# Impact of Production Diversification on Farm Resilience: Evidence from Kansas Farms

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# Motivation : Why Study Diversification ?

## Agricultural Challenges:

Farmers face risks from adverse weather, pests, diseases, and market fluctuations.

## Production Diversification:

**Recognized as an effective strategy to stabilize returns.**

## Farm Income Resilience:

A farm's ability to adapt to disturbances.

# Motivation : Why Study Diversification – Research Gap?

## Diverse Crops Bring Diverse Benefits

### Existing Research:

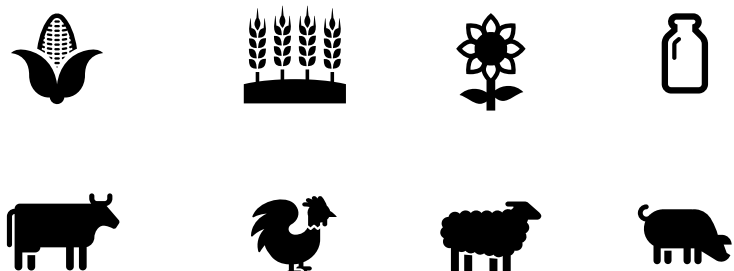
- **Environmental:** Minimize impacts on natural resources such as soil nurtrients
- **Economic**: Aid the domestic economy, enabling producers to grow crops that would otherwise be imported

Too little research on how diversification

**Impacts Farmers Profits.**

# What is Production Diversification ?

**Production Diversification means growing different crops and/or livestock**



# Research Objective

**Objective**: Investigate the impact of production diversification on farm income, specifically its role in enabling farms to withstand environmental shocks.

- A. Analyze within crop diversification effect on farm income
- B. Analyze crop vs mix farm (crop + livestock) diversification effect on farm income

# Data Set

## Kansas Farm Management Association (KFMA) data

- **Data Overview:**
  - Annual compilation of Kansas farms data that includes a diverse set of variables, including income, balance sheet ratios, production, and operational metrics.
  - Timeframe spans from 1973 to 2022, covers various periods by economic and environmental shocks.

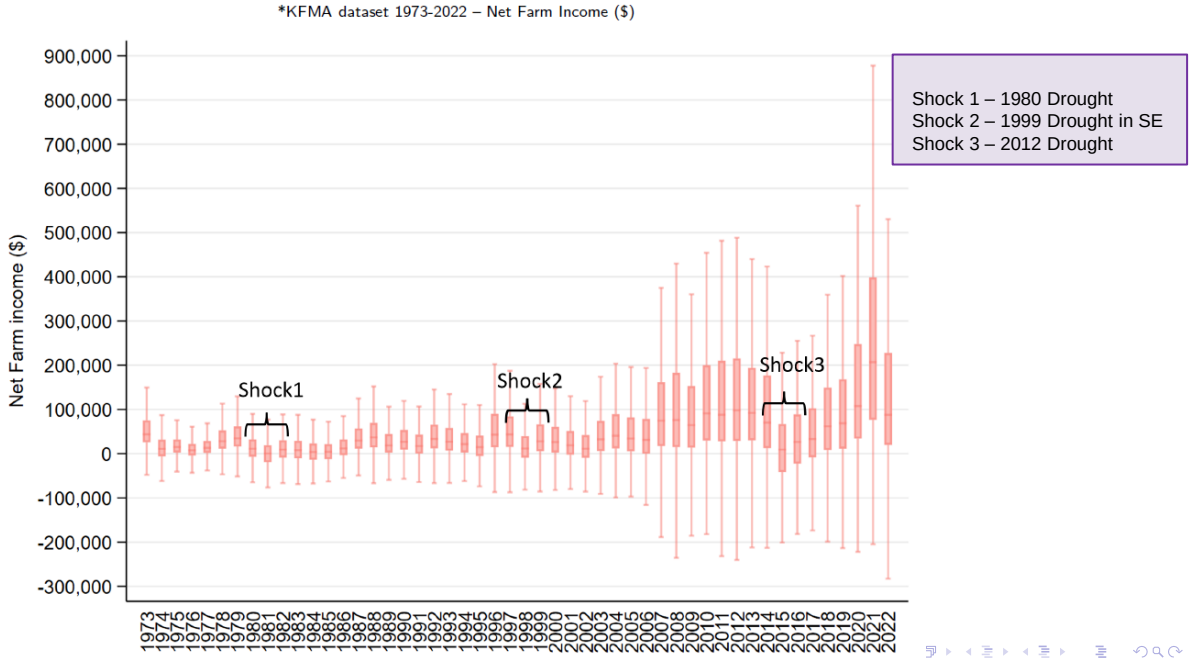
- **Relevant Data:**
  - Year 2002 - 2022(21 years) (232 Kansas farms)
  - Detailed data on assets, including production, inventory, net farm income, debt, and expenses
  - North Central (73, 31%), Southeast (61, 26%), Northeast (56, 24%), South Central (29, 13%), Southwest (7, 3%), Northwest (6, 3%)
  - Livestock only farms (1%), crop only (29%), and both livestock and crop (70%) types of farms.

