Examining Cropping Systems from a Comprehensive Agronomic Perspective

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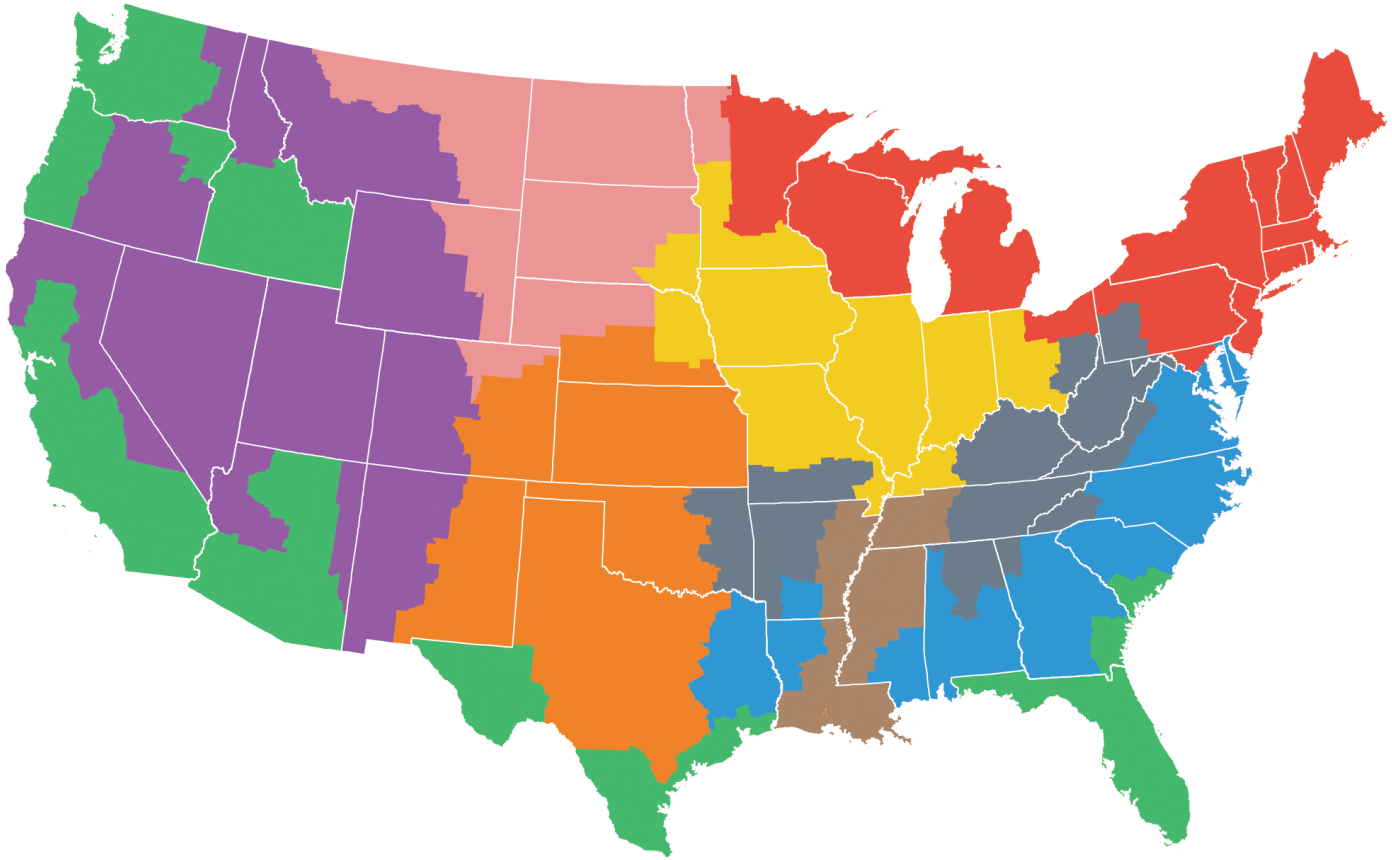
Crop Management Conference, Dec 2025

USDA Agricultural Research Service

USDA, Economic Research Service groups its nine Farm Resource Regions according to geographical commodity specializations



Note: USDA, Economic Research Service (ERS) Farm Resource Regions do not include Alaska and Hawaii because they are not included in ERS and USDA, National Agricultural Statistics Service's Agricultural Management Resource Survey (ARMS).

Source: USDA, Economic Research Service.

Crops for Discussion

Corn

- Annual 50º base
- Freeze date major

Soybean

- Annual 50º base
- Freeze date major

Cereal Rye

- Annual 32º base
- Generally not a cash crop
- Freeze date minimal

Winter Wheat

- Annual 32º base
- Freeze date minimal

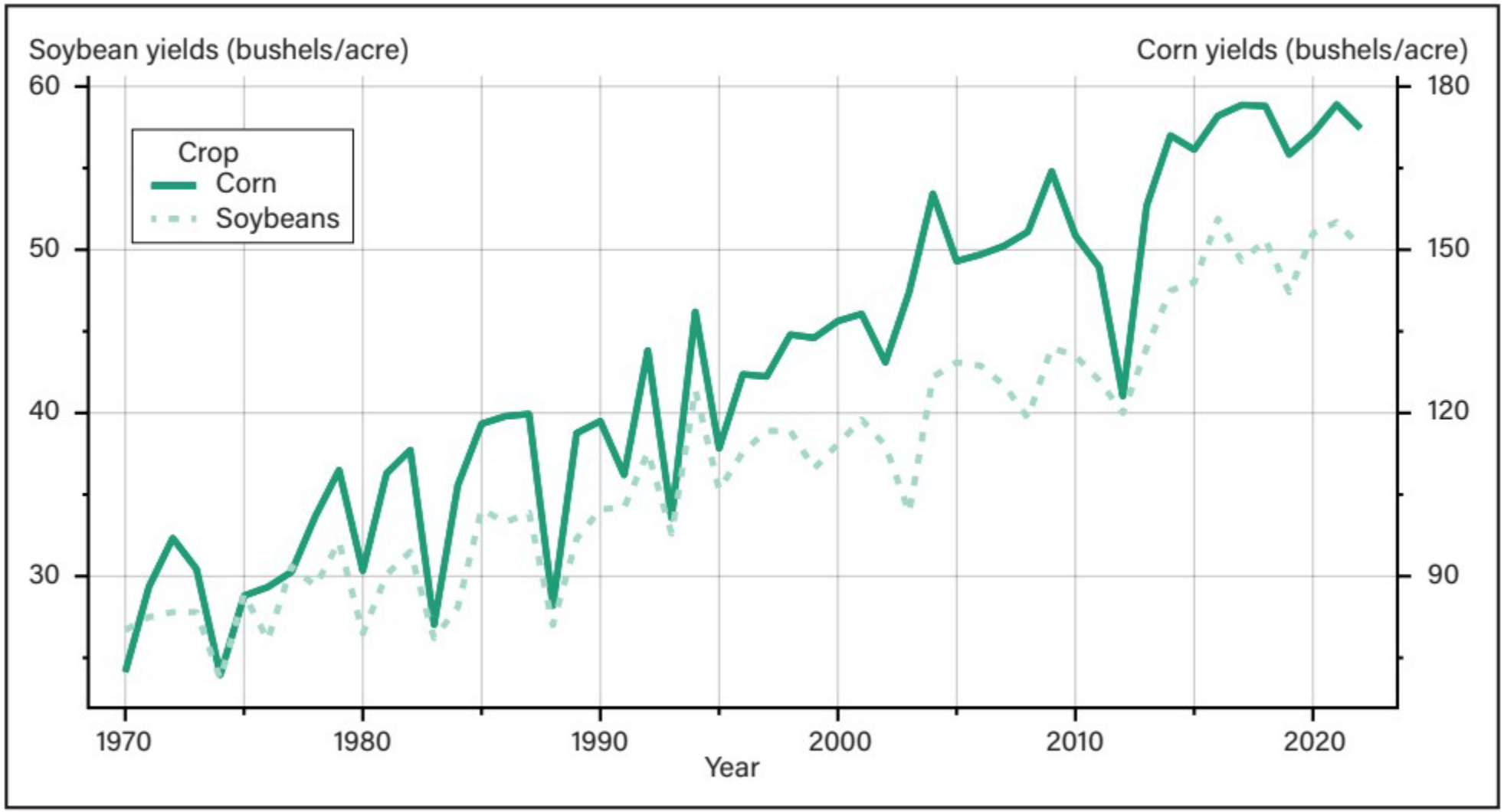
Winter Canola

- Biennial 40º base
- Freeze date minimal

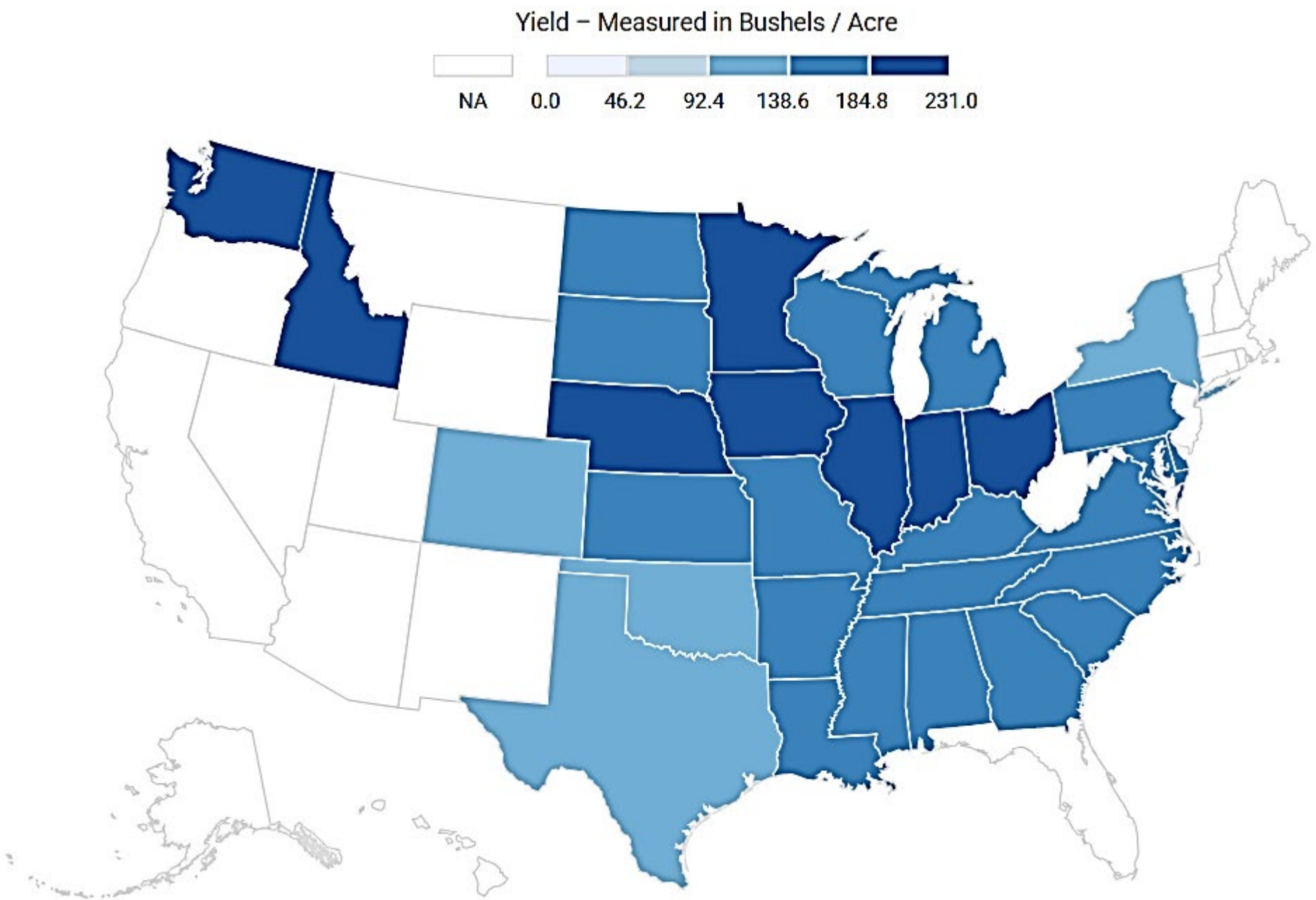
Not examining: Cotton, Peanut, Rice, Grain Sorghum

Long-Term Effort for Corn and Soybean Yield Gains

Historical yields for U.S. corn and soybeans, 1970 to 2022



Source: USDA, National Agricultural Statistics Service, 2023.

