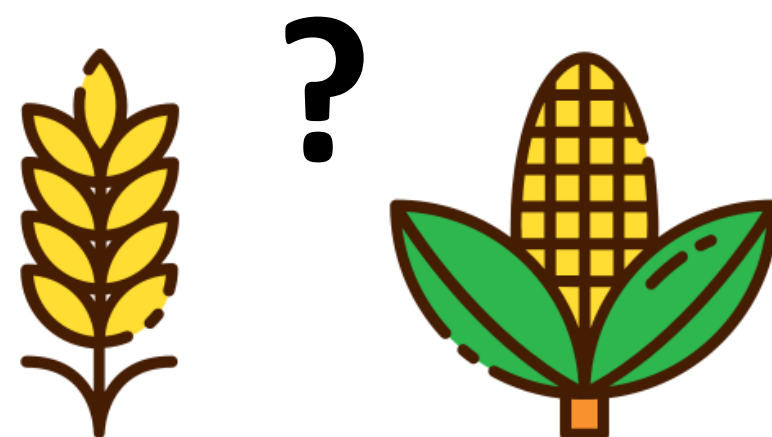
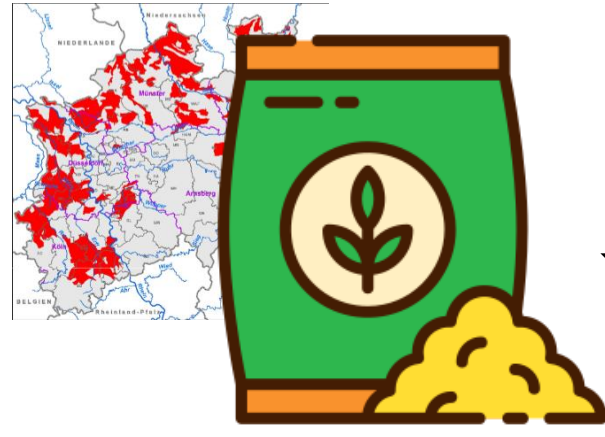


# Using Probabilistic Programming to Asses Policy Induced Adaptation of Crop Choices: A Case Study of the German Implementation of the EU Nitrates Directive

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## Motivation

- Germany tightened its implementation of the EU Nitrates Directive due to treaty violation proceedings of the EU commission.
- Core element of new legislation are stricter measures for nitrogen fertilization in areas with high nitrate pollution, so-called red areas (see Table 1).
- The adaption of crop choices, e.g. crops with lower nitrogen need like maize or sugar beet, is promoted as a compliance strategy with new legislation.
- However, there is no empirical knowledge if farmers adapt their crop choices in response to red areas.



