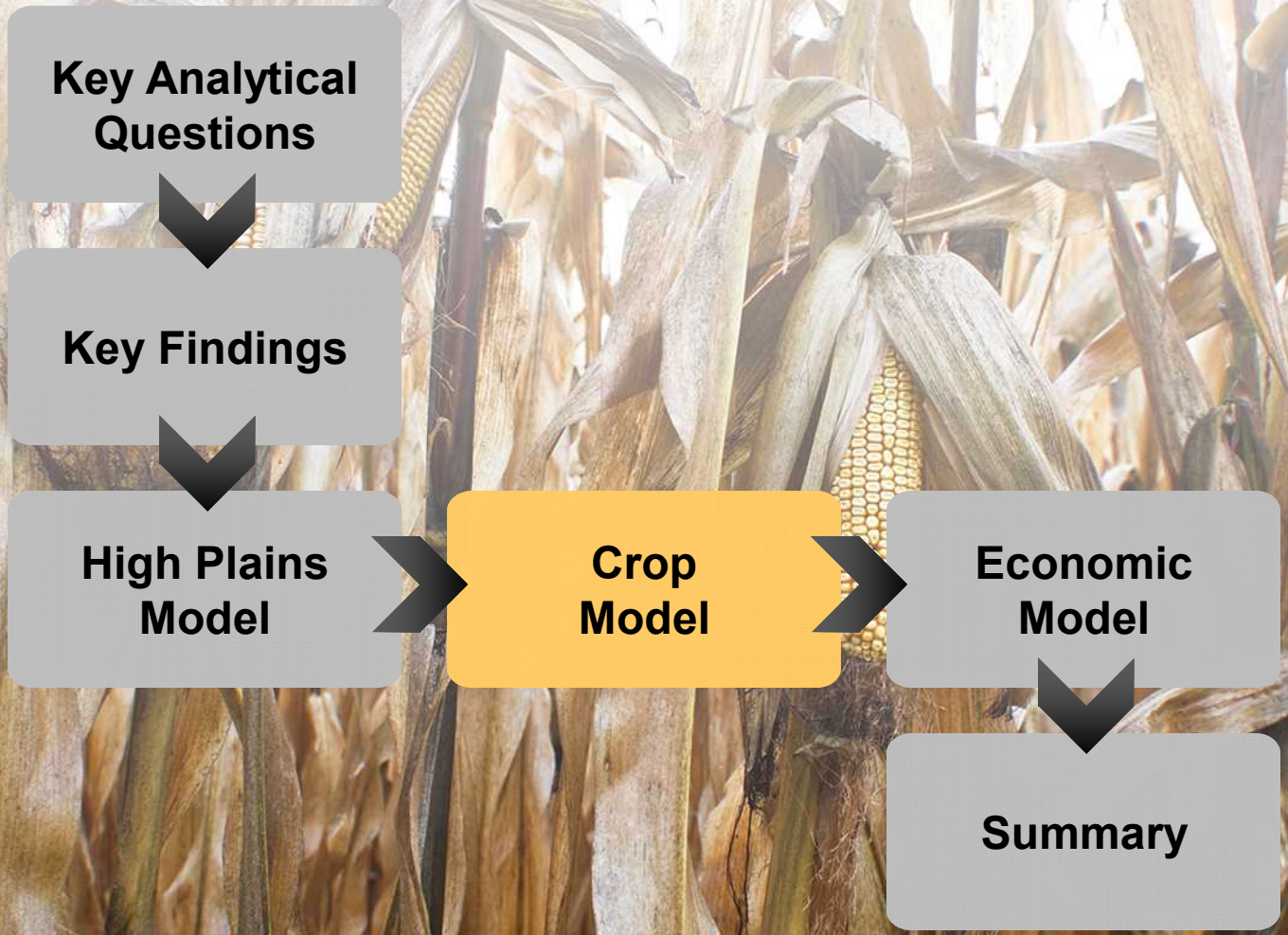
# High Plain Resource Risk Topics

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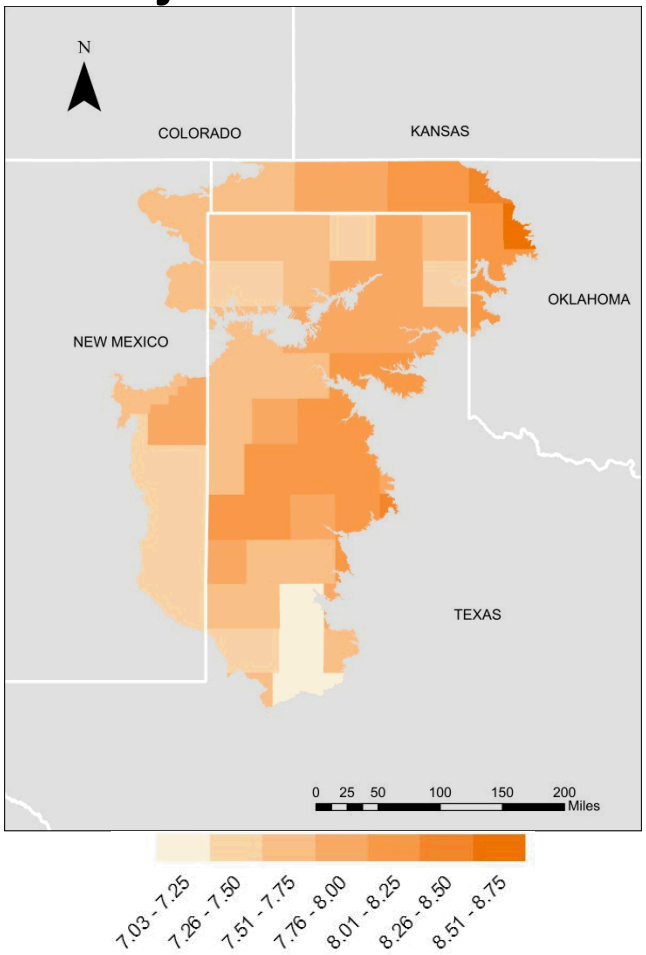
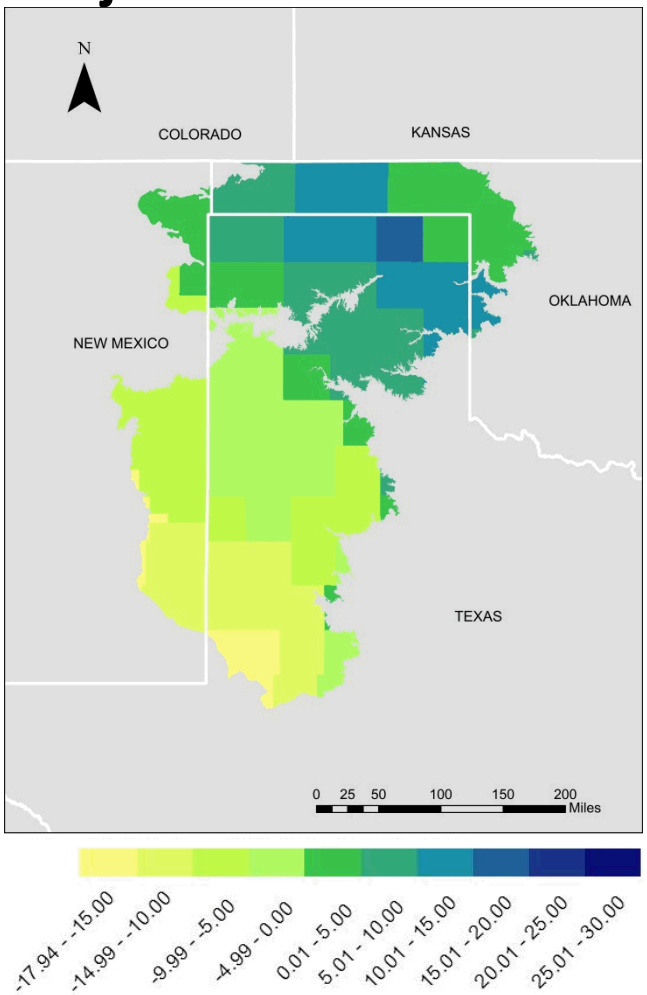
# Climate Modeling Overview