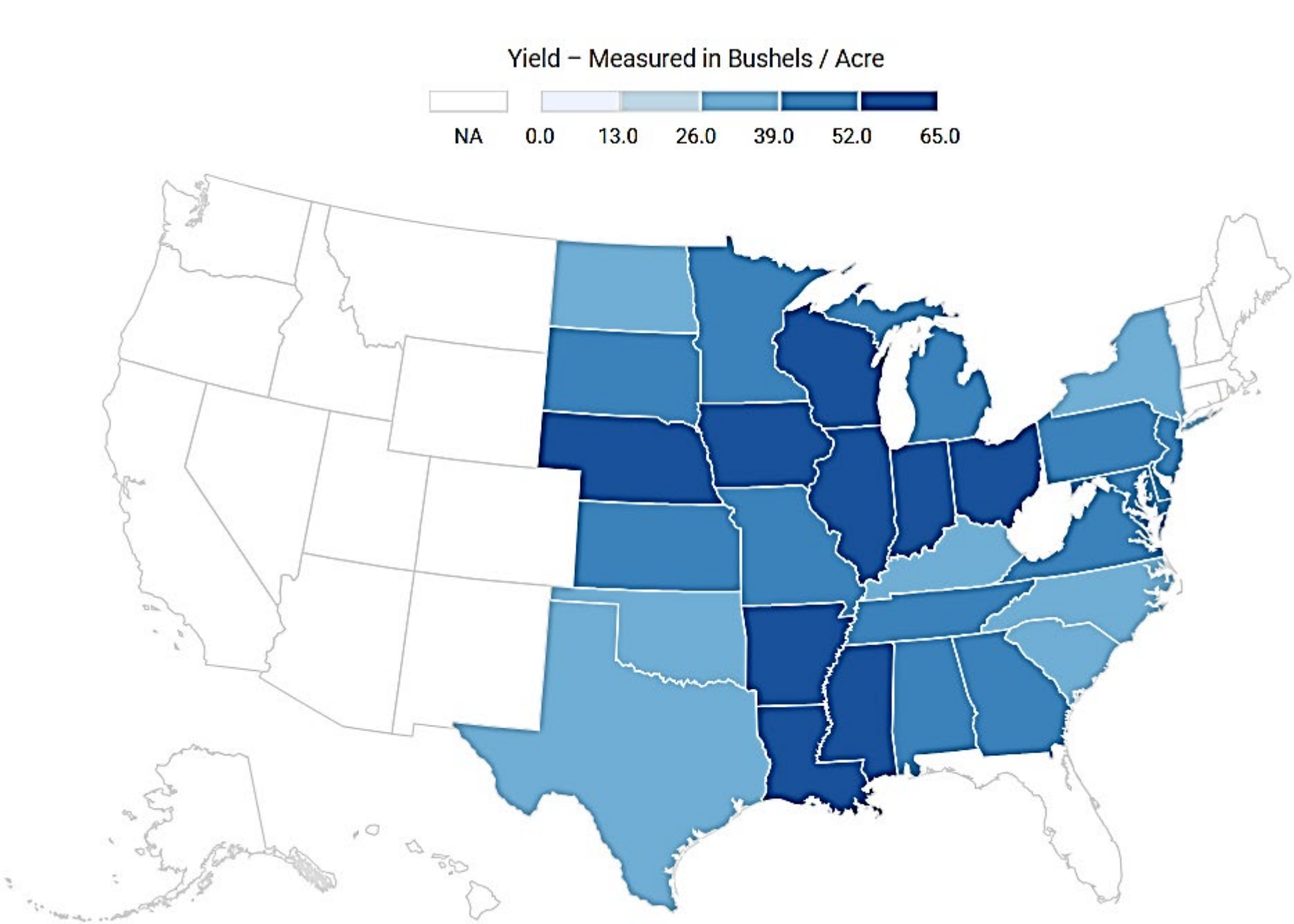


2025 Corn Yield

US: 186 bu/a

MO: 178 bu/a

Map from USDA NASS at https://www.nass.usda.gov/Data_Visualization/Commodity

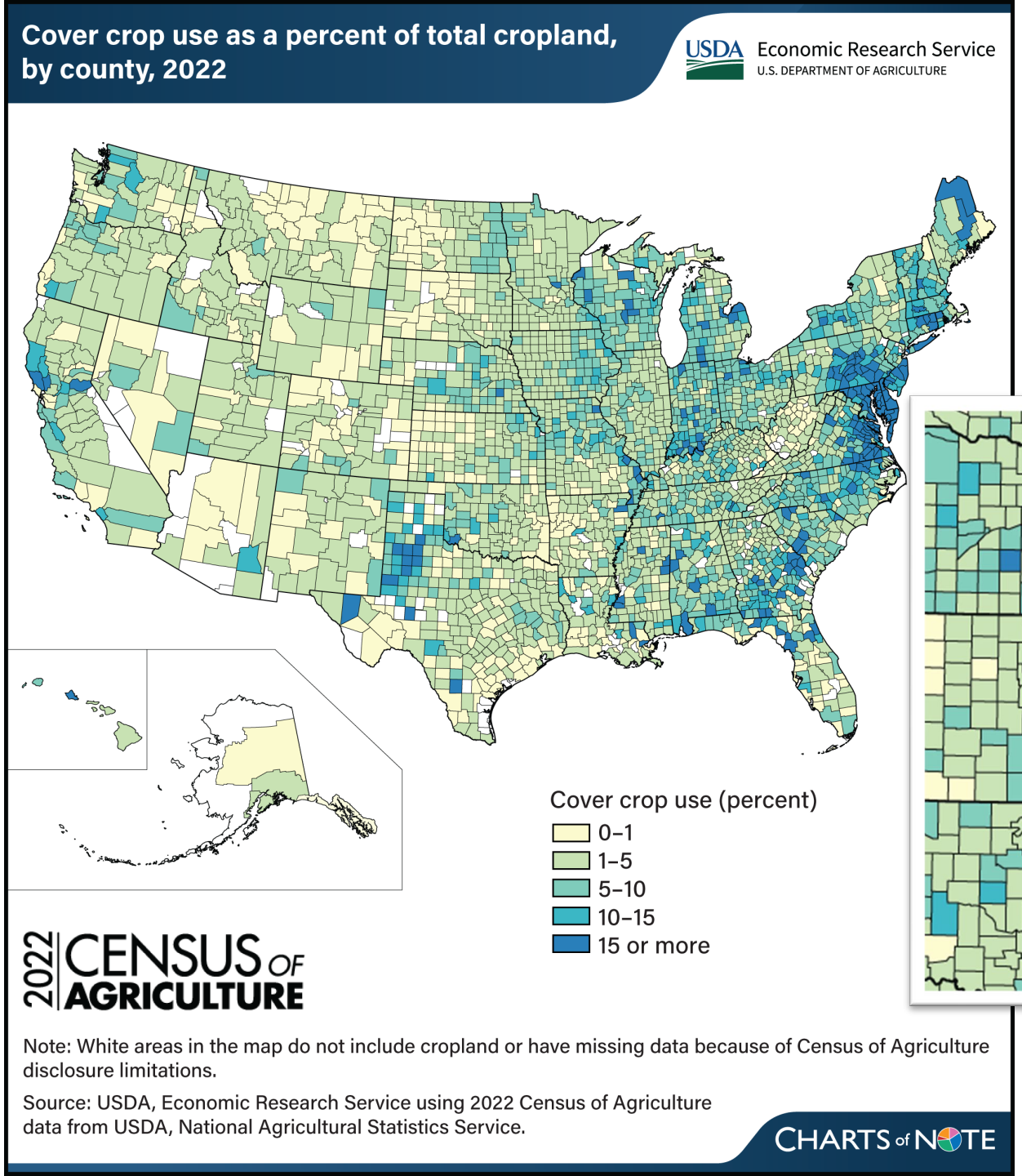


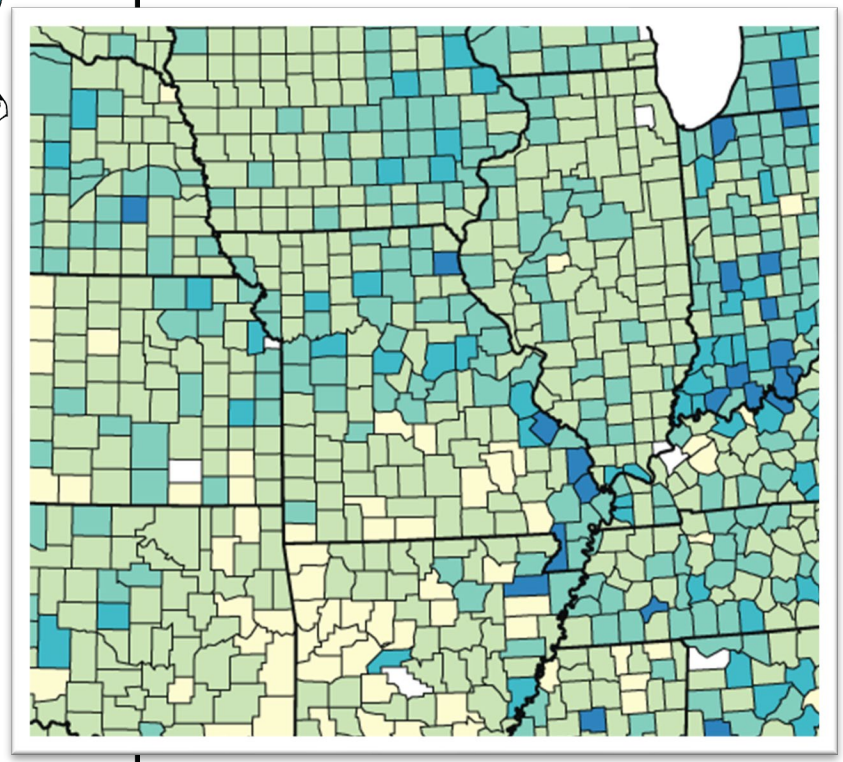
2025 Soy Yield

US: 53 bu/a

MO: 50 bu/a

Map from USDA NASS at https://www.nass.usda.gov/Data_Visualization/Commodity





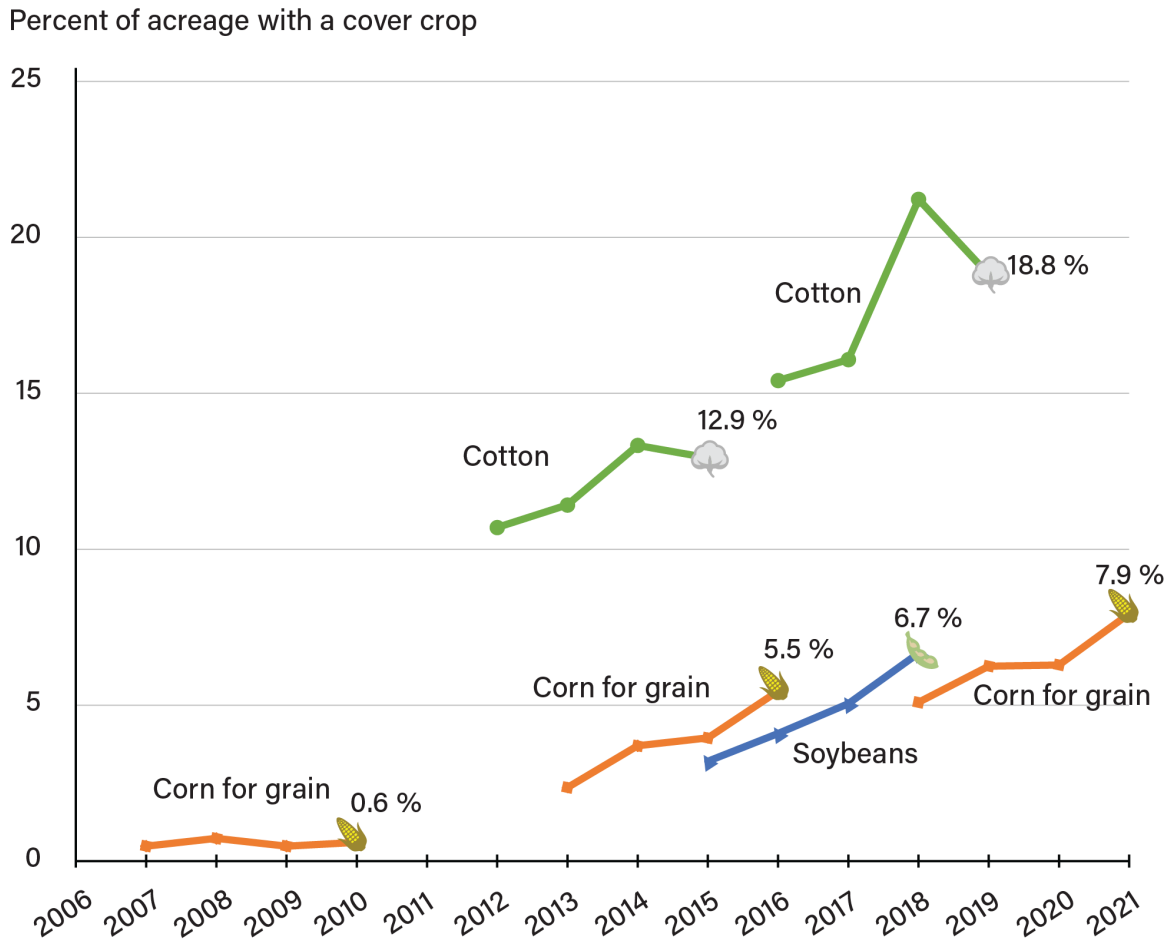
2022 Cover Crop

US: 5% (18M)

MO: ~7% (~1M)

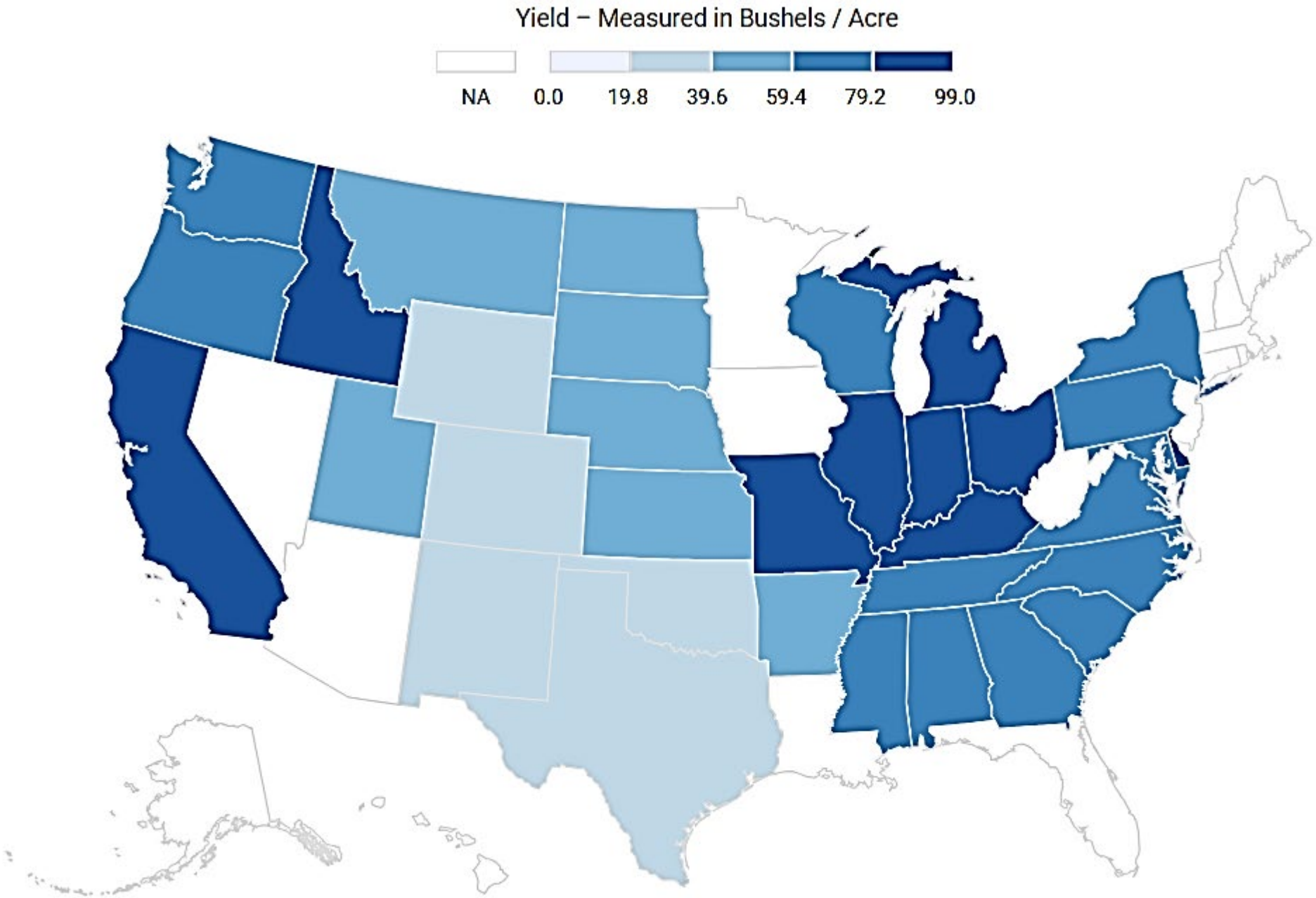
Trends in fall cover crop adoption by cash crop, 2007–21

USDA Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE



Notes: The planted crops in the surveyed fields in this chart consist of corn to be harvested for grain in the USDA's Agricultural Resource Management Survey years 2010, 2016, and 2021, soybeans in 2018, and cotton in 2015 and 2019. In the three years preceding the survey year on each line, the acreage includes a mix of other crops in rotation with the primary target crop on the surveyed fields. The samples used to calculate these percentages are restricted to fields for which the respondents reported the full 4-year cropping history. Corn numbers exclude corn planted for silage, which is about 4 percent of corn acreage and tends to include cover crops at a much higher adoption rate.

