Landscape Typologies:
A new approach to enhancing understanding of landscape services

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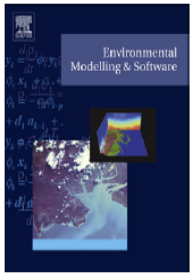

Using landscape typologies to model socioecological systems: Application to agriculture of the United States Gulf Coast

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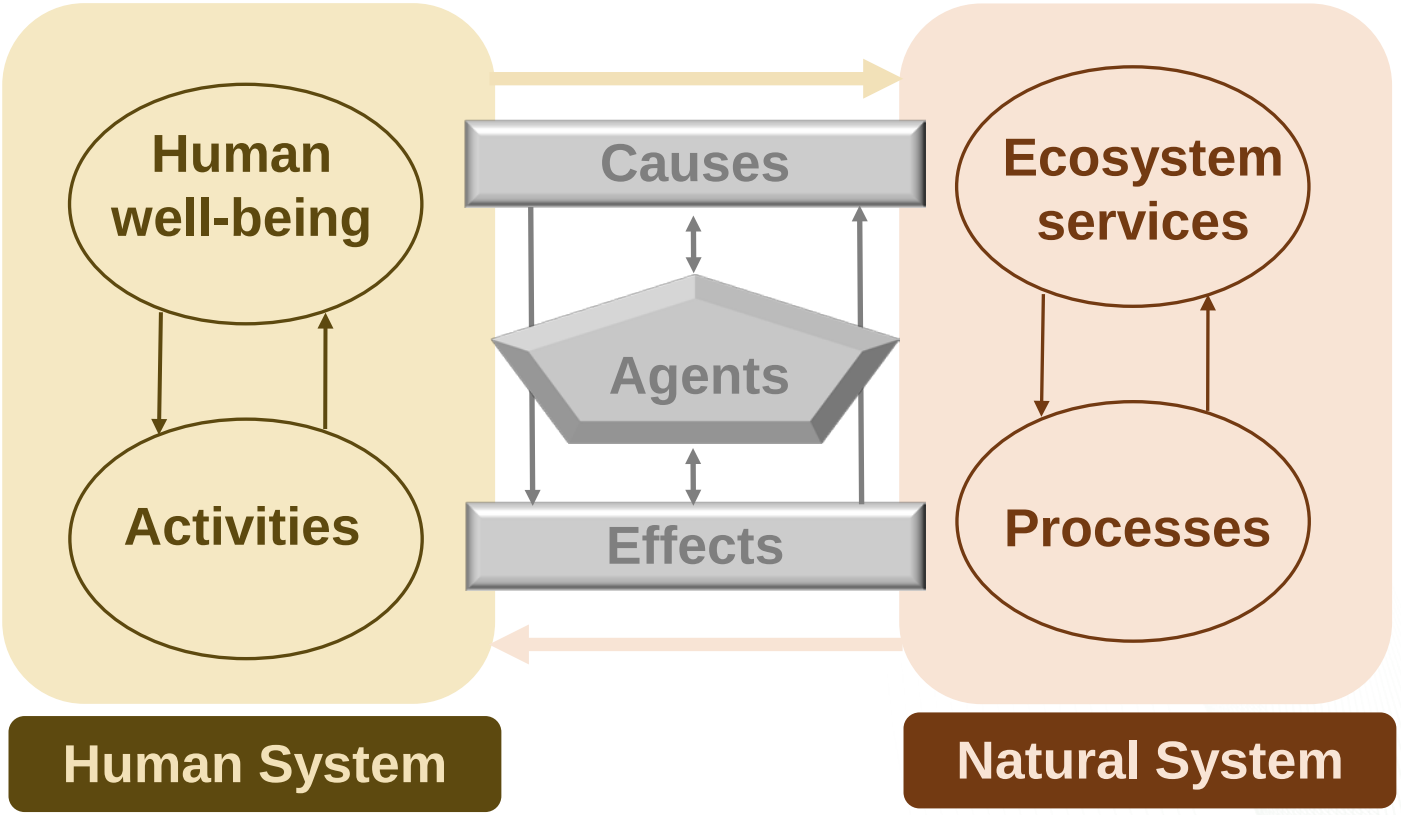
Socioecological systems (SES)



Socioecological Systems

Challenges in socioecological systems

_ Recognized the dependency

_ Embraced multi-disciplinary research

_ Understood the plurality of methods

_ Enhanced systems understanding

_ Role in policy framework

Challenges in socioecological systems

_ Focus has been on context based case studies

_ Quantification is found to be very difficult

_ Not much attention on institutions outside the systems

_ No framework for accumulating generated knowledge

- Complex interactions within socioecological systems are difficult to operationalize empirically in environmental assessment
- Context specific case studies do not facilitate bottom-up of re

Relevance of landscape typology (LT)in Socioecological studies

_ LT is a useful construct for framing and analyzing SES

_ Facilitate establishing a prognostic and diagnostic analysis linkage

_ Connecting across different scales

Landscape pattern to landscape typology

- What is landscape typology ?
- Delineating landscape types
- Linking landscape types with landscape function
- Explaining spatial variability in outcome in terms of landscape types
- Identifying specific drivers