# Summary Statistics

| Variable | Crop-only (2002) | Mixed (2002) | Crop-only (2022) | Mixed (2022) |
|---|---|---|---|---|
| **Age** | | | | |
| Age | 48.93 (10.57) | 49.55 (9.04) | 68.98 (9.13) | 66.74 (8.91) |
| **Farm Characteristics** | | | | |
| Crop Acres | 1433.78 (904.51) | 1189.31 (857.91) | 1424.40 (1034.33) | 1502.71 (1291.58) |
| Debt-Asset Ratio, Year End | 0.42 (0.47) | 0.38 (0.28) | 0.09 (0.14) | 0.16 (0.14) |
| **Adjusted Financials** | | | | |
| Value of Farm Prod.($k) | 327.77 (269.55) | 389.83 (365.64) | 737.85 (652.89) | 941.04 (899.31) |
| Net Farm Income ($k) | 49.39 (72.76) | 49.29 (109.43) | 176.80 (225.87) | 184.42 (223.97) |
| Gov Payments ($k) | 22.86 (19.64) | 27.08 (19.68) | 13.81 (27.16) | 14.81 (33.24) |
| Crop Insurance Inc. ($k) | 27.46 (40.35) | 24.82 (41.36) | 98.88 (135.26) | 102.19 (227.32) |
| Crop Insurance Exp. ($k) | 9.84 (12.79) | 5.49 (7.55) | 26.08 (26.79) | 23.92 (26.43) |
| Farm Inc. per Acre ($) | 33.02 (53.58) | 49.68 (155.41) | 111.98 (114.17) | 141.95 (202.28) |
| Farm Inc. no supp. PerAcre($) | 4.20 (60.91) | 0.65 (148.62) | 51.94 (150.77) | 94.13 (219.08) |
| **Diversification Characteristics** | | | | |
| Crop Count Above 0 acres | 3.73 (1.67) | 5.38 (2.11) | 3.11 (1.28) | 5.50 (2.51) |
| Crop Count by 10% Inc. | 2.71 (0.87) | 3.05 (0.96) | 2.37 (0.76) | 2.62 (0.84) |
| Crop Count by 10% Acr. | 2.84 (1.00) | 2.94 (0.86) | 2.46 (0.74) | 2.94 (0.90) |

