

Local Agricultural Market Responses to Biofuel Demand: A Fine-Resolution Equilibrium Model Approach

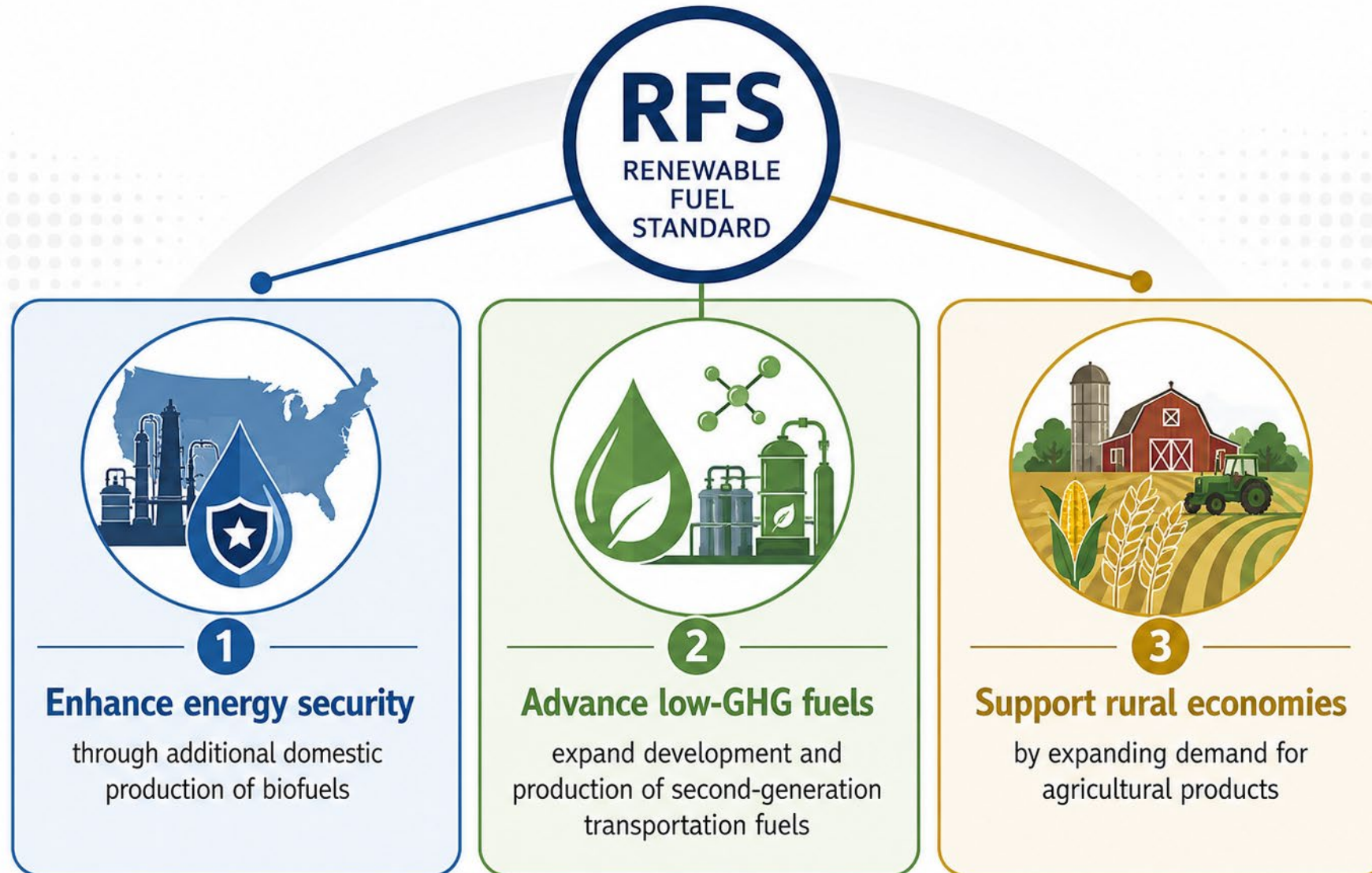
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Purdue University

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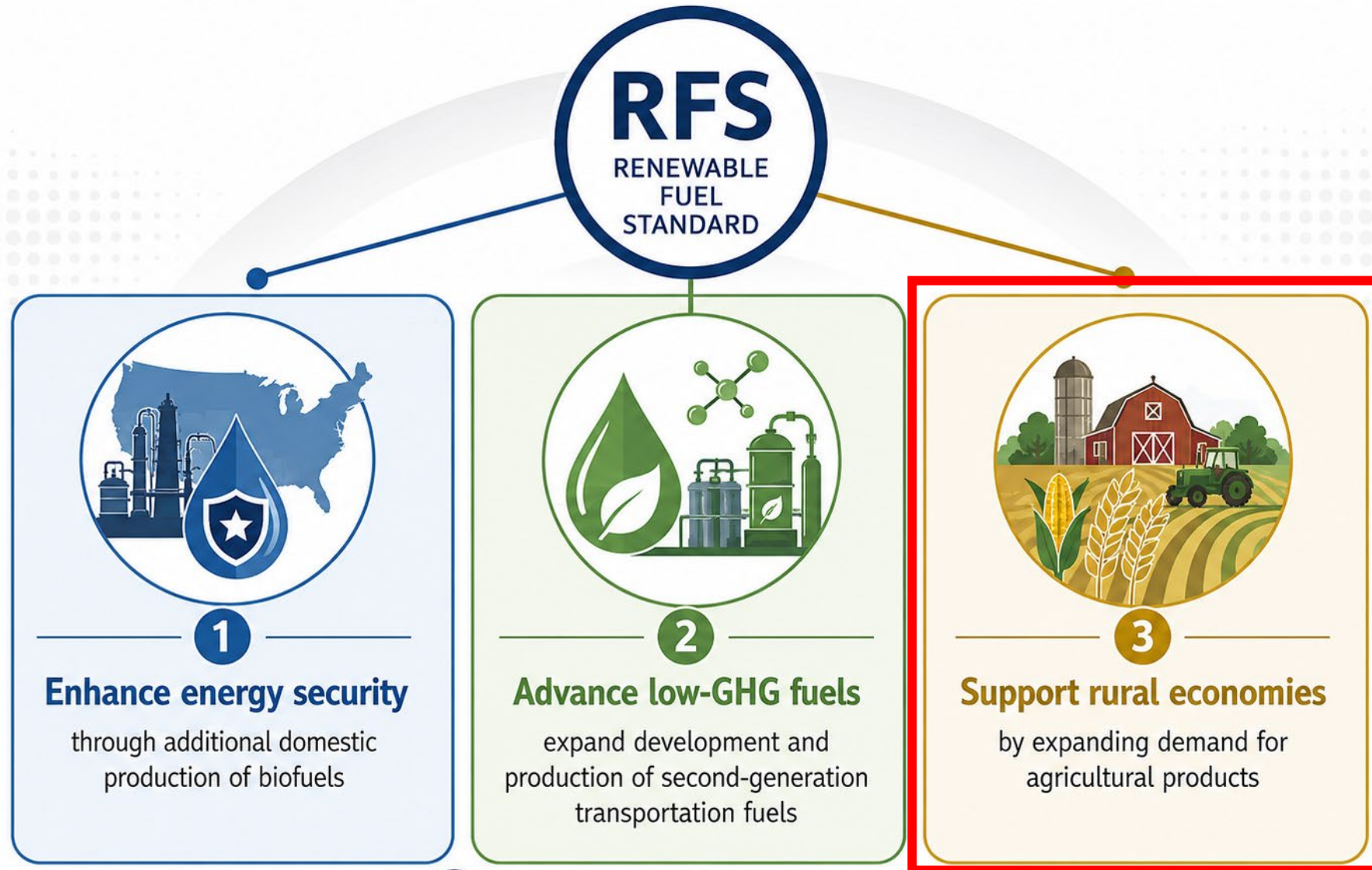


Three Primary Objectives of the U.S. RFS



Source: Based on Irwin and Stock (2018).

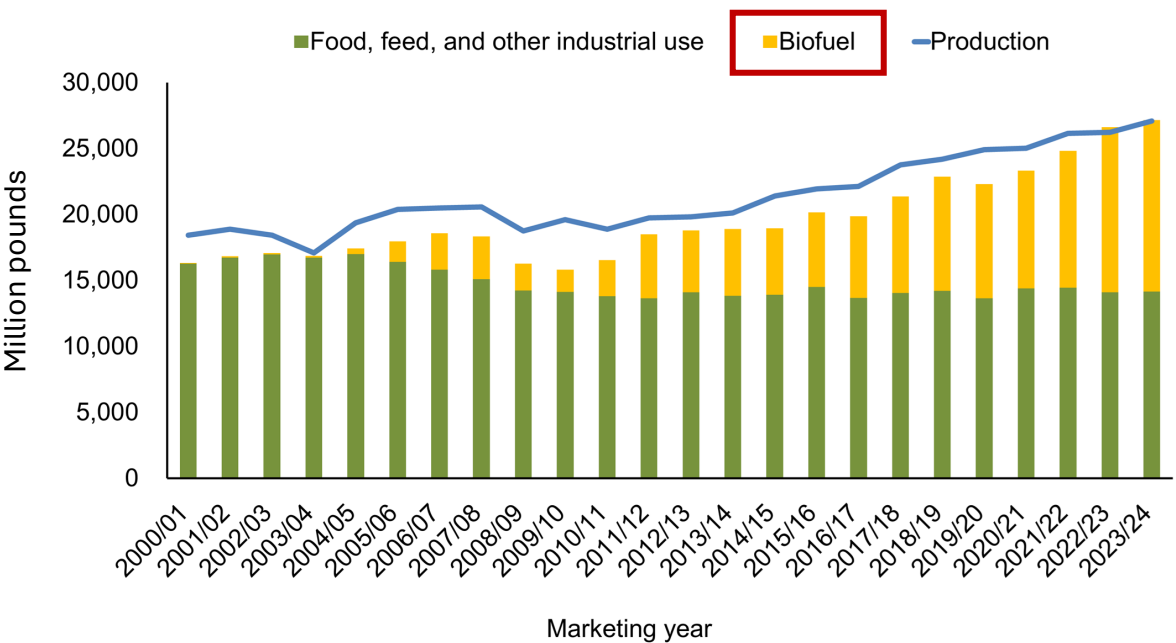
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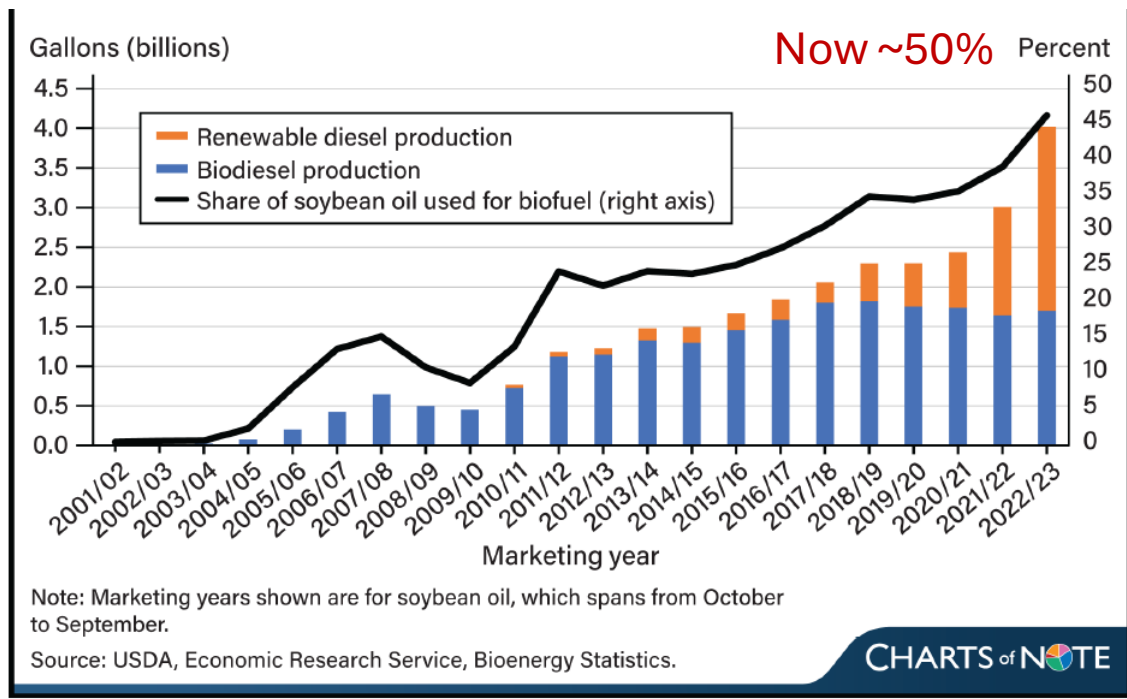
Increasing Soybean Crushing and Biofuels in the U.S.

U.S. Domestic Soybean Oil Production and Disappearance



Source: USDA, Economic Research Service using data from USDA, World Agricultural Outlook Board, *World Agricultural Supply and Demand Estimates*, July 2025.