## Max Temperature Change Projections 2010-2060

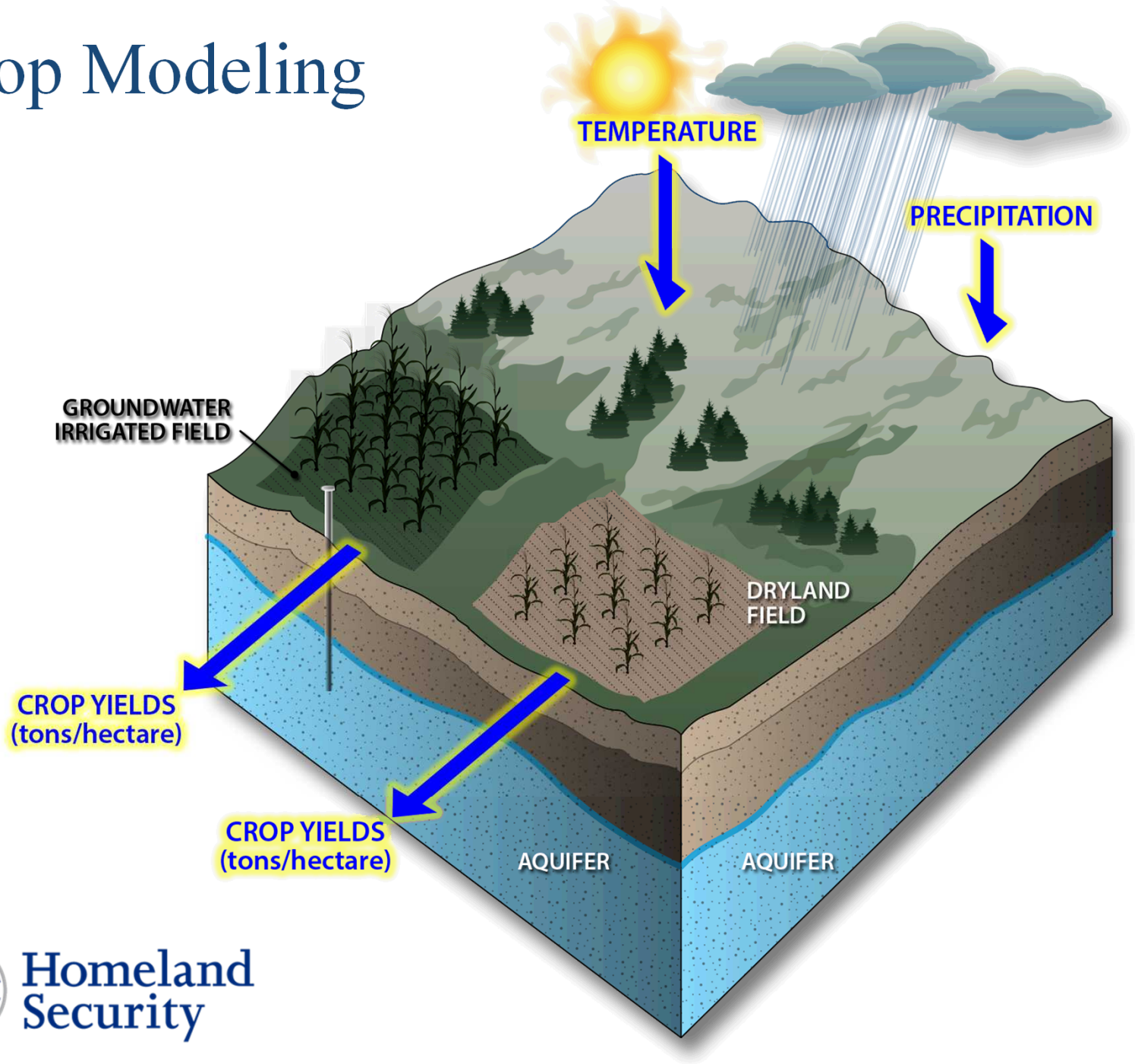



## Precipitation Change Projections 2010-2060




- Data taken from National Oceanic and Atmospheric Administration's National Climatic Data Center
- Utilized the Geophysical Fluid Dynamics Laboratory Coupled Model 3 GFDL-CM3, assuming Relative Concentration Pathway 8.5.

