Automatic Imputation for an Area Survey

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The findings and conclusions in this presentation are those of the authors and should not be construed to represent any official USDA, NISS, or U.S. Government determination or policy.

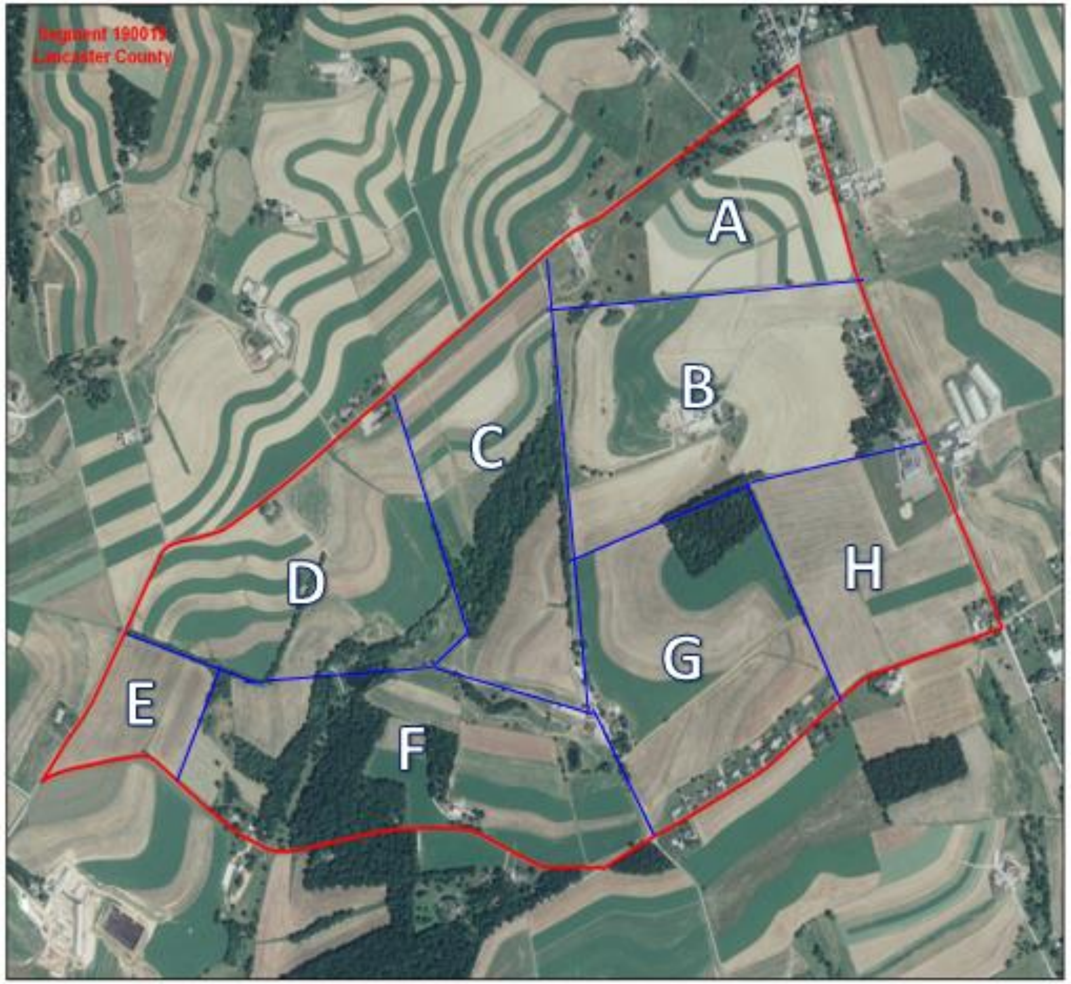
Background: June Area Survey (JAS)

- United States Department of Agriculture (USDA) National Agricultural Statistics Service's (NASS) largest annual survey

- Provides key indications for many agricultural aspects, including:
  - Planted acreage for most row crops and small grains

- Measures the incompleteness of the NASS List Frame

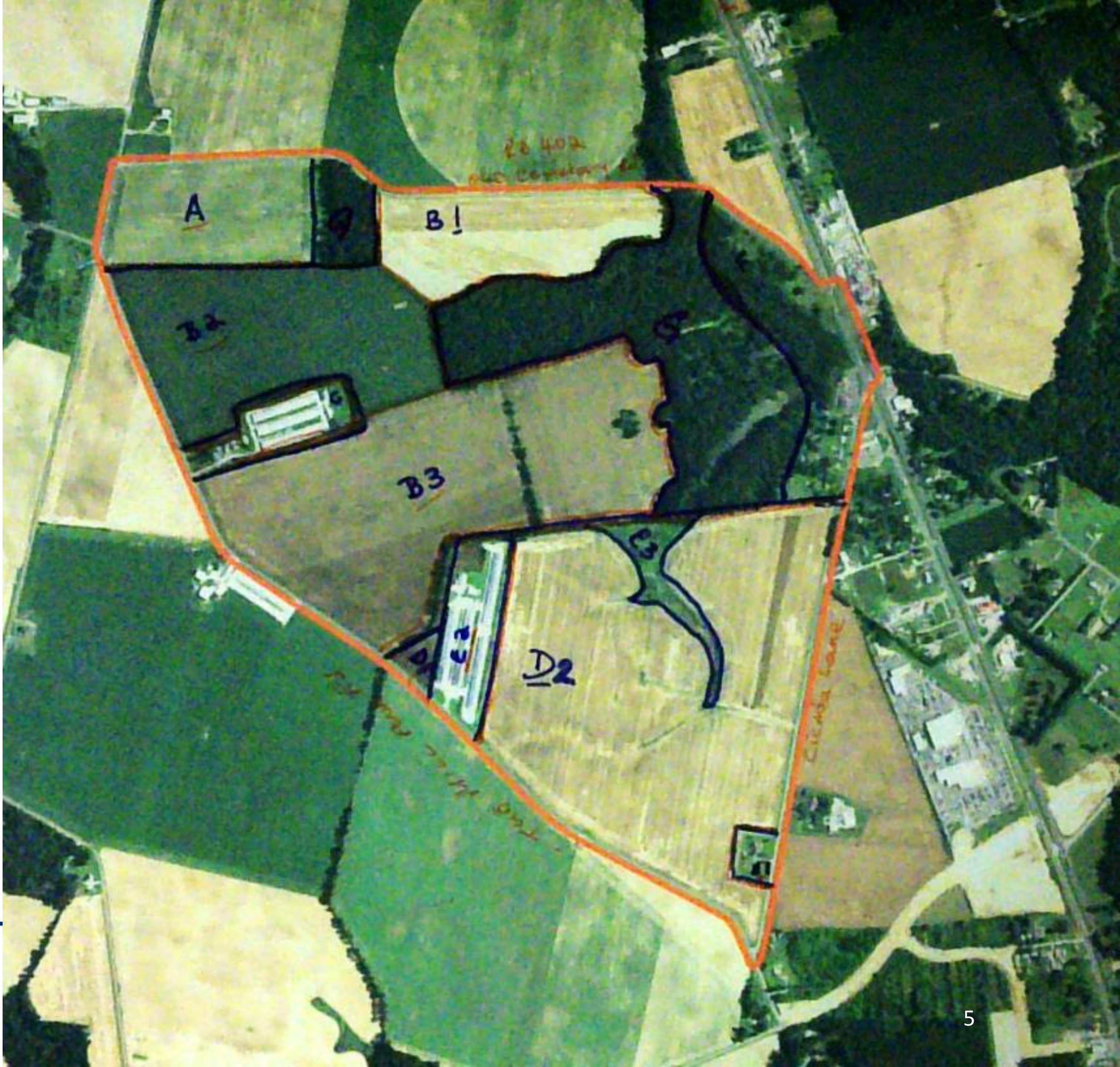
Background: June Area Survey (JAS)



