Department of Plant, Soil and Microbial Sciences
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GREAT LAKES BIOENERGY RESEARCH CENTER

Recent research on U.S. Land Use Change

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CARB LUC Public Forum

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Speaker Background

Education

- B.S. Engineering
- Ph.D. Environment & Resources
  - Dissertation: Quantifying U.S. Agricultural Land Use Change

Relevant Publications

- Characterizing U.S. Land Use Change (LUC)
  - Cropland expansion outpaces agricultural and biofuel policies in the U.S. *Environmental Research Letters. (2015).* https://doi.org/10.1088/1748-9326/10/4/044003
  - Accelerated Conversion of Native Prairie to Cropland in Minnesota. *Environmental Conservation. (2019).* https://doi.org/10.1017/S0376892918000437

- Methods for assessing U.S. LUC
  - Measuring Land-Use and Land-Cover Change Using the U.S. Department of Agriculture's Cropland Data Layer: Cautions and Recommendations. *Intl J of Applied Earth Obs and Geoinformatics. (2017).* https://doi.org/10.1016/j.jag.2017.06.007.
  - Accuracy, Bias, and Improvements in Mapping Crops and Cropland across the United States Using the USDA Cropland Data Layer. *Remote Sensing. (2021).* https://doi.org/10.3390/rs13050968

- Outcomes of U.S. LUC
  - Carbon emissions from cropland expansion in the United States. *Environmental Research Letters. (2019).* https://doi.org/10.1088/1748-9326/ab0399
  - Cropland expansion in the United States produces marginal yields at high costs to wildlife. (2020) *Nature Communications*. https://doi.org/10.1038/s41467-020-18045-z

- Comparison of Results
  - Tracking cropland transitions: A comparative analysis of U.S. land cover change data. *PloS one. (2025).* https://doi.org/10.1371/journal.pone.0313880
  - Comment on 'Carbon Intensity of corn ethanol in the United States: State of the science'. Environmental Research Letters. (2021). https://doi.org/10.1088/1748-9326/ac2e35

Overview – Areas of active U.S. LUC research

Relative agreement & evidence

(just my opinion)

1. U.S Land Use Change (LUC) ***extent***

2. Proportion of LUC ***attributable to biofuels***

3. LUC ***emissions*** and ***types of land converted***

1. U.S. Land Use Change ***extent***

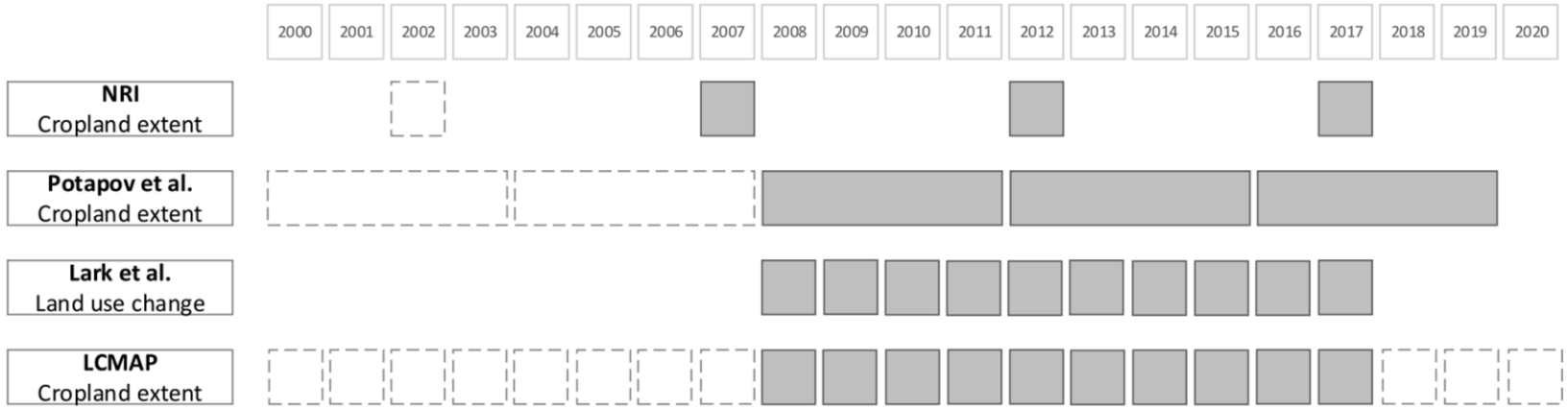
Drawing heavily from Gray Martin et al. (2025) Tracking cropland transitions: A comparative analysis of U.S. land cover change data. PloS one. https://doi.org/10.1371/journal.pone.0313880