Delineating landscape types

_ Specific

A specific landscape typology for a specific outcome from an SES.
For example, landscape typologies for regional agriculture production

_ General

A general landscape typology for understanding multiple outcome from SES

Methods: Overview

- High-dimensional statistical modeling (Bühlmann and van de Geer, 2011)
- Two step process:

  Step 1:Clustering and typology development

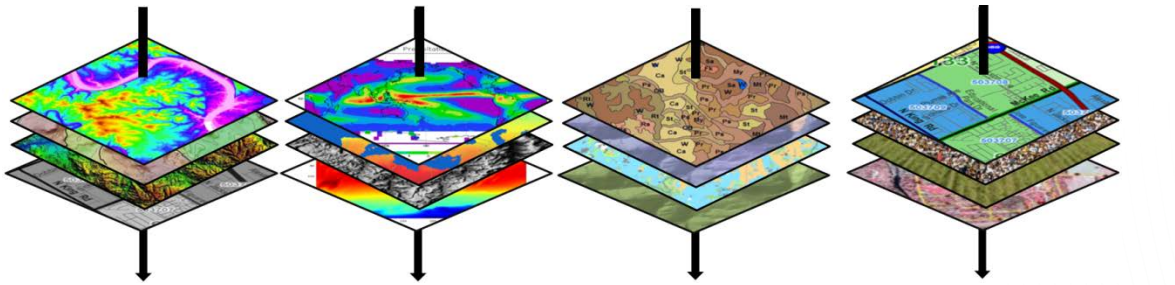
  Define and delineate a socioecological (SES) landscape typology over the study region.

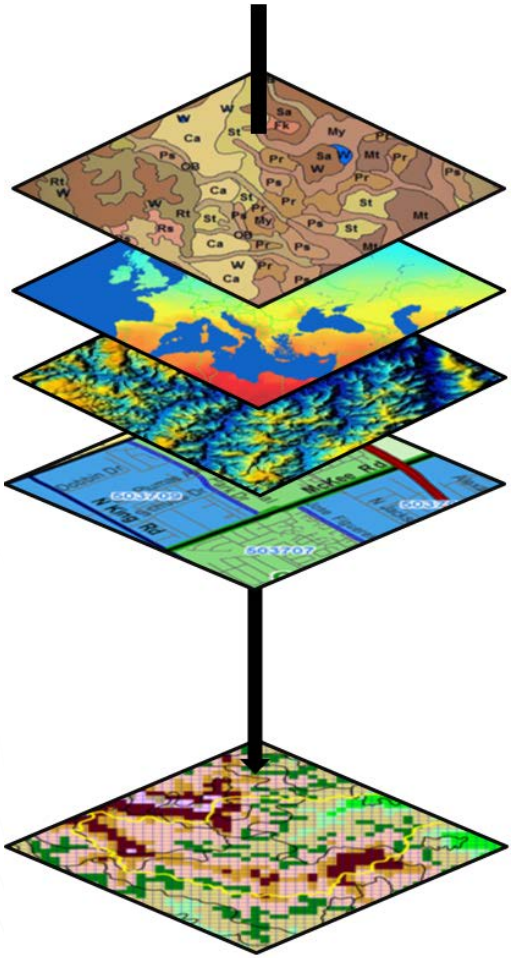
  Step 2: Regression analysis

  Exploit socioecological heterogeneity across the region to establish diagnostic relationships between outcome of interest and its drivers.

Methods: **Overview**

- Landscape typologies were developed using non-parametric hierarchical clustering techniques (Li et al., 2008)