# Crop Modeling

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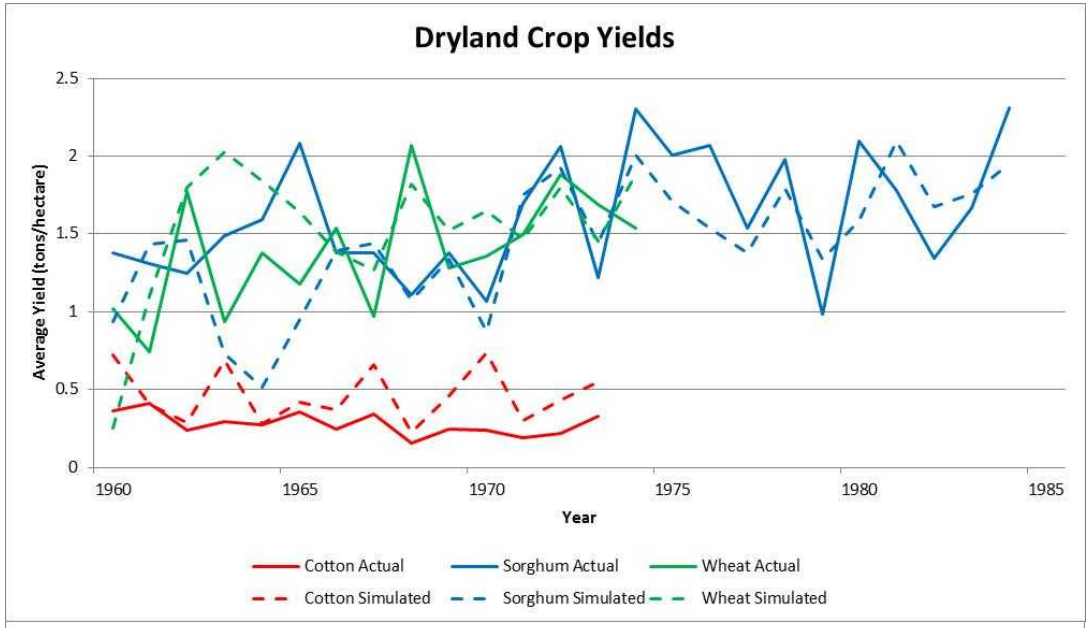
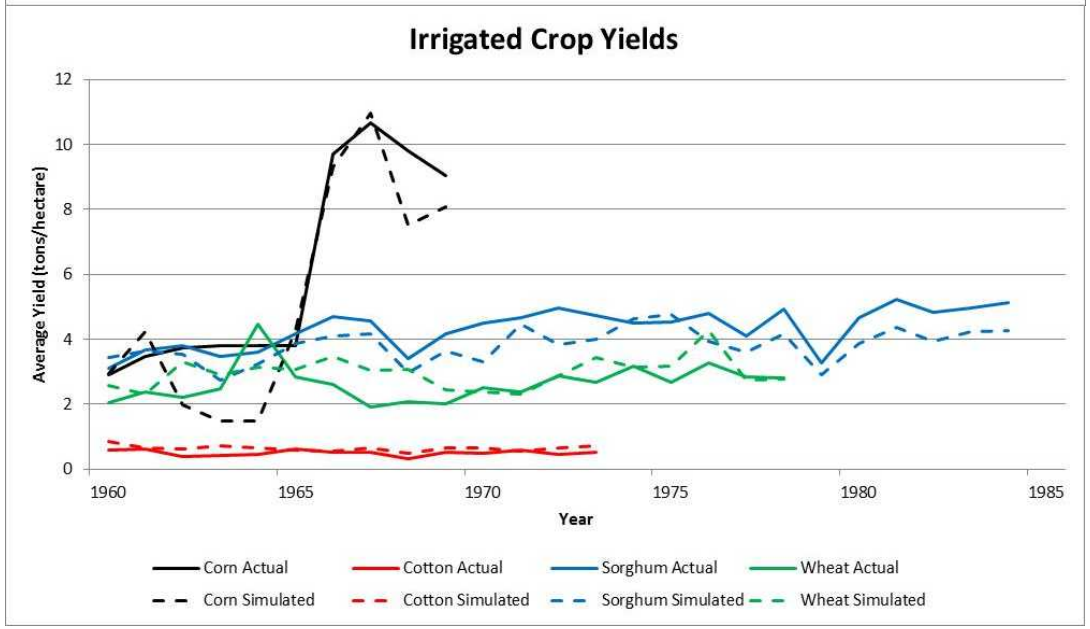
# Crop Modeling Overview