Making apples-to-apples comparisons

- ✓ **Account for definition differences**
- ✓ **Align temporal extents**

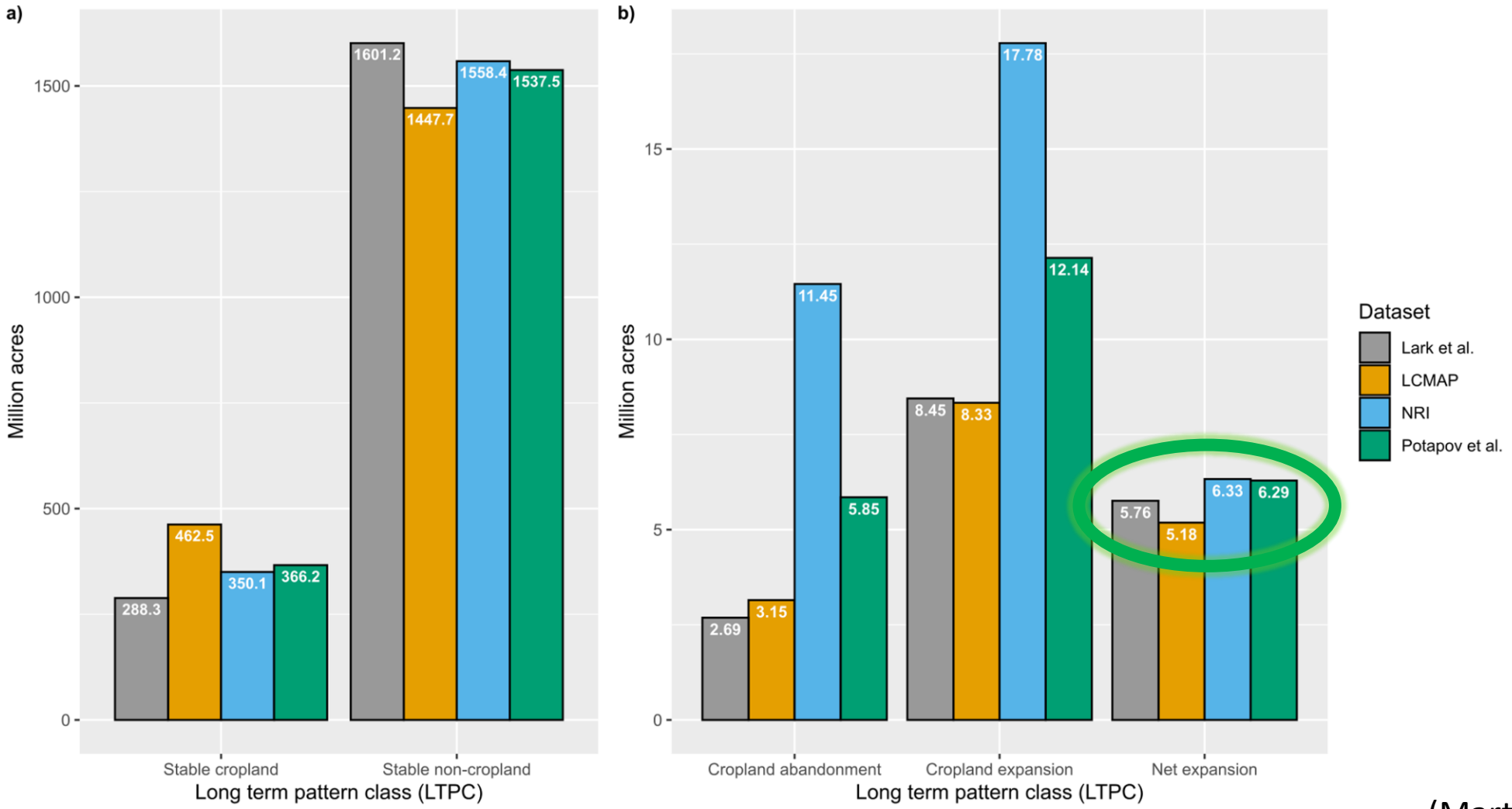
	LCMAP	NRI	Lark et al.	Potapov et al.
Cultivated land for the production of crops	Included	Included	Included	Included
Uncultivated or fallow land for the production of crops	Included	Included	Included	Included
Perennial woody crops including orchards and vineyards	Included	Included	Included	Excluded
Managed/permanent hay	Included	Included	Excluded	Included
Managed/permanent pasture	Included	Excluded	Excluded	Excluded
Unmanaged pasture or hay	Included	Excluded	Excluded	Excluded
Grassland, shrubland, and grazing land	Excluded	Excluded	Excluded	Excluded
CRP land	Partial	Excluded	Partial	Partial

https://doi.org/10.1371/journal.pone.0313880.t002



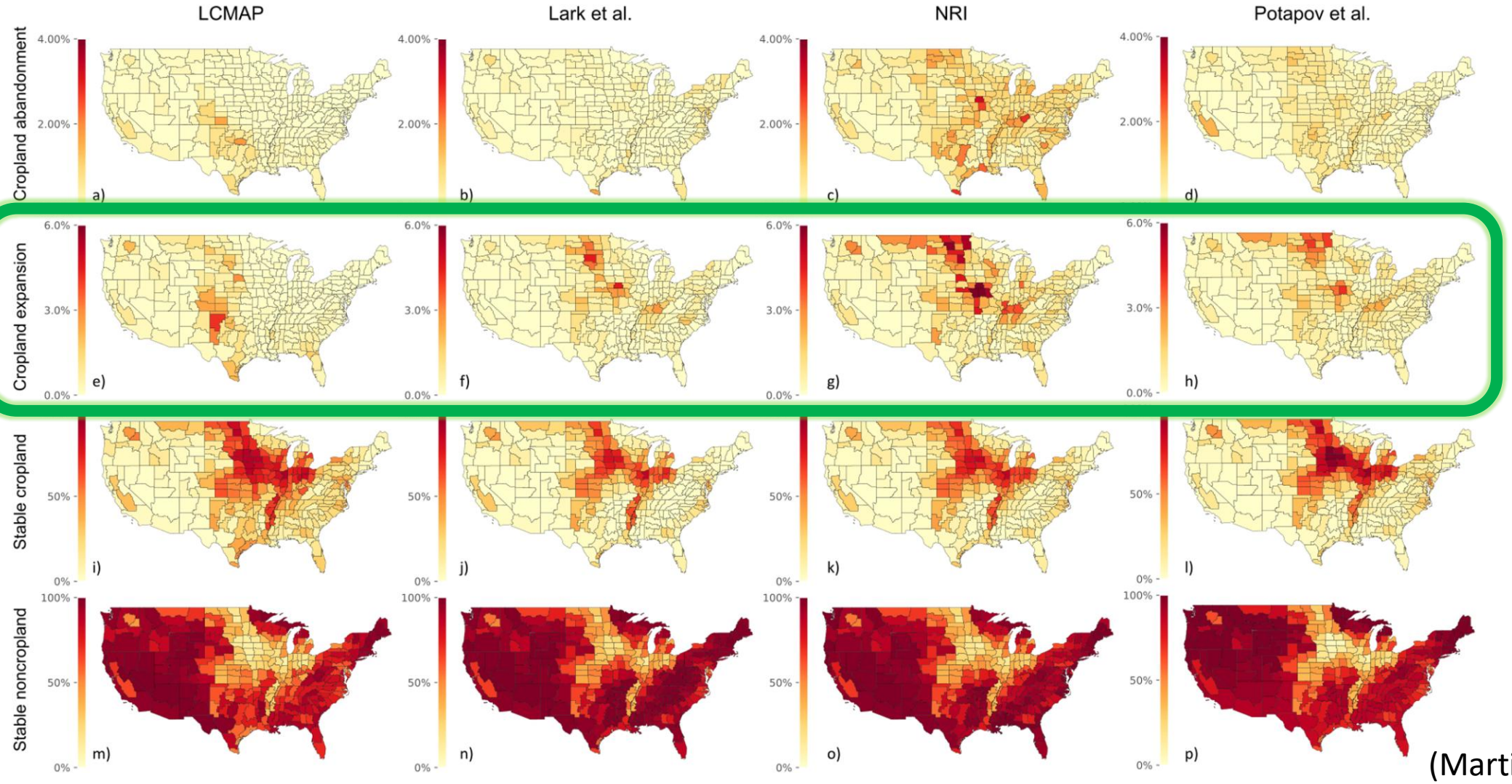
(Martin et al., 2025)