U.S. production of biofuels and share of soybean oil used for biofuel



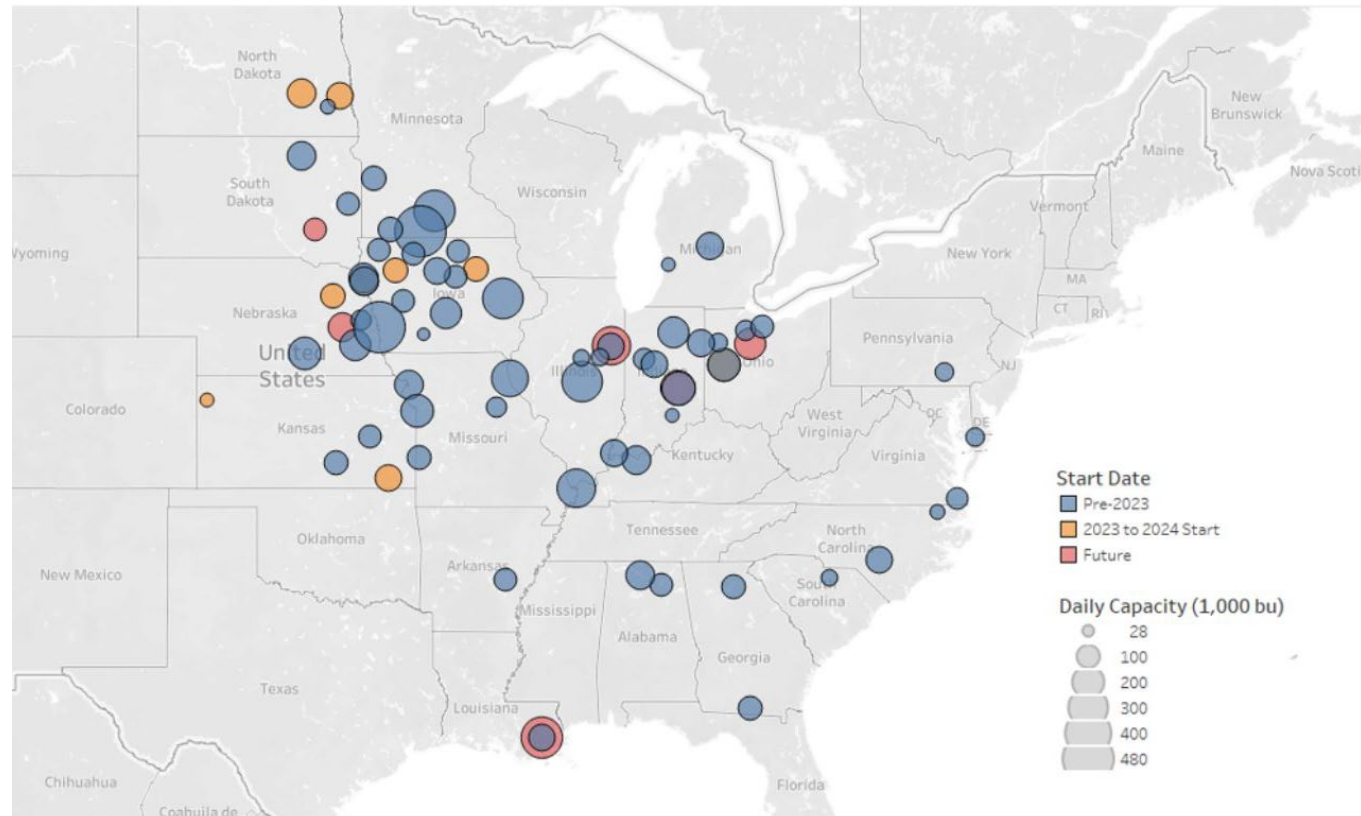
Note: Marketing years shown are for soybean oil, which spans from October to September.

Source: USDA, Economic Research Service, Bioenergy Statistics.

CHARTS of NOTE

Processing Capacity Expands to West and North

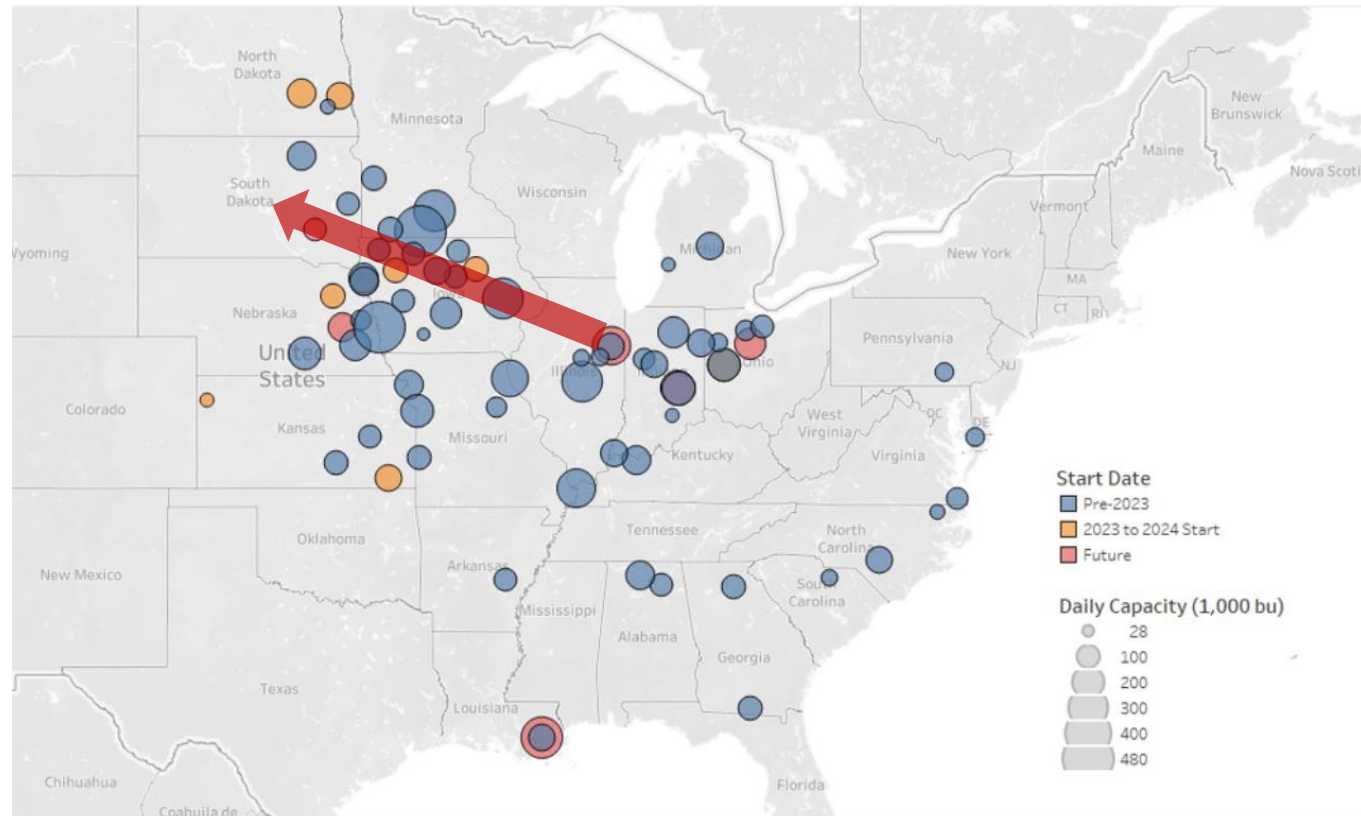
- Recent new and expanded plants and future planned plants in orange & red dots in the figure



Soybean Processing Plants (Source: Gerlt (2025))

Processing Capacity Expands to West and North

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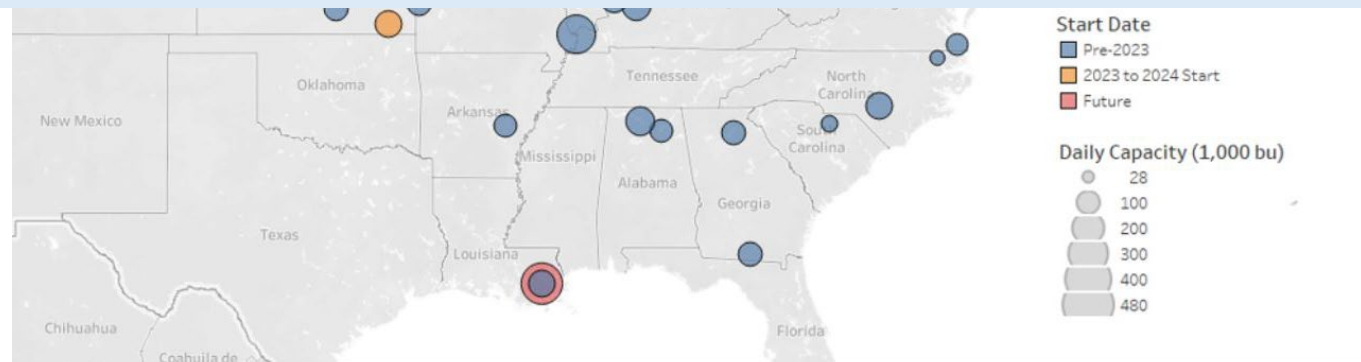
Soybean Processing Plants (Source: Gerlt (2025))

Processing Capacity Expands to West and North

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How do biofuel demand change and processing facility expansion reshape the spatial distribution of crop production, land use, and crop prices?



Soybean Processing Plants (Source: Gerlt (2025))

Contributions

- Impacts of policy-driven ethanol demand on crop prices, land use, and land values and rents are well-documented.

(Chen et al., 2021; Chen & Khanna, 2018; Lark et al., 2022; Li et al., 2019; Mosnier et al., 2013; Motamed et al., 2016; Wright et al., 2017; Kropp & Peckham, 2015; Le & Galvez-Soriano, 2026; Sampson & Yu, 2026)

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- (a) Empirical studies vs. (b) Simulation-based studies (Austin et al. 2022)
 - (a) Focused on local impact of a single crop, but limited capability to capture national/global market responses.
 - (b) Often address various biofuels, but often with coarse resolution, especially demand shock.

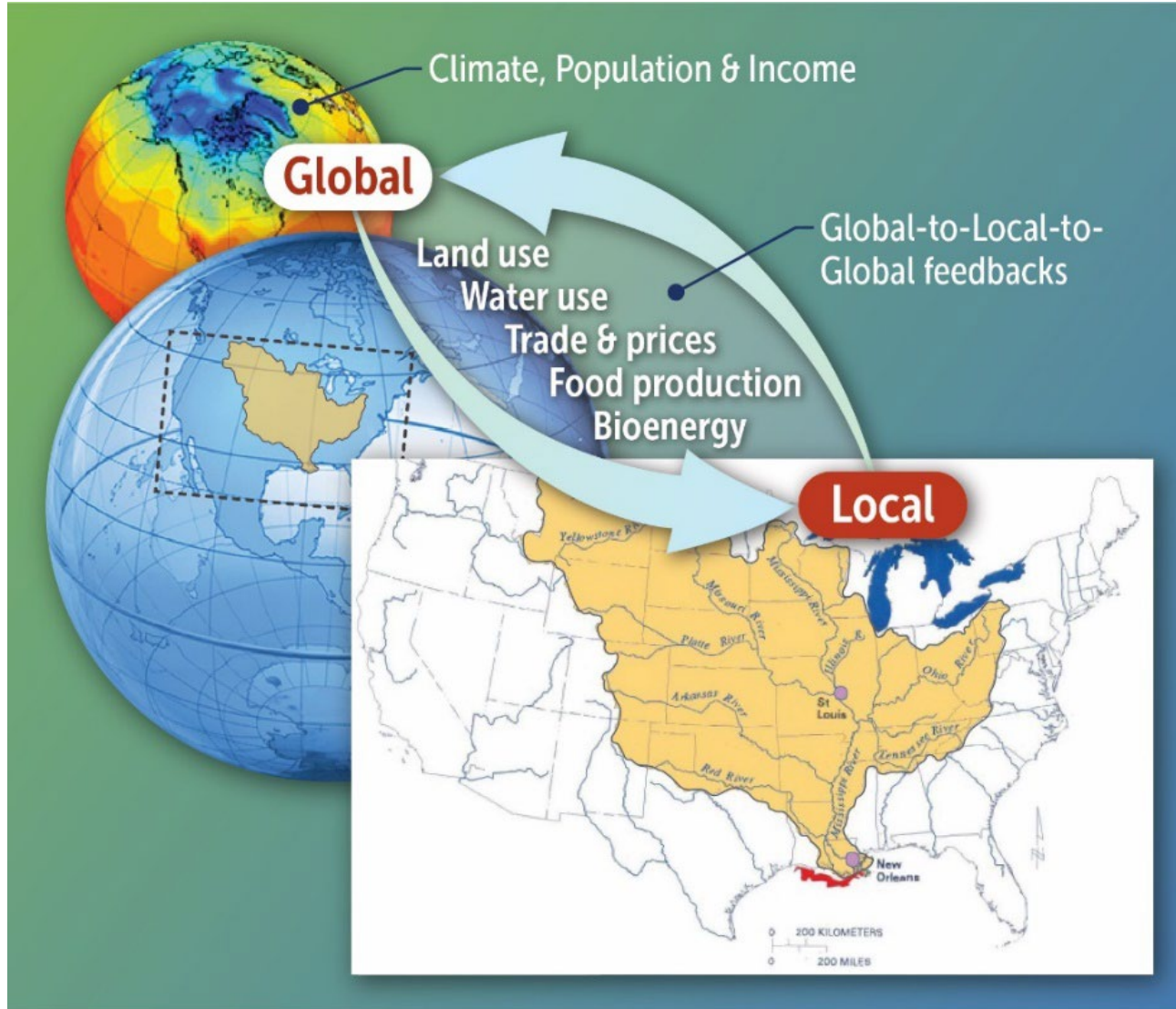
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- This study bridges two groups
 - Using a fine-resolution global partial equilibrium model
 - Simulation-based model, yet with a resolution as fine as empirical studies
 - Capable of counterfactual scenario simulations and plant-specific impact analysis