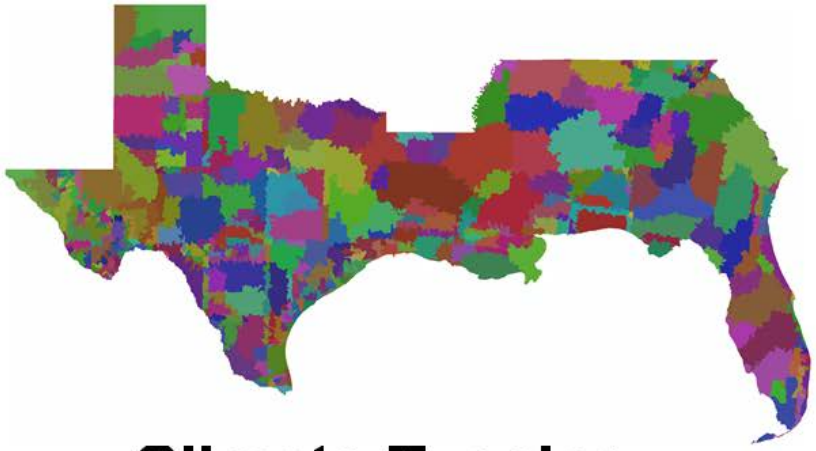


SET

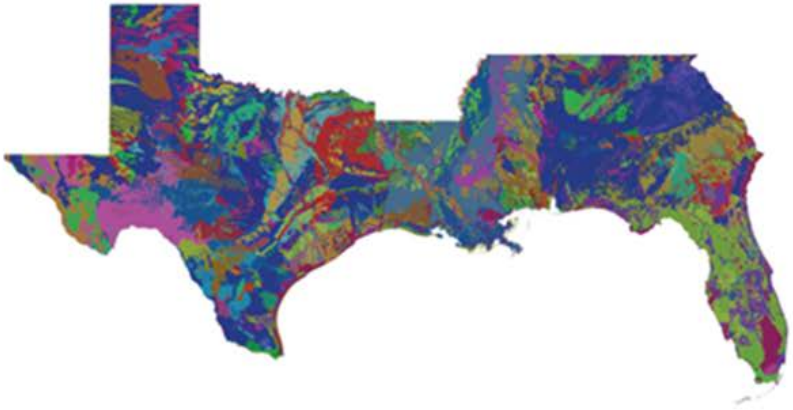
Methods: **Data**

	Climate	Topography	Soil	Socio Economic
Source	Daymet (1km grid)	NED (30m)	STATSGO	County
	1981-2010			1986-2010
	Monthly, seasonal and yearly			
Variables	Mean, SD, Max, Min for	Mean, SD, Max, Min for	Representative values for	Mean, SD, Max, Min for
	18 km grid	HUC-12 watersheds	MUKEY comp	County
	Daily max temp	Slope	Percent sand	Population Density
	Daily min temp	Elevation	Percent silt	Unemployment
	Daily precipitation	Aspect	Percent clay	Education
	Daily solar radiation	Hillshade	Soil organic matter	Household income
		Topographic Wetness Index	Bulk density	Farm Specialization
			Awailable water content	TFP
			pH	Farm Production Intensity
			Saturate hydrolic conductivity	Road density
				USDA Rural-Urban Codes