Relatively similar magnitudes of LUC extent



(Martin et al., 2025)

Spatial patterns reflect dataset definitions

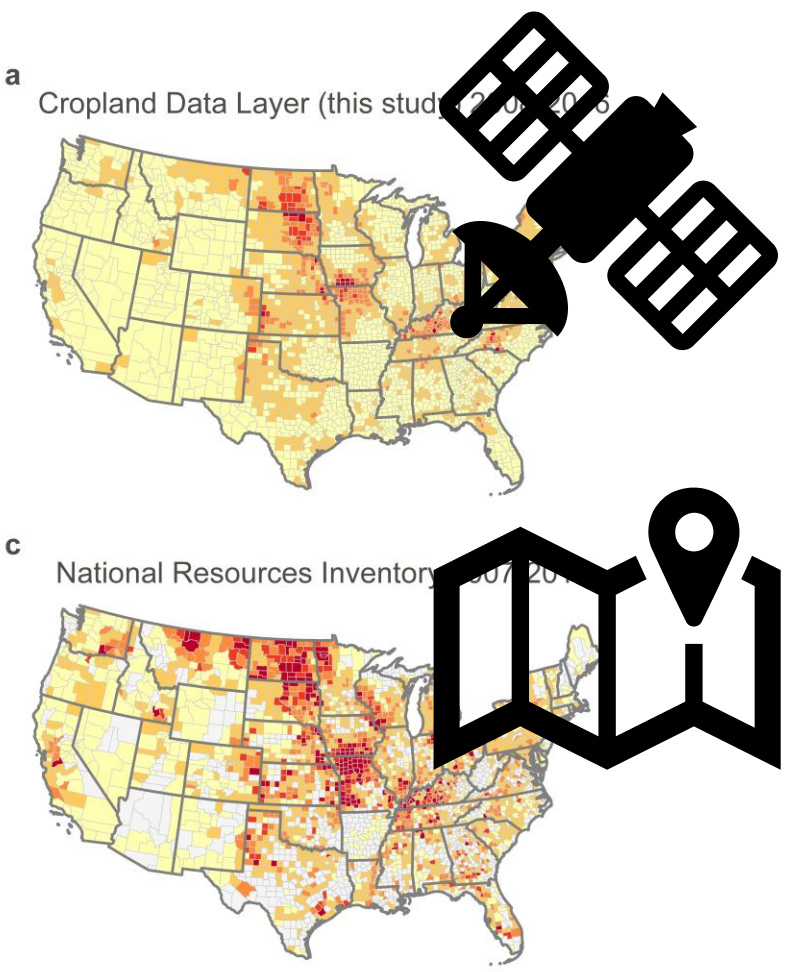


(Martin et al., 2025)

Relative consensus of net cropland expansion beginning in the late 2000s

Annual Δ
(acres/year)

Expand: 1,262,039
Aband: 439,931
Net: 822,109



Annual Δ
(acres/year)

Expand: 1,210,355
Aband: 222,206
Net: 988,149

Expand: 2,682,275
Aband: 1,742,538
Net: 939,738

Expand: n/a
Aband: n/a
Net: 1,391,946

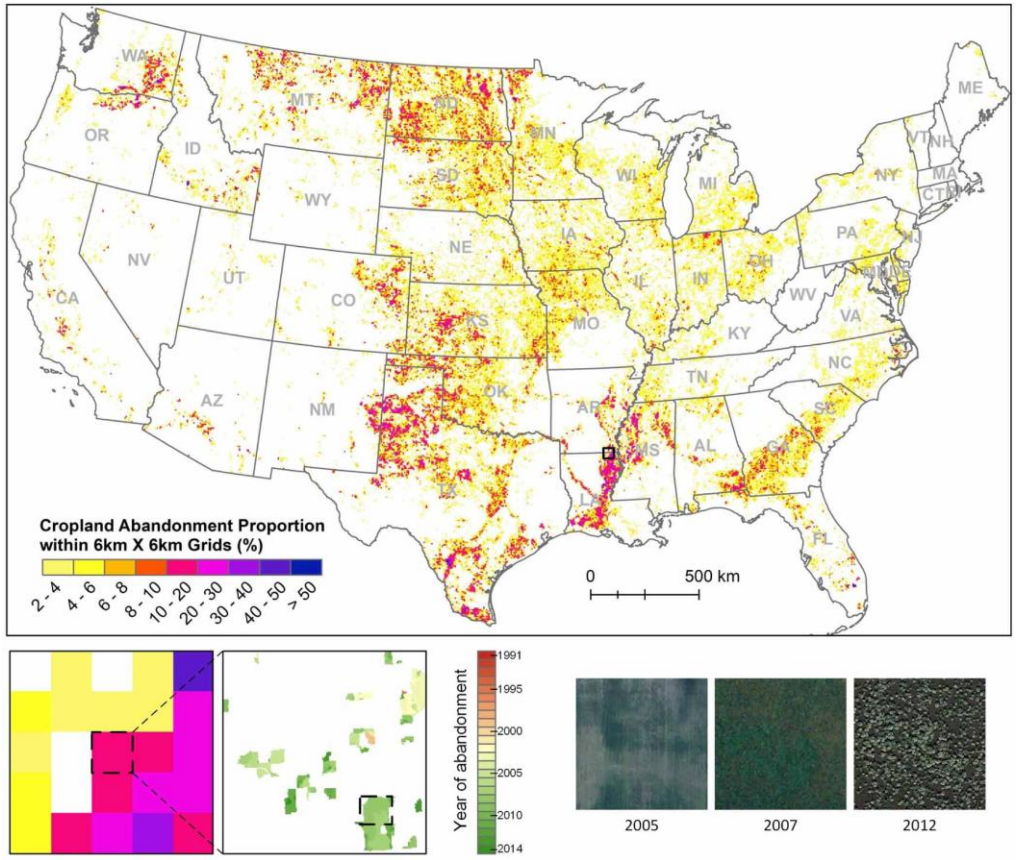
(Lark et al., 2020)

Why else do discrepancies arise in U.S. LUC estimates?