Source: USDA, Economic Research Service (ERS) using data from USDA's Agricultural Resources Management Survey on Production Practice Costs and Returns (Phase 2) for corn in 2010, 2016, and 2021, soybeans in 2018, and cotton in 2015 and 2019.



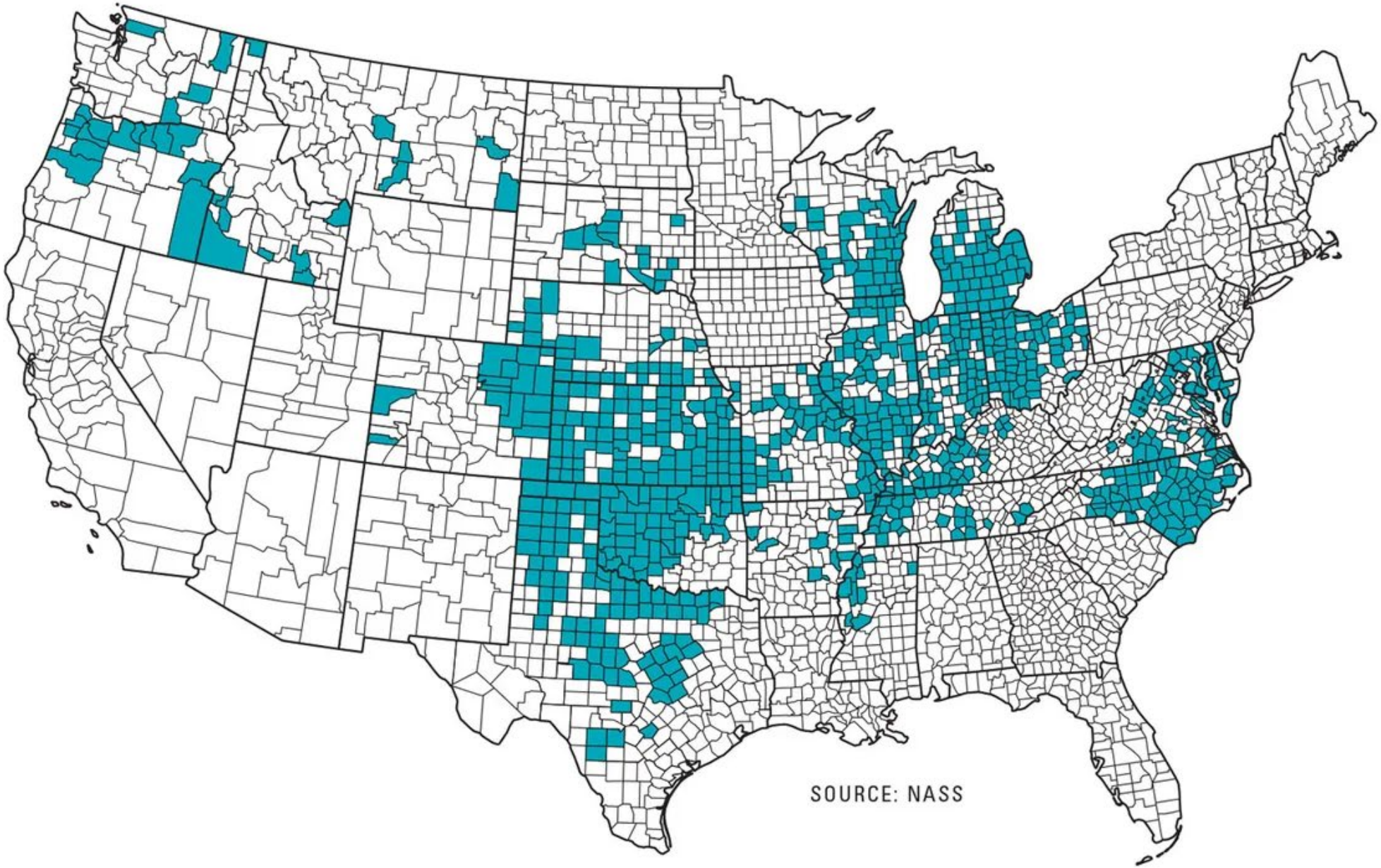
2025 W. Wheat

US: 55 bu/a

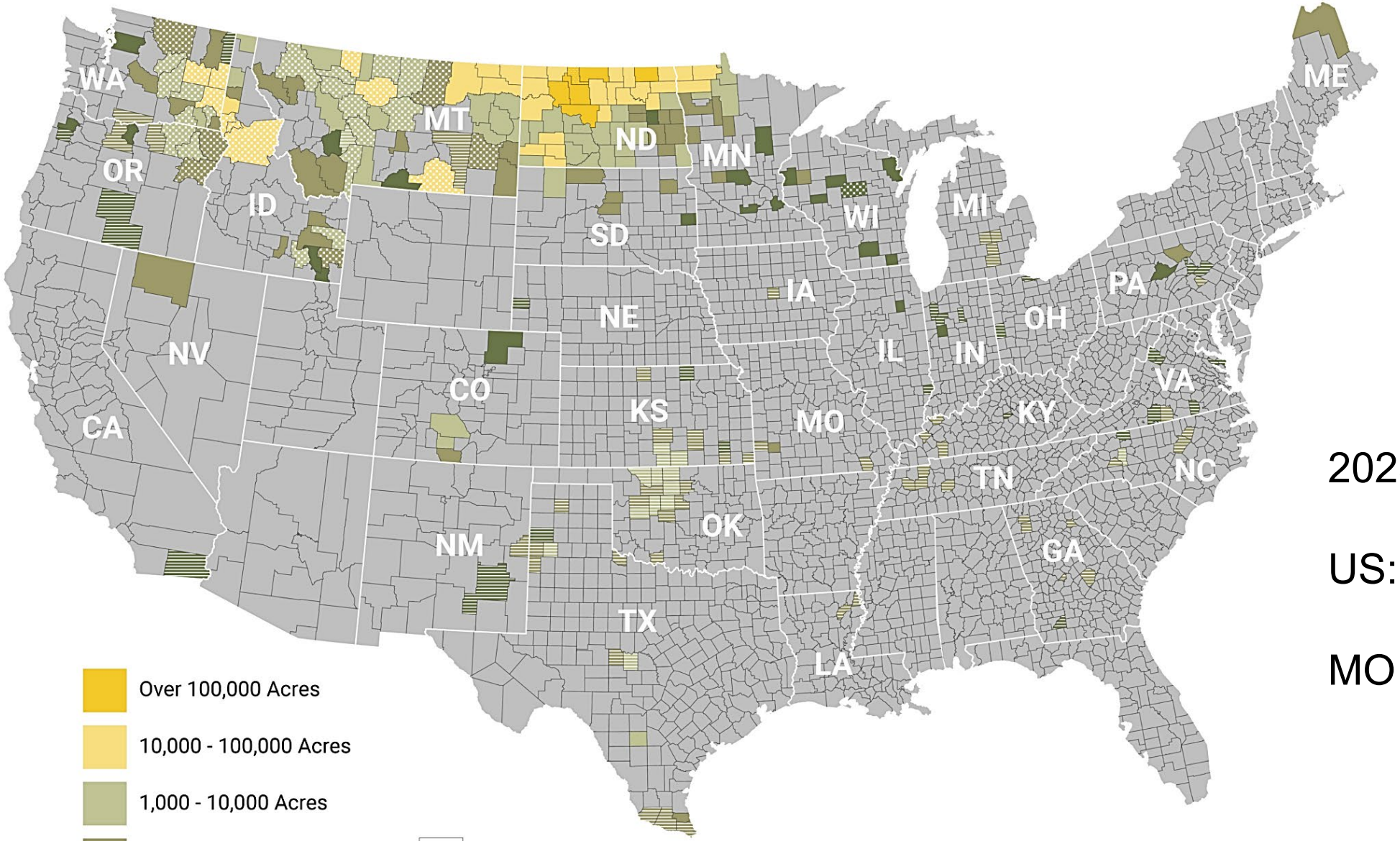
MO: 80 bu/a

Map from USDA NASS at https://www.nass.usda.gov/Data_Visualization/Commodity

COUNTIES WITH PLANTED ACRES OF WINTER WHEAT



Data from USDA NASS. Map by American Soybean Association.



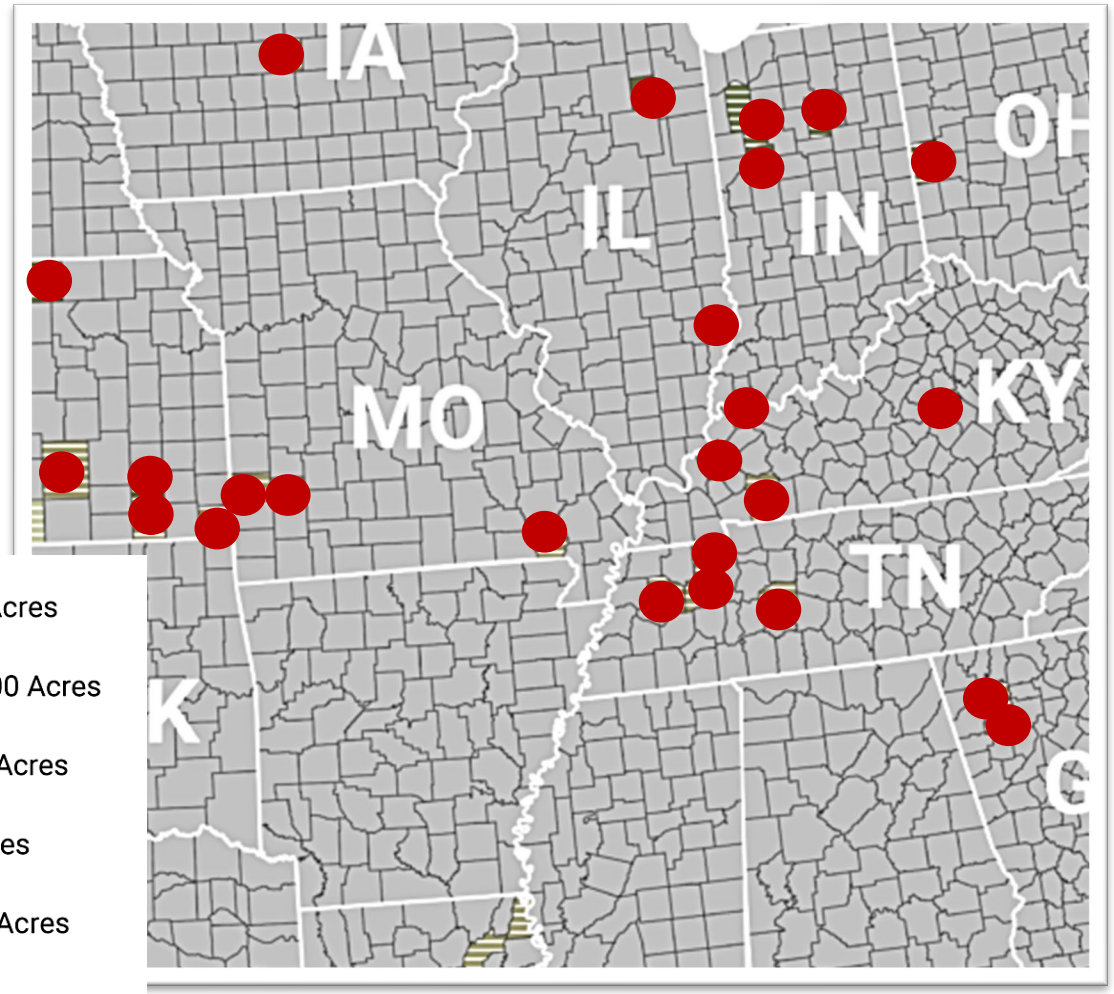
2025 W. Canola

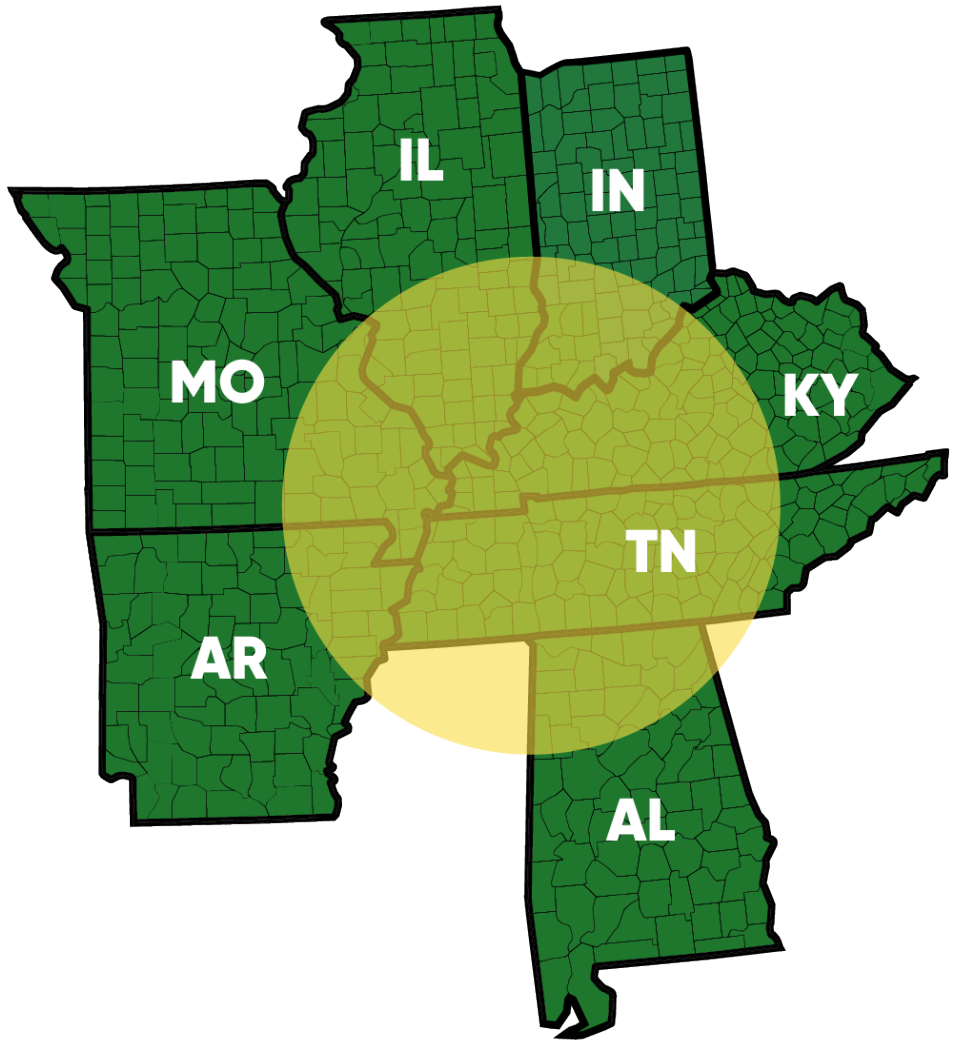
US: 36 bu/A (2024)

MO Region: 53 bu/a

Map from https://www.uscanola.com
US grain yield from USDA NASS 2024 Yield for spring and winter
MO region yields from Pioneer.com

Winter Canola Production Area





Maps from https://www.uscanola.com and Pioneer.com

Crop Suitability Factors

- Available heat
- Available water
- Managing crop stress
- Soil reserves
- Economic incentives