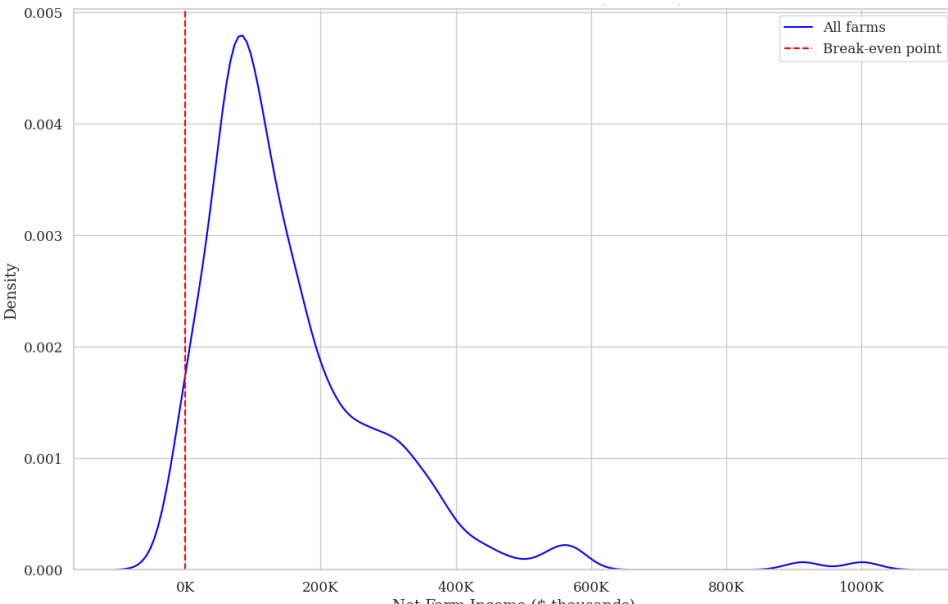
# Data Descriptives

# Historical Trends in Kansas Net Farm Income

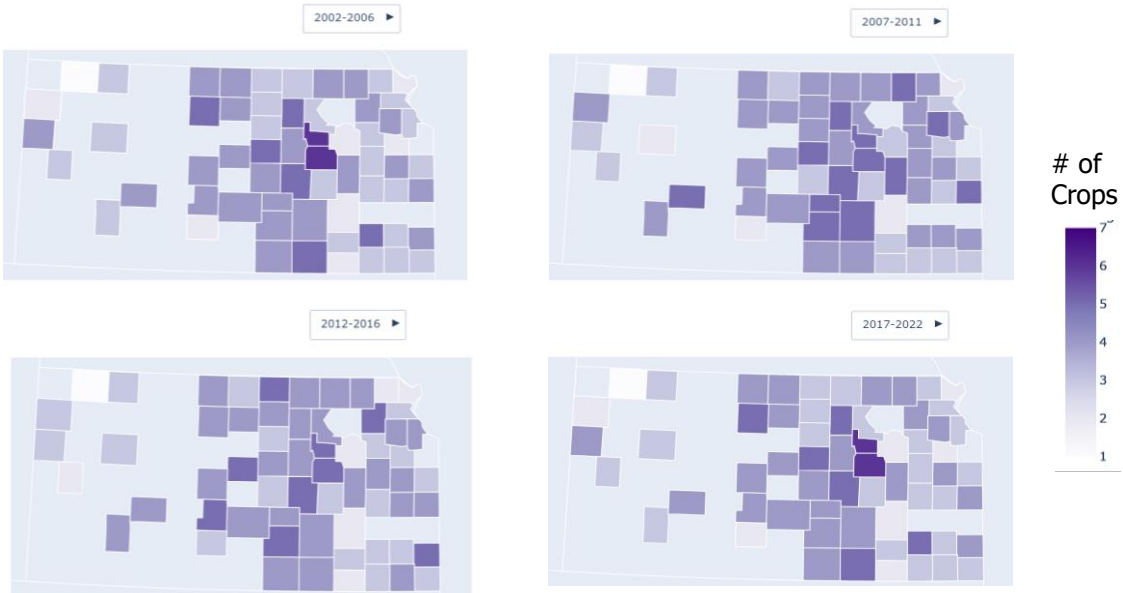



Shock 1 – 1980 Drought
Shock 2 – 1999 Drought in SE