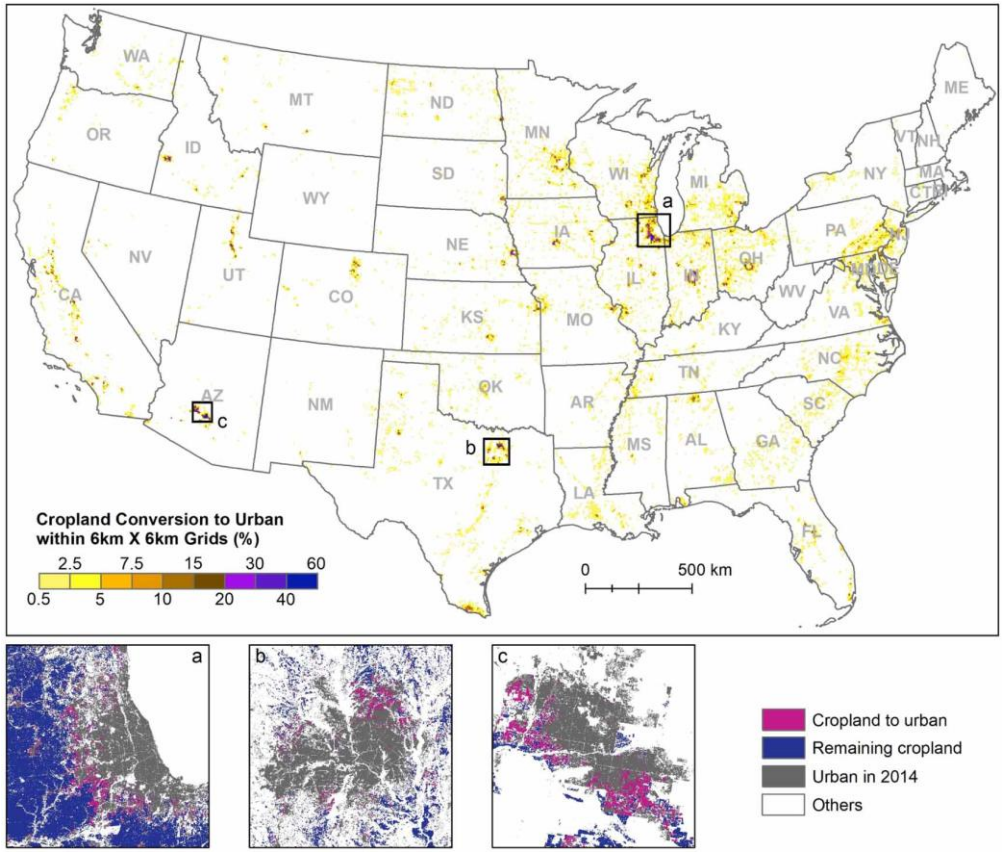
- USDA NASS planted area (a.k.a. annual NASS Survey data) is a poor indicator of cropland area and does not measure land conversion
  1. Tracks only ***select counties*** → incomplete reporting
  2. Tracks only ***principal crops*** → incomplete accounting representation
  3. Tracks only ***planted area*** → not representative of cultivation footprint
     - Excludes cultivated fallow and prevented plantings
  4. Tracks only ***net changes*** → misses gross conversions to and from crops

Countervailing forces: Loss of agricultural lands

Cropland Abandonment



Cropland Converted to Urban



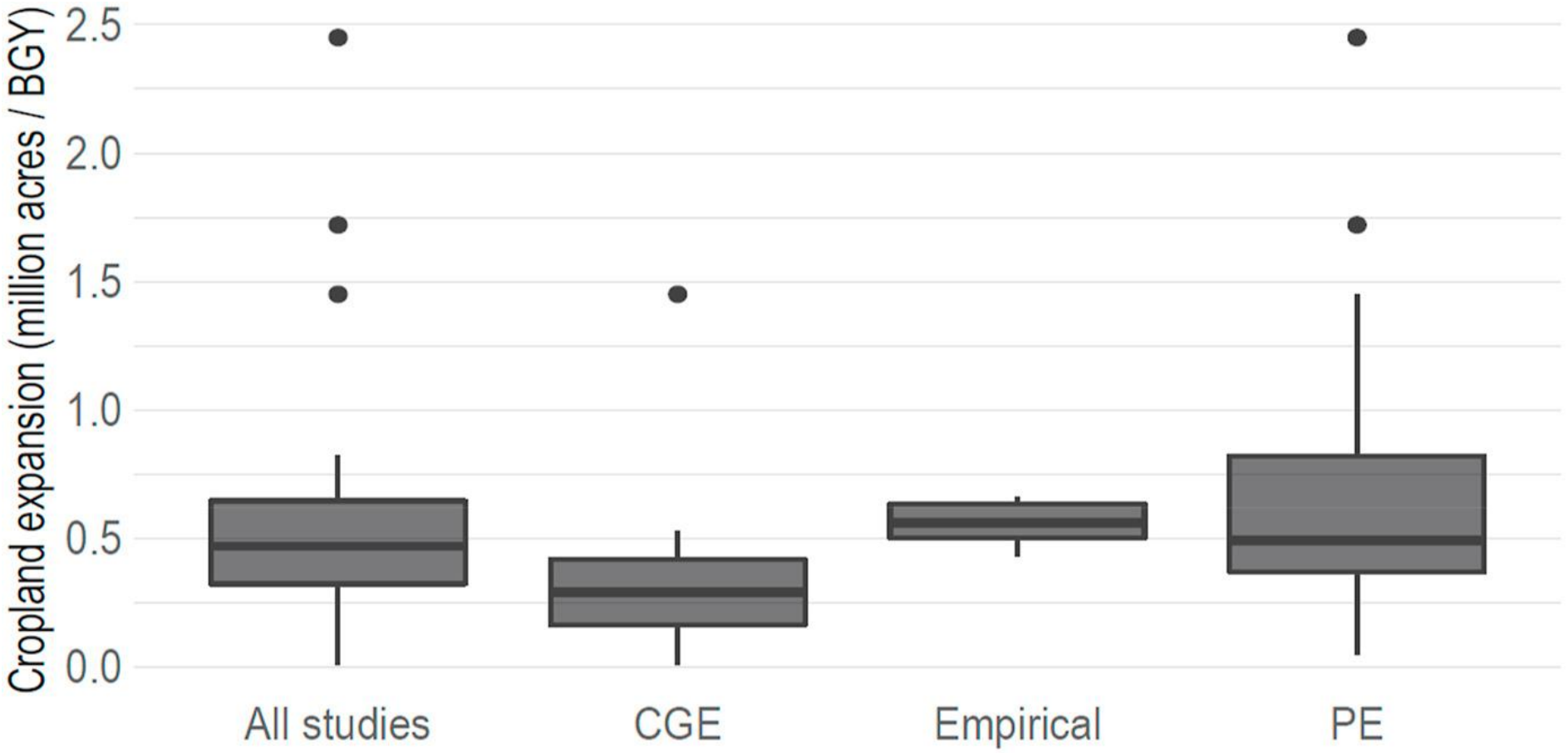
From: Xie et al. 2024: Cropland abandonment between 1986 and 2018 across the United States: spatiotemporal patterns and current land uses. *ERL*