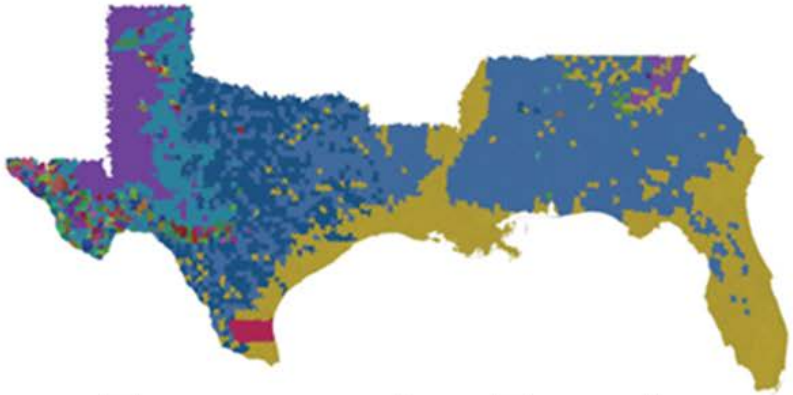
Regional landscape typologies



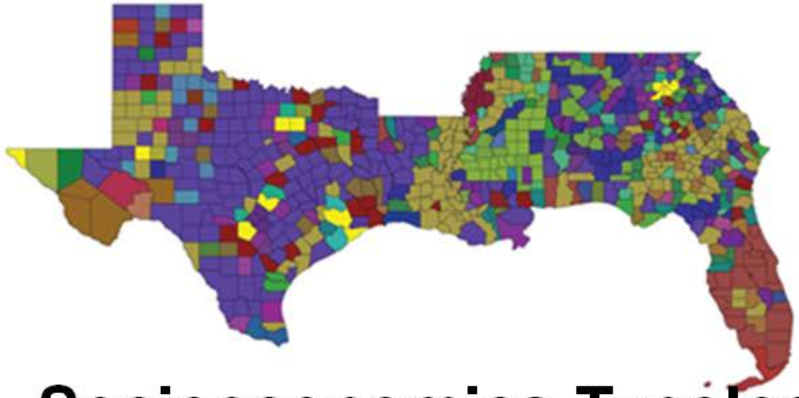
Climate Typology



Soil Typology

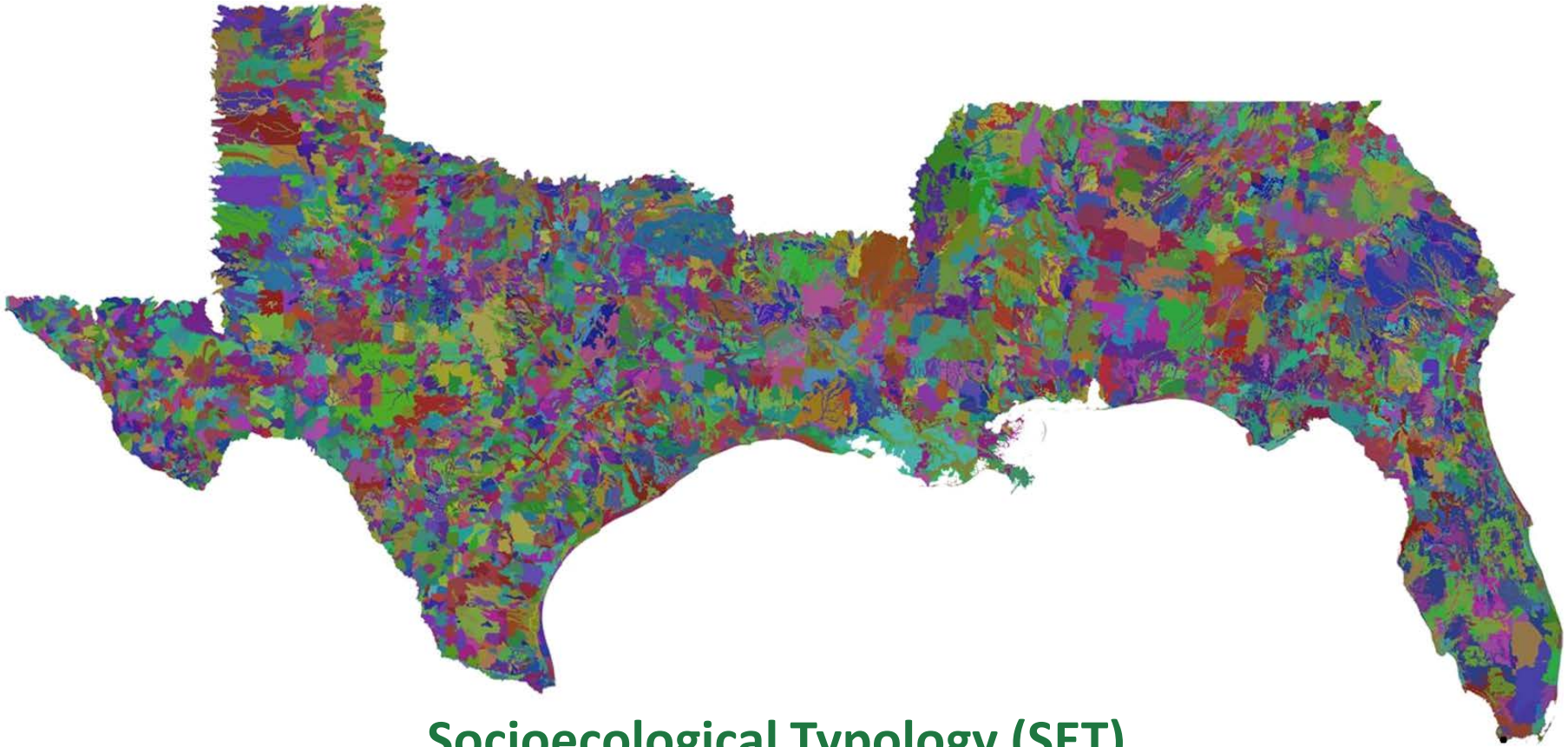


Topography Typology



Socioeconomics Typology

_ Climate, topography, and socioeconomic typologies into a regional socioecological typology (SET)



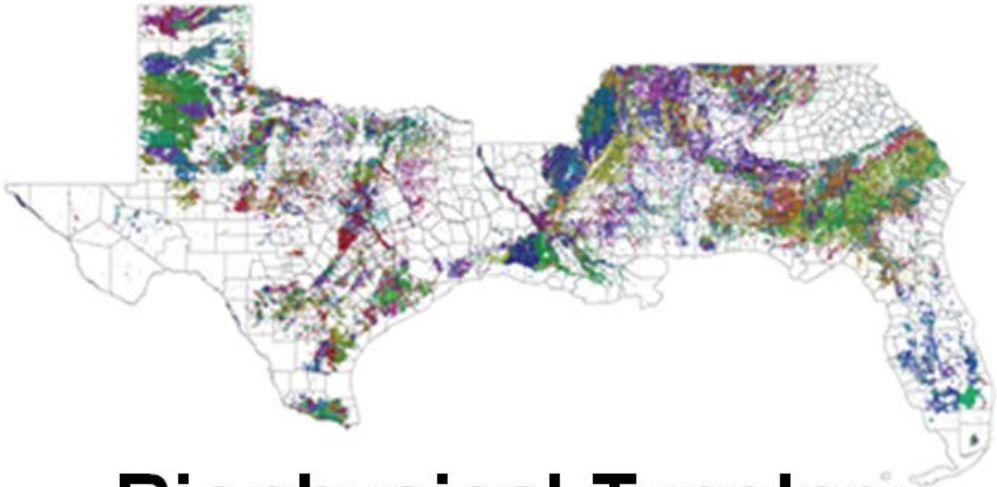
Socioecological Typology (SET)