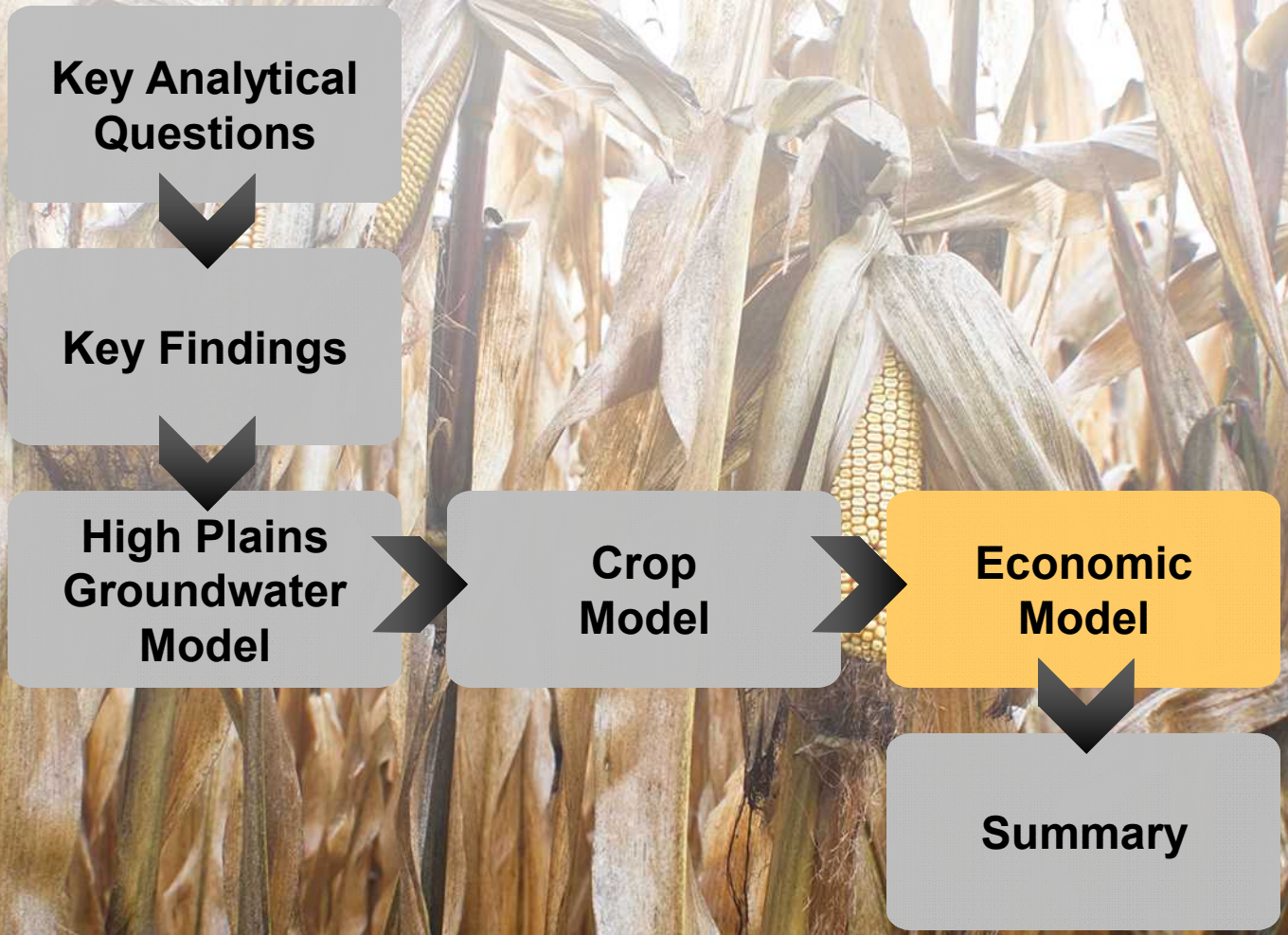

- **Environmental Policy Integrated Climate (EPIC) model calibrated to historic yields over 25-year period**
  - **Corn**
  - **Cotton**
  - **Sorghum**
  - **Wheat**
- **Considered differences between dryland and irrigated practices**
- **Aggregate results over four representative counties across FEMA Region VI**

## Projected Impacts to Crop Yields by 2060

| | Reduction in Irrigated Crop Yields (percent) | Reduction in Dryland Crop Yields (percent) |
|---|---|---|
| Corn | 29-37 | 25-35 |
| Grain Sourgum | 22-32 | 24-33 |
| Cotton | 22-30 | 20-29 |
| Winter Wheat | 3-4 | 9-11 |

*Assumes no improvement in farming practice or technology to mitigate impacts*

# High Plain Resource Risk Topics

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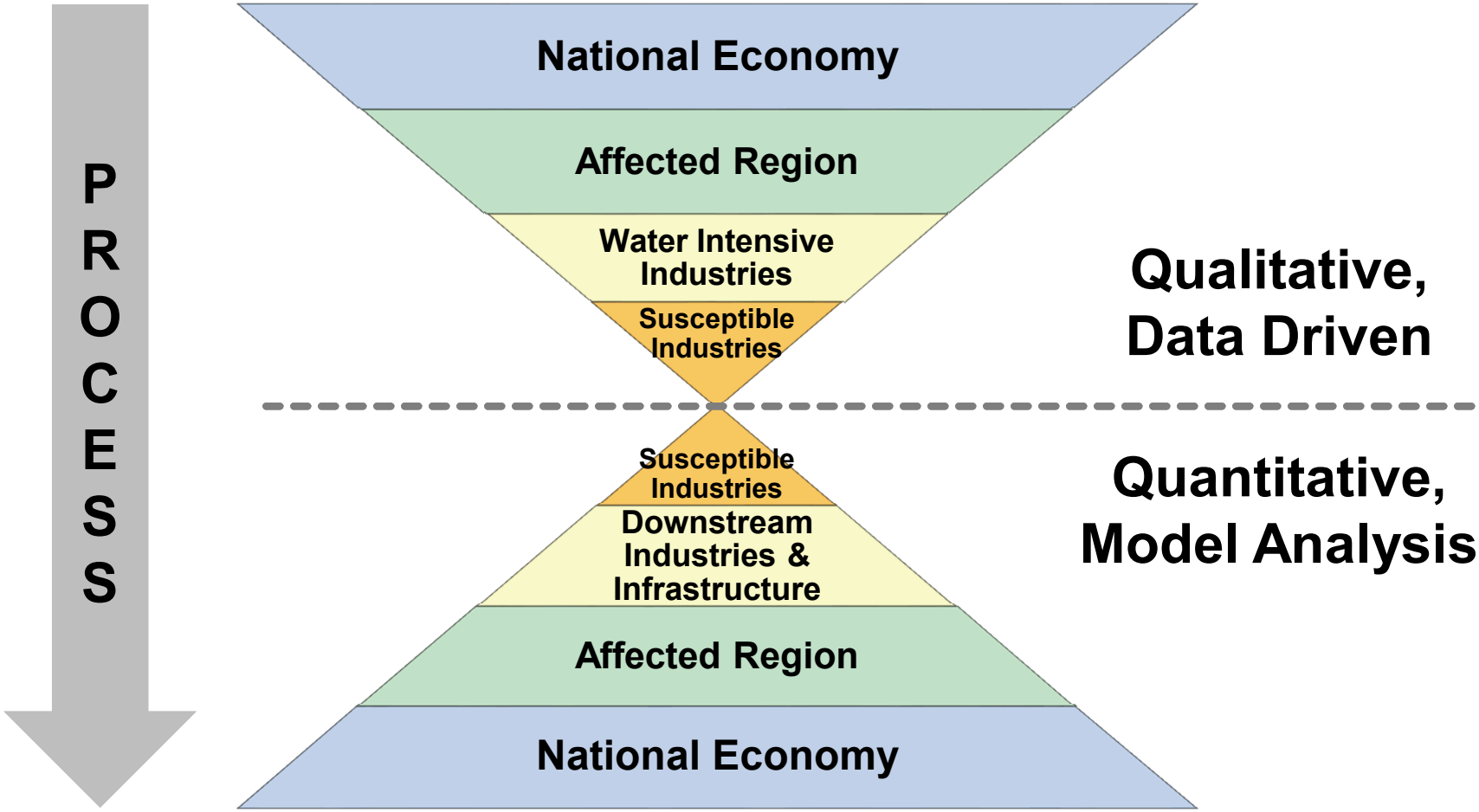
# Economic Modeling

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# Economic Model: Market Participation

## PREVIOUS RESEARCH

- Characteristics contributing to exit in farm industry
- Farm and farm operator attributes:
  - Age of operator
  - Size of farm
  - Farm specialty
- Hoppe and Korb, 2006

## NISAC RESEARCH

- Additional characteristics of concern for High Plains Aquifer:
  - Irrigation
  - Irrigation costs
  - Depth to groundwater
- Results: 1 ft of drawdown in the aquifer increases the probability of exit by 0.9%