- Area-frame based
- Segments of land sampled and remain in survey for five years
- Sampled segments divided into tracts representing unique land operating arrangements

Unique Nonresponse Challenges for JAS Tracts

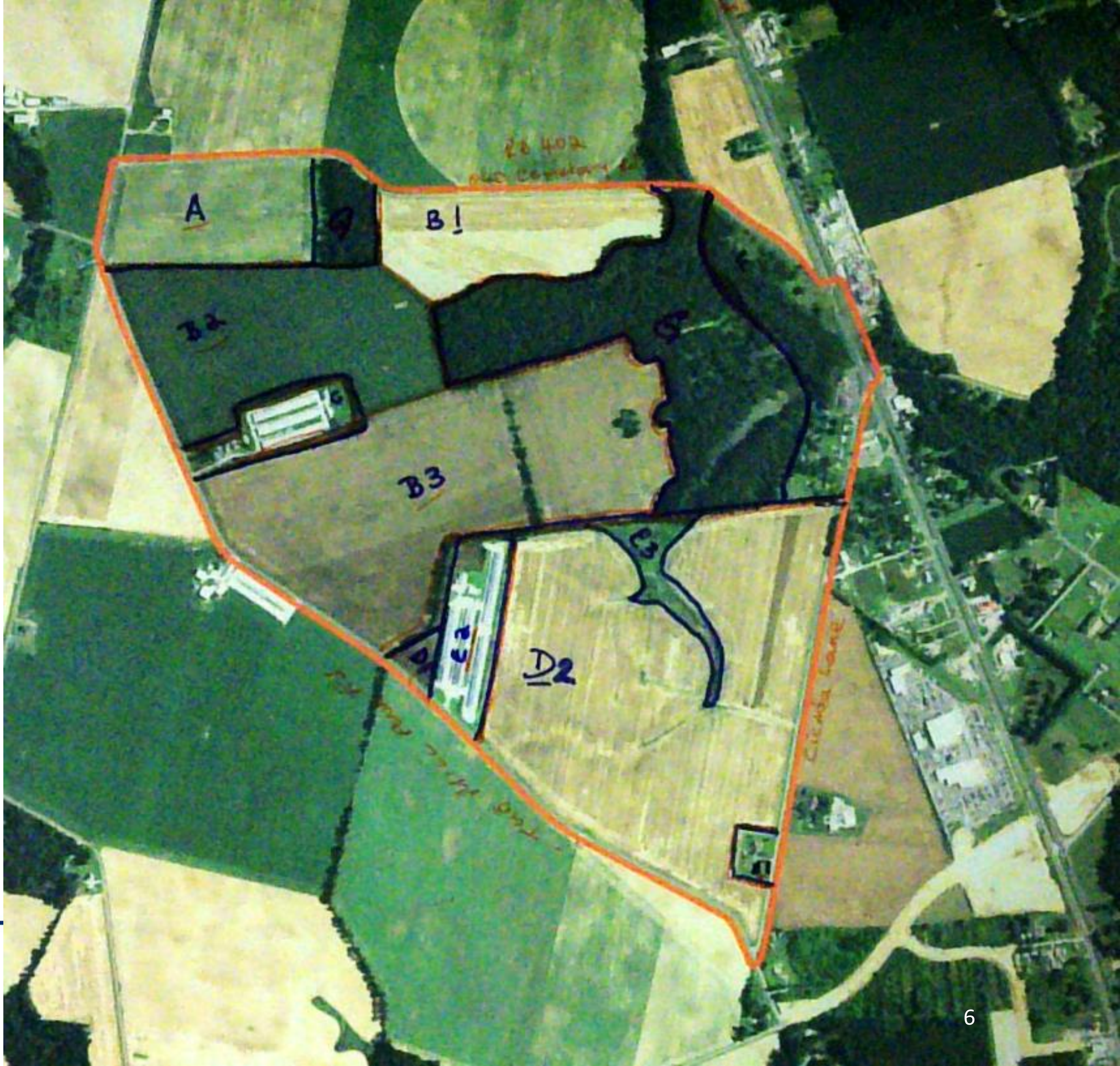
- Data collection based mostly on in-person and telephone interviews
- Extensive screening activities are needed to identify in-scope land tracts, especially for new segments