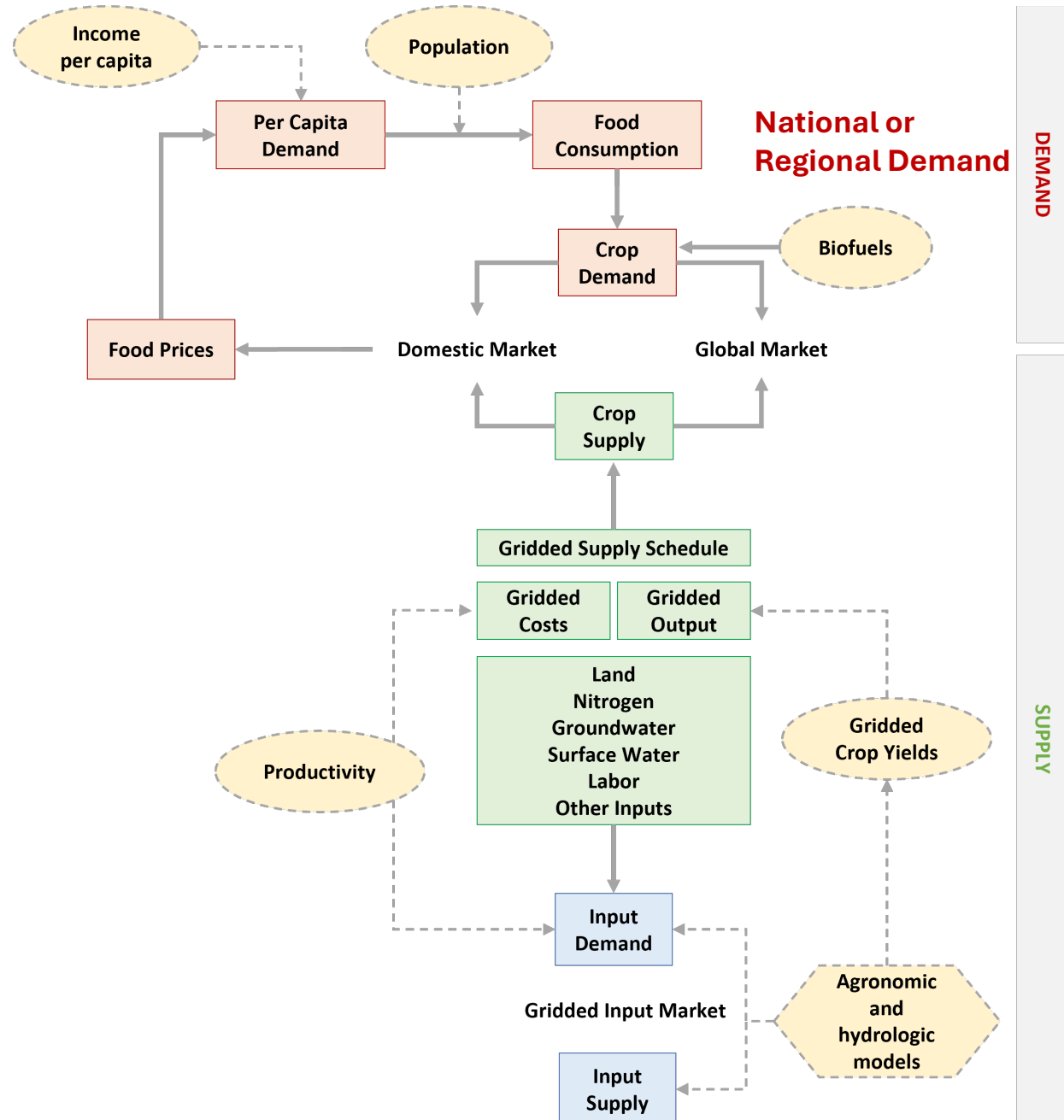
SIMPLE-G: Global-to-Local-to-Global Analysis



- SIMPLE-G: **S**implified International **M**odel of agricultural **P**rices, **L**and use, and the **E**nvironment-**G**ridDED version
- Global/national forces drive local decision-making that varies by locality
- Local responses have national/global consequences
- 17 world regions capture the global picture

SIMPLE-G Structure

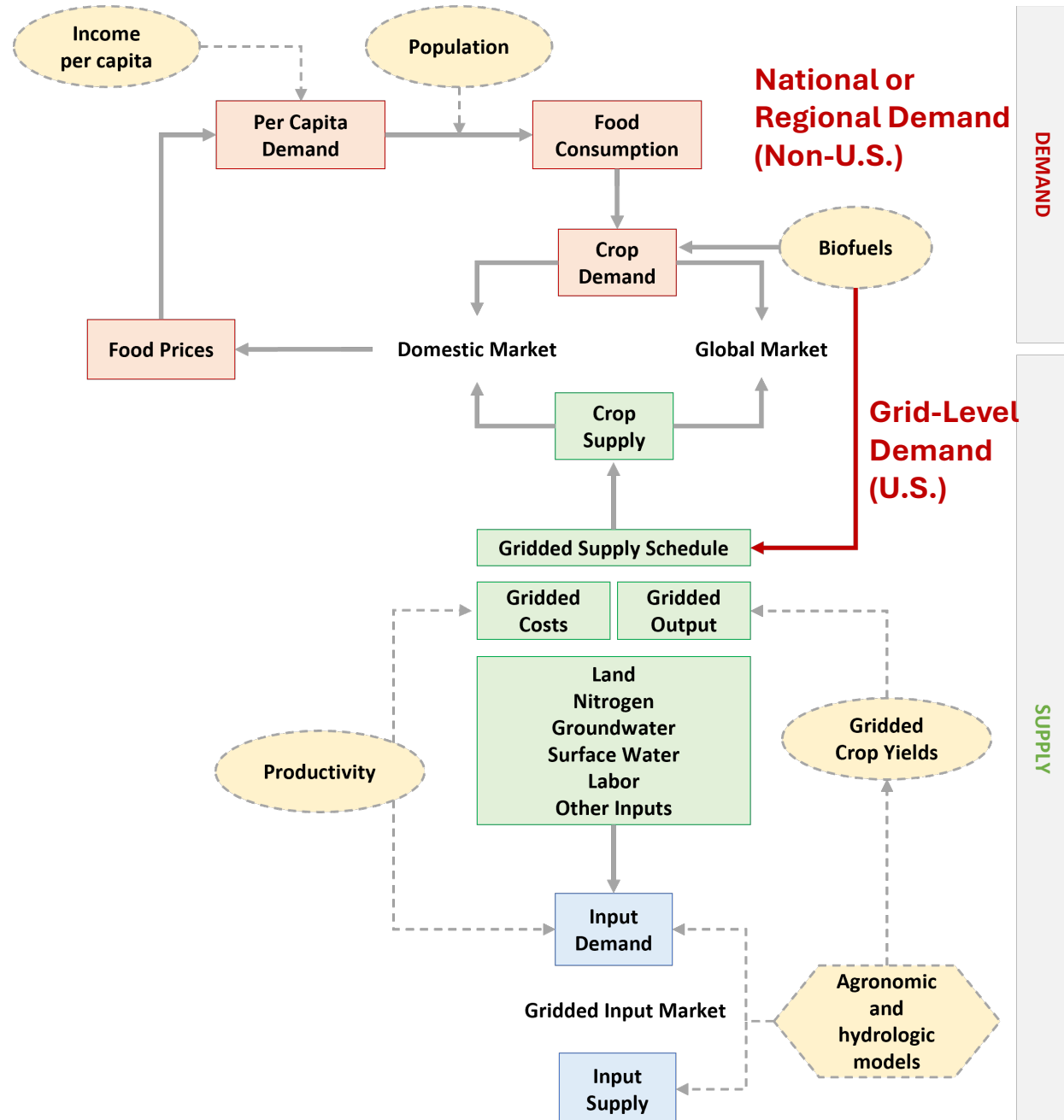
- Multi-crop version with 8 crop varieties
- Grid-level production (5 arc minute, 8-9 km in the US)
- Regional-level demand (direct consumption, food processing, livestock feed, biofuel)



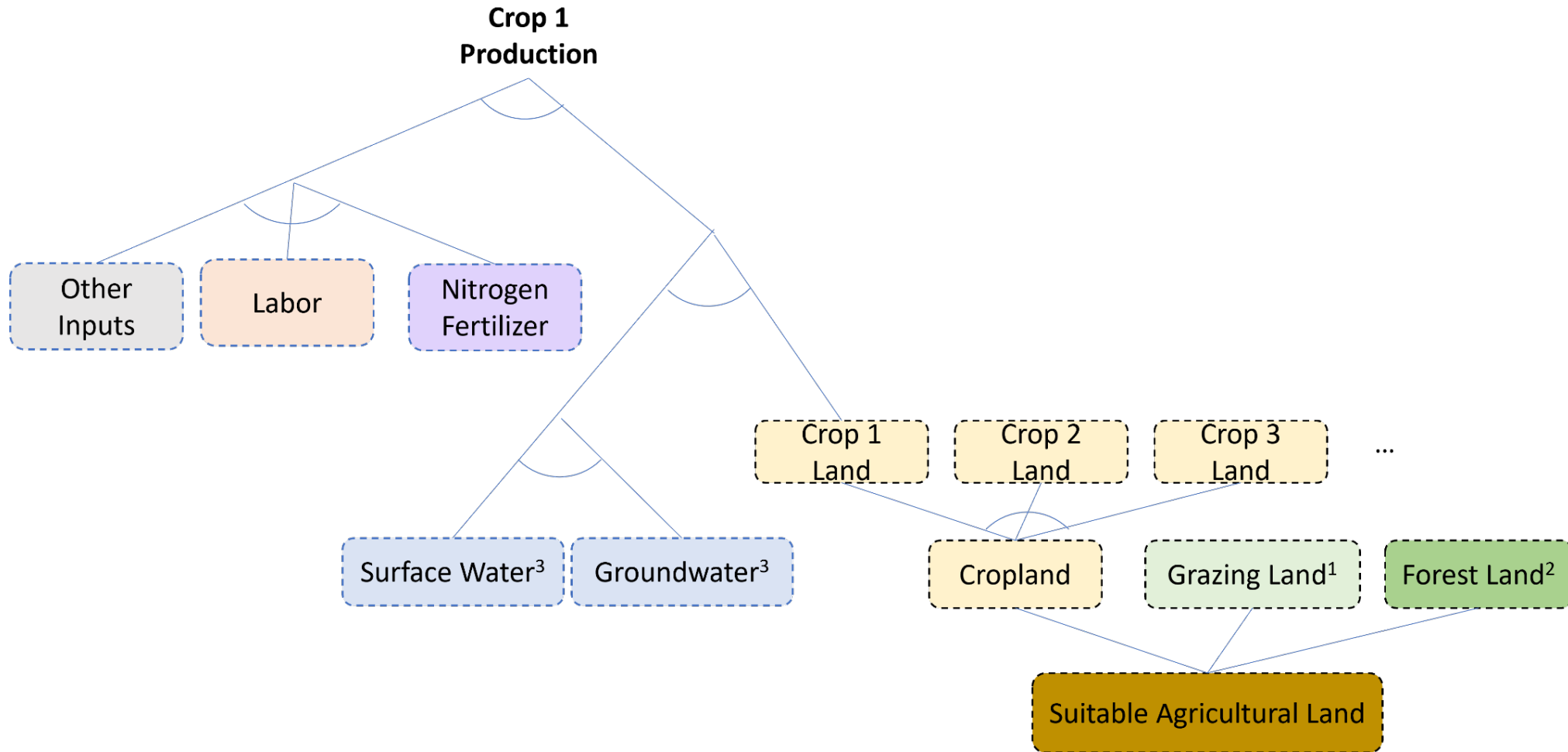
SIMPLE-G Structure with Grid-Level Crushing Demand

- Now, biofuel demand change directly impacts grid-level production for the U.S.