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# Economics: Scenario Description

| State Name | Current Pumping (percent) | | Managed Pumping (percent) | |
|---|---|---|---|---|
| | 2012–2030 | 2012–2060 | 2012–2030 | 2012–2060 |
| New Mexico | -31 | -55 | -32 | -56 |
| Oklahoma | 19 | 86 | 20 | 94 |
| Texas | -49 | -78 | -49 | -77 |

- **Farm Proprietor Income Adjusted**: *Decrease in market participation (farm exit).* Micro-econometric empirical model estimates marginal effect of increased utility (energy) costs on farm exit

- The table presents the projected percentage change in the number of farm operations for FEMA Region VI from the econometric model

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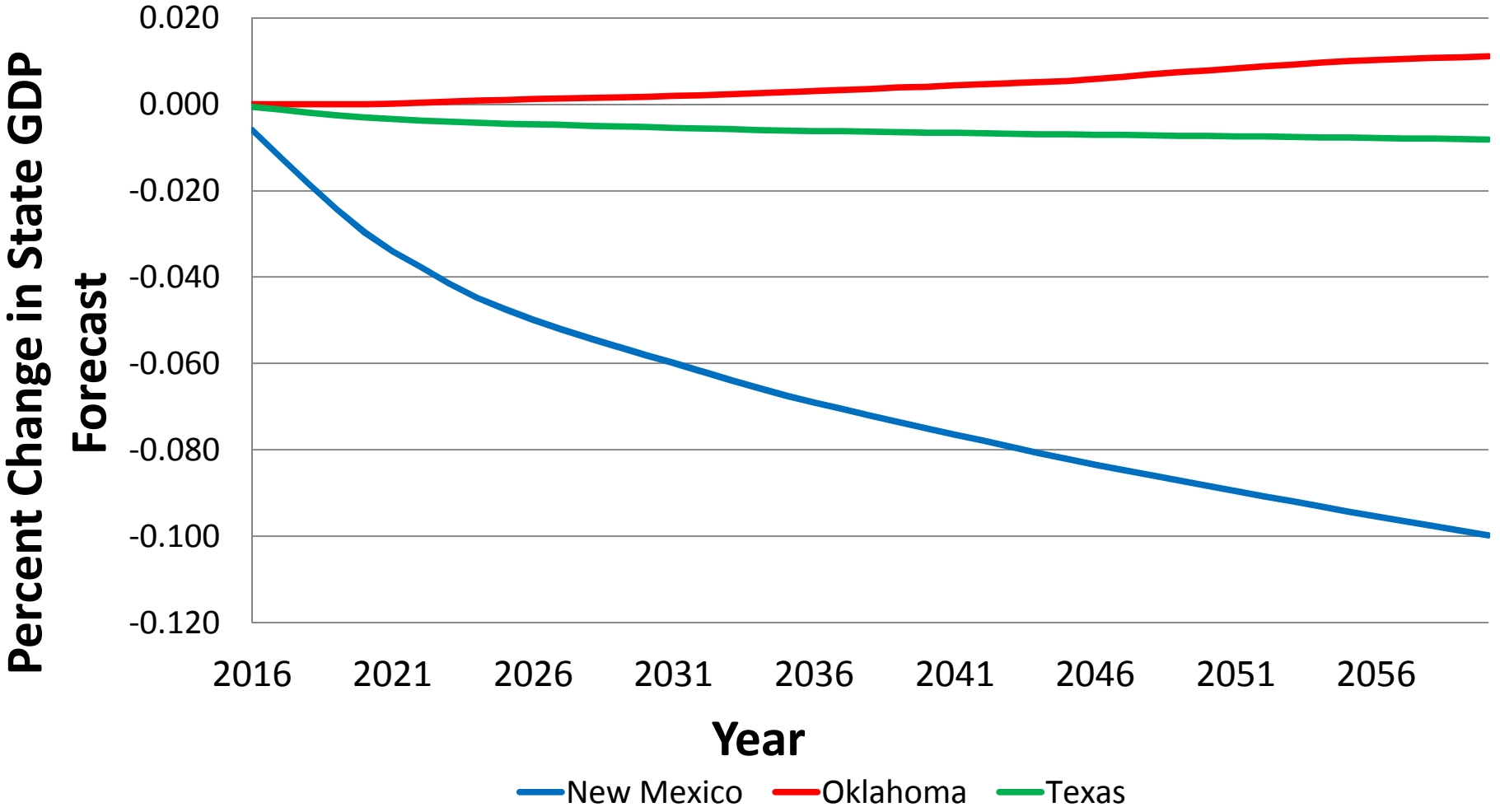
# Scenario 1: State GDP Growth Forecast, Pumping Rates Maintained at 2010 Withdrawals