Application1: Productivity of regional agroecosystems

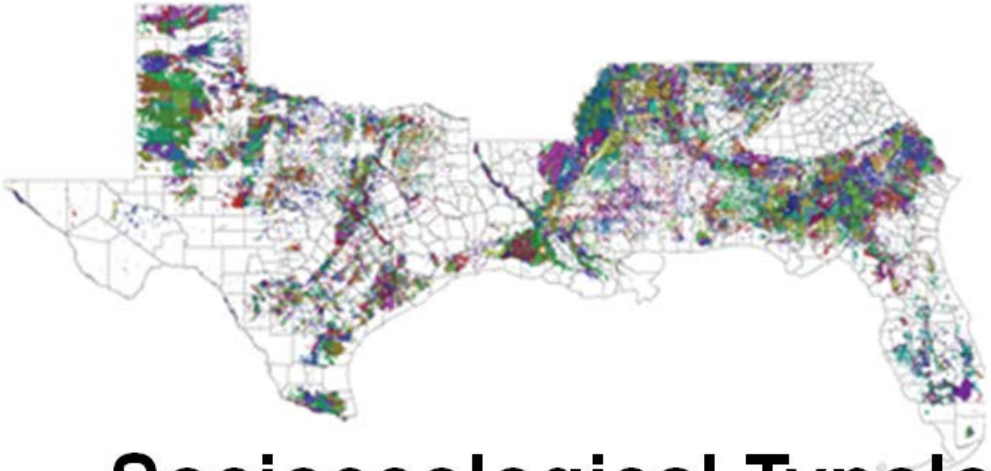
_ Climate risk–hazard framework

- Process-based farm or crop models
- Empirical models
- Integrated assessment models

A mild climate stress can in some contexts lead to devastating crop losses, while in other cases a major weather abnormality might result in only a slight decrease in crop production



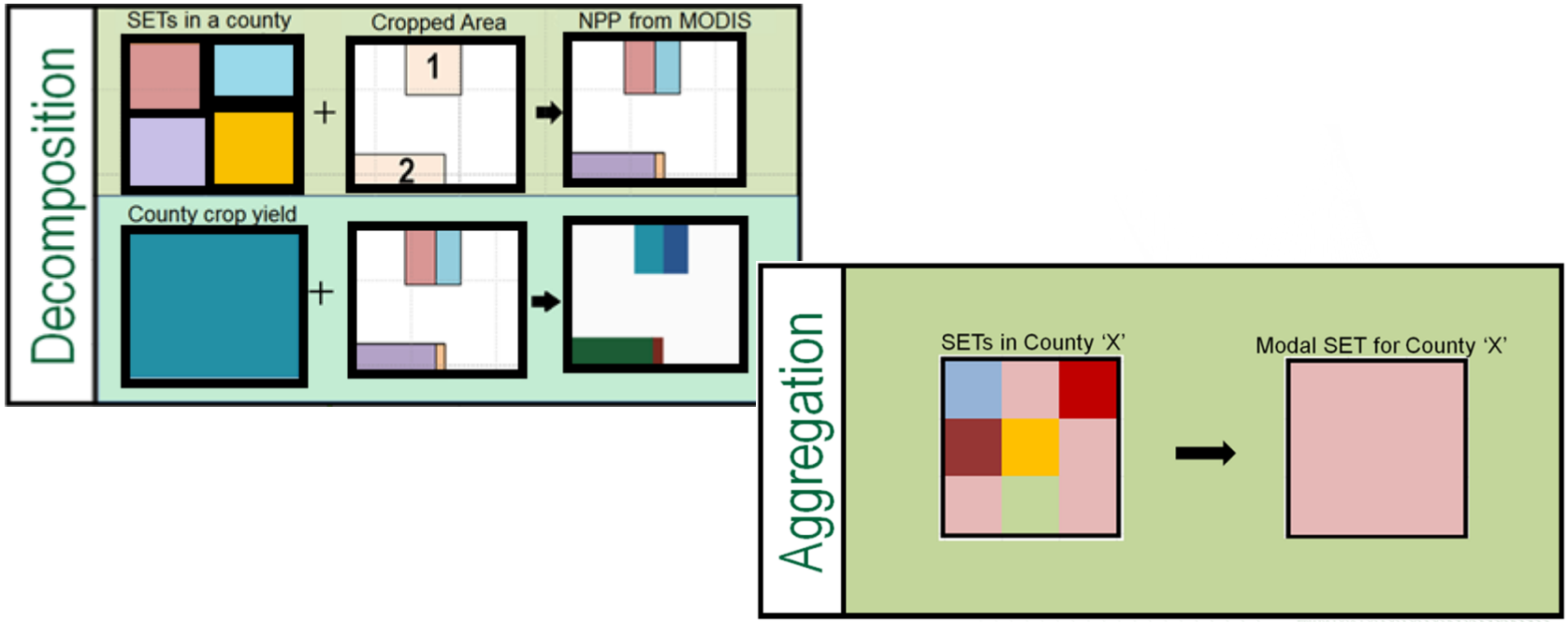
Biophysical Typology



Socioecological Typology

Regression analysis

_ We assigned a county crop yield over SET types using both decomposition and aggregation approaches



Regression analysis

- Corn yield were regressed against SET types using the Country Product Dummy Method (World Bank)