Δ National Biofuel Demand
↓
 Δ Grid-level Soybean Crushing
↓
 Δ Grid-level Production



Grid-Level Production Structure



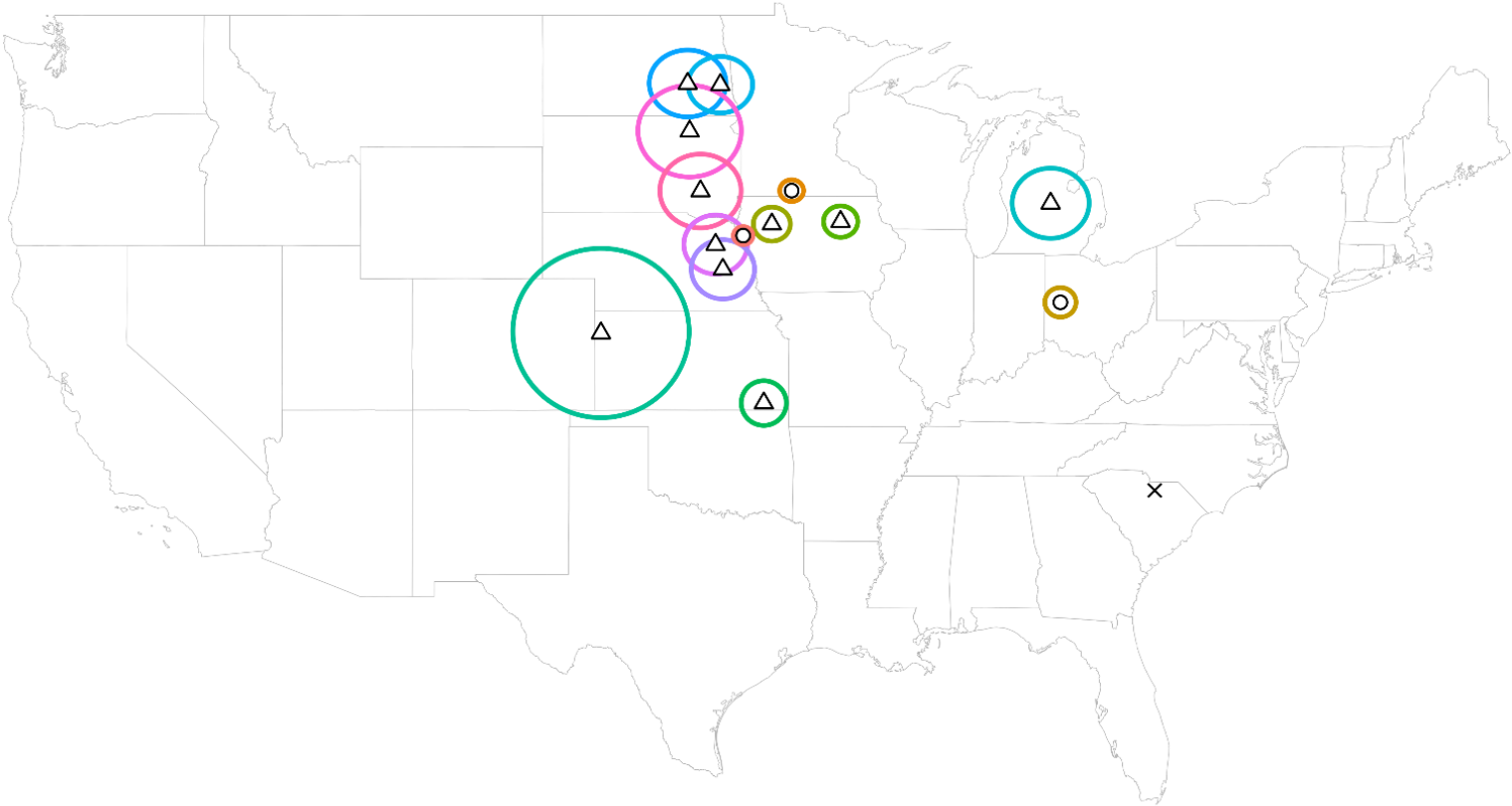
1 Grazing land is the land used for livestock production; excluding CRP grassland

2 Forestland produces timber; unmanaged or managed forest is not distinguished

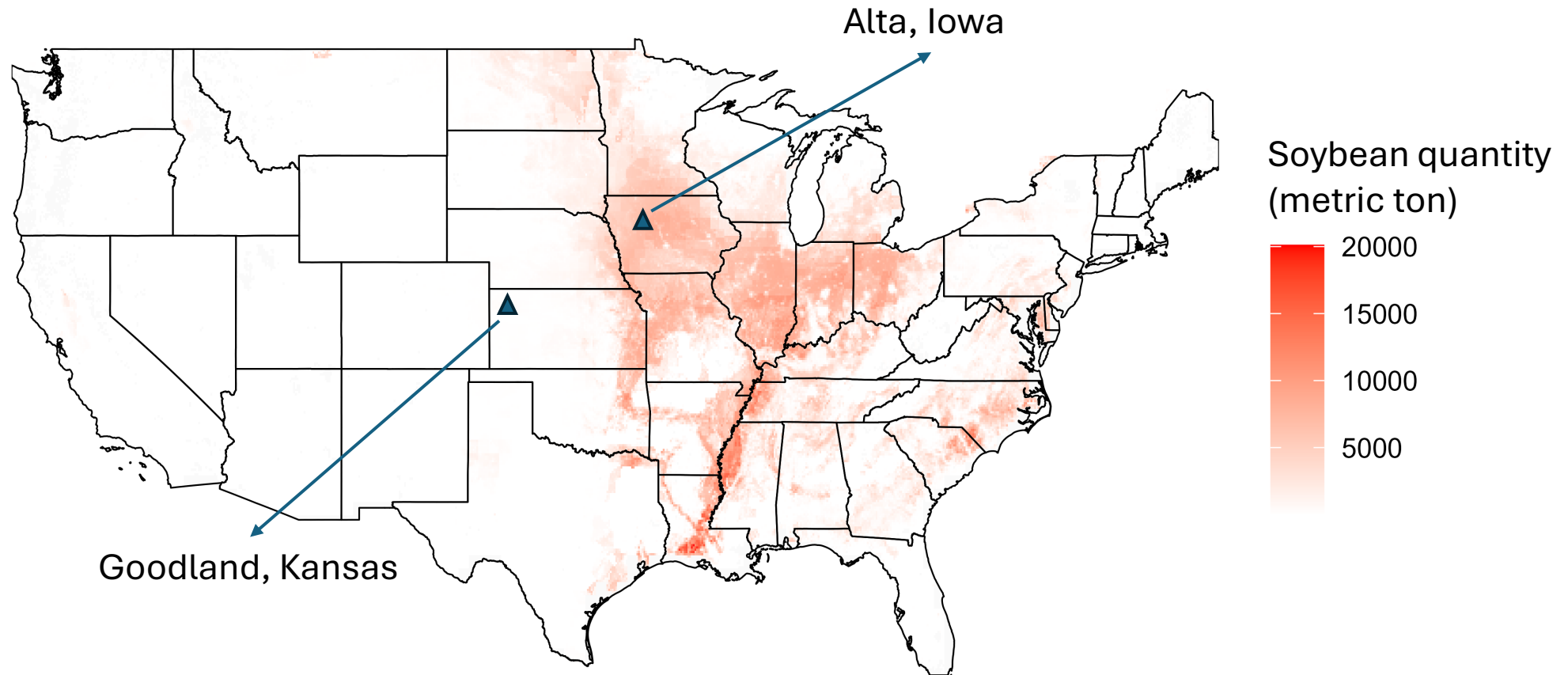
3 Water used only in the irrigated land

Crushing Expansion (2017-2025) & Supply Zone

Soybean supply zone **when in independent operations**
(change, state, city/county)



Baseline Soybean Production Quantity



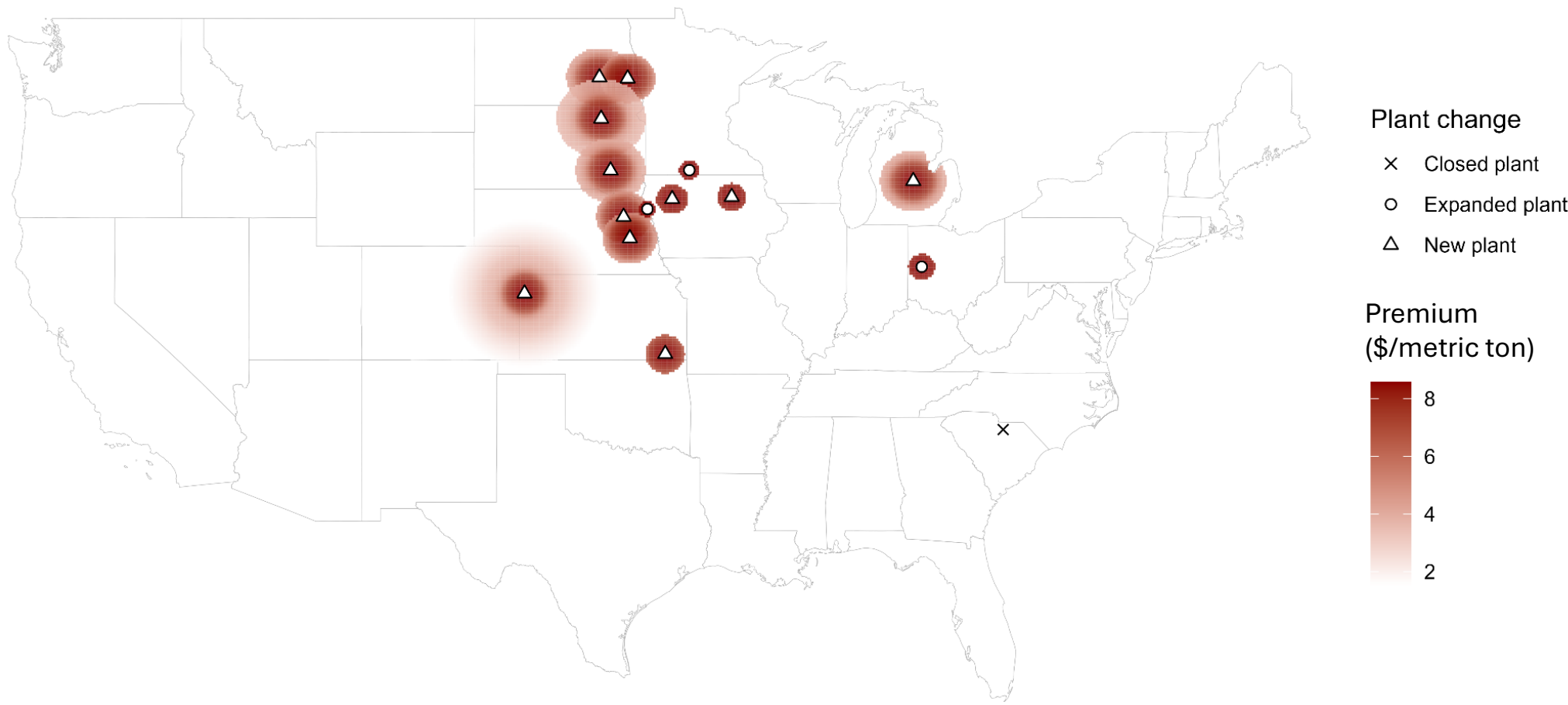
Premium by Distance to Crushing Plants

- Impacts of new plants on local prices (or bases)
(McNew & Griffith, 2005)
- Local prices received by farmers
= price at a terminal market
– transportation cost
(Motamed et al., 2016)
- Premiums approximated using local basis differences by distance to crush plant
(Wu et al., 2025)