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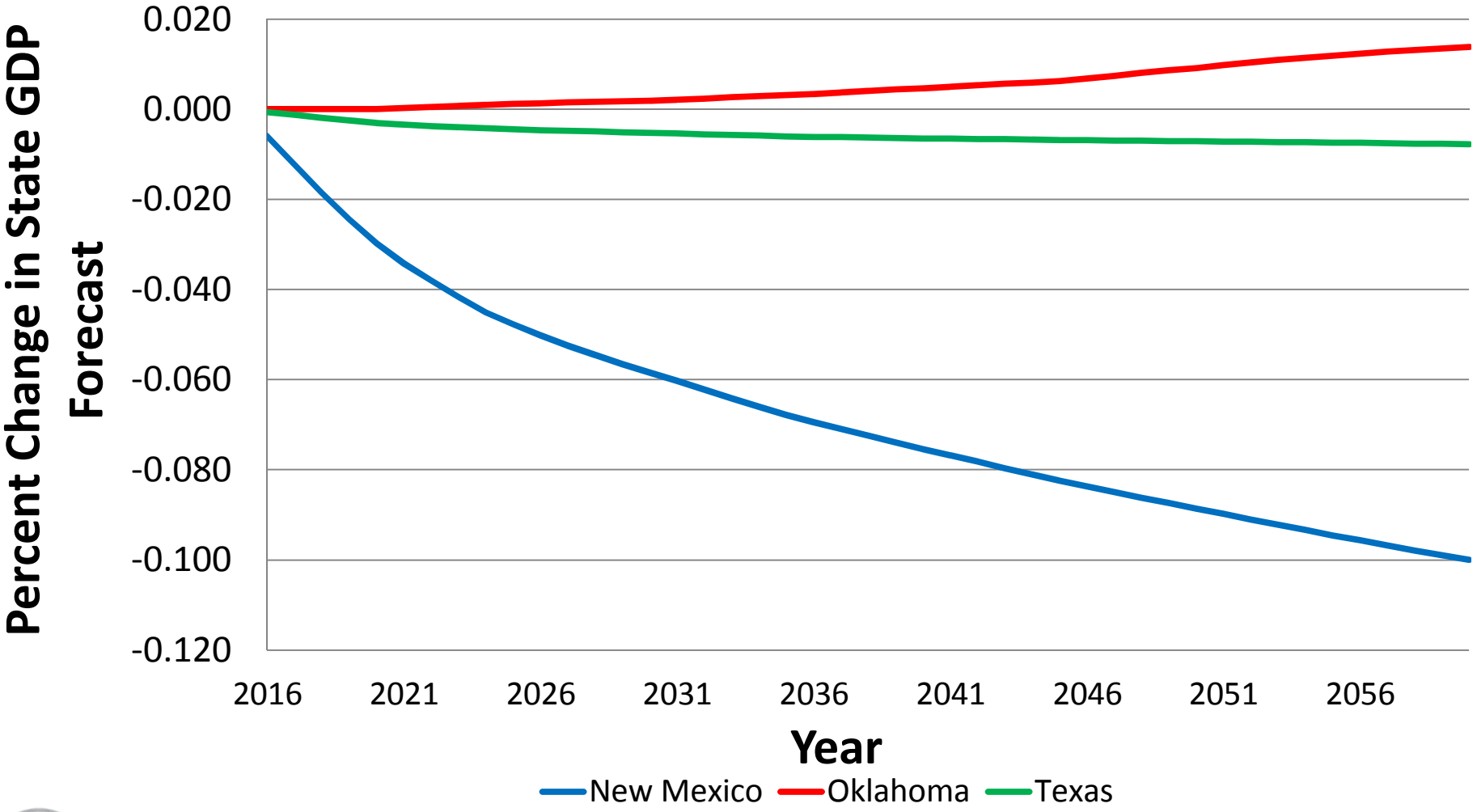
# Scenario 1: State GDP Growth Forecast, Pumping According to Each State's Water Management Plan

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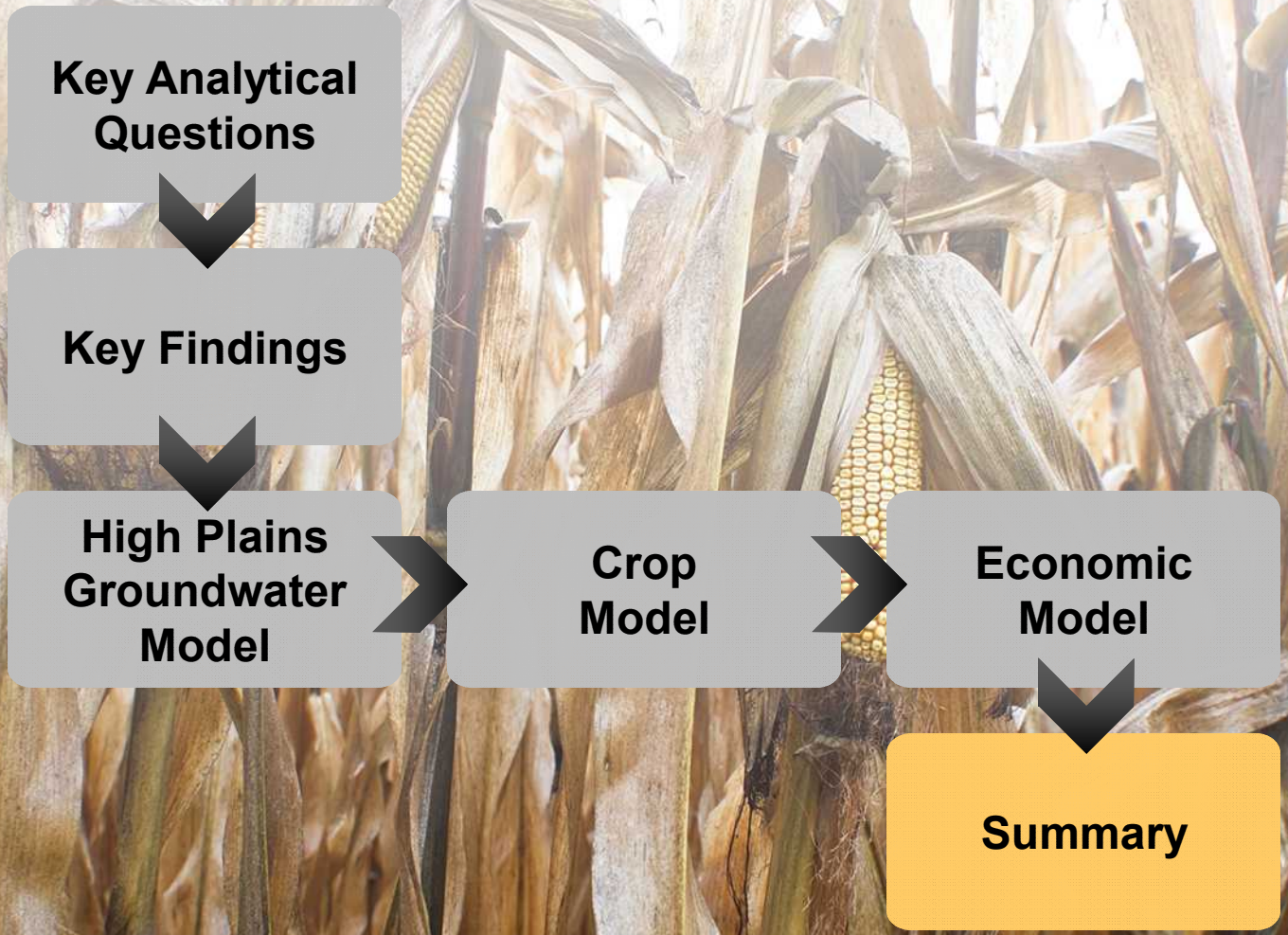