Shock 3 – 2012 Drought

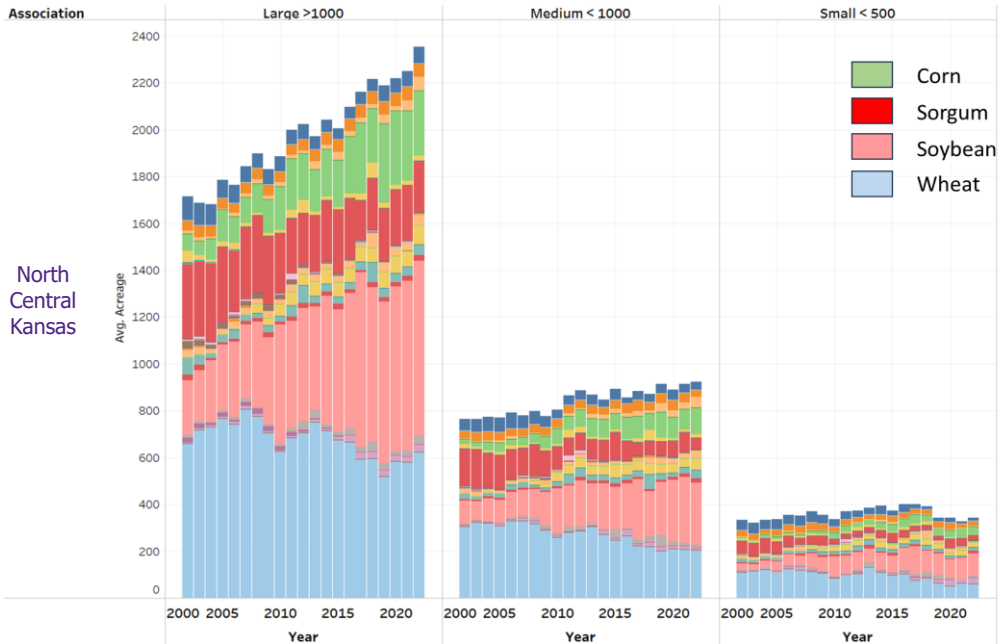
# Kansas Net Farm Income Distribution



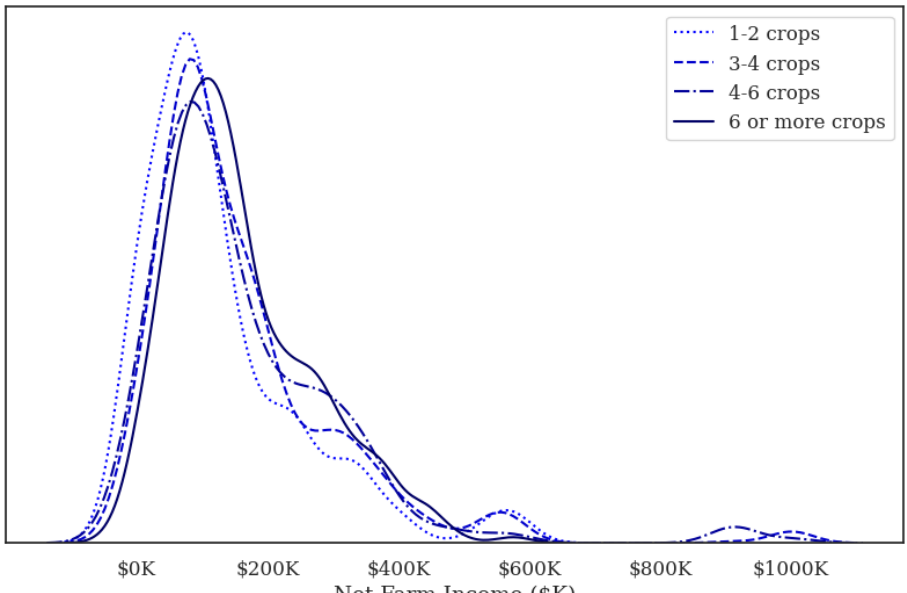
# Historical Trends in Crop Counts Across Kansas