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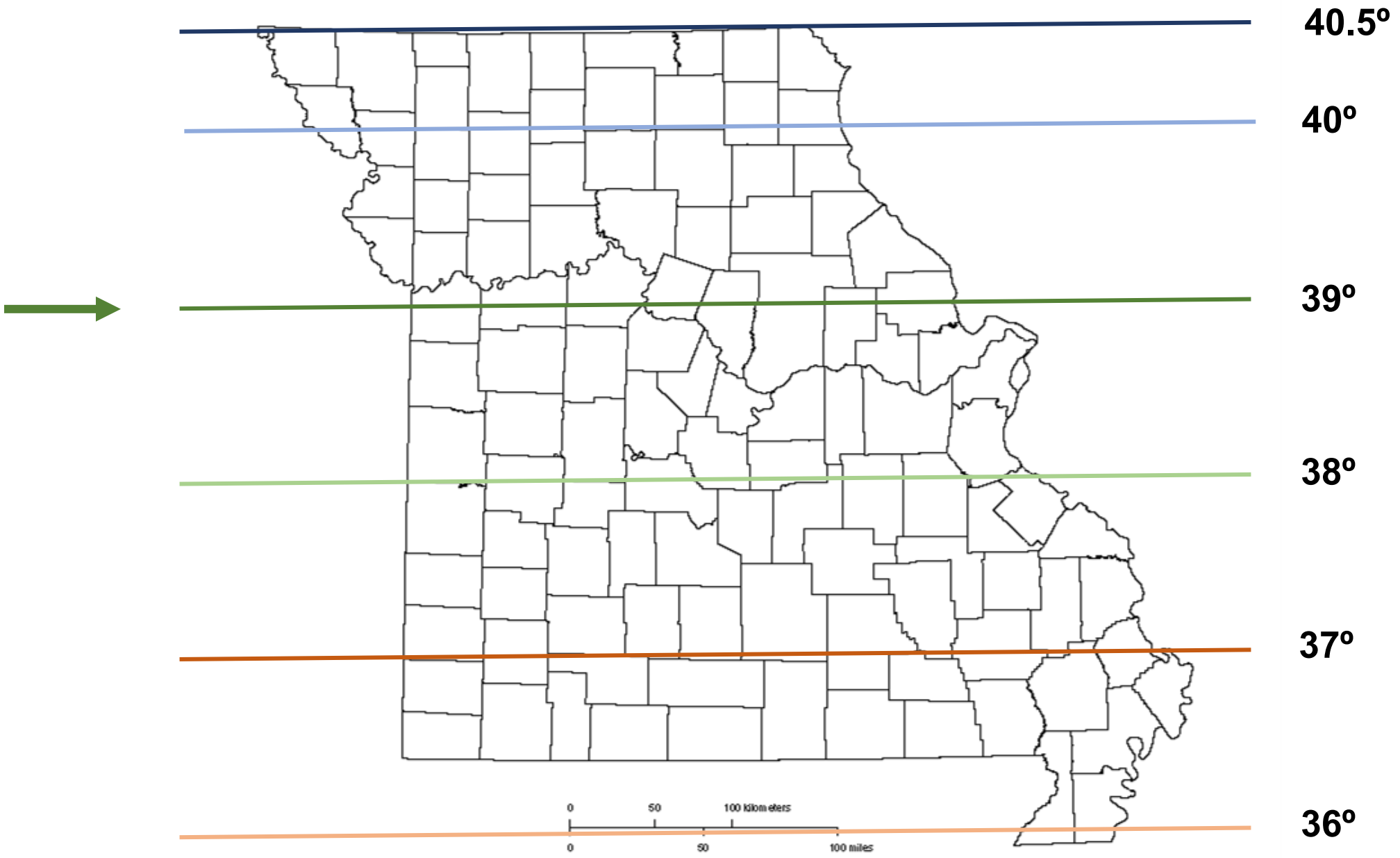
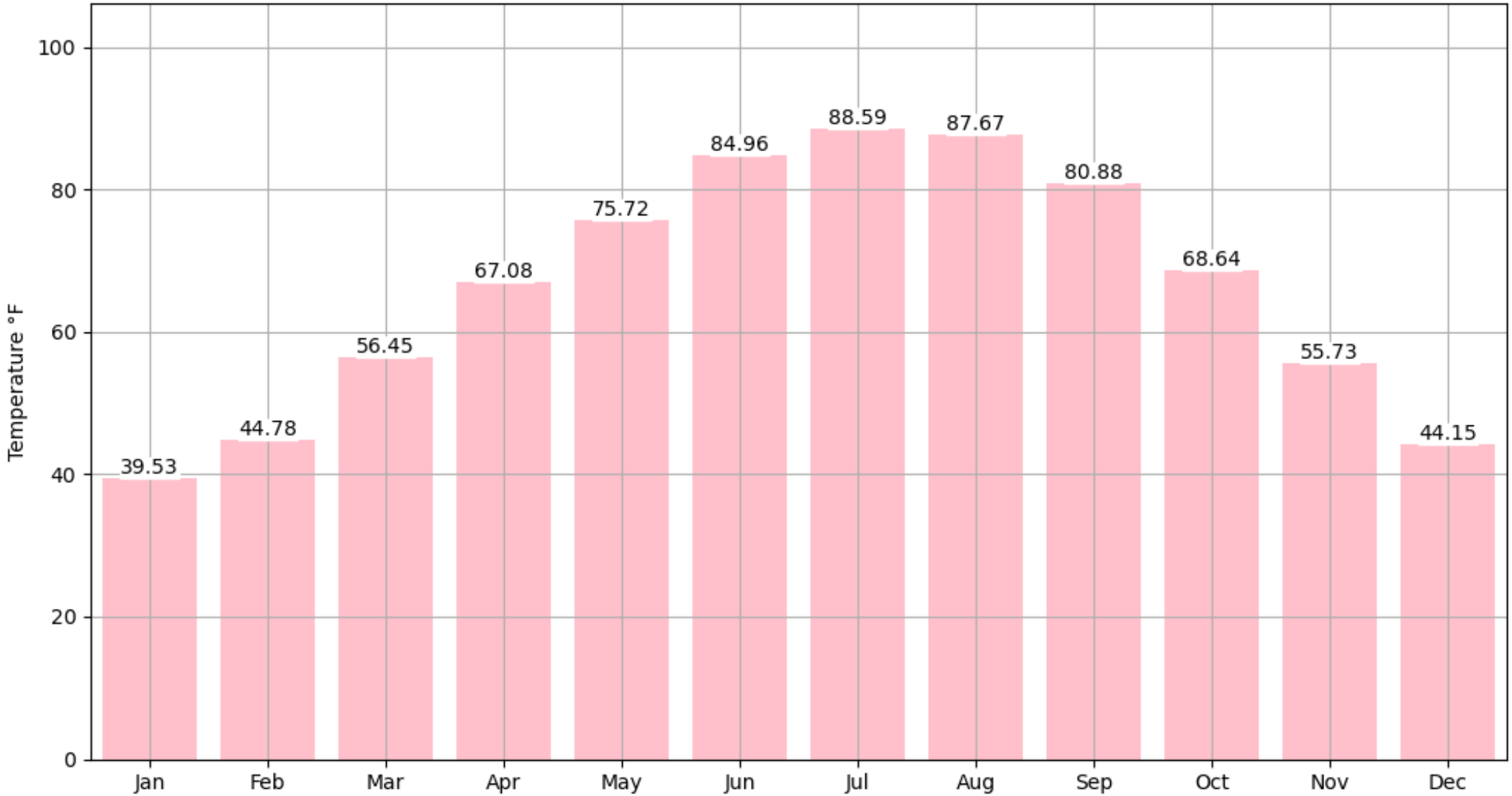

40.5º
40º
39º
38º
37º
36º
0
50
100 kilometers
0
50
100 miles

[MO1801] COLUMBIA U OF M
Climatology Average High Temperature [1994-2025]



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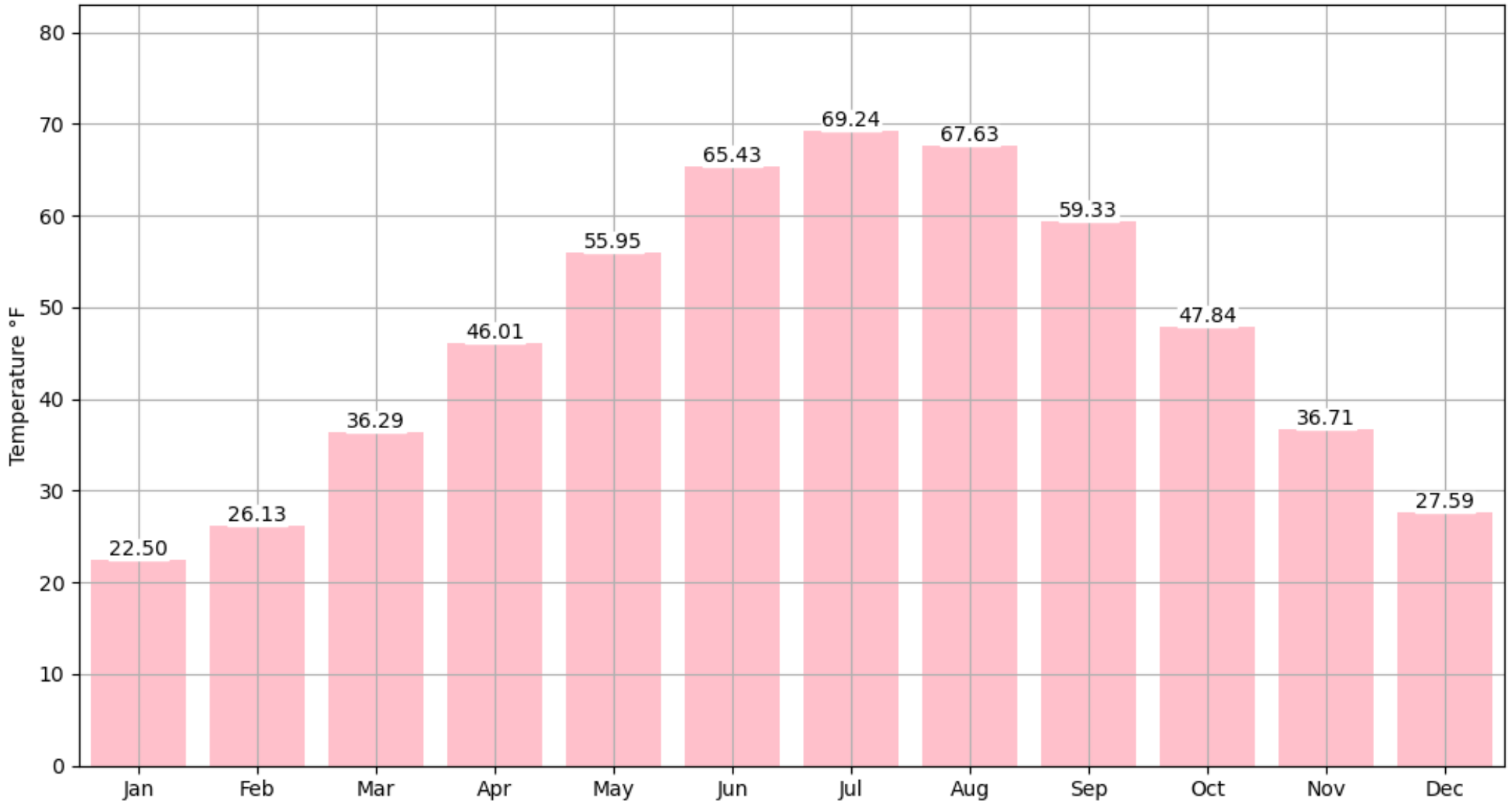
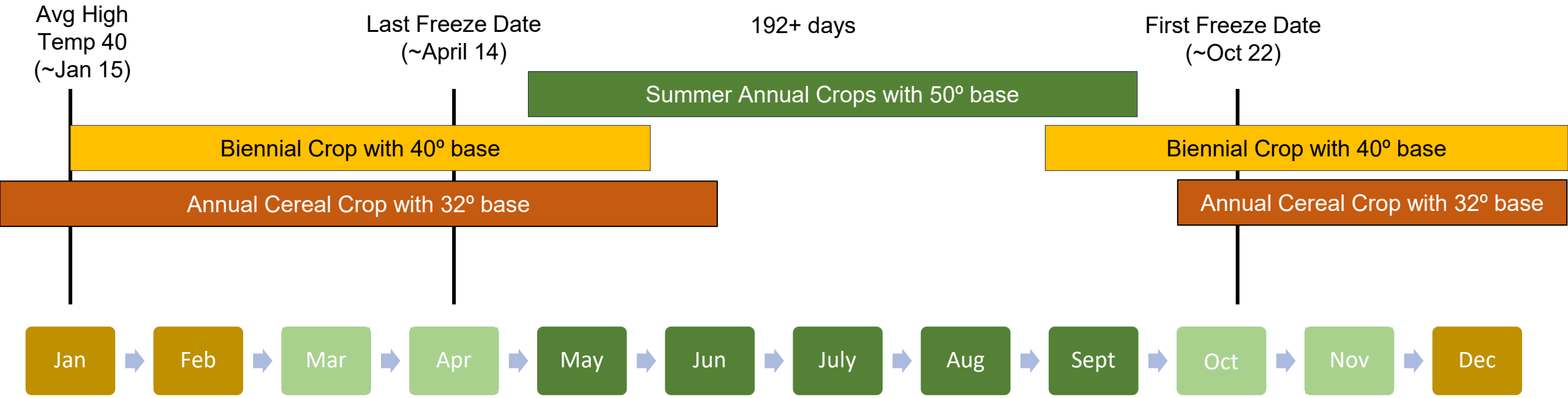
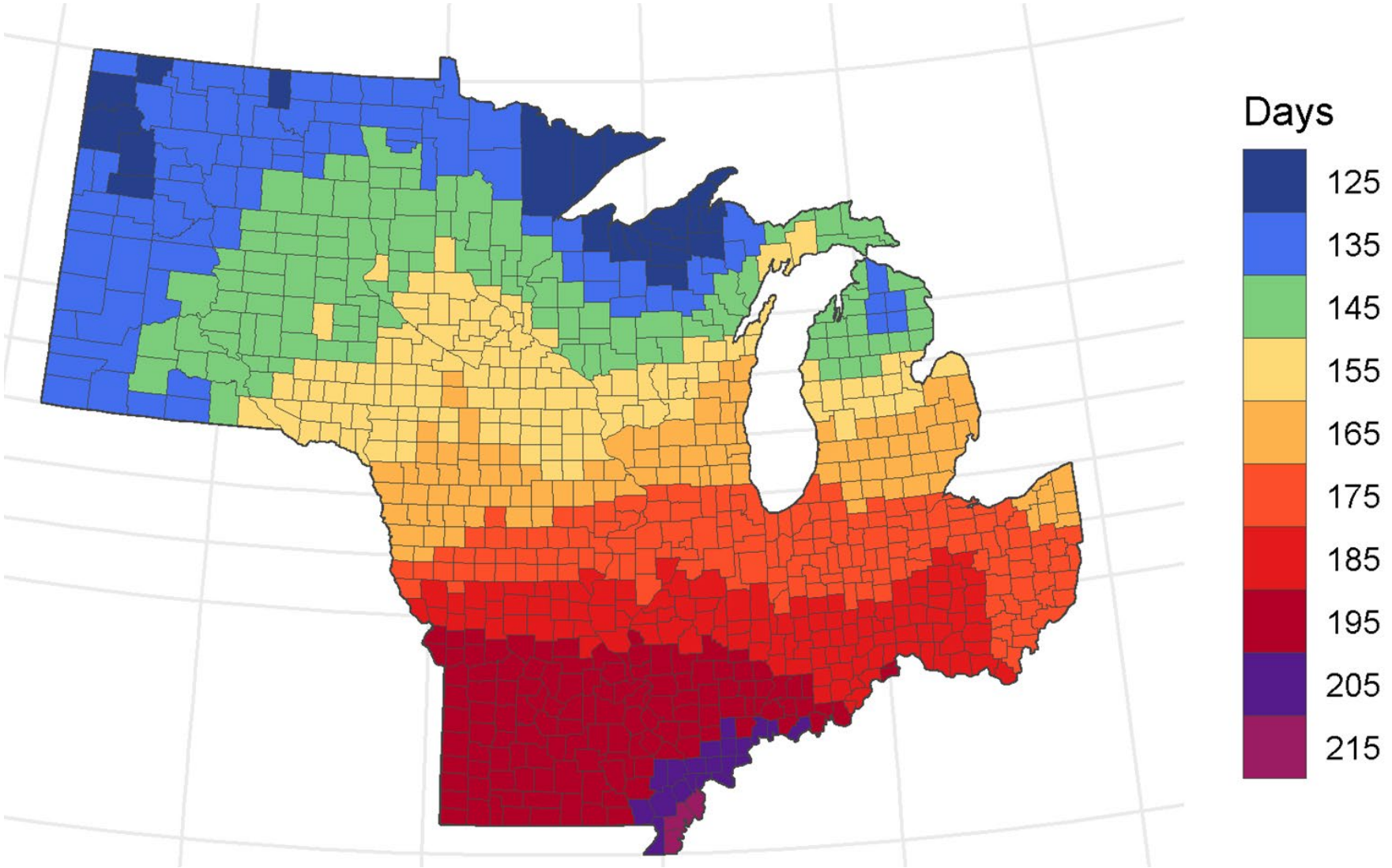