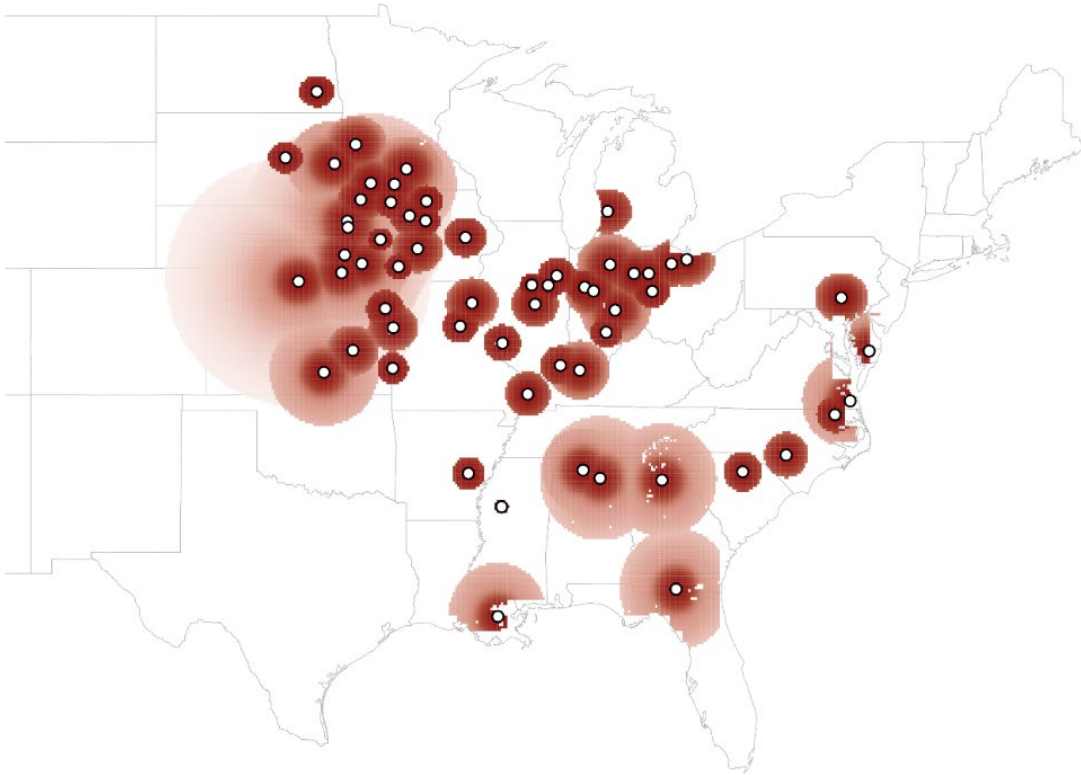
Soybean Supply Zones & Premiums

When in independent operations

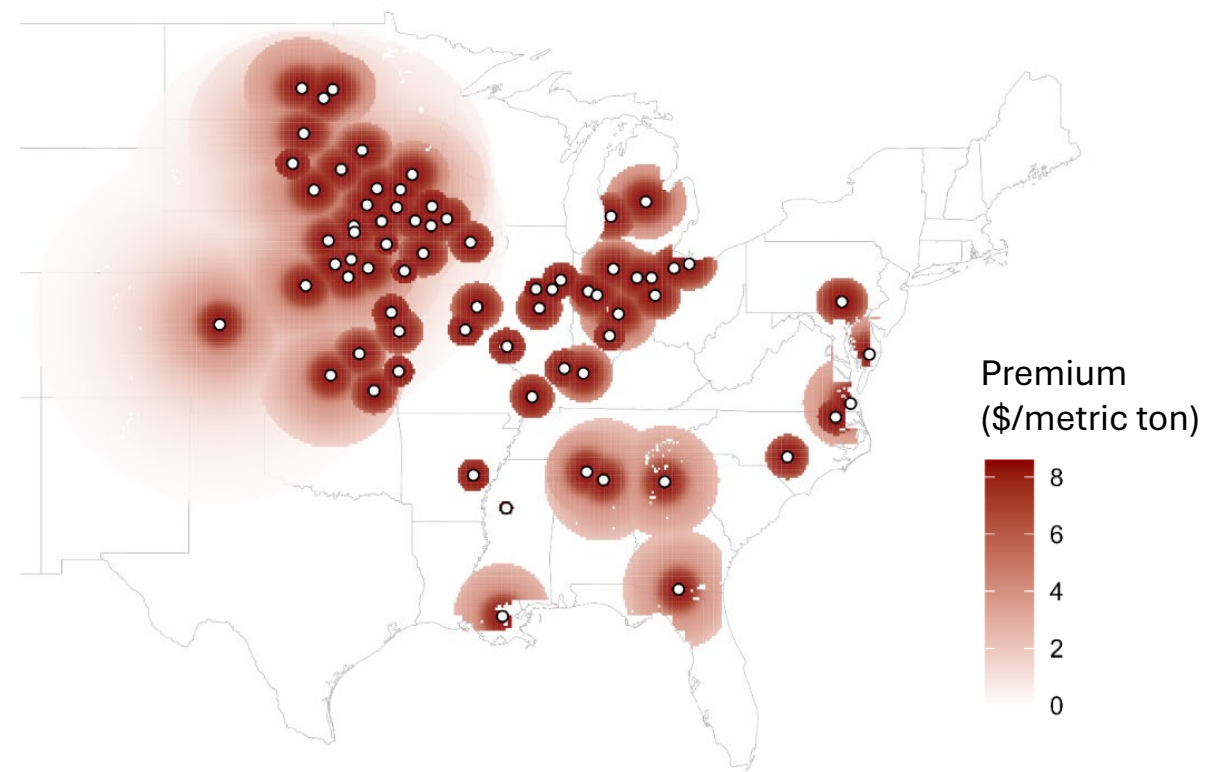


Premiums with Simultaneous Operations

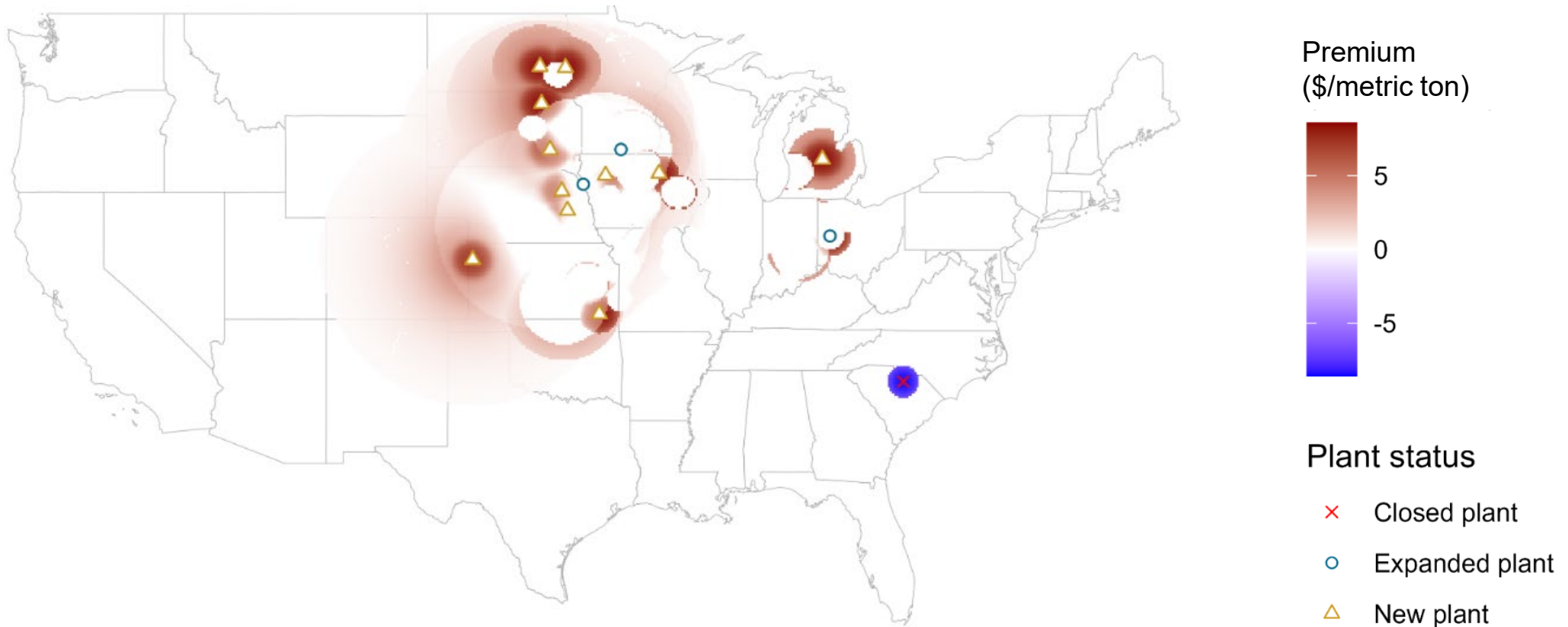
Premium Map with 2017 Plant Landscape



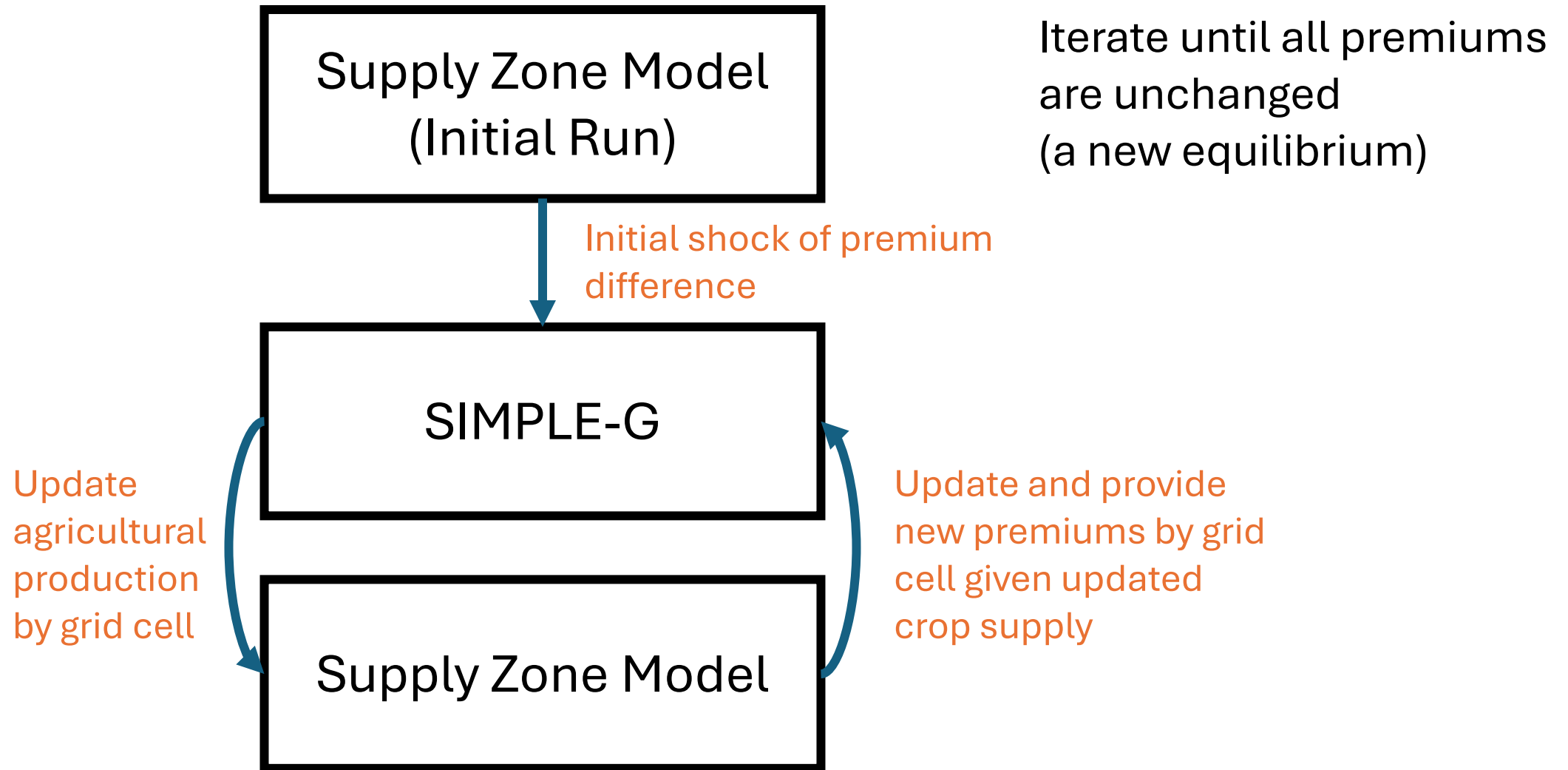
Premium Map with 2025 Plant Landscape



Changes in Premium Received by Produce (2017-2025)