# Historical Trends in Crop Shares




# Distribution of Farm Income Over Crop Diversity




Peak of the distribution flattens with increase in crops

There is longer tail, extending towards higher income levels

# Methodology – Base Model

To identify the impact of drought and crop diversity on farm Income, we consider the following model:

**The baseline model for Farm Income is specified as follows:**

$$\begin{aligned}\text{Income}_{it} = \beta_0 &+ \beta_1 \text{Drought}_{it} + \beta_2 \text{Diversity}_{it} \\ &+ \beta_3(\text{Drought}_{it} \times \text{Diversity}_{it}) + \gamma X_{it} + \alpha_i + \lambda_t + \varepsilon_{it}\end{aligned}$$

$$\text{Income}_{it} = \text{IHS}(\text{Adjusted Net Farm Income}_{it})$$

$\text{Drought}_{it}$ : drought measure for farm $i$ in year $t$

$\text{Diversity}_{it}$ : crop diversity measure for farm $i$ in year $t$

$X_{it}$ : vector of covariates (e.g., farm size, location, total assets)

$\alpha_i, \lambda_t$ : farm and time fixed effects

# How to Measure Crop Diversification ?

**Indices are computed to reflect the level of diversification.**

- The Herfindahl-Hirschman Index (HHI) indicates the concentration of acreage or income among crops, higher values indicating less diversification.
- The Shannon Diversity Index (SDI) reflects the diversity of crops, with higher values indicating greater diversification.
- The Crop Share Threshold Counts tally the number of crops making atleast 10% of the total acreage or income.

| Diversification Index | Formula |
|---|---|
| **Herfindahl-Hirschman Index (HHI) for Acreage** | $\mathbf{HHI_{acreage}} = \sum (\mathbf{share}_{i,\mathbf{acreage}})^2$ |
| Shannon Diversity Index (SDI) for Acreage | $SDI_{\text{acreage}} = -\sum_{1}^{10/} (share_{i,\text{acreage}} \times \ln(share_{i,\text{acreage}}))$ |
| Crop Share Threshold Count (by Income) | $\text{Count}_{\text{income}}(share_{i,\text{income}} > 0.10)$ |
| Crop Share Threshold Count (by Acreage) | $\text{Count}_{\text{acreage}}(share_{i,\text{acreage}} > 0.10)$ |

# Diversification Measures - Mean, SD, Min, and Max

Table: Descriptive statistics for diversification indices in 2002 and 2022.

| | 2002 | | | 2022 | | |
|---|---|---|---|---|---|---|
| Variable | Mean (SD) | Min | Max | Mean (SD) | Min | Max |
| HHI (Acreage) | .3675 (.1437) | 0 | 1 | .3986 (.1768) | 0 | 1 |
| HHI (Income) | .3689 (.1544) | 0 | 1 | .4477 (.1872) | 0 | 1 |
| SDI (Acreage) | 1.2027 (.3809) | 0 | 2.0936 | 1.1095 (.4443) | 0 | 2.2224 |
| SDI (Income) | 1.2318 (.3810) | 0 | 2.0394 | .9893 (.4141) | 0 | 1.9553 |
| Crop Share Count (Income) | 2.9 (.9711) | 0 | 6 | 2.5 ( .8322) | 0 | 5 |
| Crop Share Count (Acreage) | 2.9 (.9067) | 0 | 6 | 2.7 ( .8899) | 0 | 5 |

**Key Observations:**

- The HHI measures have slightly increased from 2002 to 2022, indicating a trend towards greater concentration in both acreage and income.
- SDI measures have decreased over the same period, reflecting the same trend.
- The decrease in crop share count for share at least 10% for income from 2002 to 2022.

# How to measure Drought Severity ?

US Drought Monitor measures DSCI as a weekly measure of drought intensity and spatial extent.