39° Latitude: Columbia

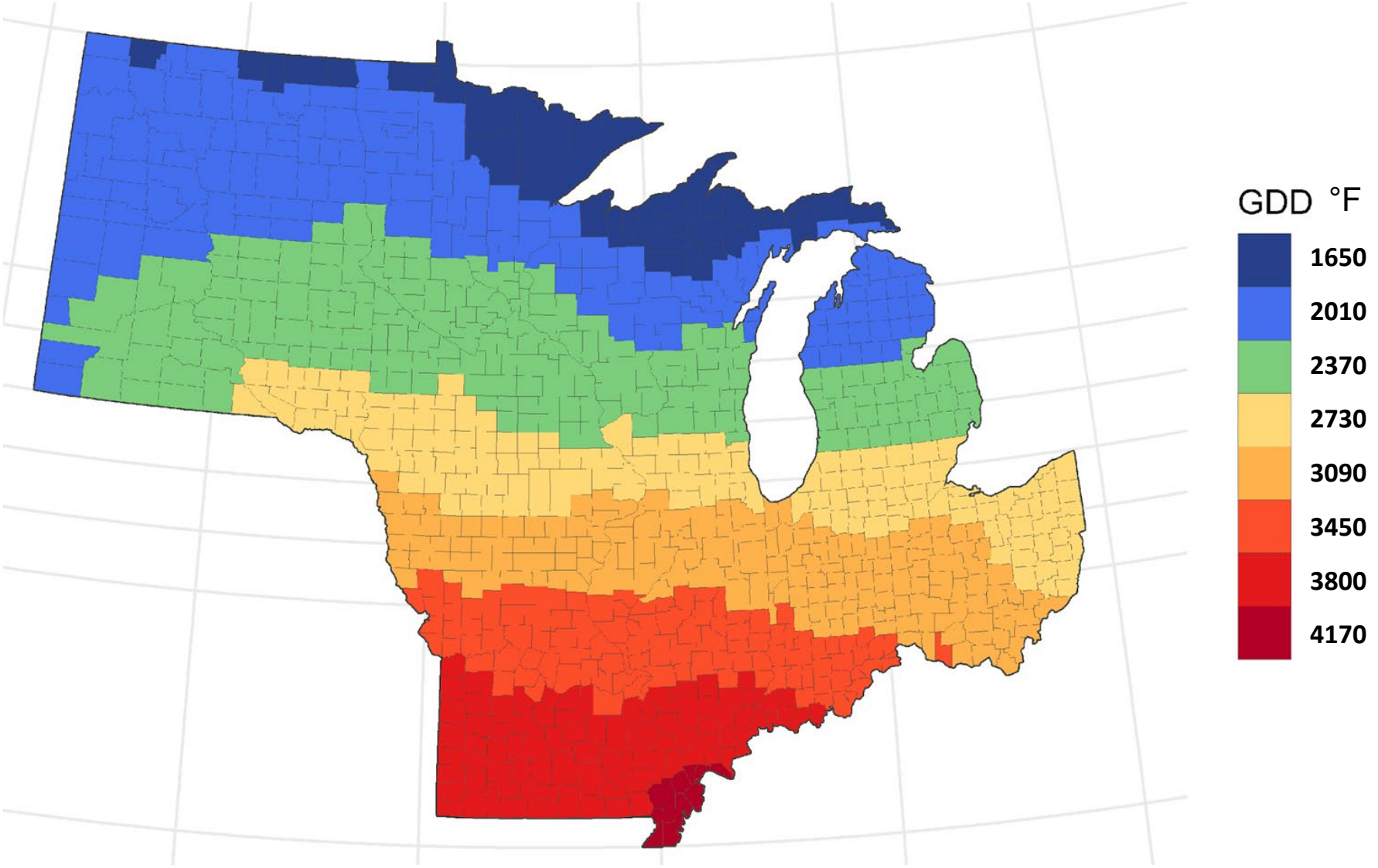


Frost-Free Period in Calendar Days



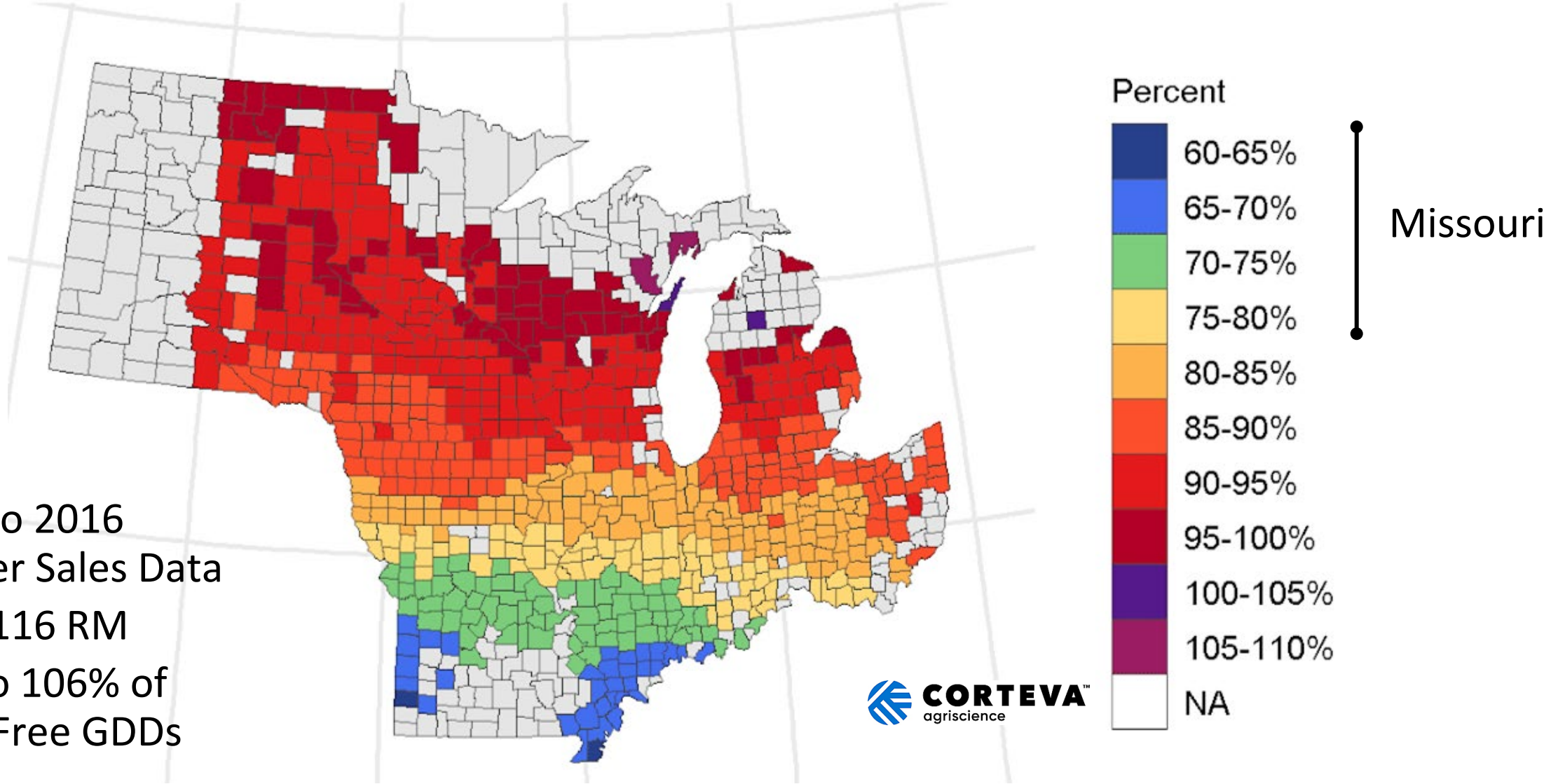
Abendroth et al. (2019) https://acsess.onlinelibrary.wiley.com/doi/pdfdirect/10.2134/agronj2019.02.0118

Frost-Free Period in Growing Degree Days



Abendroth et al. (2019) https://acsess.onlinelibrary.wiley.com/doi/pdfdirect/10.2134/agronj2019.02.0118

Use of Frost-Free Period by Current Corn Hybrids



- 2000 to 2016 Pioneer Sales Data
- 76 to 116 RM
- 63% to 106% of Frost-Free GDDs

Abendroth et al. (2021) https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.15565

Crop Suitability Factors

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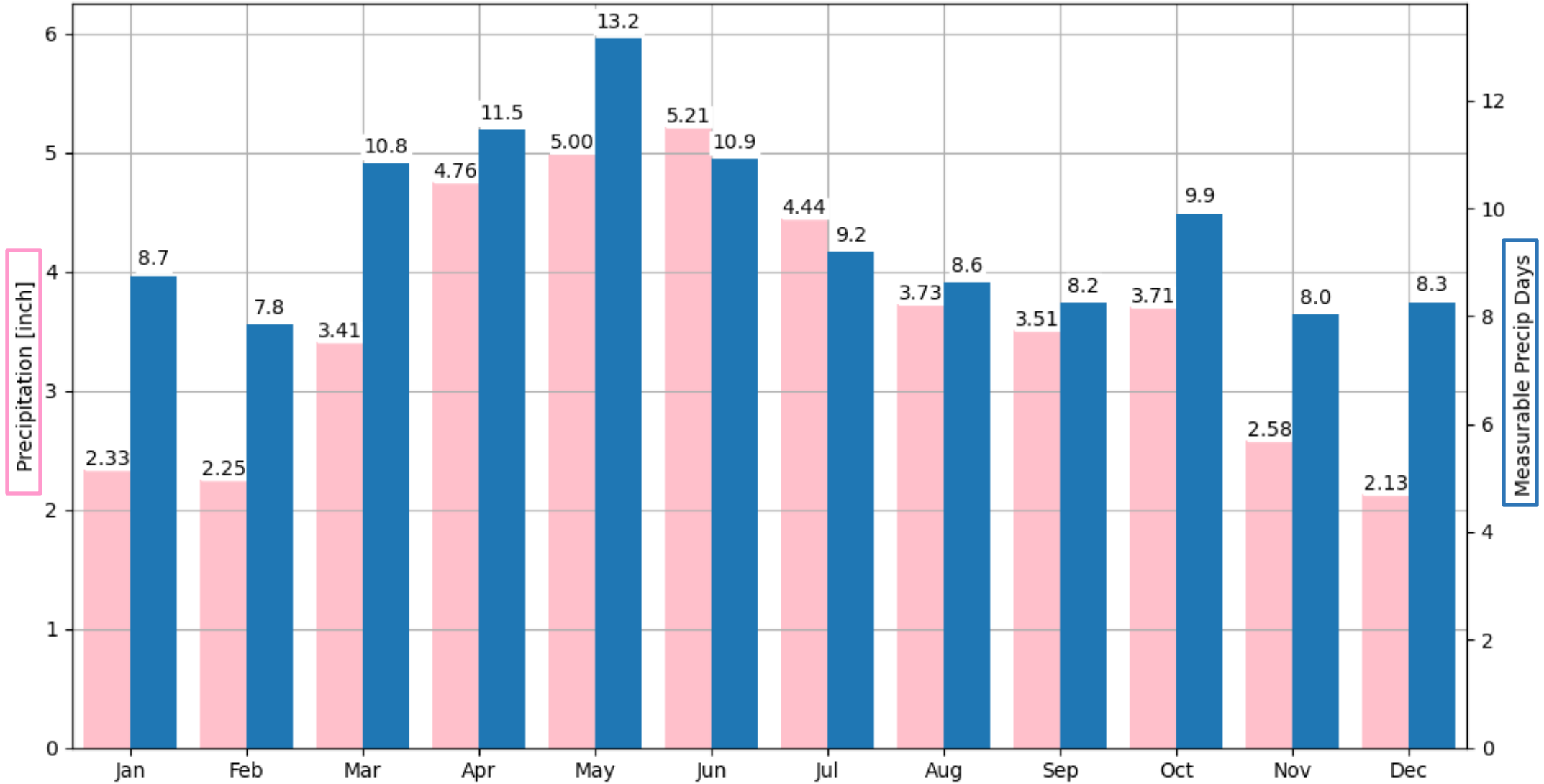
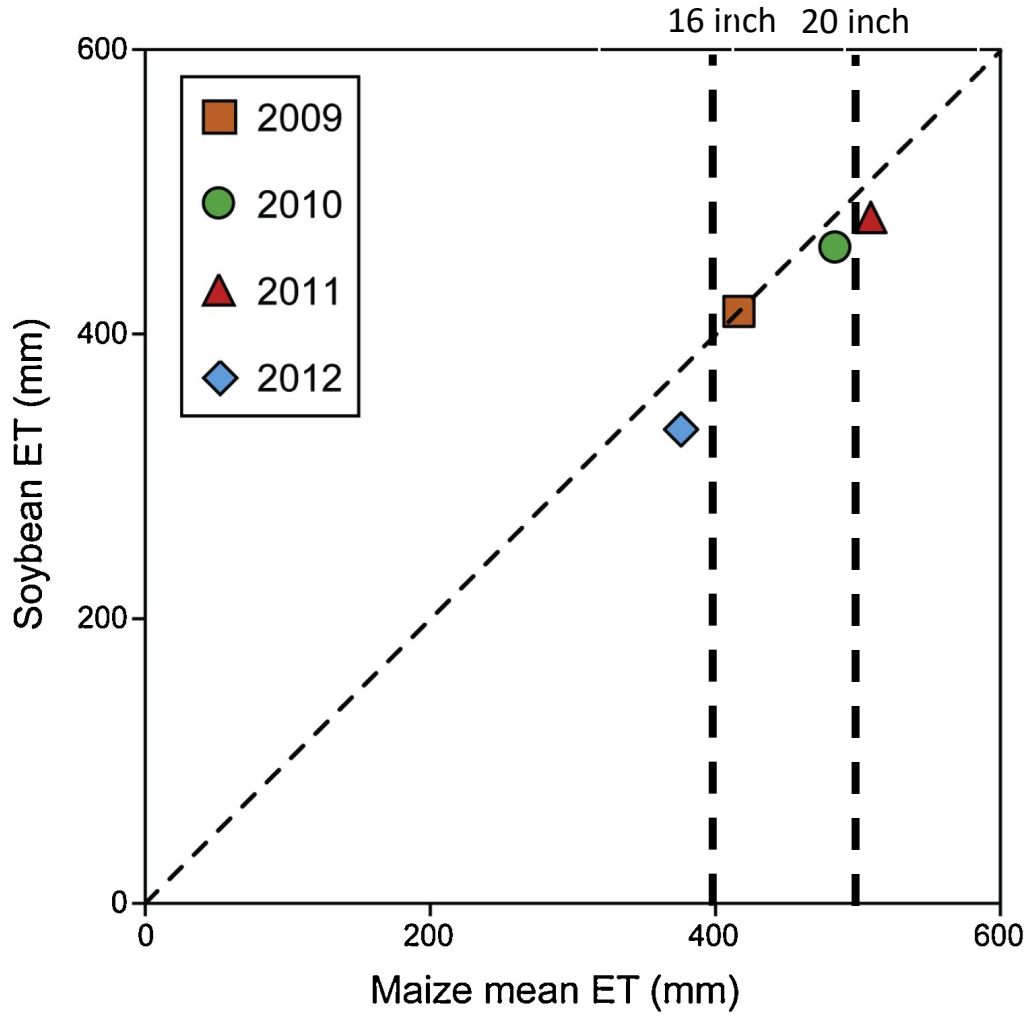
[MO1801] COLUMBIA U OF M
Climatology Total Precipitation [1994-2025] 43.05 inches over 115 days