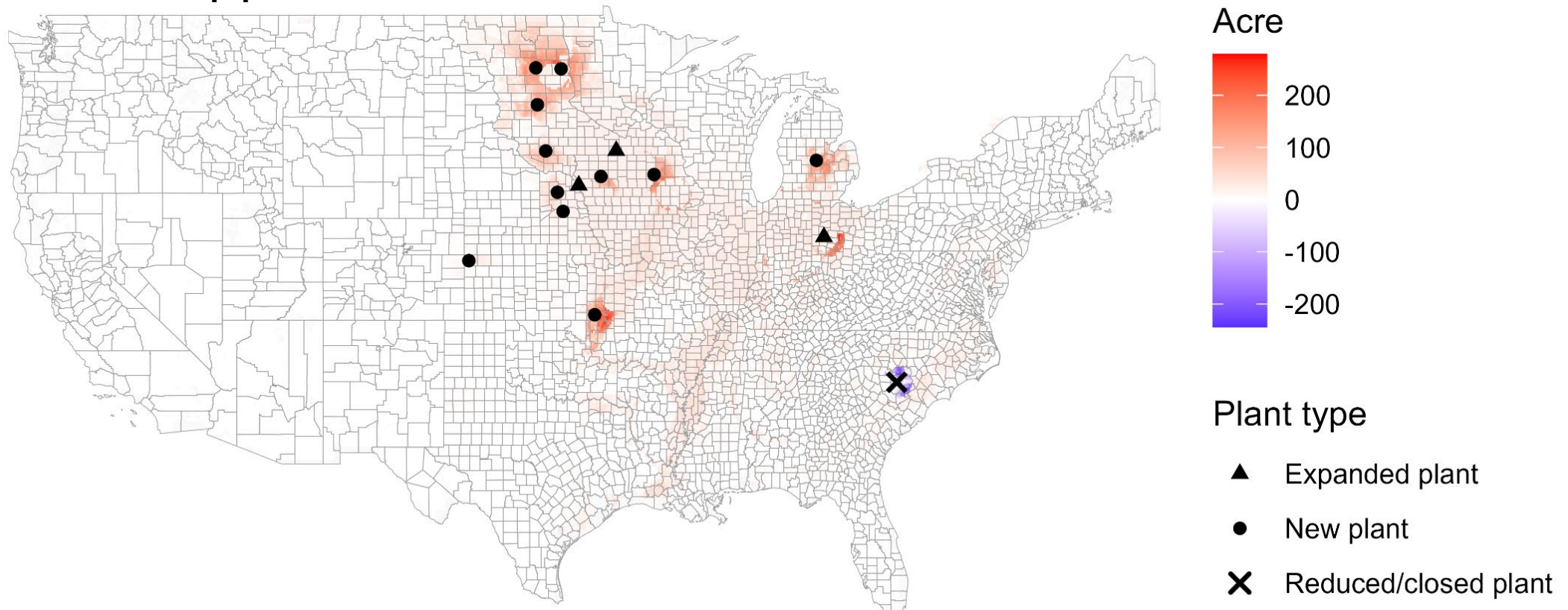


Iterative Simulation Approach



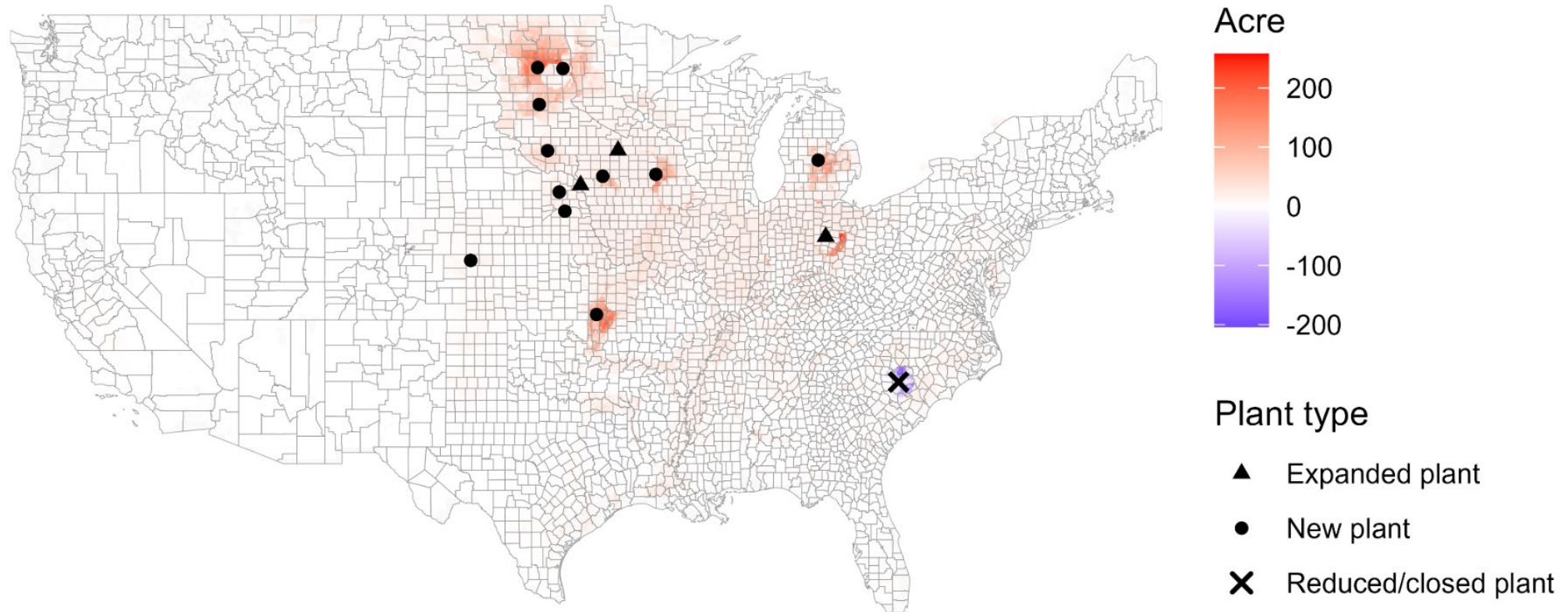
Direct and Indirect Impacts: Soybean Land

- Direct impacts near new (●) and expanded (▲) plants
- Indirect (market-mediated) impacts near the Heartland and Mississippi Portal



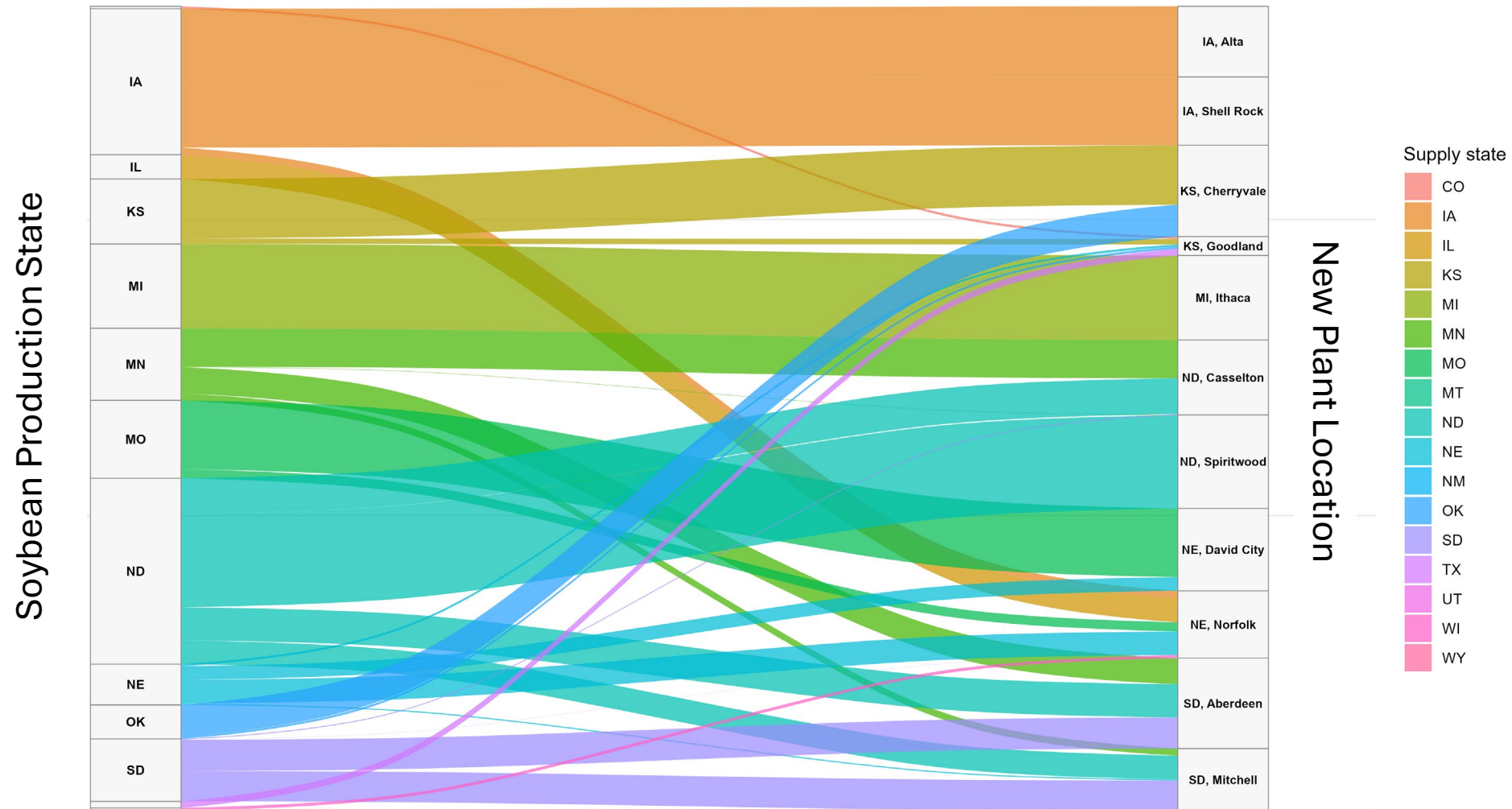
Direct and Indirect Impacts: Total Cropland

- Similar pattern of total cropland expansion



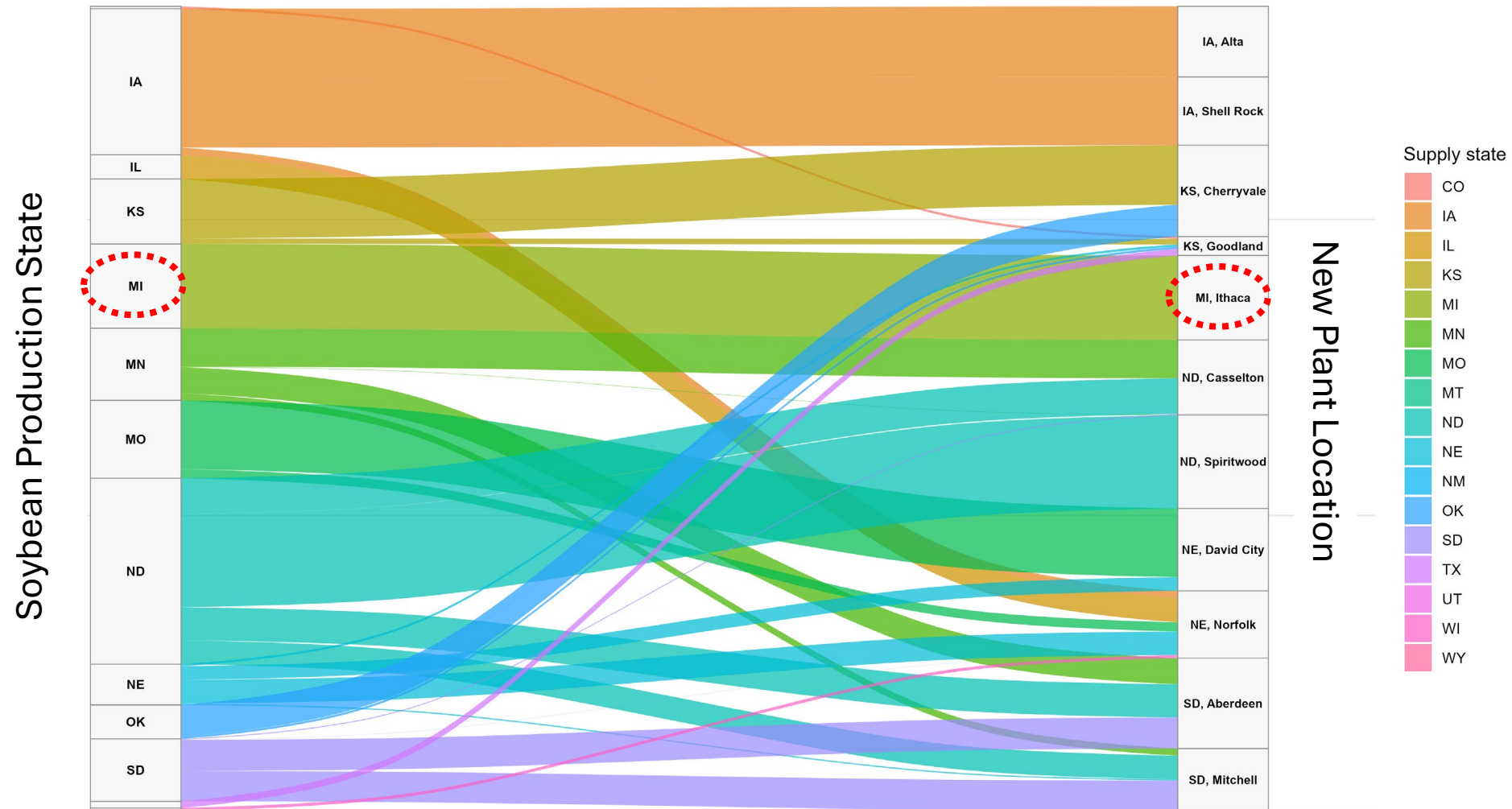
Spillover to Neighboring States and Feedstock Flow