## Background (please zoom in)

Figure 1: Red areas in North Rhine-Westphalia

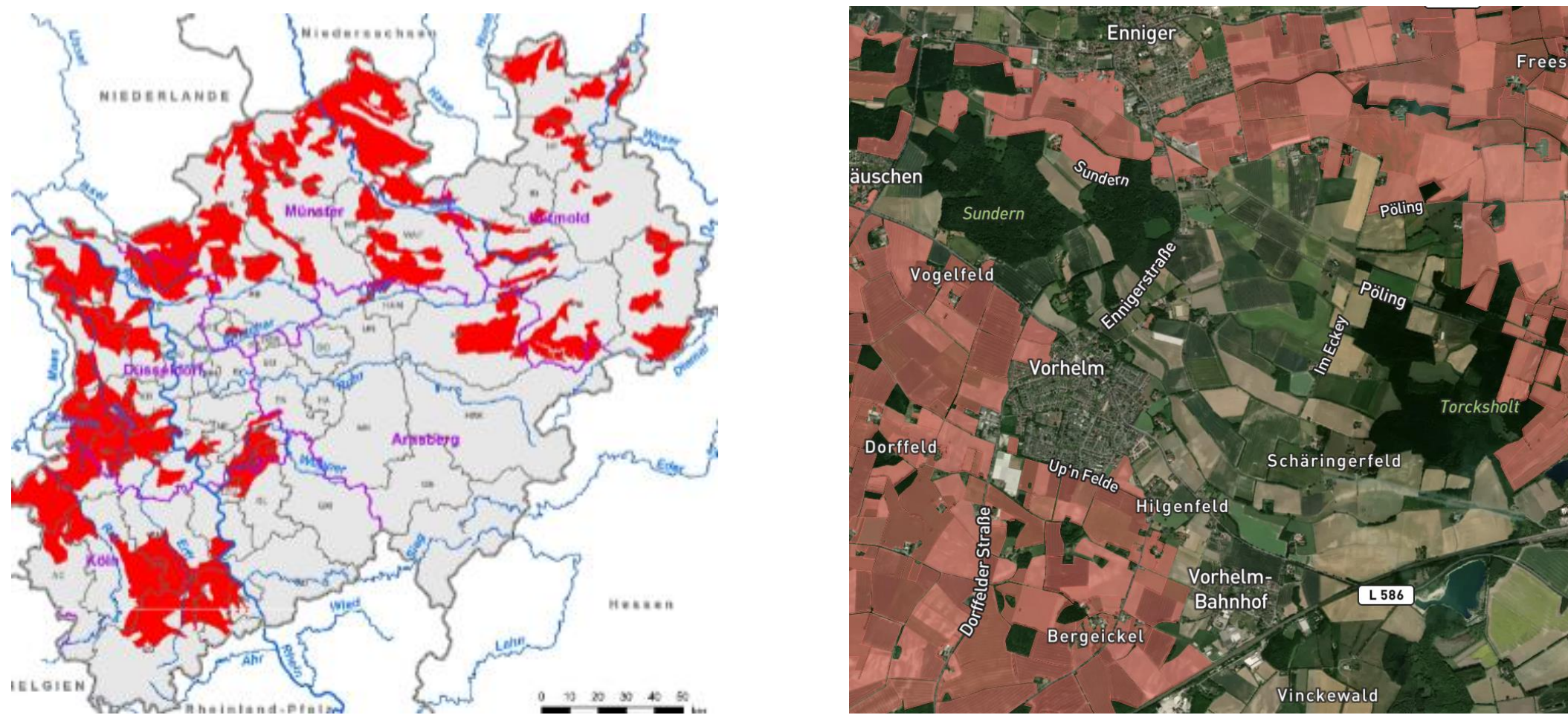


Table 1: Core measures out-& inside of red areas (simplified)

	Outside of red areas	In red areas
Fertilizing planning provides nitrogen (N) fertilizer target	Not exceed target value	Target value is lowerd by 20%
Maximum of 170 kg manure N ha <sup>-1</sup>	On farm average	Plot specific
Catch crops	Optional	Compulsory