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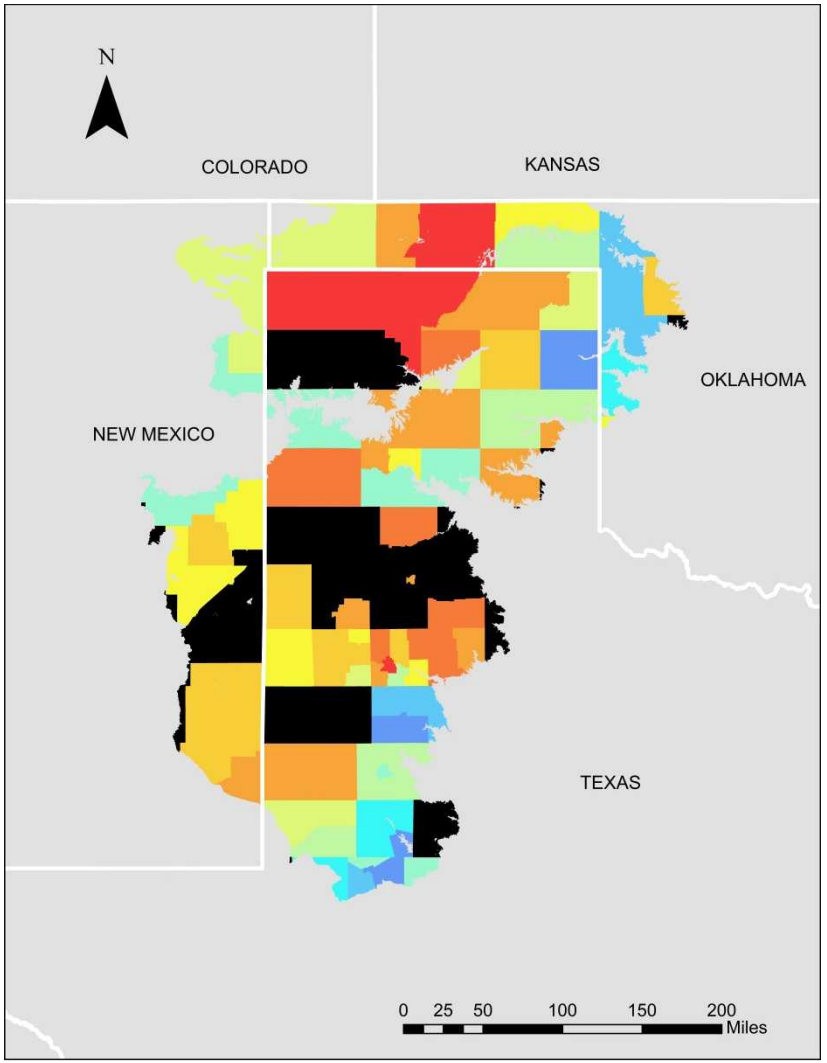
# Summary

- **Climate projections impose a downward trend on crop yields**
  - **Historically, climate-related impacts on agriculture have been overcome by innovations, including irrigation**
  - **Declining water levels are likely to limit such adjustments in the future**
- **Current pumping rates are not sustainable in many counties**
- **1 ft of drawdown in the aquifer increases the probability of exit by 0.9%**
- **Pumping according to each state's water management plan**
  - **Leads to at most a 0.1 percent decrease in State GDP over 50 years for New Mexico**
  - **Less than 0.1 percent decrease in State GDP over 50 years for Texas**

## Pumping Induced Groundwater Depletions

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For more information visit:
www.dhs.gov/criticalinfrastructure

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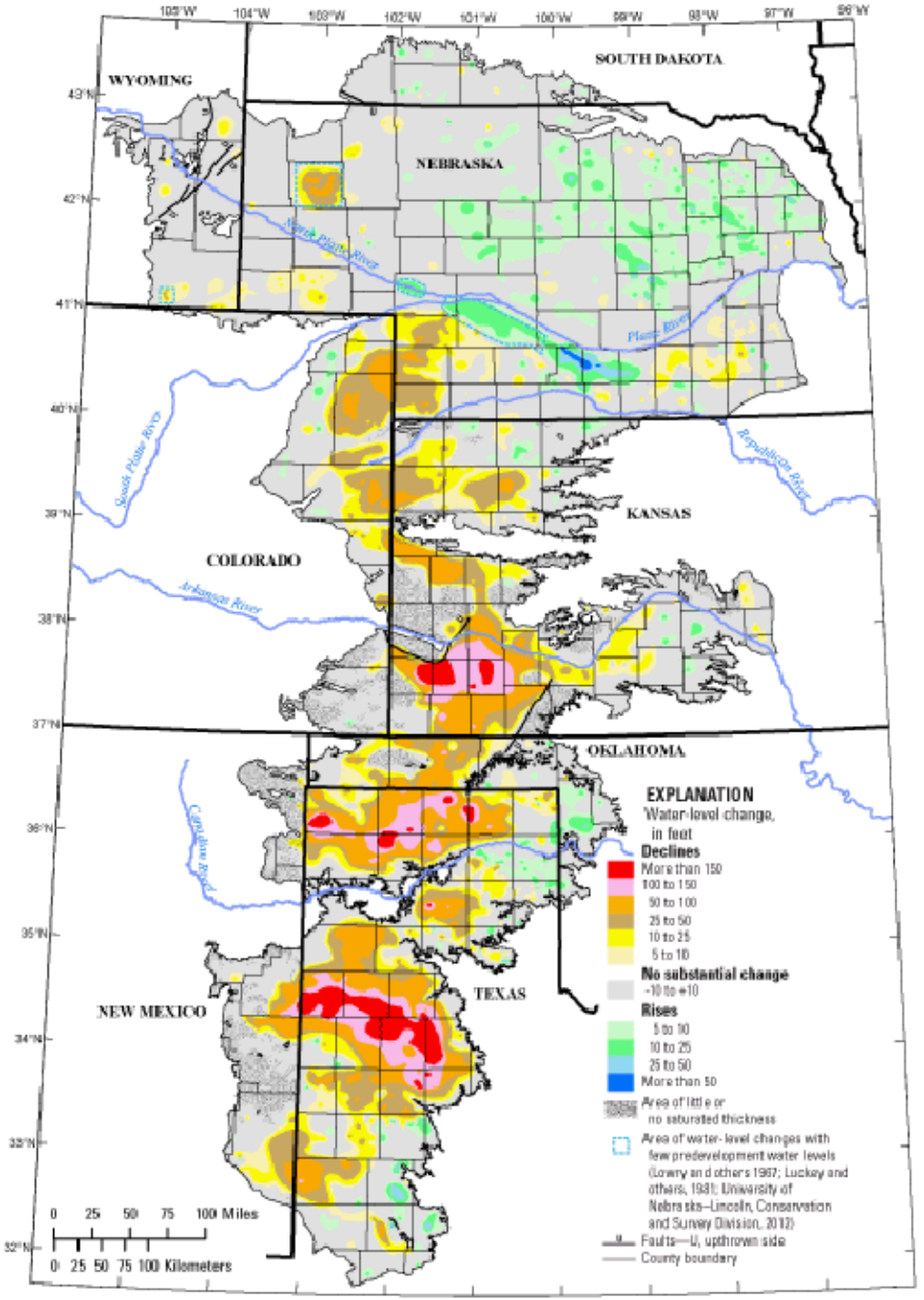
# Groundwater Level Decline: Predevelopment to 2011 (USGS)