Corn and Soybean Evapotranspiration



- Experiment in Michigan
- ET values higher in Missouri
- Columbia example:
  - Annual Precip = 43 in
  - Corn or Soybean ~ 20 in
  - Remaining ~ 23 in
- Winter Wheat ~ 20 in
- Winter Canola ~ 15 in

Figure from Zaman Hussain et al. (2019) Ag Water Management
https://www.sciencedirect.com/science/article/pii/S037837741830876X#fig0020

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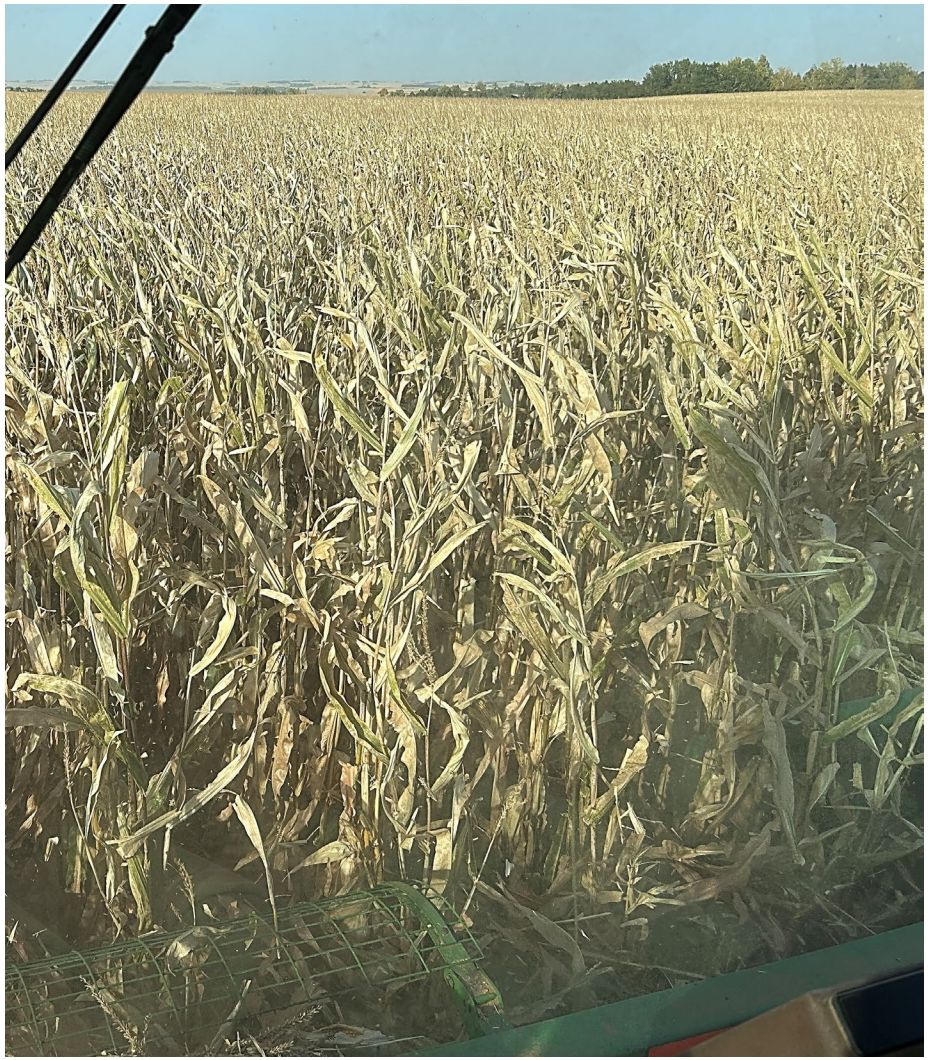
Corn with natural senescence (no stress)

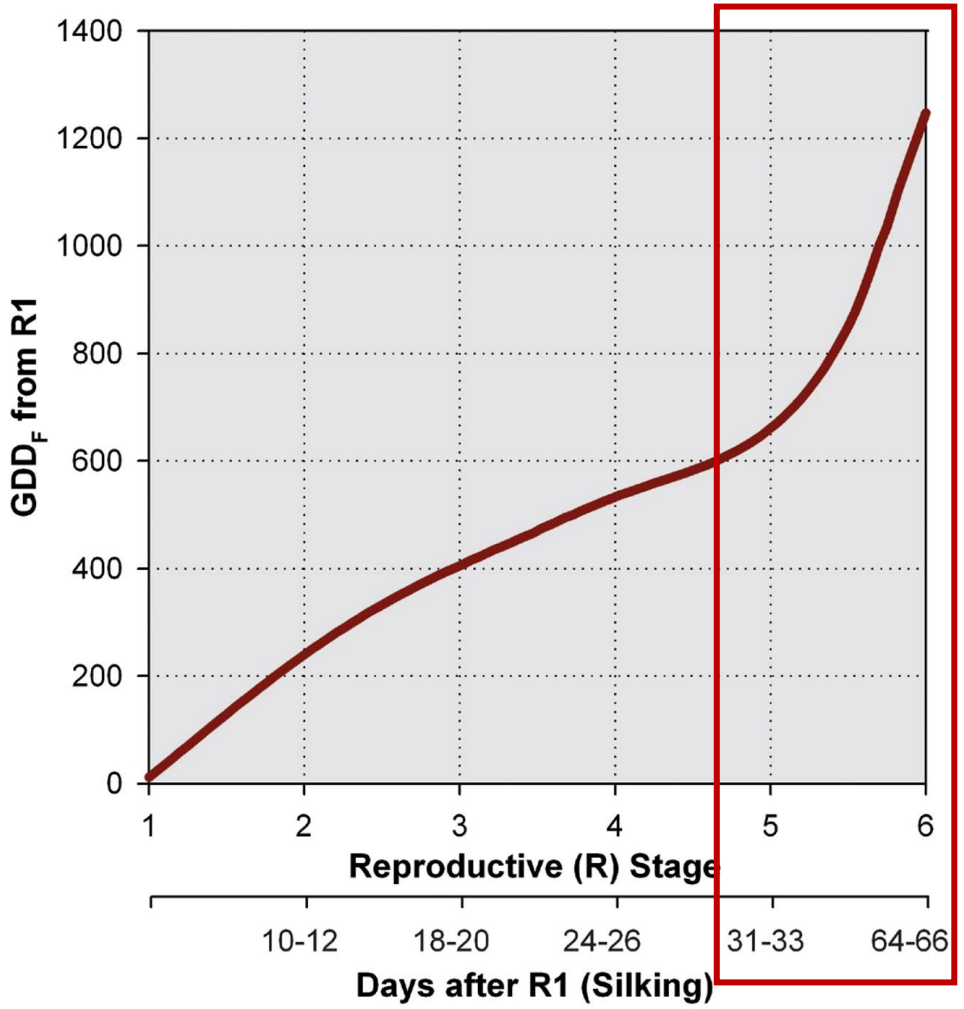


Photos by L. Abendroth

Corn with premature senescence (stressed)

Photos by R. Garza

Premature senescence impacts dent stage



			Average per Substage	
R Stage	% Moisture	Dry Matter (% of Total Dry Weight)	GDD$_F$	Days
5.0	60%	45%	75	3
5.25 (¼ milk line)	52%	65%	120	6
5.5 (½ milk line)	40%	90%	175	10
5.75 (¾ milk line)	37%	97%	205	14
6.0 (Physiological Maturity)	35%	100%		
TOTAL (AVERAGE)			575	33

Abendroth et al. (2011) Corn Growth and Development

Reproductive Stages

- Utilize photosynthetic capacity to form starch
- Stress before the dough stage (R4) results in kernel abortion
- Stress at dent stage results in lighter kernels
- Stress throughout grain filling period results in compounding of yield reductions

Abendroth et al. (2011) Corn Growth and Development

Premature senescence impacts dent stage

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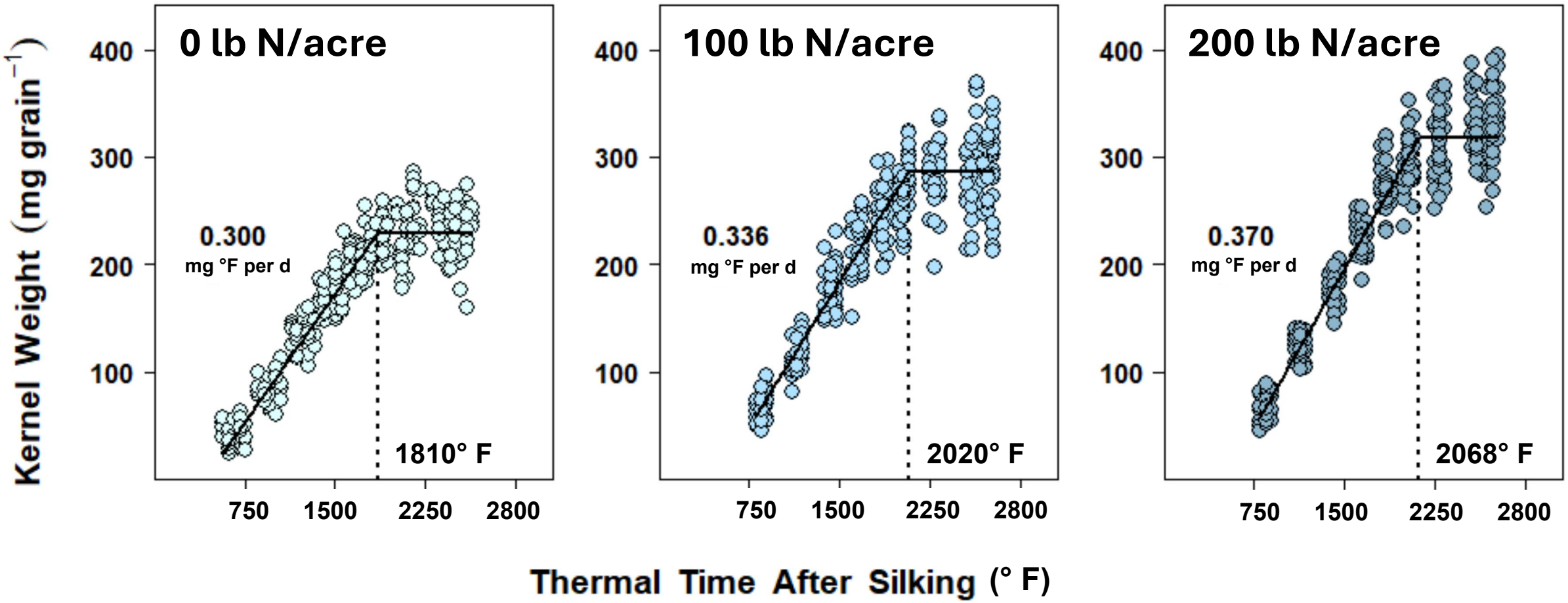
6.0 (Physiological Maturity)	35%	100%		
TOTAL (AVERAGE)			575	33

- If at 5.5 (24 days early):
  - 90% of DM
  - 178 x 0.9 = 160.2 bu/a
  - 18 bu/a x $3.90 = $70.2/a
- If at 5.75 (14 days early):
  - 97% of DM
  - 178 x 0.97 = 172.7 bu/a
  - 5 bu/a x $3.90 = $19.5/a

Abendroth et al. (2011) Corn Growth and Development

Premature senescence stops grain fill early



Olmedo Pic and Vyn. 2021. https://doi.org/10.3390/plants10061222. Edits by Abendroth from metric to American units.