**Intensity classes**

| Category | Drought Intensity Level | Percentile |
|---|---|---|
| D0 | Abnormally dry | 20 to 30 |
| D1 | Drought, moderate | 10 to 20 |
| D2 | Drought, severe | 5 to 10 |
| D3 | Drought, extreme | 2 to 5 |
| D4 | Drought, exceptional | less than 2 |

* Jointly by USDA, National Oceanic and Atmospheric Administration (NOAA), National Drought Mitigation Center (NDMC) ; Akyuz, F. A. 2017 ;Kuwayama et al 2018

# Methodology – Conceptual Strategy

We estimate **Two variations of the model** to provide a comprehensive analysis:

- HHI with DSCI
- HHI with individual drought levels (D0-D4)

- Predict farm income using the estimated fixed effects and mean HHI Index (diversification baseline).
- Analyze the effect of change in diversification levels on farm income prediction

(increased diversification scenario +0.1, +0.2 ).

# Results

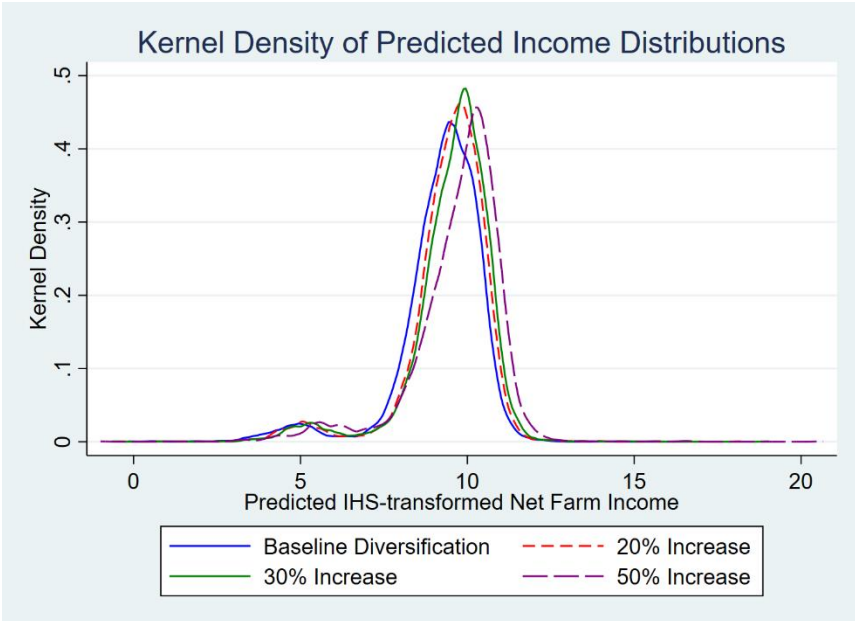
Table: Impact of Crop Diversity and Drought on Farm Income

| | (1) HHI & DSCI | (2) HHI & Levels |
|---|---|---|
| HHI | -2.528* | -2.540 |
| | (1.379) | (1.803) |
| DSCI | -0.000** | |
| | (0.000) | |
| D2 | | -0.116*** |
| | | (0.036) |
| D4 | | -0.129*** |
| | | (0.048) |
| HHI × D4 | | 0.177** |
| | | (0.075) |
| Crop Acres | 0.001*** | 0.001*** |
| | (0.000) | (0.000) |
| Debt-to-Asset Ratio | -3.824*** | -4.038*** |
| | (0.729) | (0.720) |
| Govt Payments (lag) | -0.067 | -0.074 |
| | (0.071) | (0.071) |
| Insurance Income (lag) | -0.038 | -0.033 |
| | (0.026) | (0.027) |
| Insurance Expense (lag) | 0.036 | 0.025 |
| | (0.062) | (0.062) |
| Constant | 8.923*** | 9.244*** |
| | (1.082) | (1.198) |
| Observations | 4,624 | 4,394 |

*Note*: Standard errors in parentheses. * pj0.10, ** pj0.05, *** pj0.01. All models include year and association fixed effects. Dependent variable: IHS-transformed adjusted net farm income. Standard errors clustered at farm level in parentheses.