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# Census of Agriculture Data

- Data from surveys starting with 1982 to 2012
  - Data from 1978 is available. but limited; observations are missing
  - Transition from Census to the USDA and the paper to electronic transition
- Starting with the 2002-2012 Survey
  - 37 Sections, 158 questions
- The 1982-1997 Survey contained more questions and sections
- Ogallala County Data
  - 308,126 observations representing 76,057 unique farm operations
- Farm Characteristics Evaluated (summary representation)
  - Year farm operation began
  - Total value of production
  - Type of operation
    - Beef or hog, Crop or grain, or cash crops
  - Expenditure on fuels and oil
  - Expenditure on utilities
  - Loans received
  - Irrigated land harvested
  - Total acres harvested
  - Cattle by weight or dairy
  - Hours worked off farm

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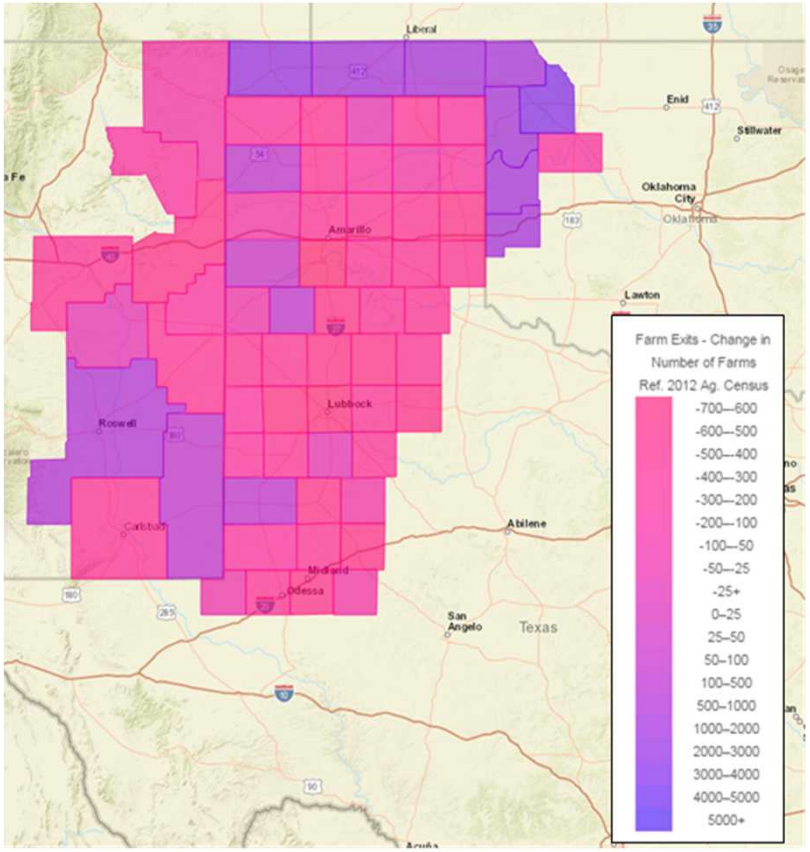
# Methodology and Mathematical Model

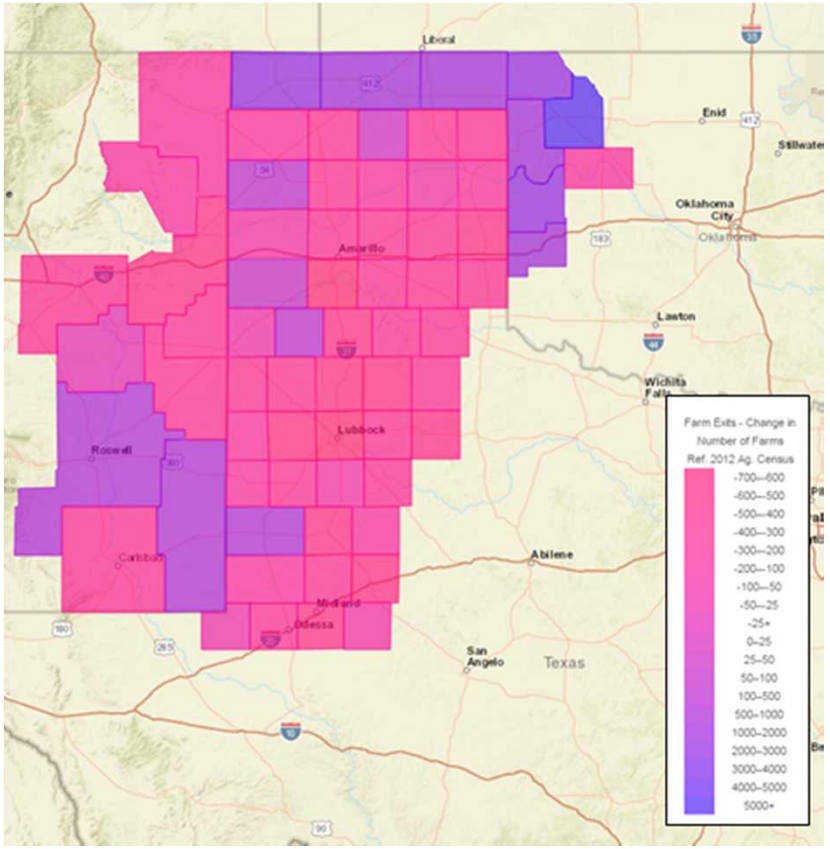
- A random effects logistical regression model is used to estimate annual exit probabilities for farm operations
  - Random effects approach accounts for variability in longitudinal data for of single farm operation
    - Longitudinal data have the potential to bias the results
    - Random-effects error term corrects the bias
  - The probability of farm exit is estimated using a logistic regression model
    - The annual probability of exit is a vector of farm- and time-specific water costs and farm operation and farm-operator characteristics

# Farm Exit Change Projections 2012-2060

Scenario 1: Pumping Rates Maintained at 2010 Withdrawals




Scenario 2: Pumping According to Each State's Water Management Plan

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