## Results

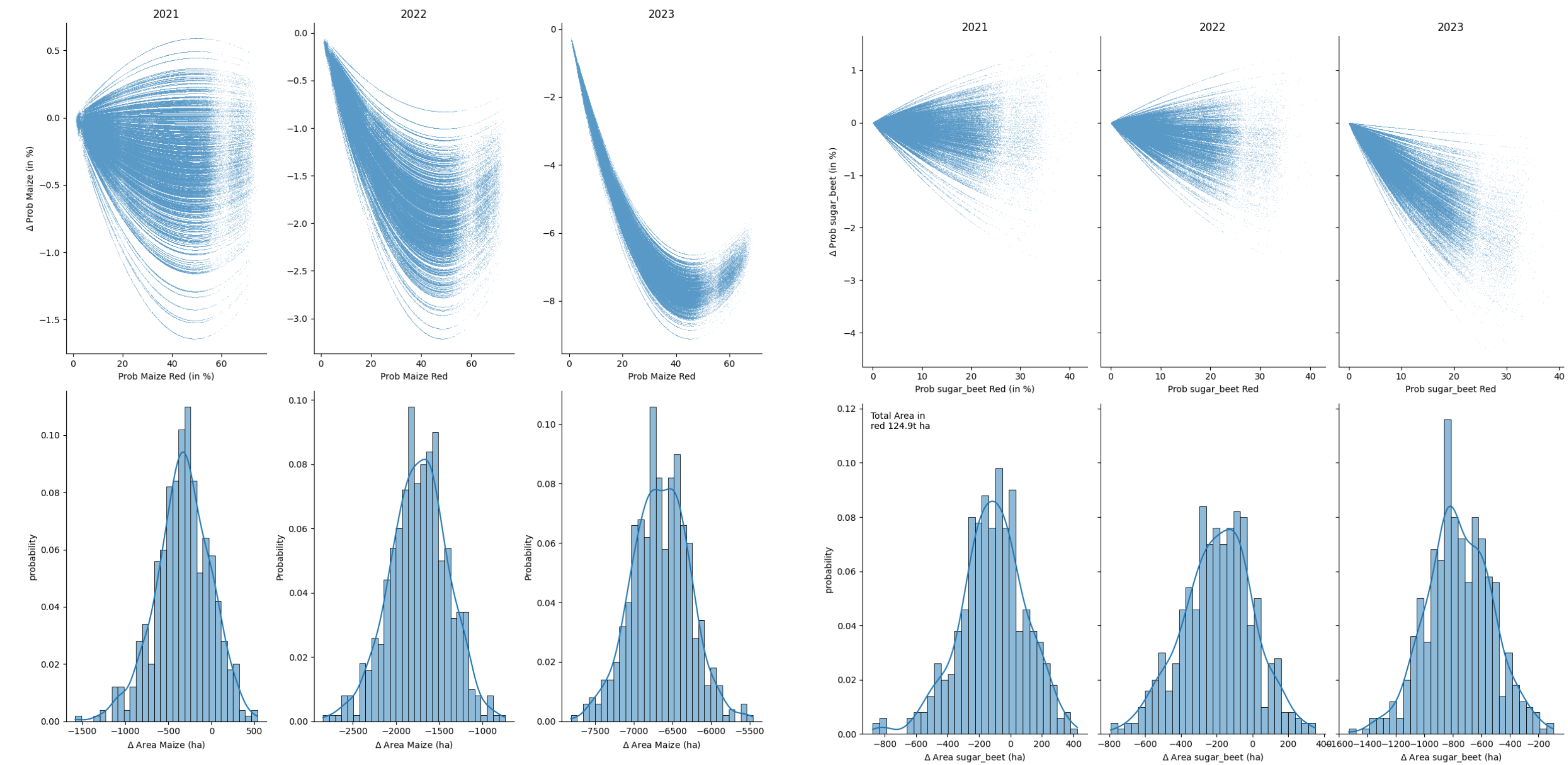


Figure 3: Estimated changes for maize and sugar beets due to the implementation of red areas (for plots red since 2021)

## Research aim

- Detect changes of crop choices that are induced by the regulations within red areas for the German federal state of North Rhine-Westphalia (see Figure 1).
- Developing a probabilistic programming approach to link changes in crop choice to spatial data.

## Methods

We employ a novel Bayesian probabilistic programming approach (using *NumPyro*) offering:

- Bayesian representation of uncertainty
- Data generating process at the center
- Flexibility similar to machine learning
- Data driven