Xie et al. (2024)

2. Estimating the subset of LUC *attributable to biofuels or policy*

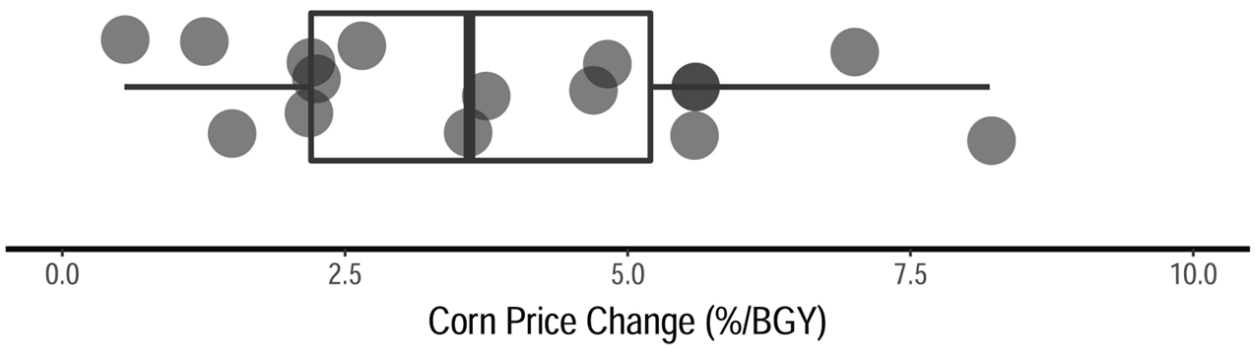
Review of LUC attributable to biofuels policy

Miao (2013)
Ifft et al. (2018)
Hendricks et al. (2014)
Hertel et al. (2010)
Oladosu et al. (2013
Fatal & Thurman (2014)
Stevens, A (2015)
Li et al. (2019)
Taheripour et al. (2020)
Searchinger et al (2008)
Motamed et al. (2016)
Barr et al. (2011)
Brown et al. (2014)
Krumel et al. (2015)
Chen & Khanna (2018)
Khanna et al. (2020)
Lark et al. (2019)
Wright et al. (2017)
EPA (2010)
Bento et al. (2015)
Cai et al. (2013)
Elliot et al. (2014)
Mosnier et al. (2013)
Taheripour et al. (2017)
Chen et al. (2021)

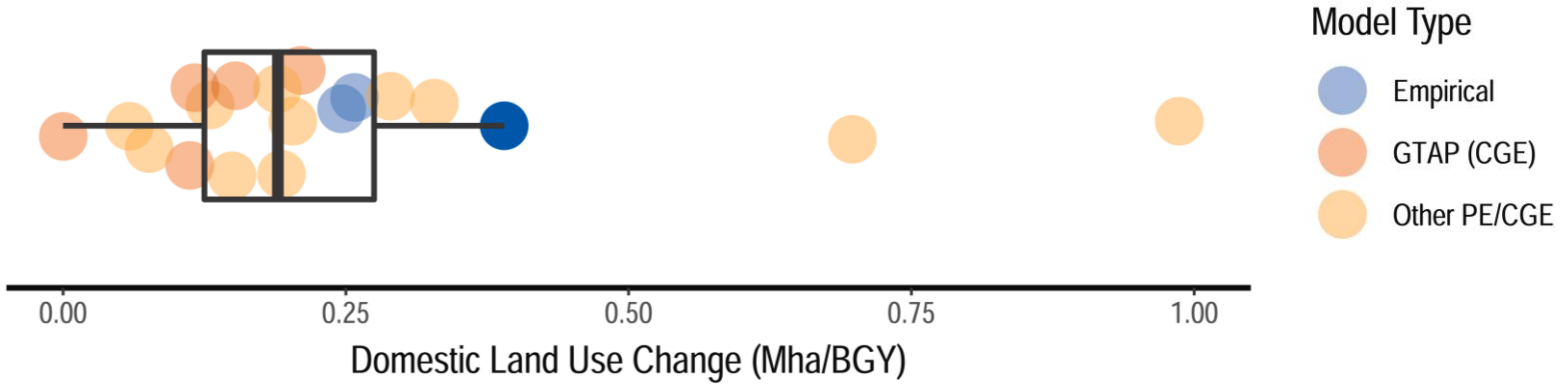


From: Austin, Jones, and Clark (2022) A review of domestic land use change attributable to U.S. biofuel policy

Crop price and LUC effects



Data from: J. O'Malley and S. Searle (2021)
The impact of the U.S. renewable fuel standard on food and feed prices. The Int Council on Clean Transportation Briefing.



Data from: Austin, Jones, and Clark (2022)
A review of domestic land use change attributable to U.S. biofuel policy

Note: Plot boxes represent the interquartile ranges (IQR) and median values with whiskers reflecting 1.5*IQR

From: Economic red herrings and resistance to new modeling hinder progress in assessing ethanol's land use change. *PNAS (Lark et al. 2022b)*