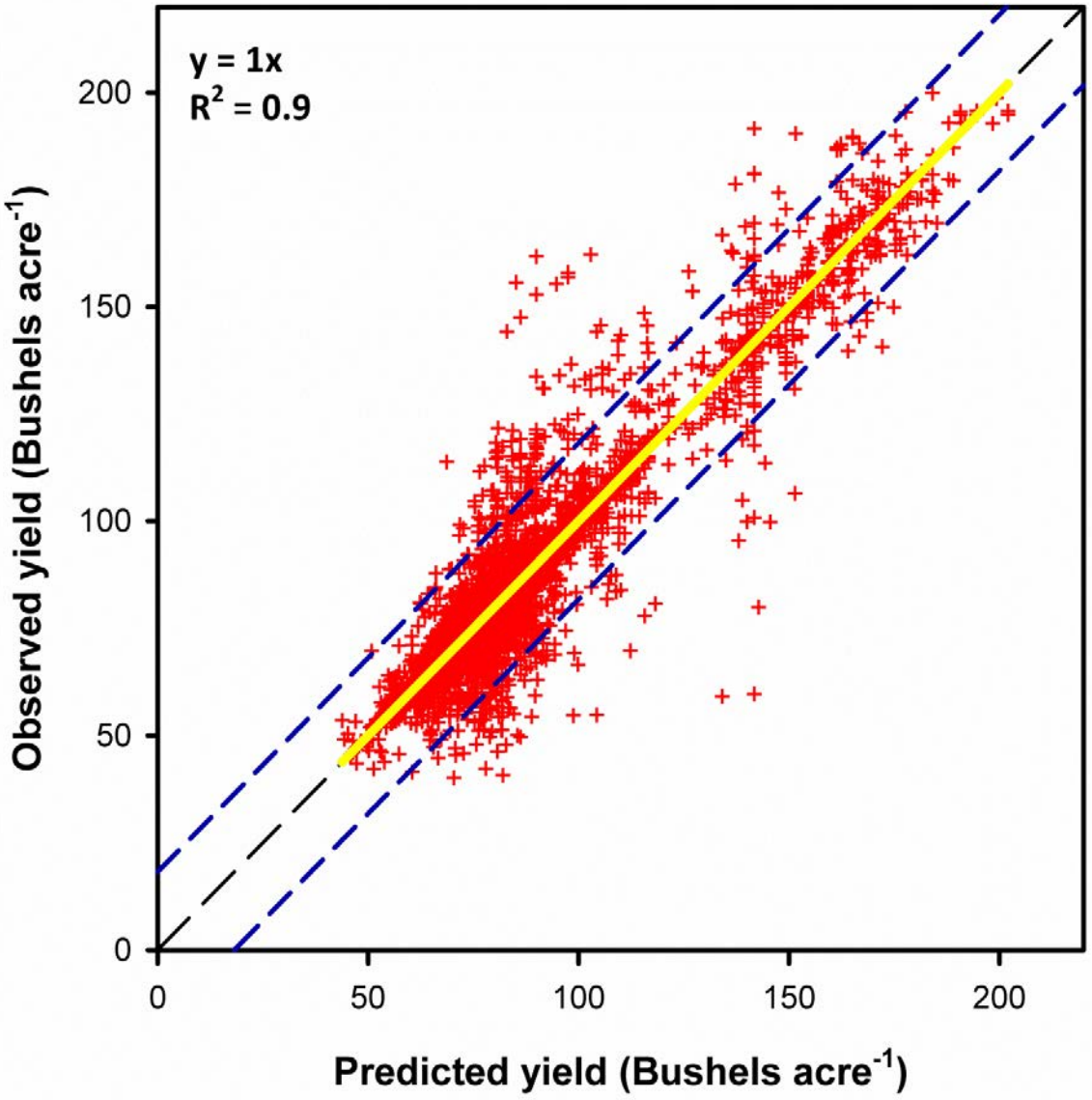
Observed variations in the price of a commodity are defined in terms of the multiple attributes of the commodity and the region that represents the market for that commodity (Diewert et al.,2009; Rao et al., 2010).

Regression analysis

- For example, if a type within the SET contained a specific climate type that climate type was scored with a value of 1 otherwise it received a value of 0; likewise for the topography, and the socioeconomic types.

$$\mathbf{Y_j = F\left(C_{jc}, S_{je}, T_{jt}, SE_{je}, Int\right)\ j \in c, s, t, e}$$