- Drought negatively impacts farm income
- Less diversification (higher HHI) also negatively affects farm income.
- The positive interaction term indicates that less diversified farms may be less negatively affected by severe drought than more diversified ones.

# More Diversification => Potential for Higher Farm Income



# Concluding Remarks

**Limitations and Remarks**

- We restricted samples to the farms in Kansas.
- We find the immediate effects of diversification are positive on farm profit, but negative result in the drought event .
- Long-term effects needs to be analyzed in more detail with policy changes

**Further direction**

- Including Diversification with Livestock
- Expanding samples to overall US farms using USDA cropland data

# Some Open Questions

- What could be the underlying reasons why less diversified farms seem less affected by severe drought?

- What strategies farms planning to employ to balance diversification and risk management in the face of increasing climate variability?

# U.S. Agricultural Policies and Crop Diversification (1933-2018)

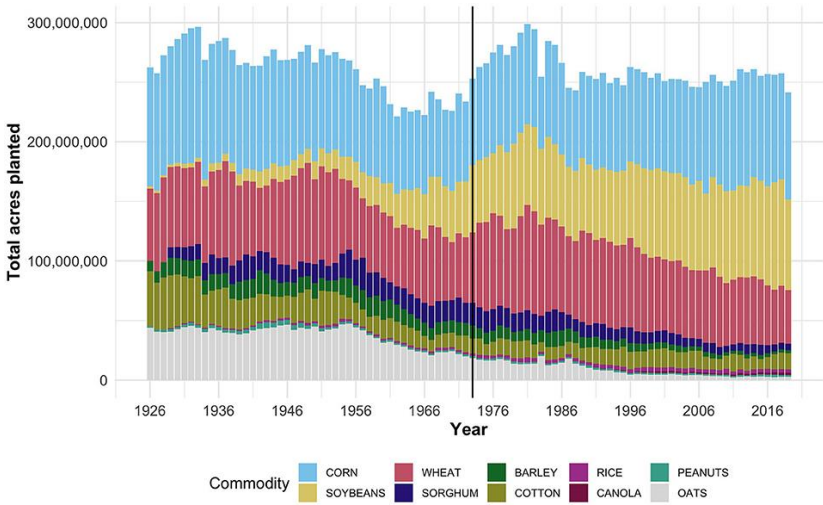
## Recent Trends and Current State

| 1933 Agricultural Adjustment Act | 1961-1970s: Shift to Federal Control | 1985 Food Security Act | 1996 "Freedom to Farm" Act | 2018 Farm Bill: Steps Towards Diversification |
|---|---|---|---|---|
| • First Farm Bill, limited scope (8 crops)<br>• **Focus on economic relief, not diversification** | • Emergency Feed Grains Act (1961)<br>• "Fencerow to Fencerow" era (1970s)<br>• Result: **Expansion of corn, soy, wheat; decline in other crops** | • Introduced Conservation Reserve Program (CRP)<br>• Acreage Limitation Program (ALP)<br>• **Limited diversification on subsidized lands** | • Increased planting flexibility, but...<br>• **Prohibited fruit and vegetable production on contract acreage** | • Greater flexibility to switch between PLC and ARC programs<br>• Expanded support for specialty crops and organic farming<br>• **Increased funding for research on crop diversity** |

**Overall Policies on Diversification:**

- Historical policies favored commodity crop specialization
- Recent policies offer some flexibility, but structural barriers remain

# Motivation: US Crop Acreage Use




**Farm Bills**

- Historical policies favored commodity crop specialization (1933 only 8 crops mentioned)
- Recent policies offer some flexibility and support, but structural barriers remain (2018 52 distinct crops mentioned )

**Figure 1**. Total acres planted of 10 major U.S. crops between 1920 and 2019. Top 10 crops determined by acres planted. A vertical line at 1973 indicates the passing of the 1973 Farm Bill and marked transition toward crop specialization. Source: https://doi.org/10.3389/fsufs.2020.00098 USDA NASS Survey.

Thank you