Crop Suitability Factors

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- Available water
- Managing crop stress
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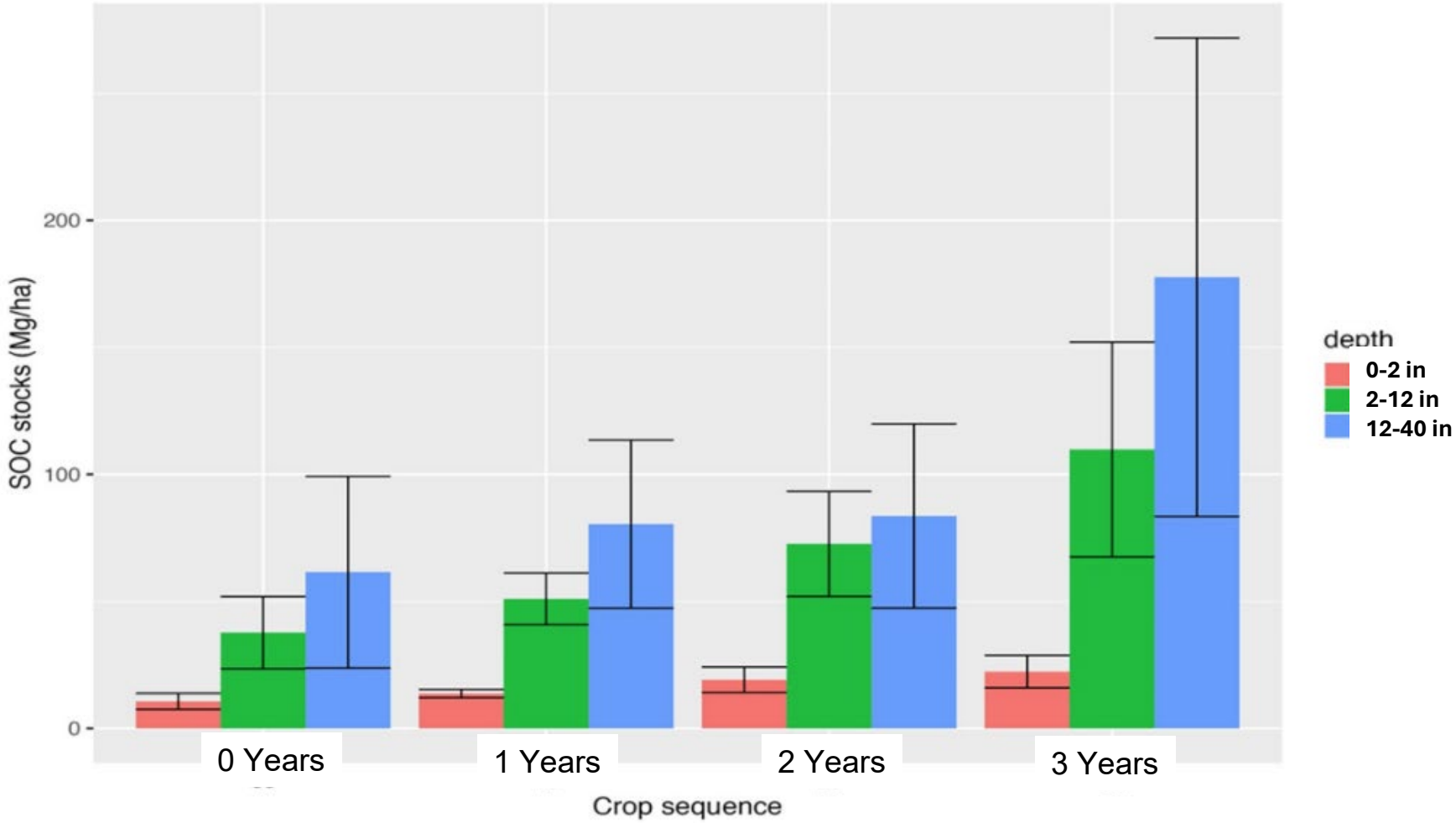
Soil Organic Carbon Stocks: More Corn

- Examined SOC after 3 years with corn in the rotation 0, 1, 2, or 3 times
- Corn is correlated with a higher level of SOC stocks than soybean
- More years with corn, the higher the SOC stocks



Wu et al. 2025. Carbon Balance and Management (2025) 20:6 https://doi.org/10.1186/s13021-025-00293-5
Conversions from metric to American by Abendroth

Amount of Dry Crop Residue Left in Field (not Grain)

Based on 2025 MO Yields, USDA LTAR MO Data, and Standard Harvest Ratios:

- Corn 6900 lb/a
- Soybean 2200 lb/a
- Cereal Rye 2000 lb/a
- Wheat 3500 lb/a
- Canola ____ lb/a (?)

Values are general ballpark, significant range can exist

Crop Suitability Factors

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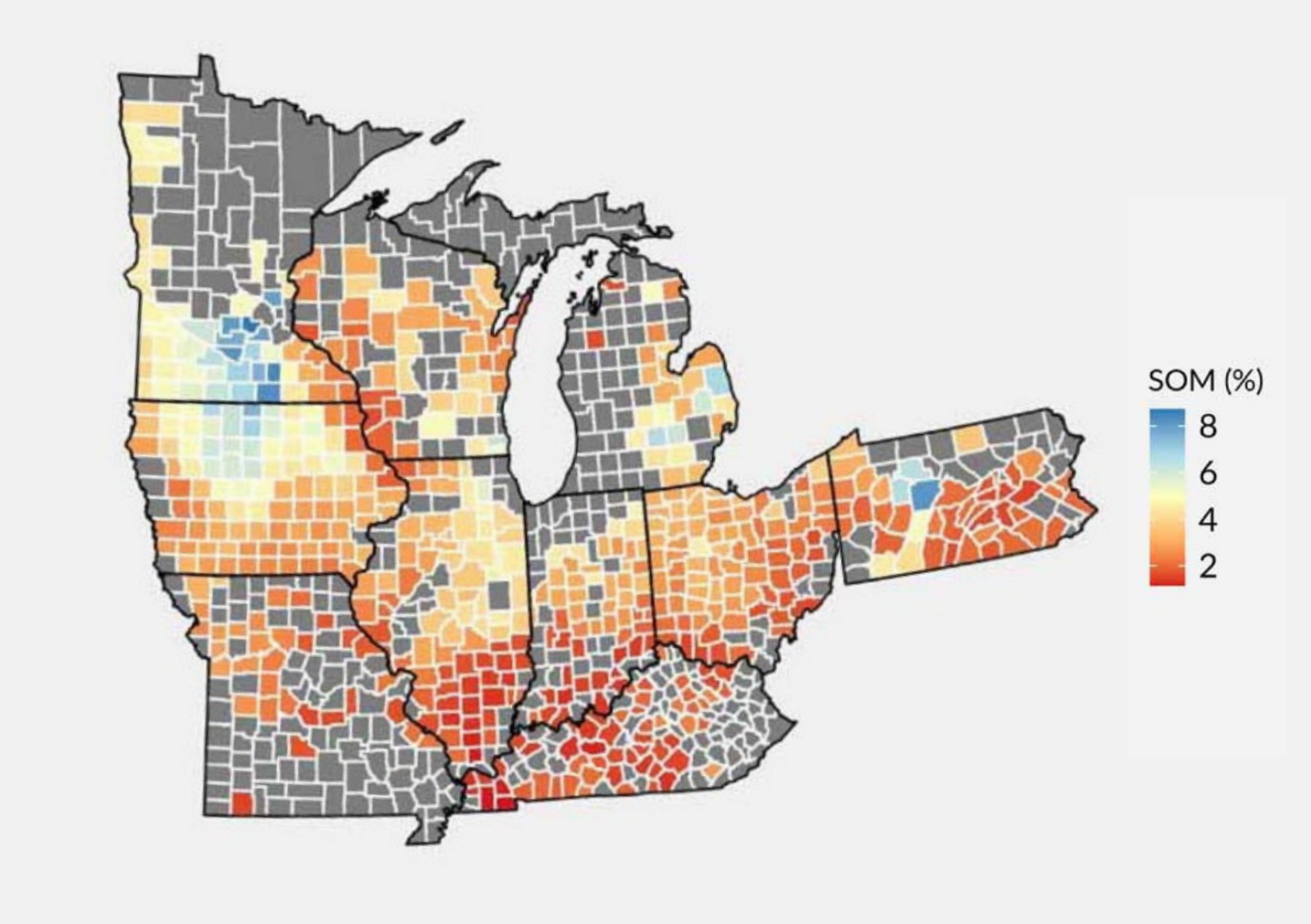
Soil Organic Matter (SOM): Corn Yield Volatility

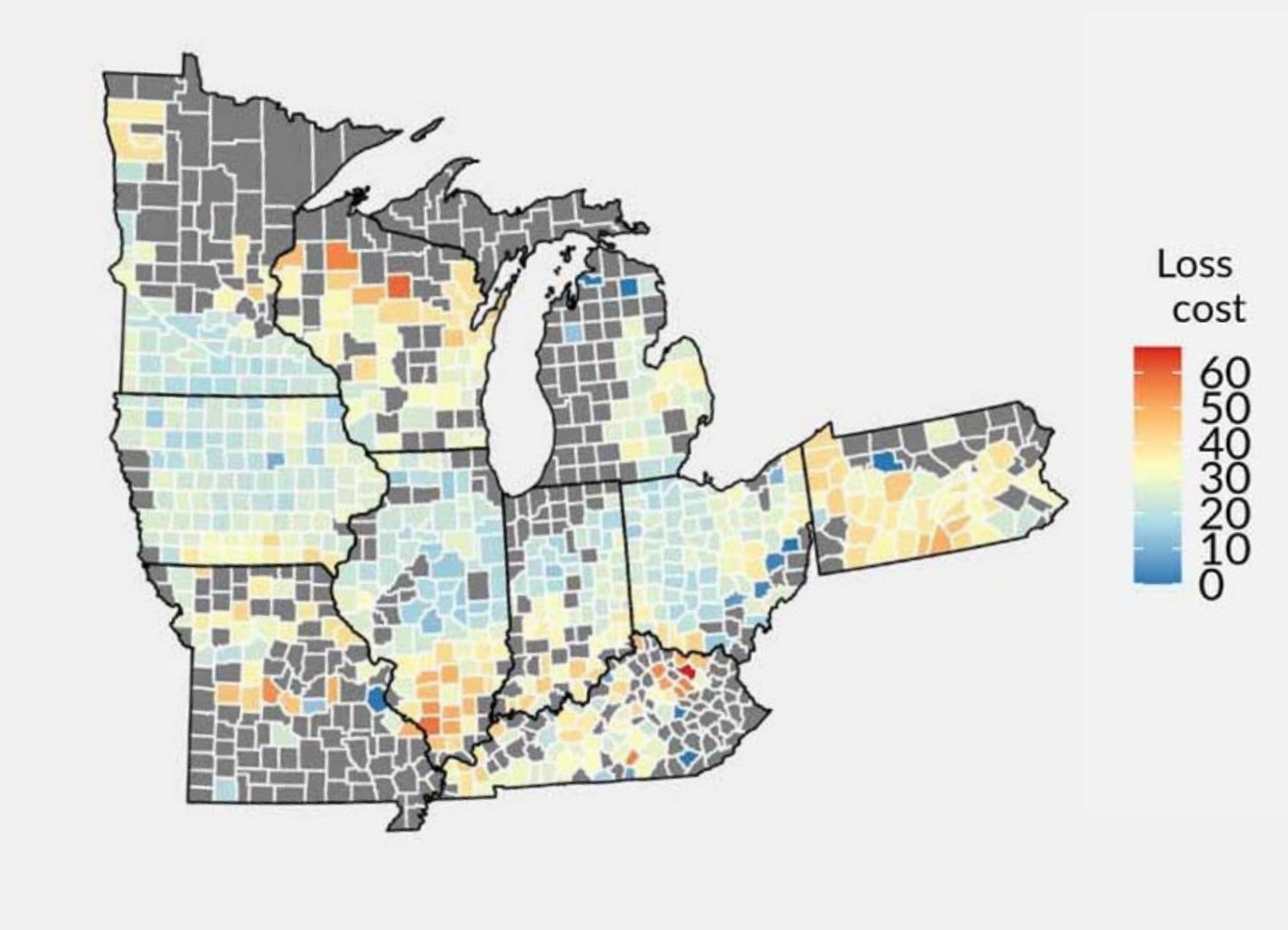
- 2000-2016 Non-irrigated
- Counties with >2.5% SOM had yield ranges:
  - Normal conditions 98-107%
  - Drought 91–104%
- Counties with <2.5% SOM had yield ranges:
  - Normal conditions 99-114%
  - Drought 82–104%



Kane et al 2021 Environ. Res. Lett.

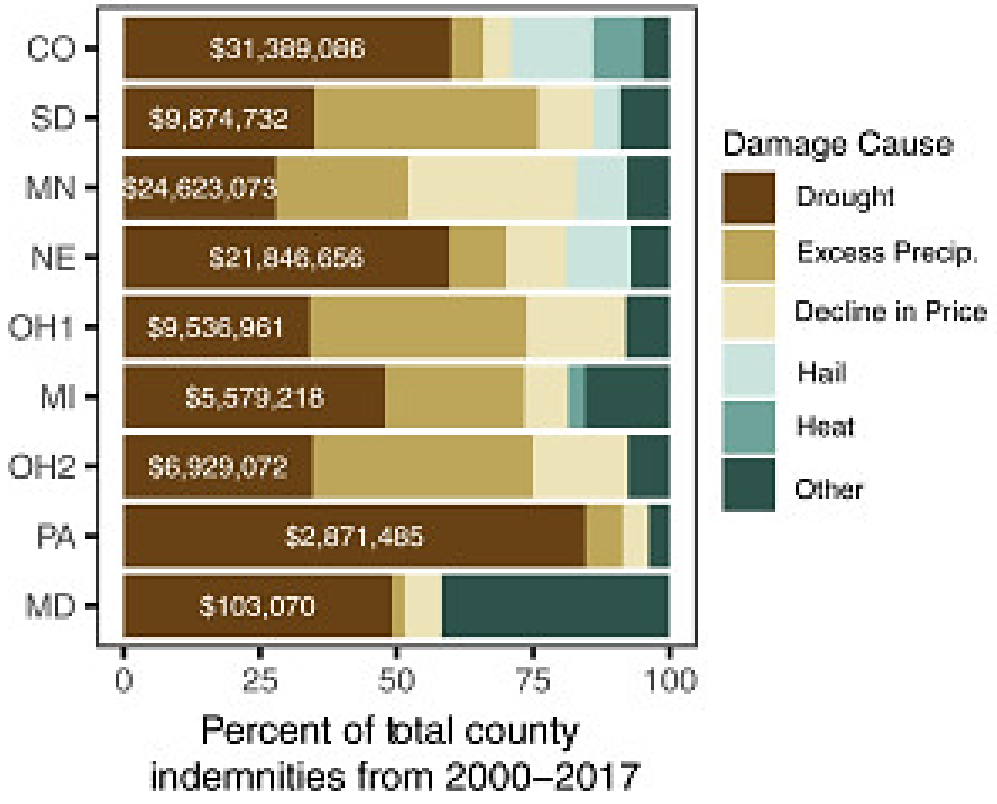
Soil Organic Matter: Insurance

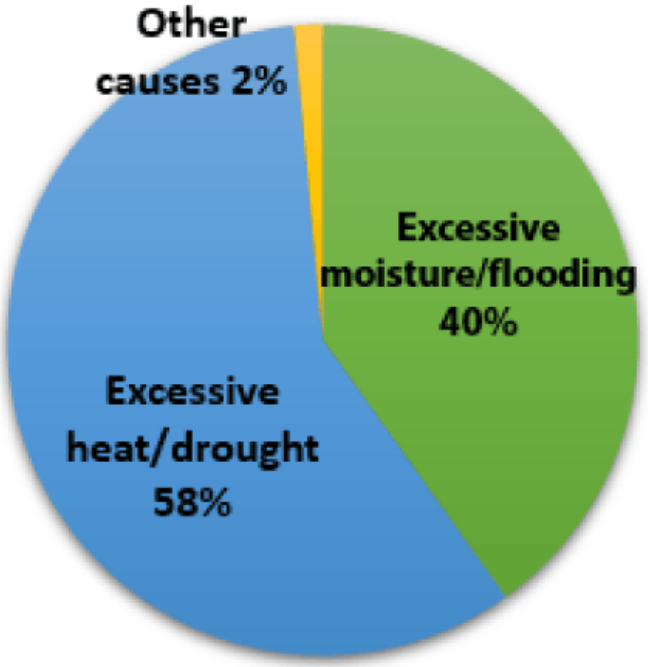
- Suggests strategy for rain-fed US agriculture to incorporate differences of soil properties into insurance planning
- May make more sense to incentivize a transition to additional/other crops than focus exclusively on economic protection through insurance



Kane et al 2021 Environ. Res. Lett.