Insights from modeling—from policy to field level

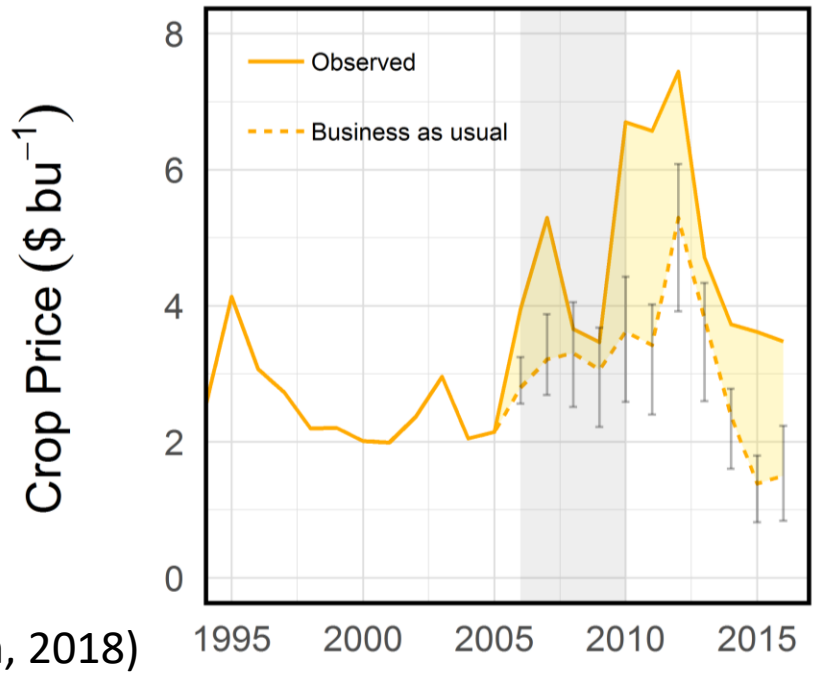
Policy Action

↓

Δ Biofuel demand

↓

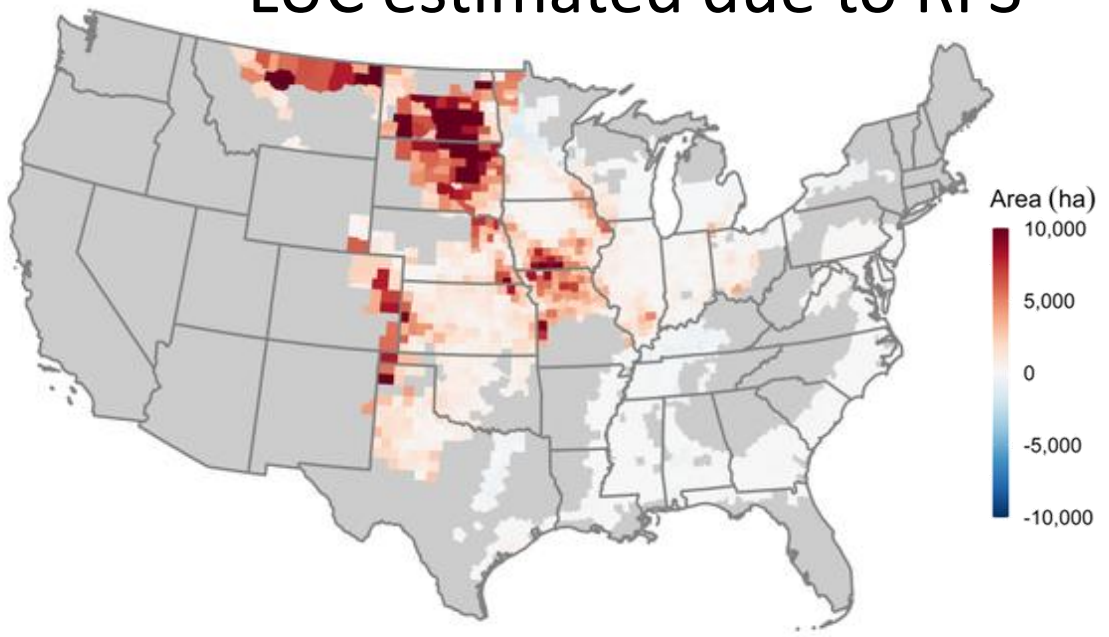
Δ Corn $



(Smith, 2018)

(NOTE: *Alternatives to equilibrium models exist*)