Unique Nonresponse Challenges for JAS Tracts

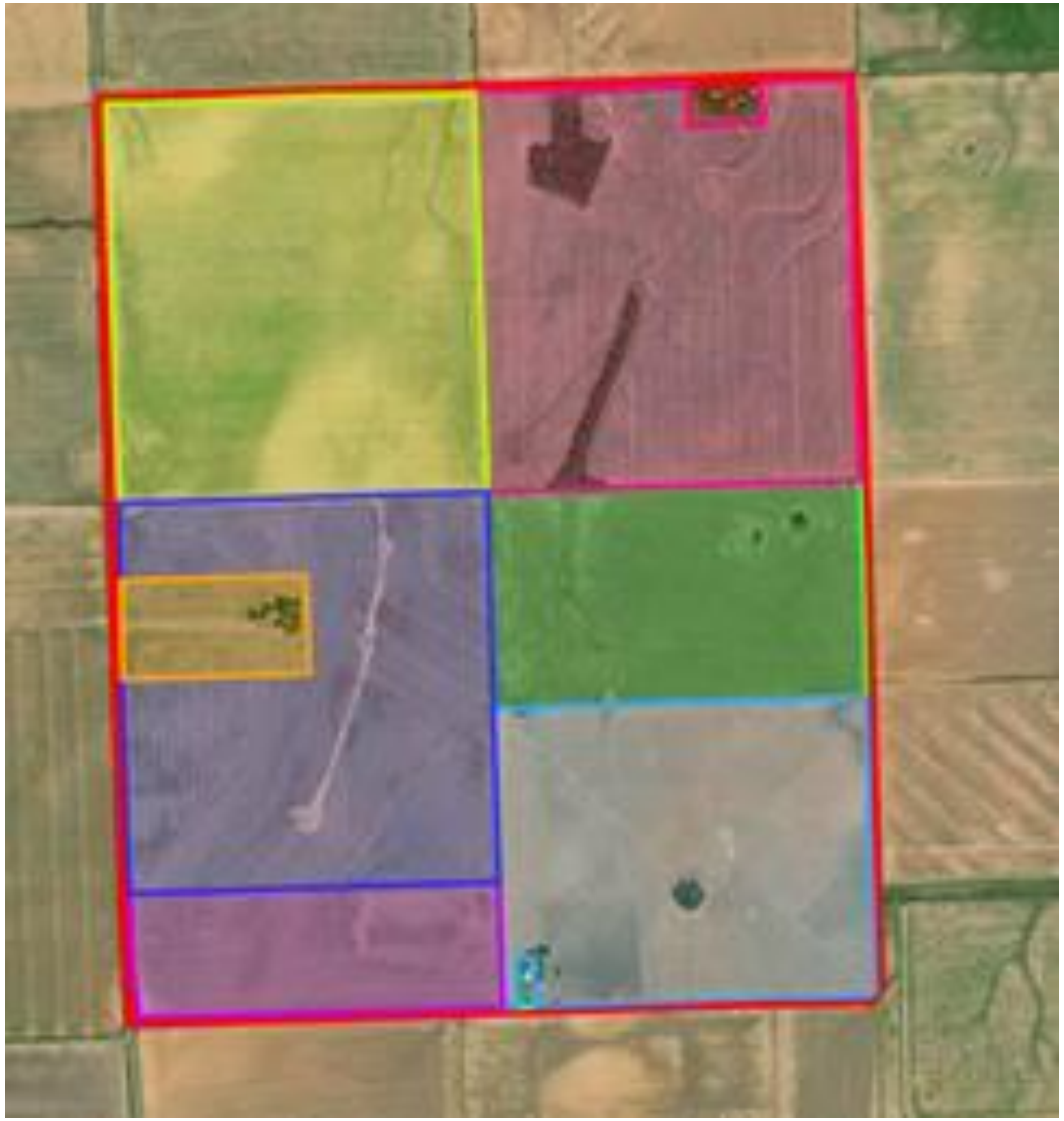
- Land-use arrangements may change during the five-year sample period

- **Digital records of tract boundaries** have historically never been created, making it difficult to link external, ancillary data to those tracts



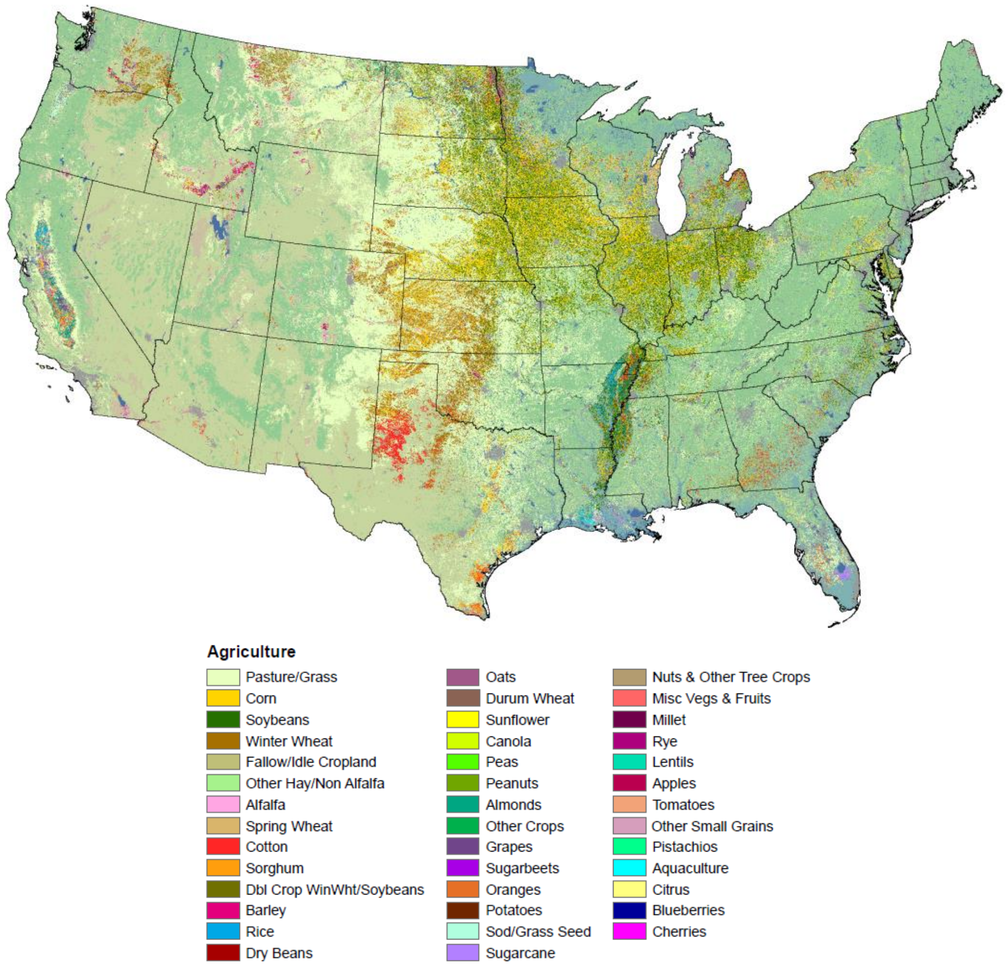
Availability of New Data

- Beginning 2021, digitization of all in-sample tract boundaries performed
- Resulting in geospatially-referenced record of tracts
- Allowing them to be linked to other data for estimation and imputation