Complexity in Rotations = Stable Yields





Bowles, et al. One Earth 2: 284 - 293

Source of Missouri crop loss by indemnity payments, 2011 to 2021. (Source: USDA, RMA)
Brown and Massey, 2022, https://extension.missouri.edu/publications/mp749

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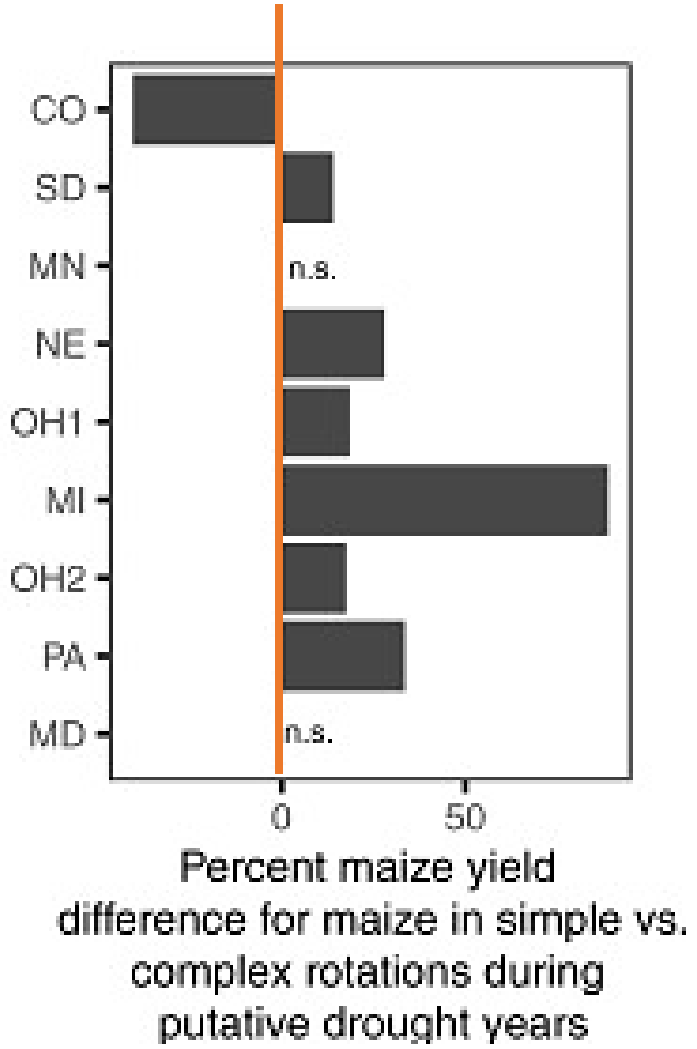


General trend:

More diverse rotations increased corn yield over time and across all growing conditions (28.1% on average)

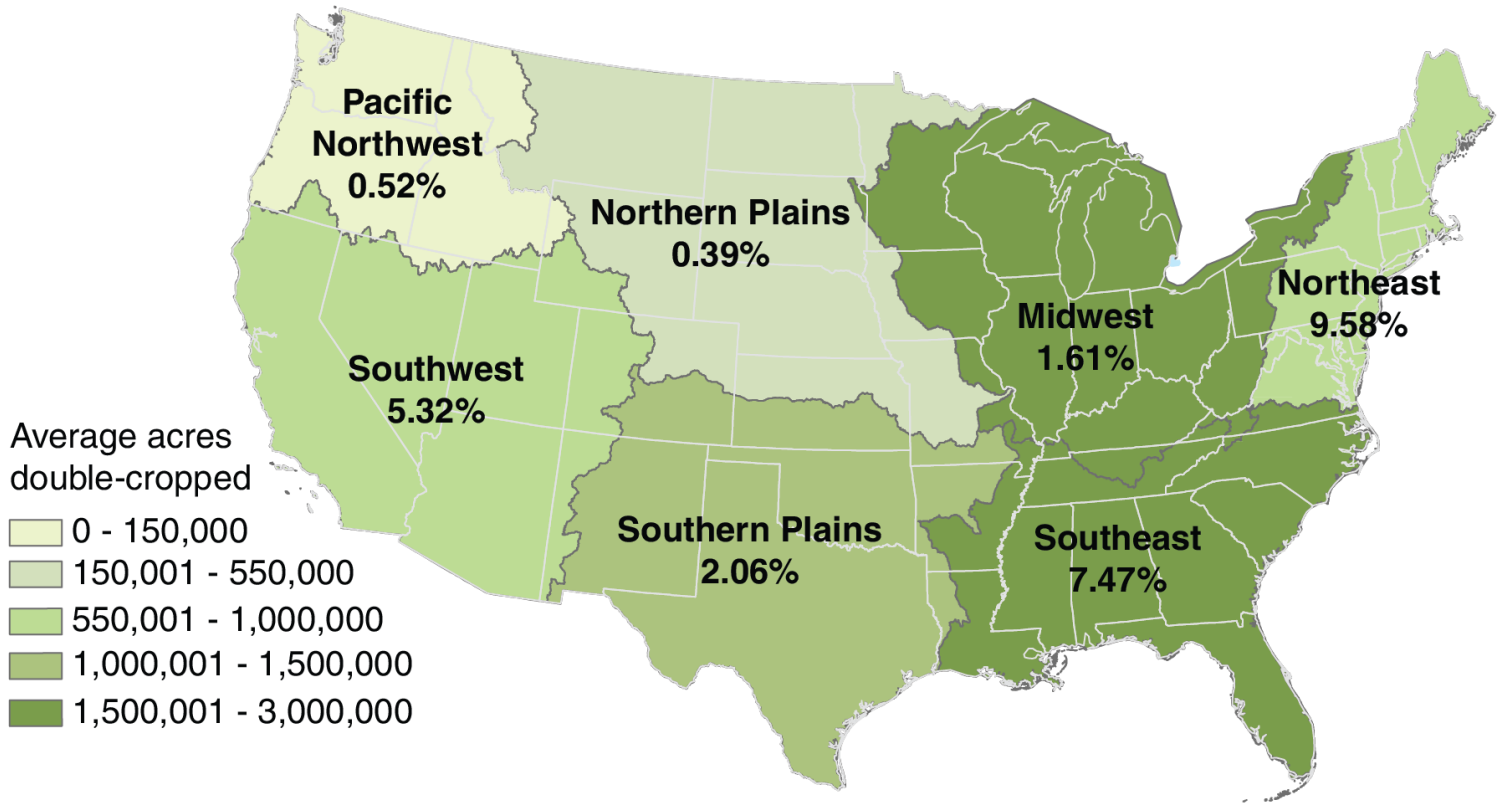
Drought years:

More diverse rotations had substantially less of a reduction in yield (14–90%)

Bowles, et al. One Earth 2: 284 - 293

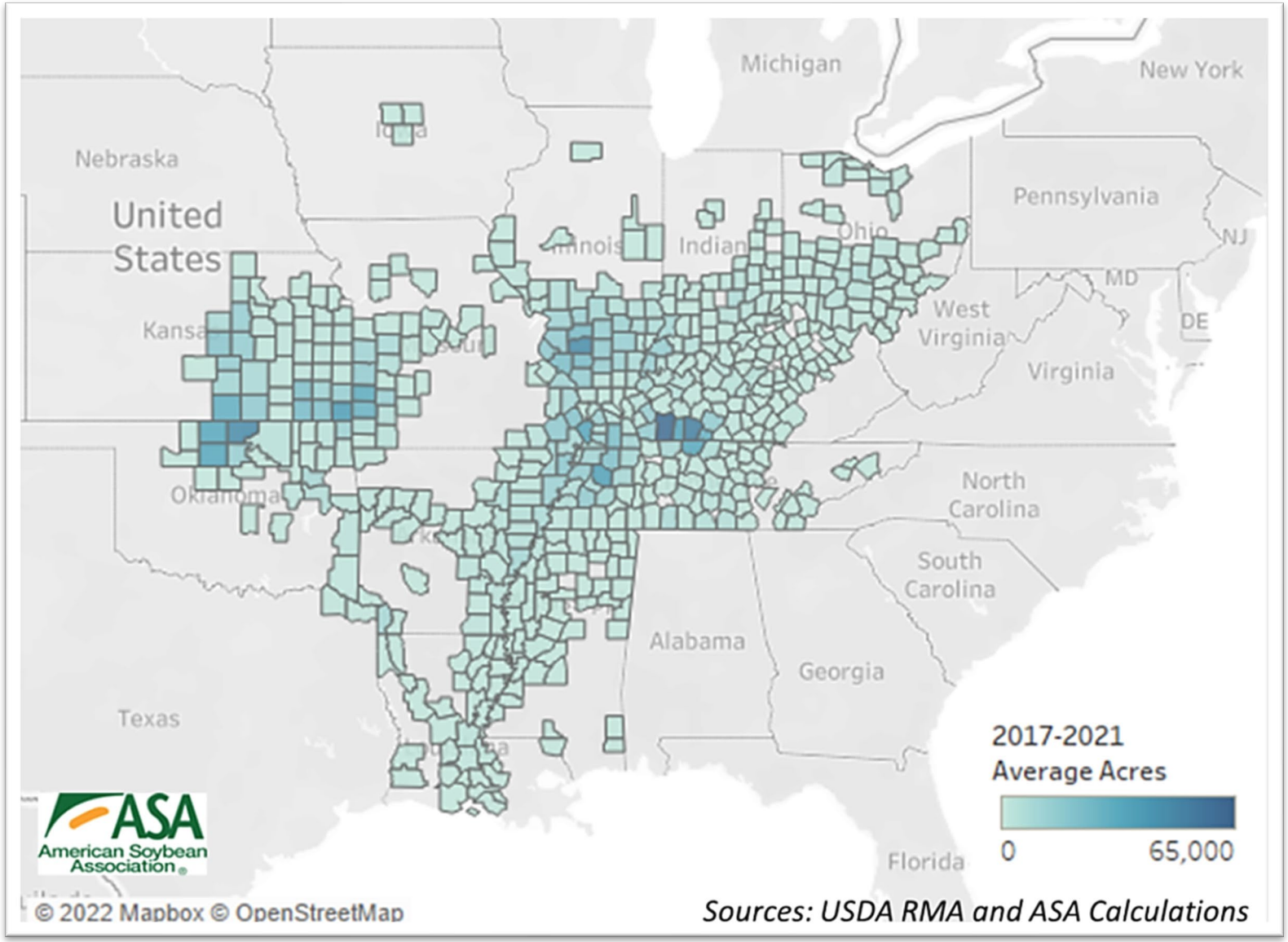
US Acres with Double Crop

Average double-cropped acreages by region, 1999-2012

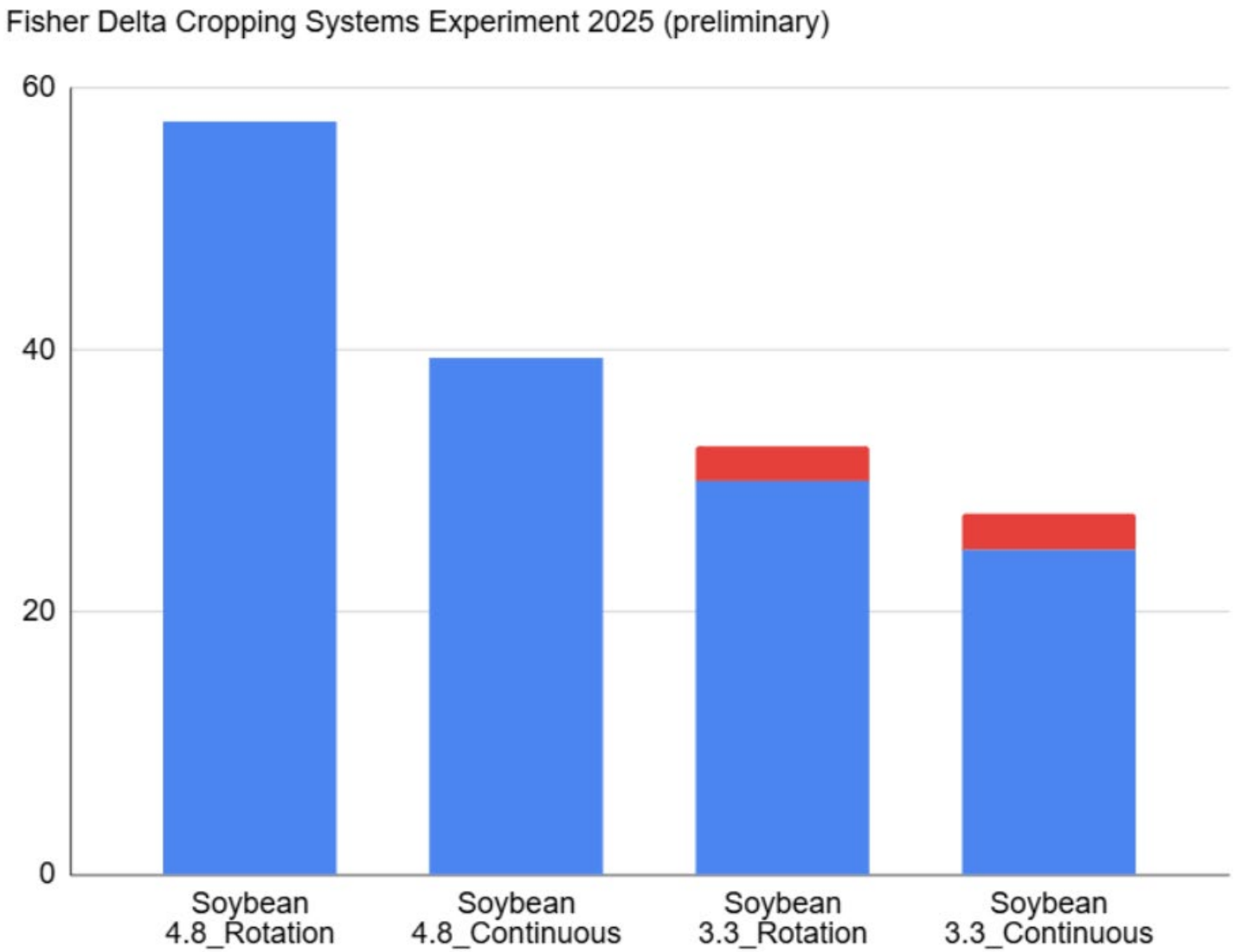


Note: On the map, the colors correspond to the average acres double cropped, while the labels show average double-cropping acreages as a percent of each region's total cropland acreage. Region boundaries are derived from U.S. Geological Survey hydrologic unit code boundaries.
Source: USDA, Economic Research Service calculations made using USDA, National Agricultural Statistics Service (NASS) June Area Survey data from 1999-2012. Estimates are weighted with NASS-supplied survey weights.

Double Crop Soybean (most likely with wheat), 2017-2021



Soybean Yields: 4.8, 3.3, 2.1 RM



Preliminary data by Abendroth (2025)

Fisher Delta REEC

USDA Agricultural Research Service

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Thank you to Michelle Maile, Rosie Garza, Bradley Wilson, USDA ARS