~20-25% of recent grass-to-crop LUC estimated due to RFS

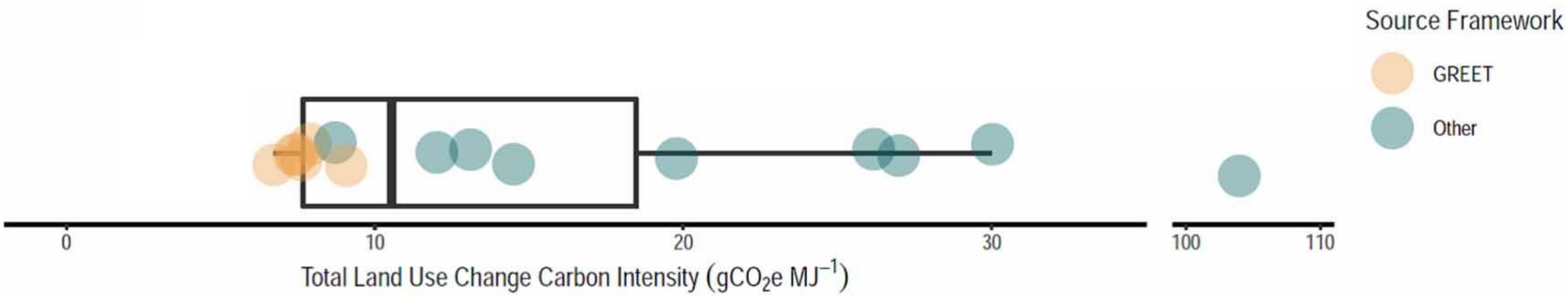


Lark et al. 2022, *PNAS*

3. LUC emissions and types of land converted

Emissions estimates vary by modeling framework

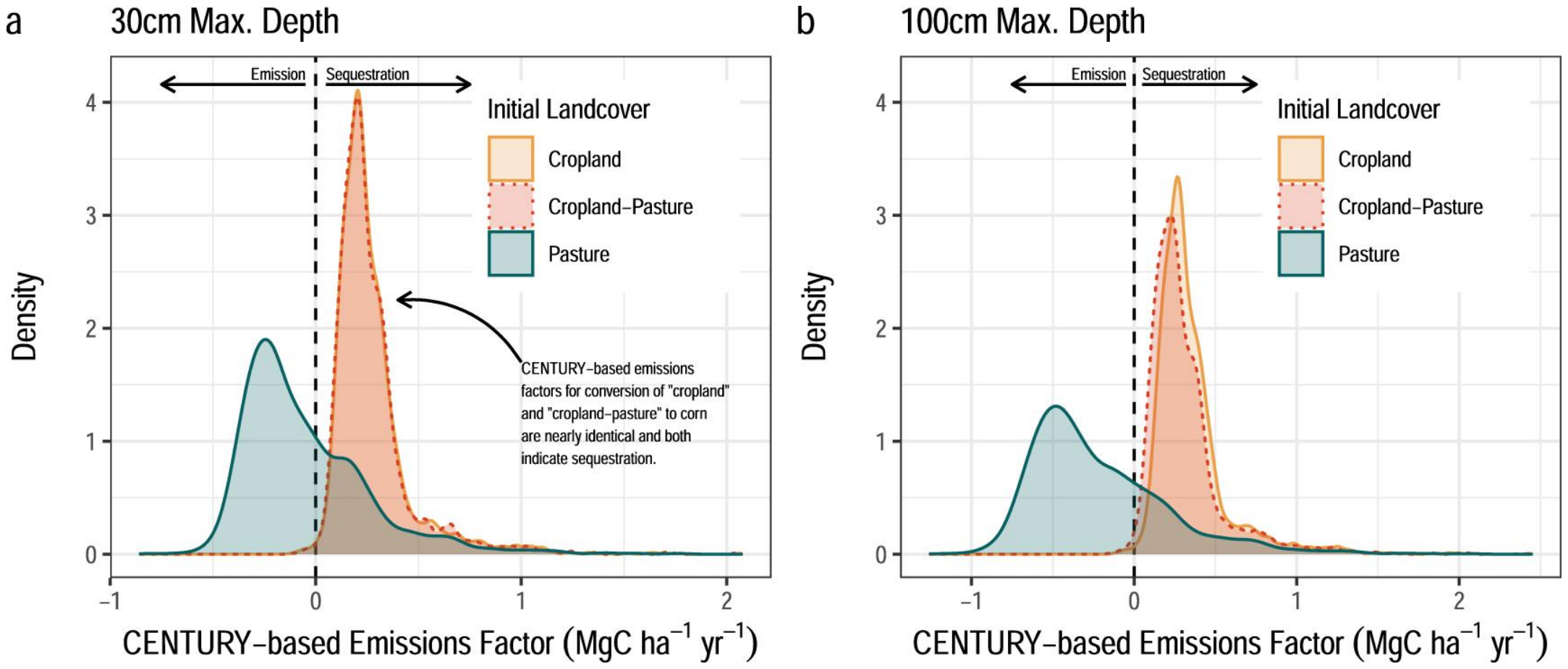
- Important note: Number of studies ≠ level of confidence



From: Spawn et al. (2021) Comment on 'Carbon Intensity of corn ethanol in the United States: State of the science'. Environmental Research Letters. https://doi.org/10.1088/1748-9326/ac2e35

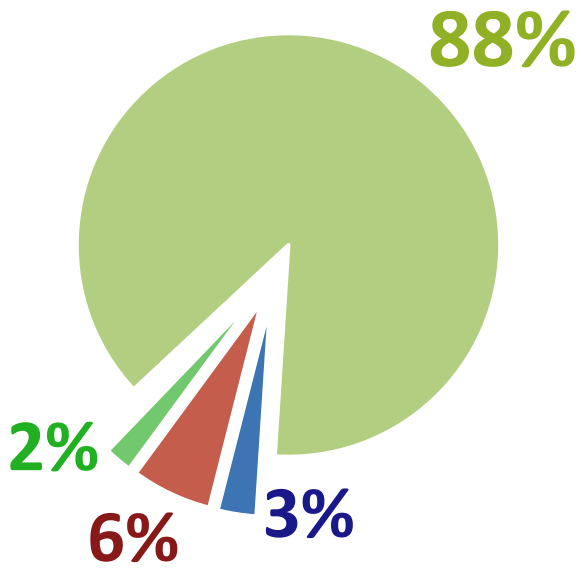
Emissions also vary by types of land converted

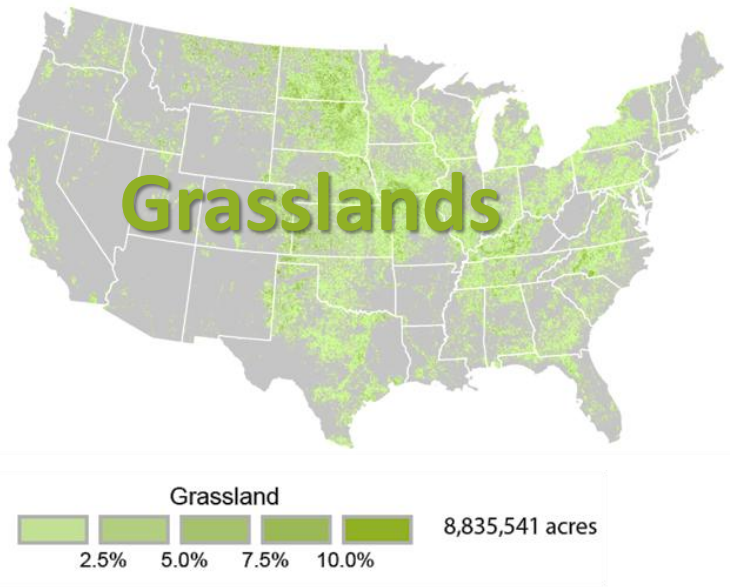
(and how they're modeled)