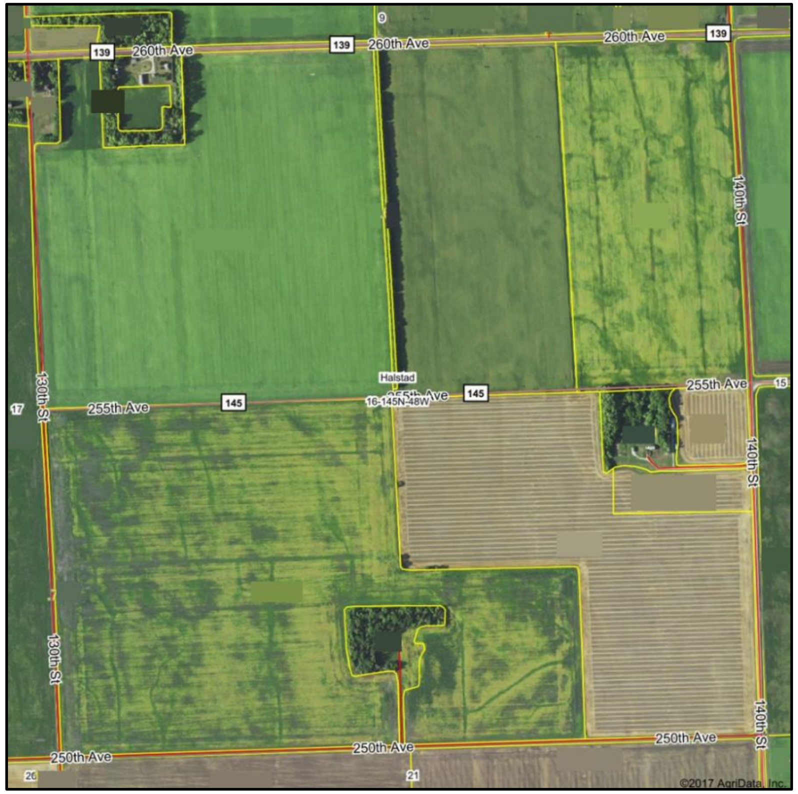
Auxiliary Data: Cropland Data Layer (CDL)

- Crop-specific land cover classification product created by USDA NASS
  - Raster product at 30-meter resolution
  - Available for the conterminous U.S. annually since 2008
  - Pixel-level crop data for over 100 crop categories
  - Only available at the end of the year



Auxiliary Data: Farm Service Agency (FSA)

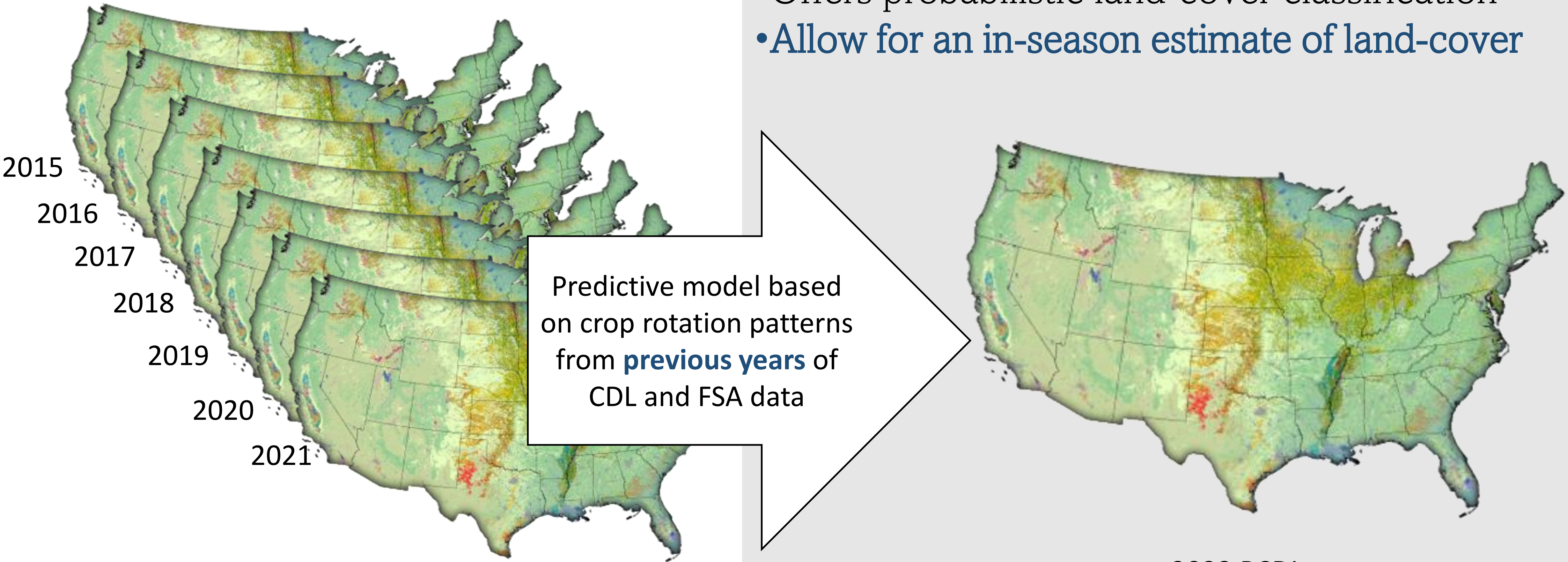
- FSA-578 Form
  - Available for all land associated with a USDA program in a calendar year
  - Provides crop information (what producers are growing and where)
- FSA Common Land Units (CLUs)
  - Smallest unit of land that has a permanent contiguous boundary, common land cover and land management, common owner, & common producer
  - CLUs linked to corresponding FSA-578 data



https://www.agridatainc.com/Home/Products/Mapping%20Features/Land%20Resource%20Intelligence/FSA%20Field%20Boundaries%20(CLU)