SET Model for corn



Regression analysis

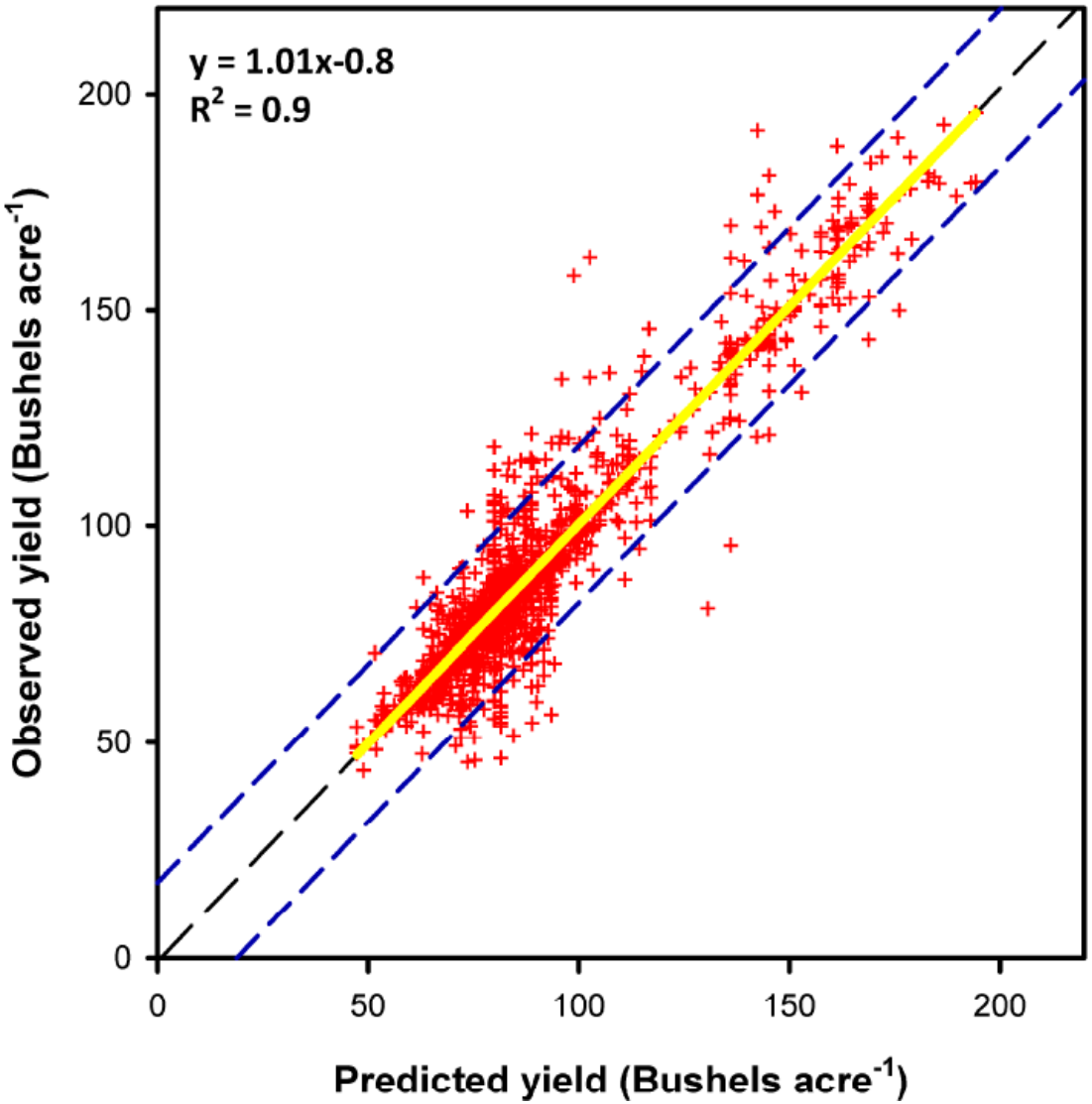
_ Cross-validation

_ Soybean and cotton

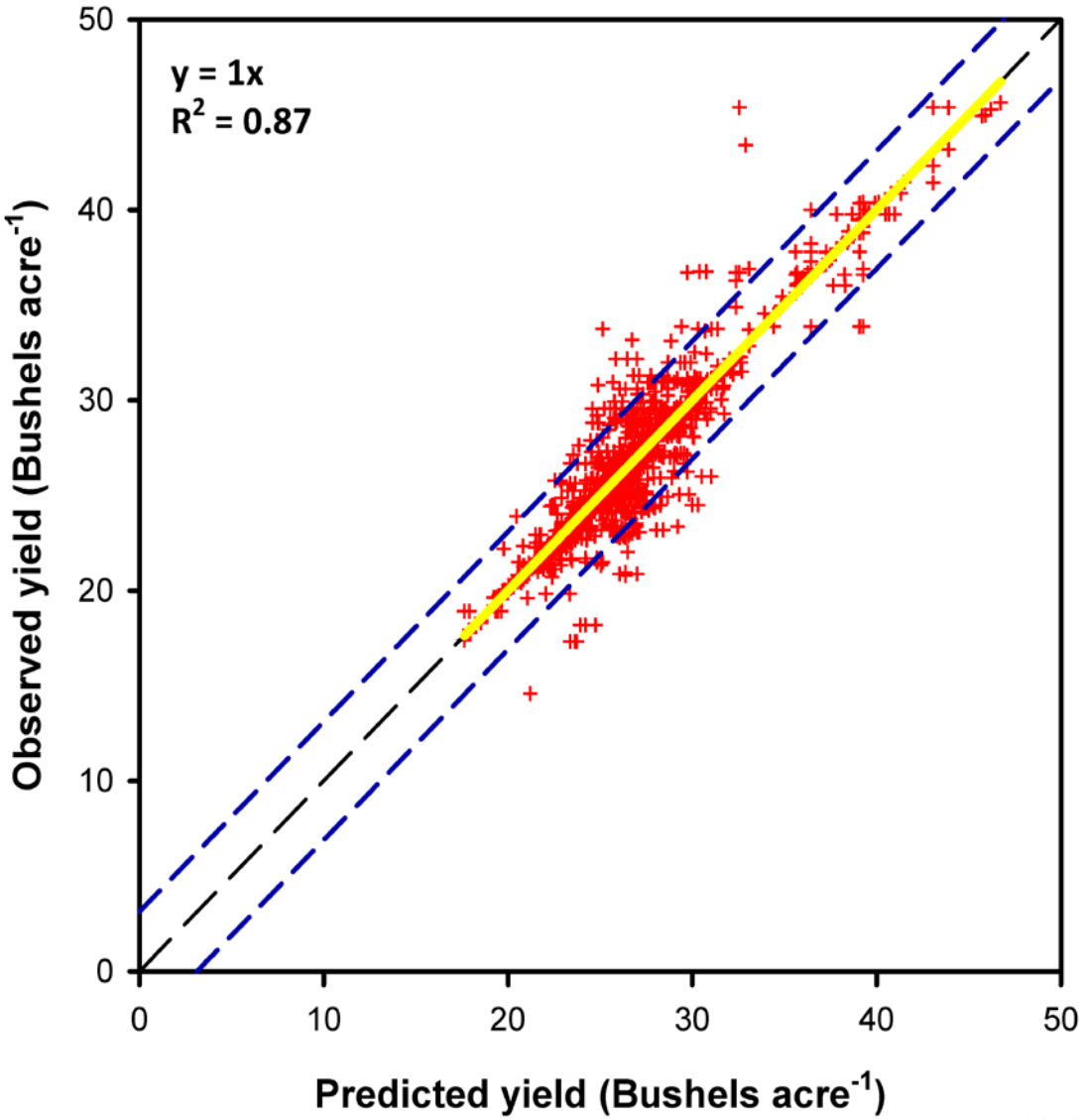