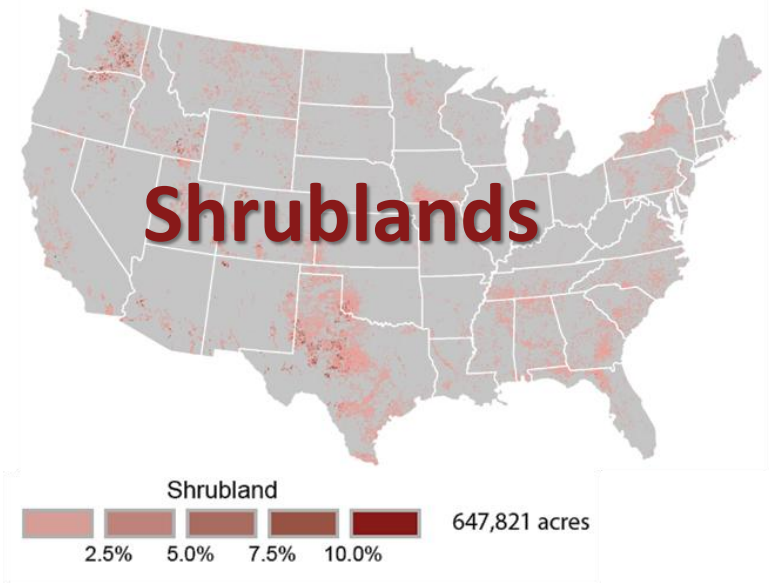


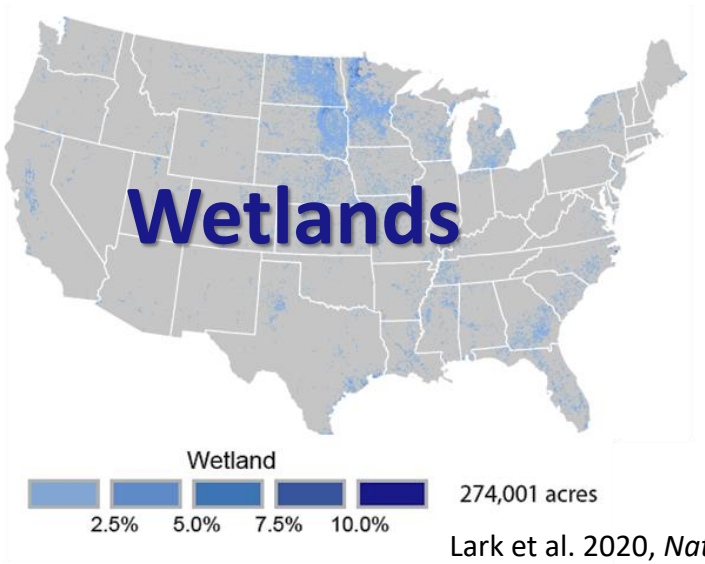
From: Spawn et al. (2021) Comment on 'Carbon Intensity of corn ethanol in the United States: State of the science'. Environmental Research Letters. https://doi.org/10.1088/1748-9326/ac2e35

Recent U.S. LUC by landcover type



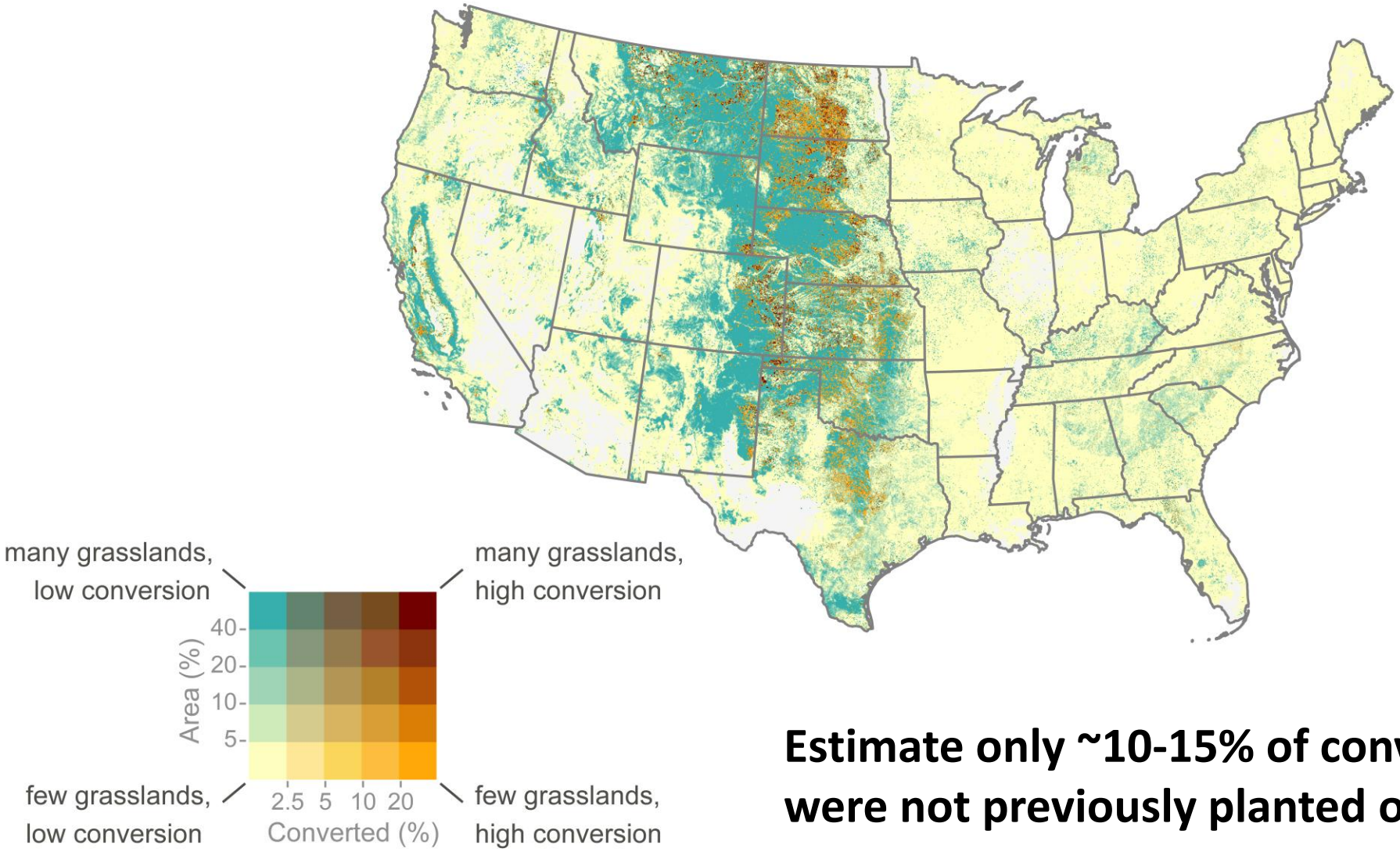






Lark et al. 2020, *Nature Comms*

How much is conversion is from intact grasslands?



Estimate only ~10-15% of converted grasslands were not previously planted or plowed

Lark et al. 2020, *Nature Comms*

Conclusions

- There is a clear consensus of both gross and net US grassland-to-cropland conversion in recent years
- A portion of LUC and emissions can likely be attributed to biofuels, but the magnitude of this is highly uncertain
- There is a need (and opportunity) to improve the characterization of converted lands and associated GHG emission factors

Thanks for your time, and for your interest!

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