New Auxiliary Data: Predictive CDL (PCDL)

- Offers probabilistic land-cover classification
- Allow for an in-season estimate of land-cover



Predictive model based on crop rotation patterns from **previous years** of CDL and FSA data

2022 PCDL

Entropy Layer of PCDL

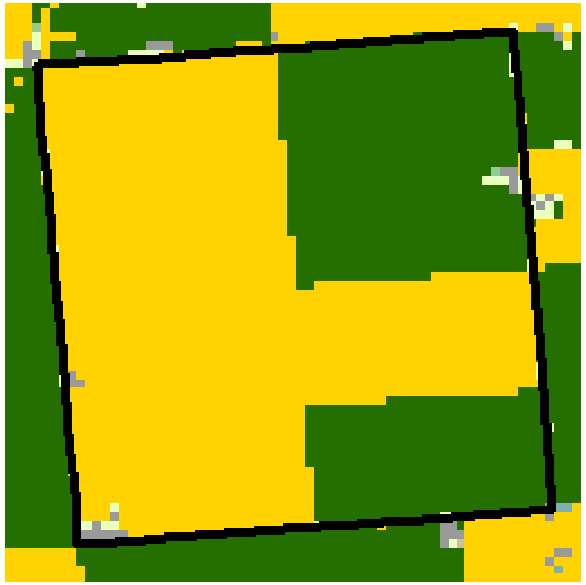
- Designed to provide a sense of confidence in the PCDL for the area of interest

- Low entropy = High predictability
- High entropy = Low predictability

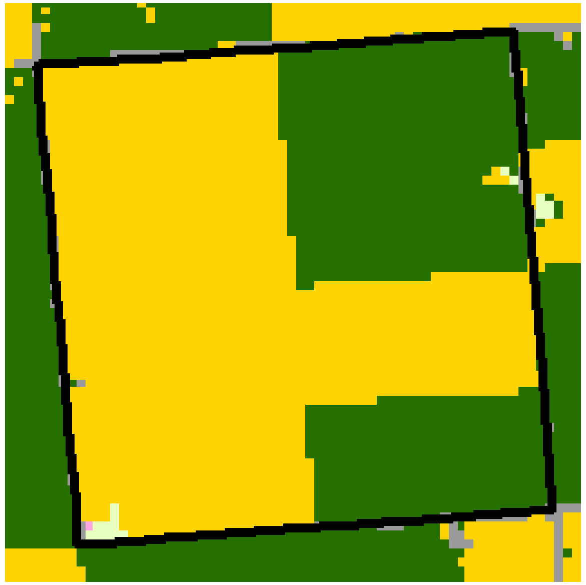
Entropy Layer of PCDL

🟨 Corn

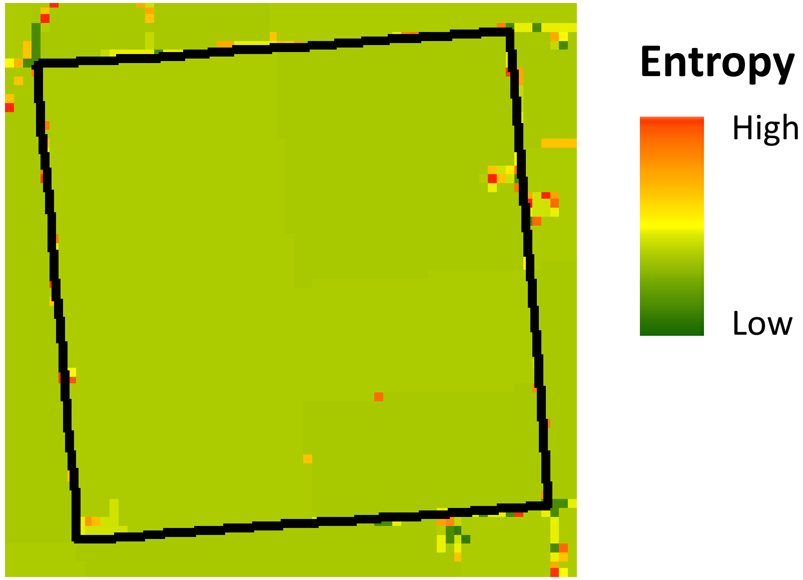
🟩 Soybeans



FSA CLUs linked to 578 data & Official CDL “Truth”

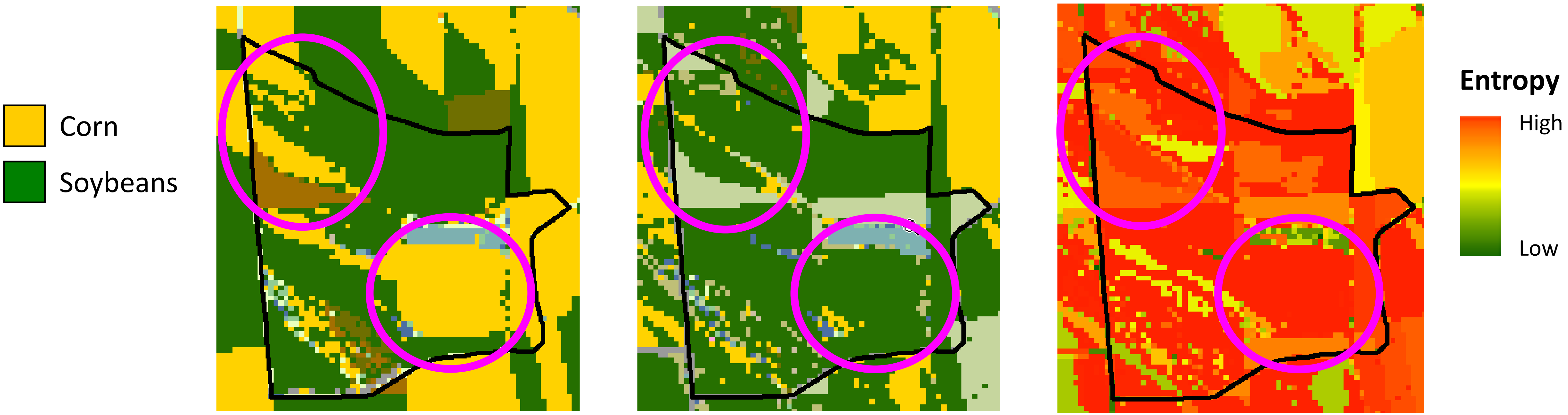


Predictive CDL



Entropy Layer Low Entropy

Entropy Layer of PCDL



FSA CLUs linked to 578 data & Official CDL "Truth"