- Feedstock supply is not limited to the hosting state



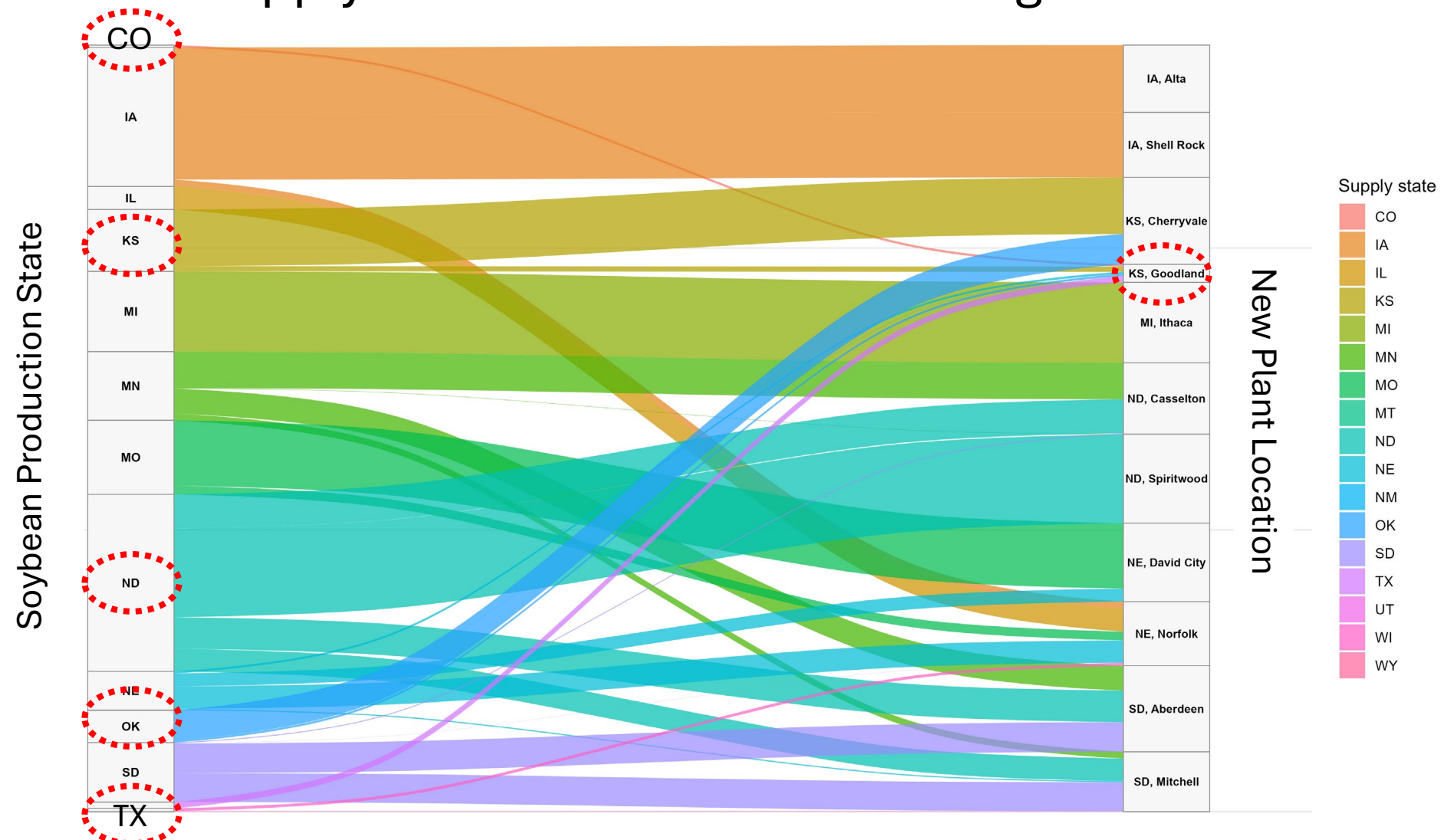
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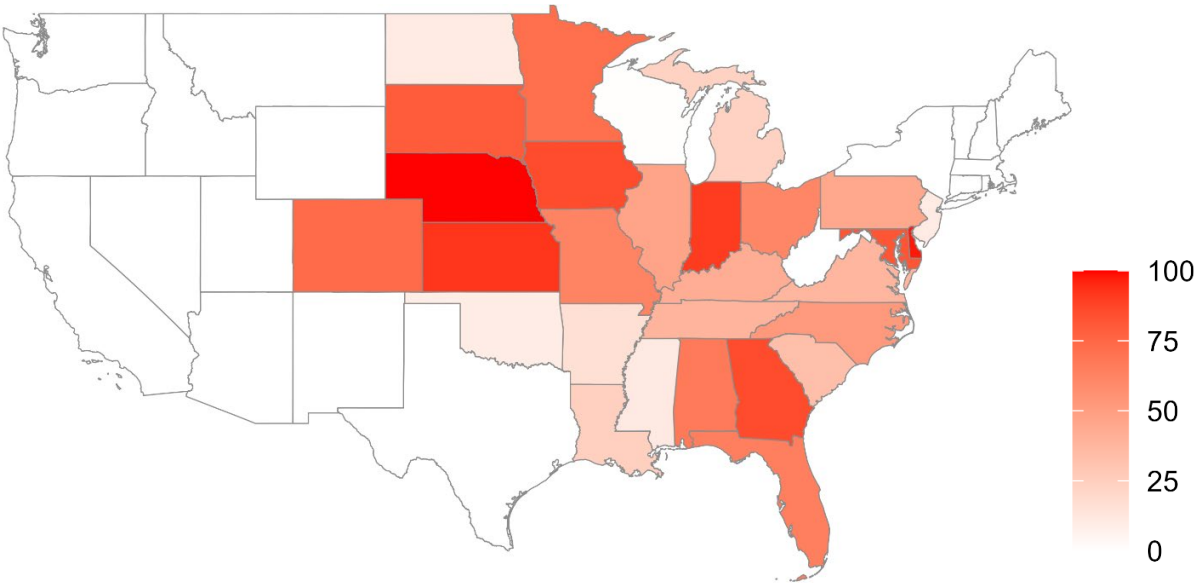
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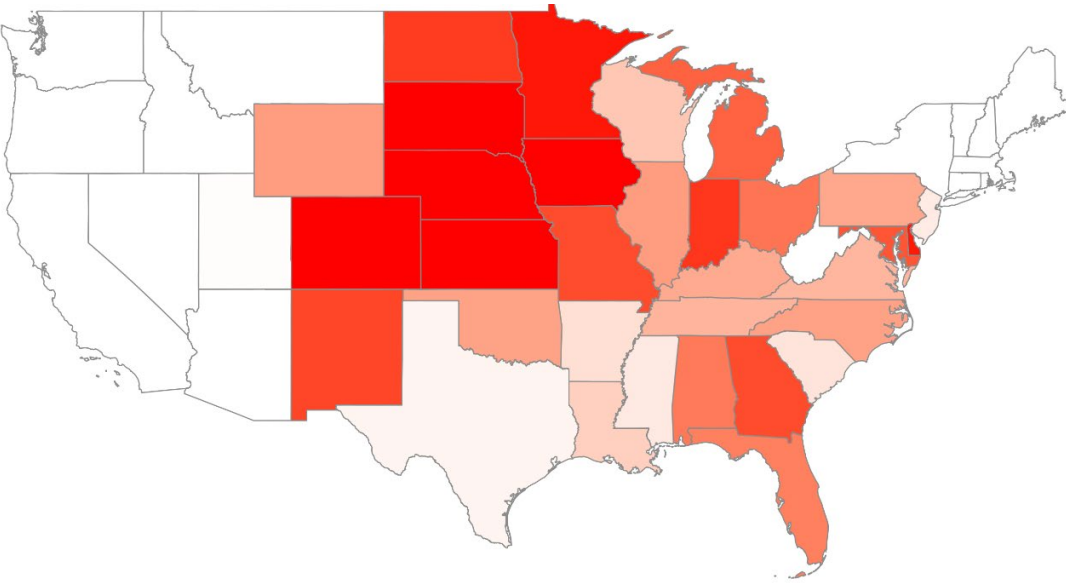


Increasing In-State/Domestic Consumption

State Share of Soybean Production Supplied to
Crush Plants with 2017 Plant Landscape



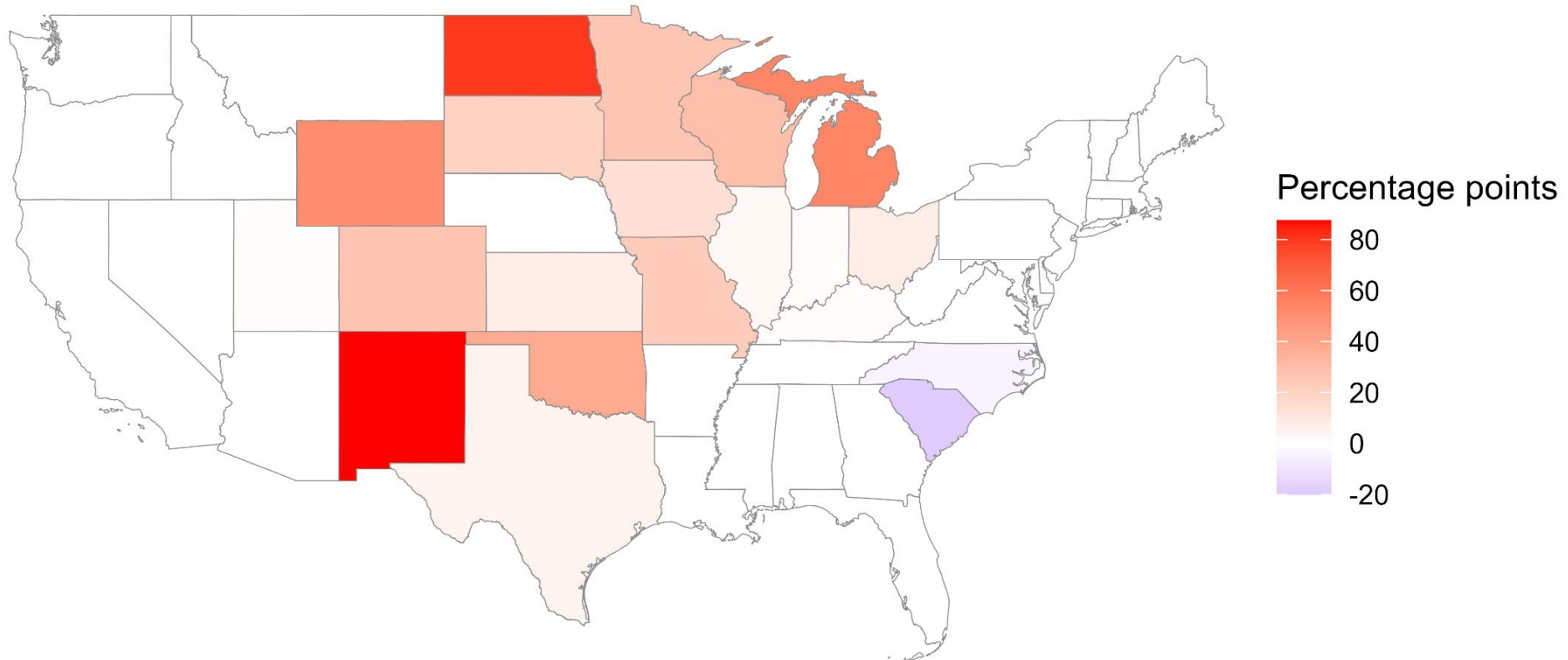
State Share of Soybean Production Supplied to
Crush Plants with 2025 Plant Landscape



Increasing In-State/Domestic Consumption

→ potentially improve resilience against external shocks

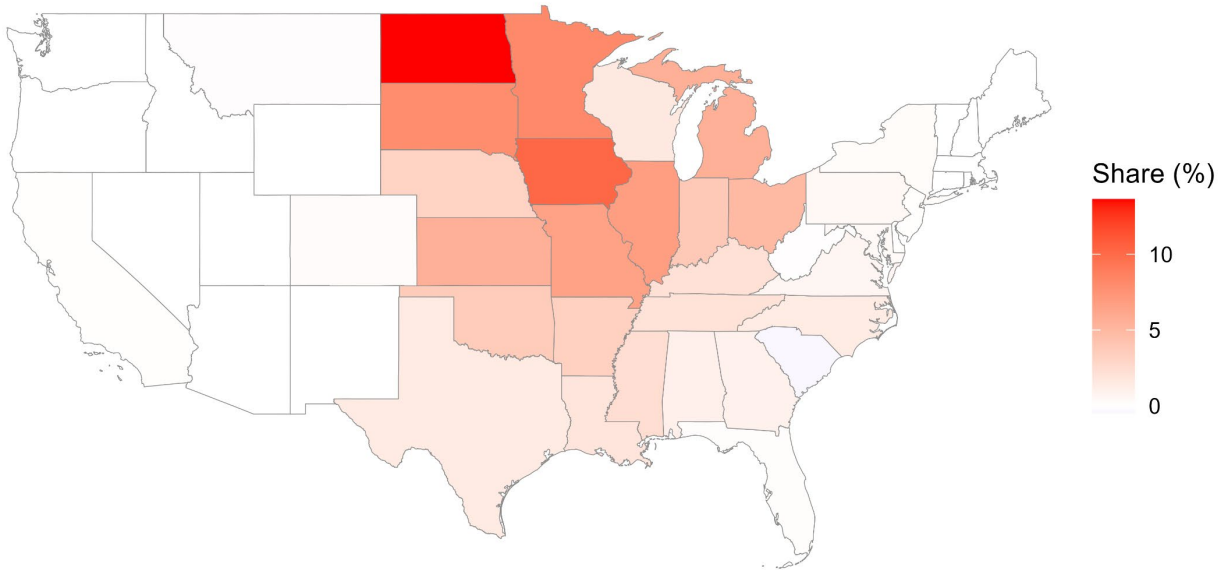
Change in State Share of Soybean Production Supplied to Crush Plants



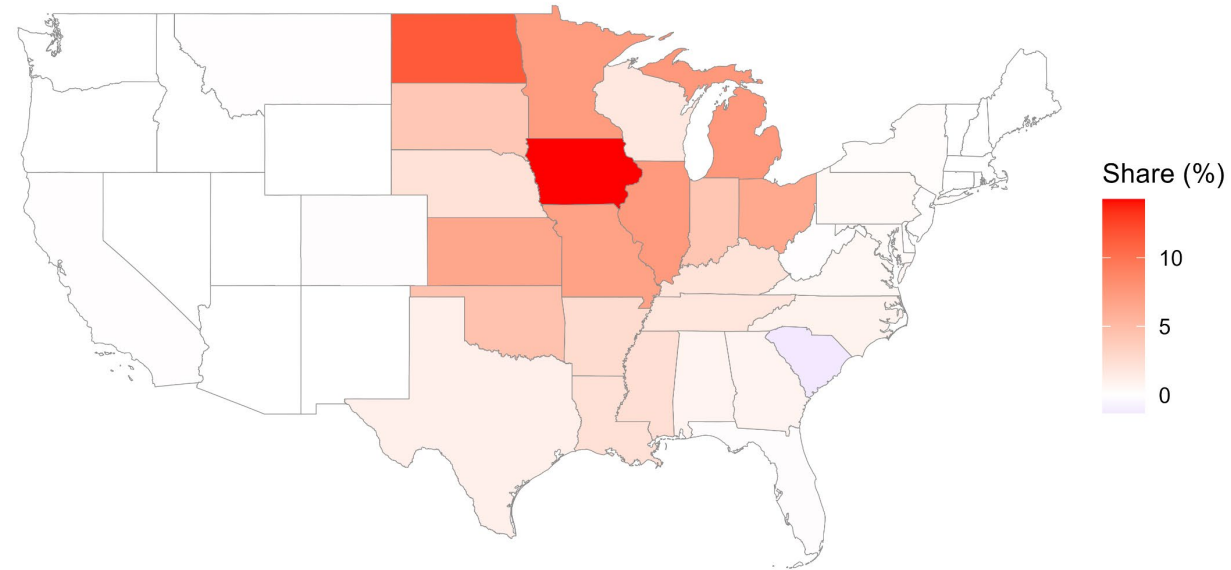
Which State Contribute/Benefit More

- North Dakota and Iowa account for the most of changes in soybean production expansion.