Regularization with hierarchical modeling

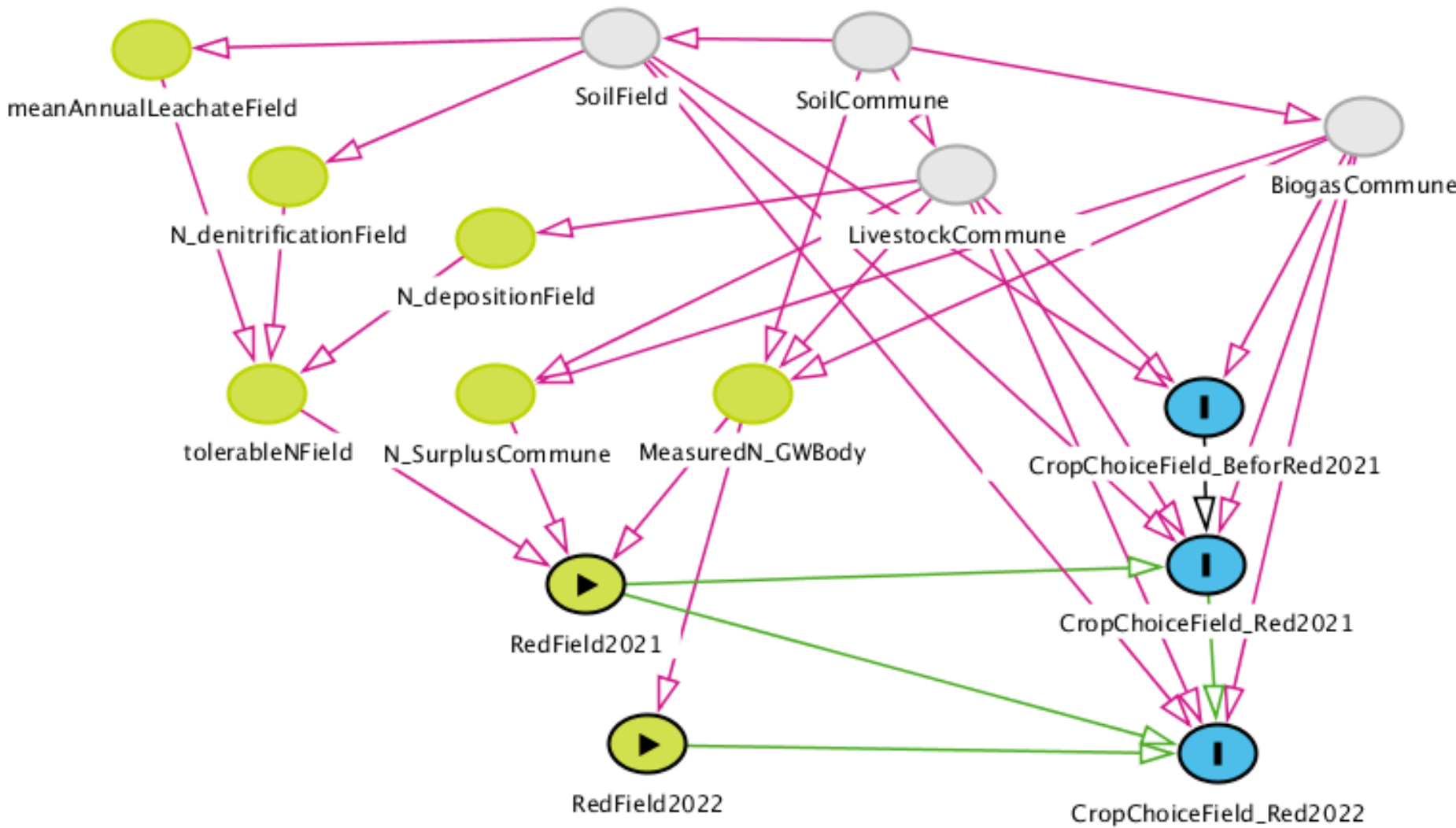


Figure 2: Assumed data generative process

## Conclusion

- Preliminary results reveal that farmer adaptation of their crop choices is modest.
- This is might due to a) the novelty of the policy, b) other preferred compliance strategies, and/or c) non-binding measures.
- Results illustrate heterogeneity in the estimated effects of red areas



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