Predictive CDL

Entropy Layer
High Entropy

Research Question

- Can automatic imputation be performed at the tract-level by incorporating digitized tracts, the PCDL and the Entropy Layer?

Data Preparation

- 2019 & 2021 JAS survey data utilized
- PCDL and FSA data summarized within digitized tract boundaries and linked to respective JAS survey data
- Data was subset to “low hanging fruit” records:
  - Number of PCDL crops < 2
  - Mean entropy of tract < 0.1 (Sartore, et al., 2022)
  - Digitized tract acres between 10 and 1000 acres

Imputation Model

- Cubist model
  - Used to predict FSA crop acreage at the crop level, based on PCDL, entropy, and other covariates (e.g., lat/long, state, sampling stratum)
  - Implemented using *caret cubist* packages in R software

- Model fit on 2019 data
- Predictions made on 2021 data

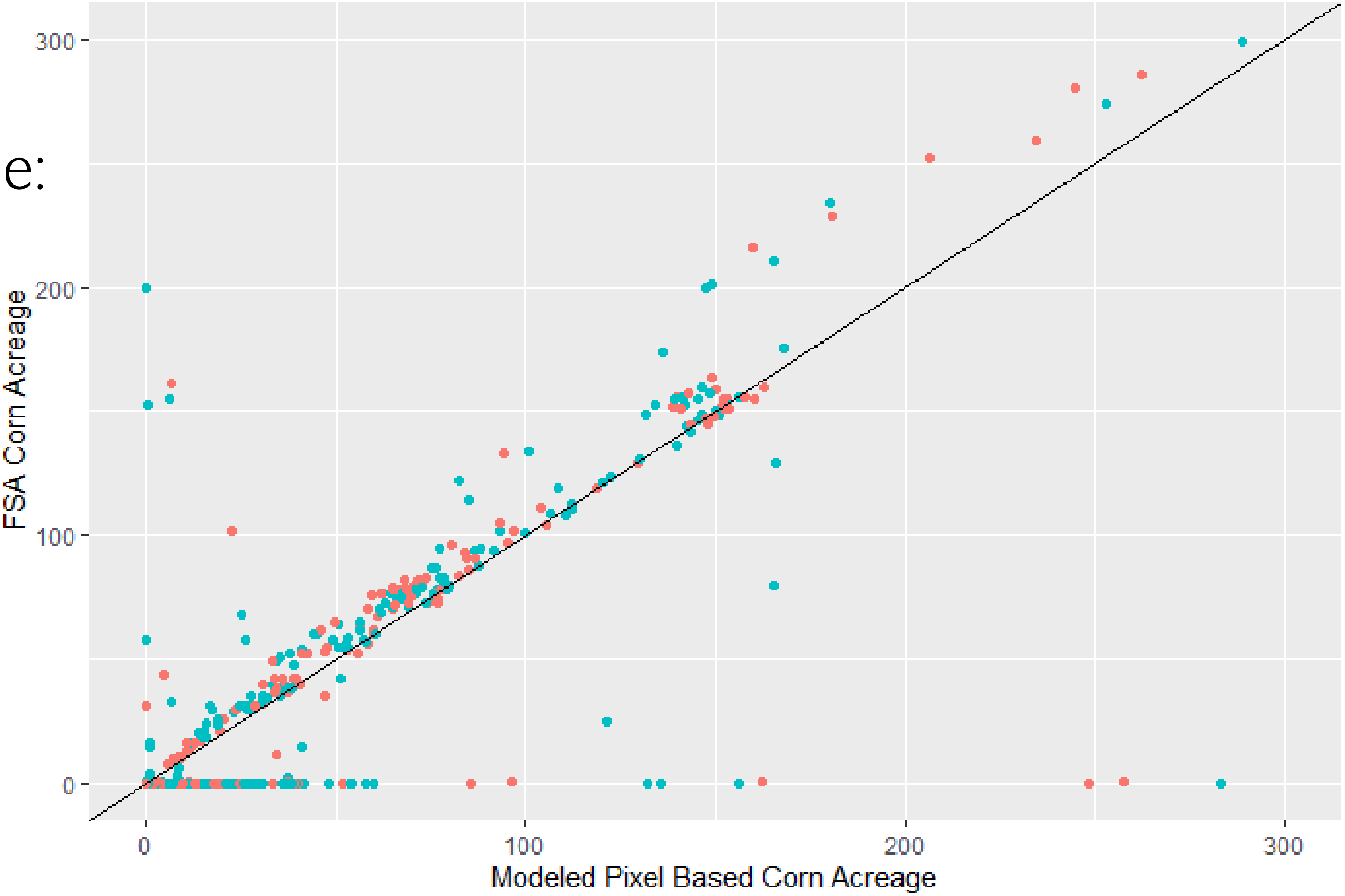
Results: Corn

- Color coded by JAS response:

●	0 = manually estimated
●	1 = reported

- $R^2 = 0.781$
- MAE = 4.783 acres
- Important model variable:
  - PCDL Corn

Model vs FSA Data

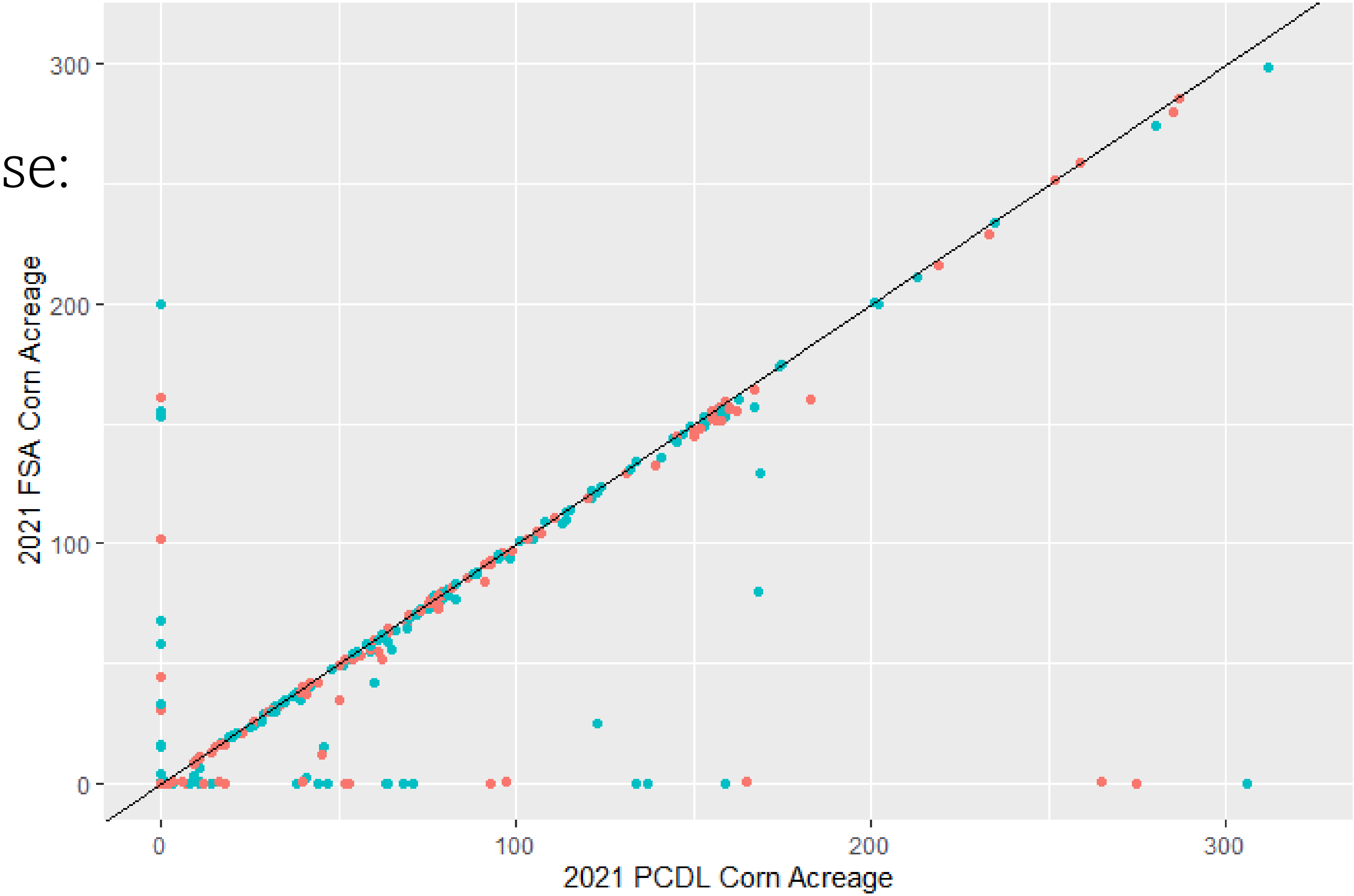


Results: Corn

- Color coded by JAS response:
  - ● 0 = manually estimated
  - ● 1 = reported

- $R^2 = 0.807$
- MAE = 2.797 acres

PCDL vs FSA Data



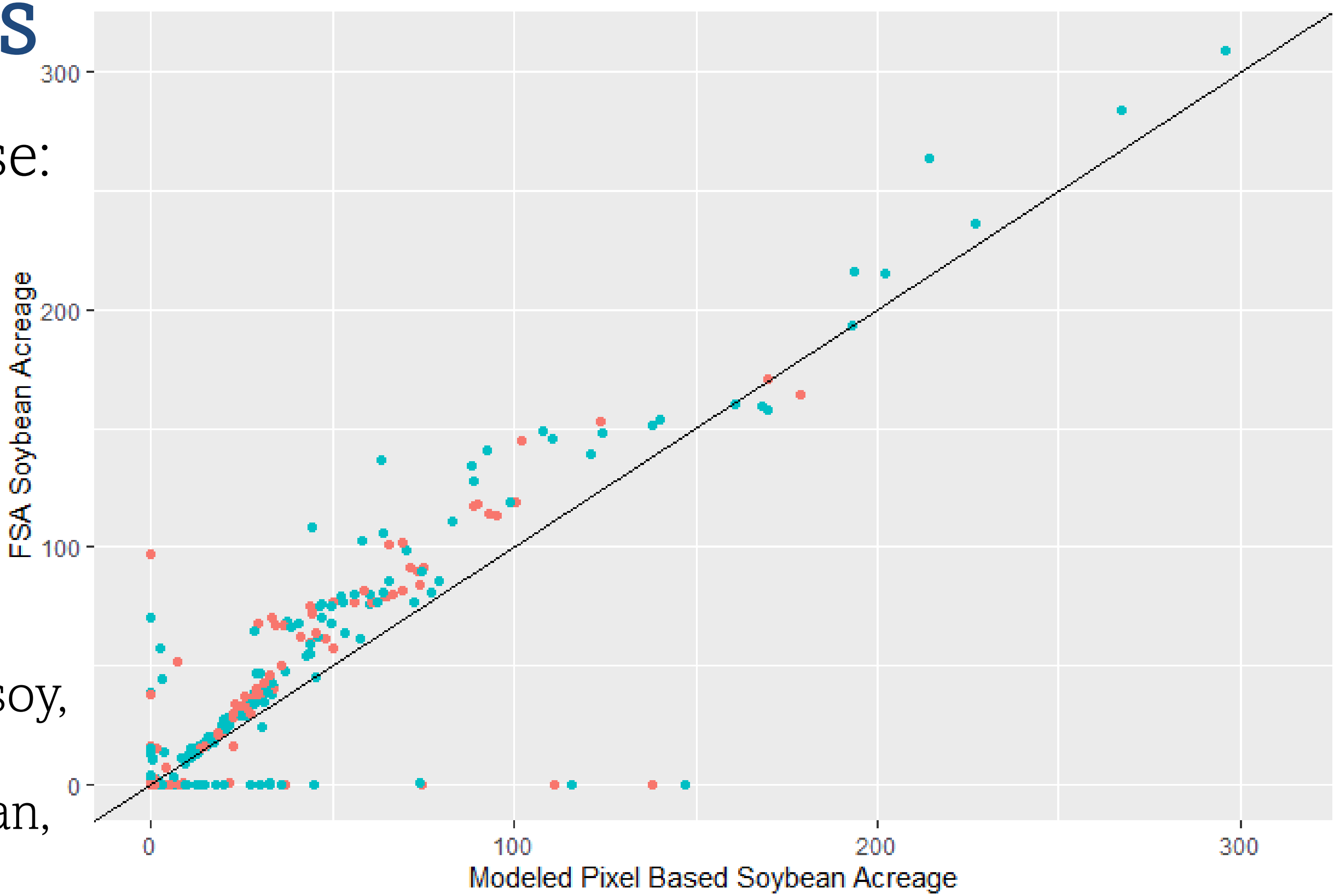
Results: Soybeans

- Color coded by JAS response:

  - ● 0 = manually estimated
  - ● 1 = reported

- $R^2 = 0.86$
- MAE = 2.82 acres
- Important model variables:
  - PCDL combined soy, PCDL soy, digitized tract acres, state, entropy mean, entropy median, latitude, longitude

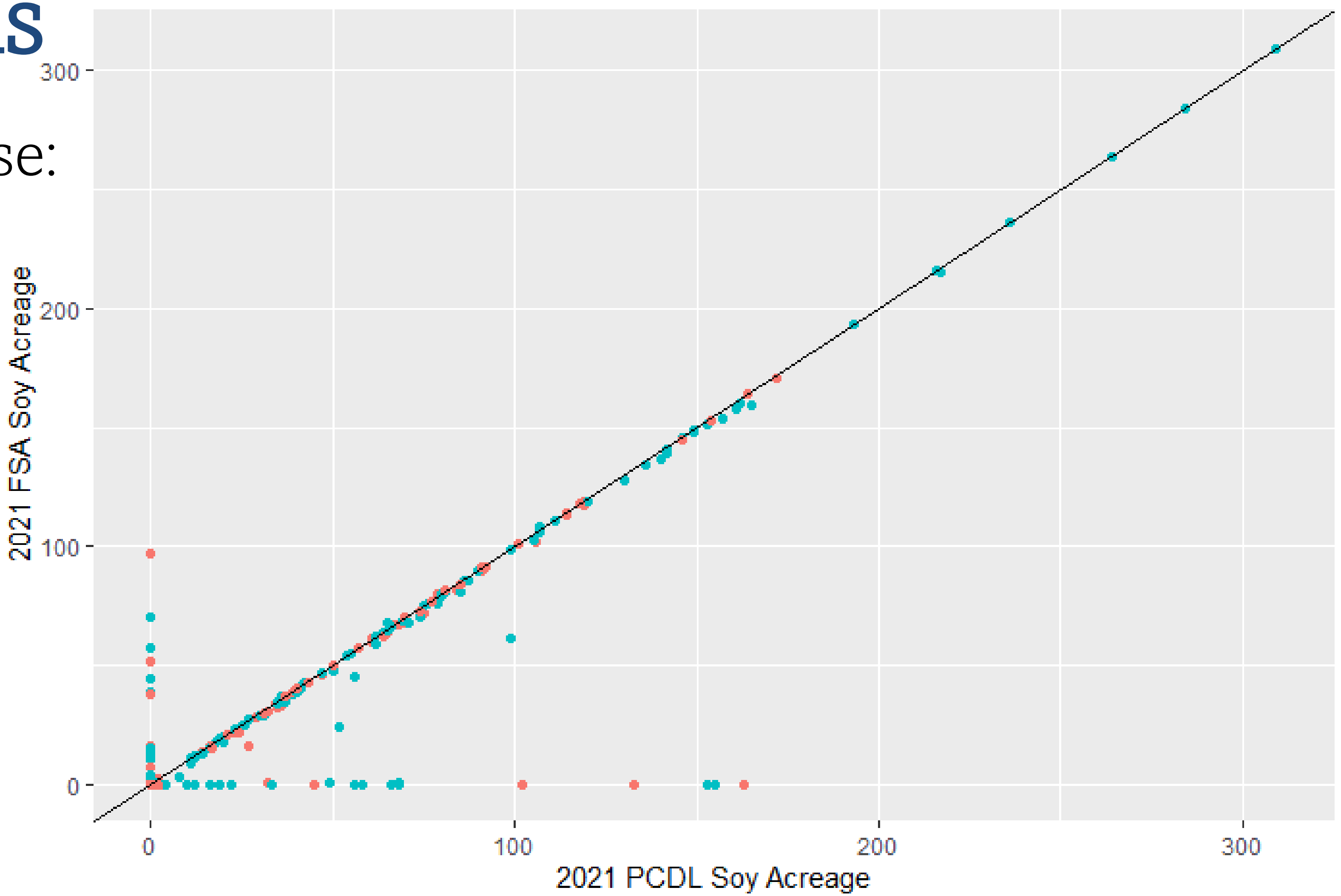
Model vs FSA Data



Results: Soybeans

- Color coded by JAS response:
  - ● 0 = manually estimated
  - ● 1 = reported
- $R^2 = 0.884$
- MAE = 1.336 acres

PCDL vs FSA Data



Discussion

- PCDL outperforms imputation model for “low hanging fruit”
  - Automatic imputation can easily be performed

- However, “low hanging fruit” represents a small portion of records

Future Research

- Expand beyond "low hanging fruit" records
- Find optimal level of entropy where PCDL is useful for the purposes of imputing JAS tract nonresponse
- Improve imputation model by incorporating additional auxiliary data
  - Economic data
  - Environmental data

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Thank you!

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