State Share of National Soybean Acre Change



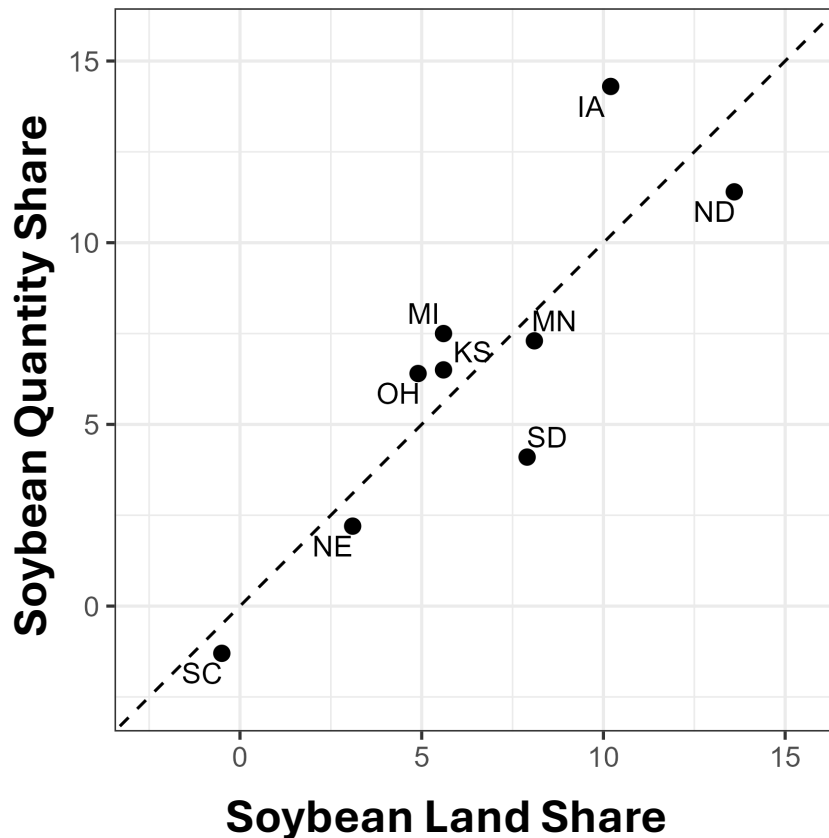
State Share of National Soybean Quantity Change



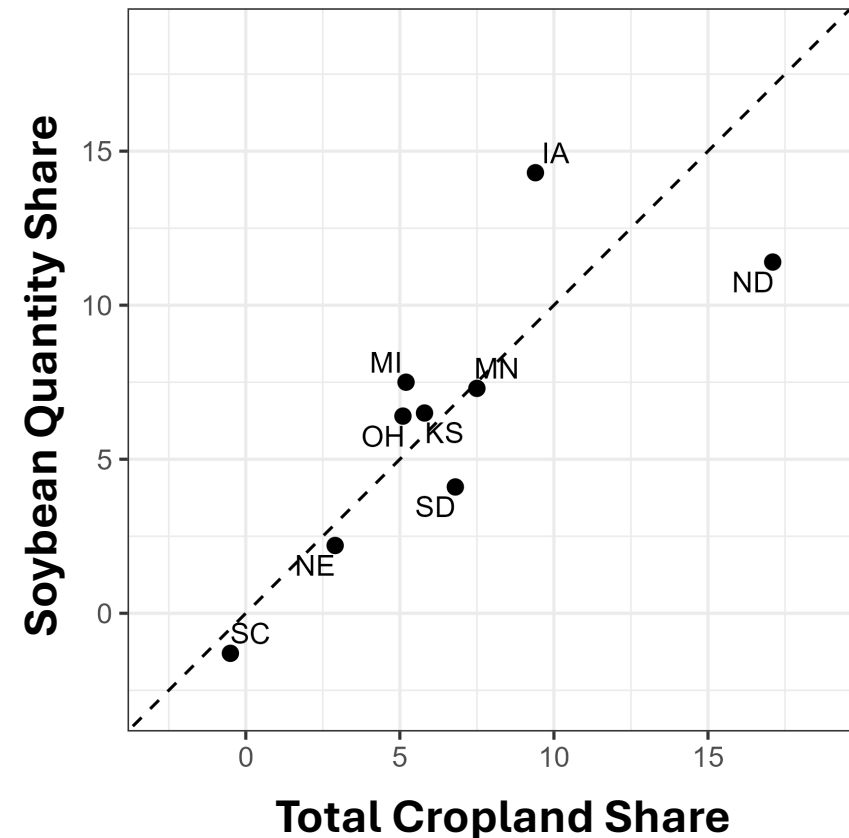
Where to Build Crush Plants

- Dakotas less productive than Iowa: Greater share of cropland expansion relative to share of soybean production change

Soybean Land Share vs. Soybean Quantity Share



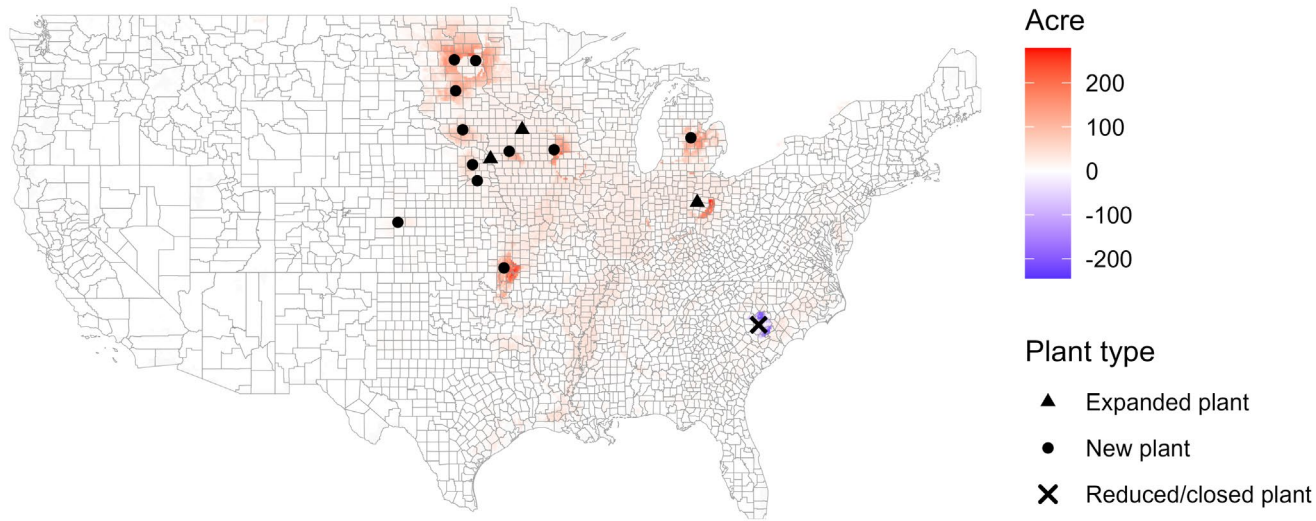
Total Cropland Share vs. Soybean Quantity Share



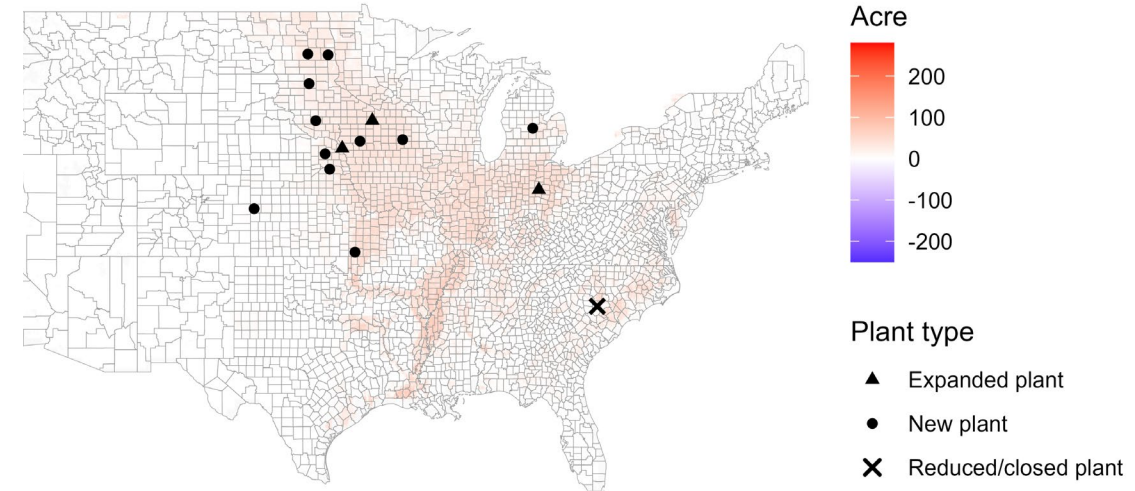
Comparison: National Shock → Even Distribution

- Generally, more increases in Heartland and Mississippi Portal
- Less total cropland expansion → more efficient land allocation
- NC and SC also show increase (plant closure not captured)

Site-specific Shock: Soybean Land Change



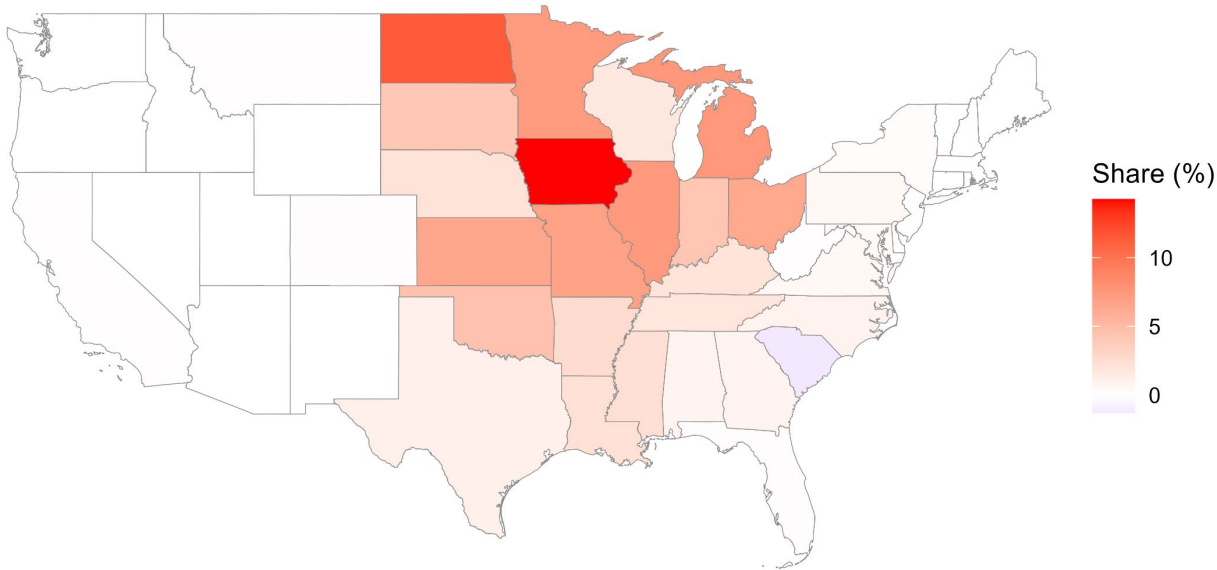
National-level Shock: Soybean Land Change



Comparison: National Shock → Efficient Allocation

- More contribution of feedstock from the Heartland and Mississippi Portal regions

Site-specific Shock: State Share of National Soybean Quantity Change



National-level Shock: State Share of National Soybean Quantity Change