_ Aggregated county SET model

_ County fixed-effect model

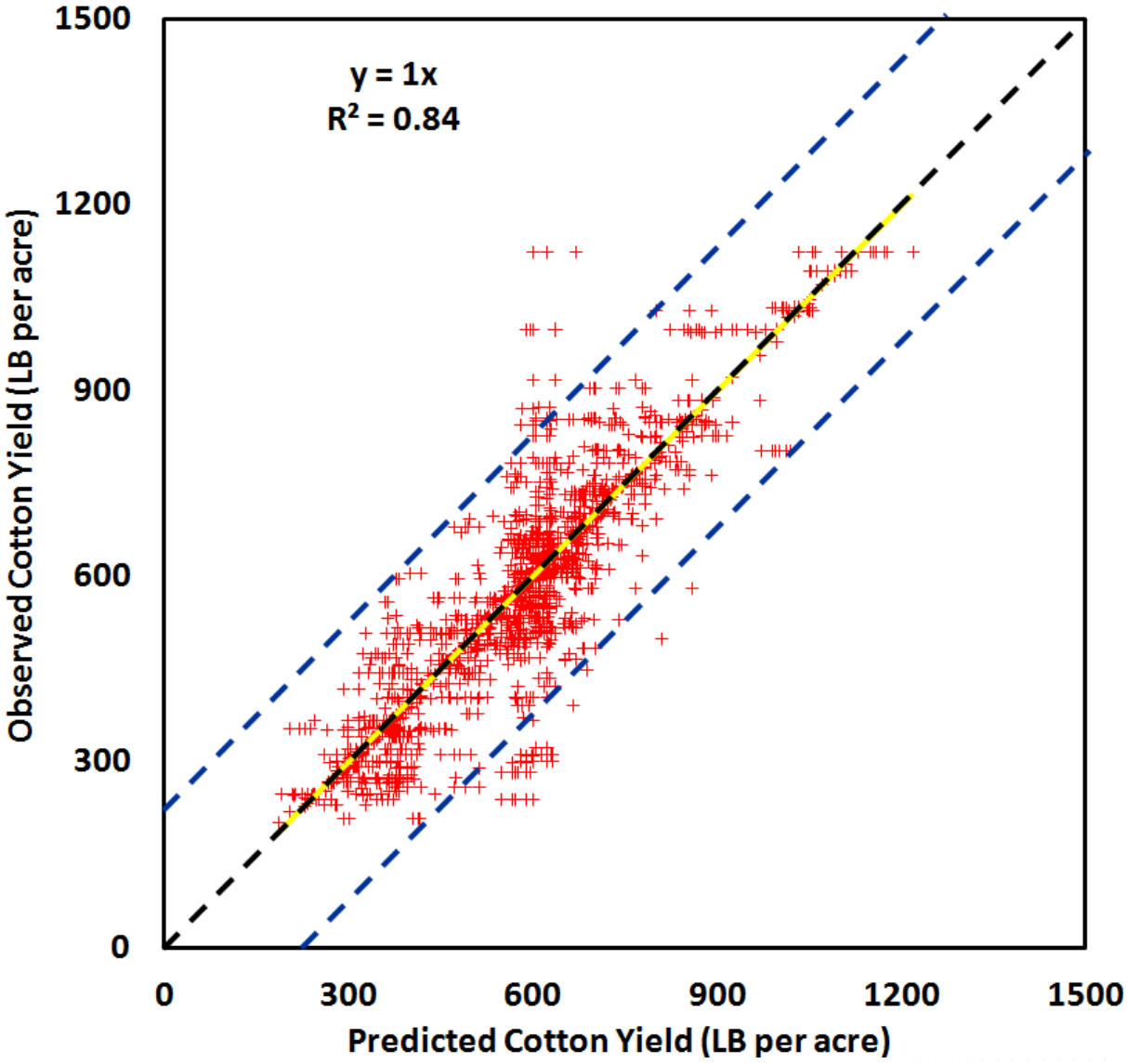
Cross validation for corn



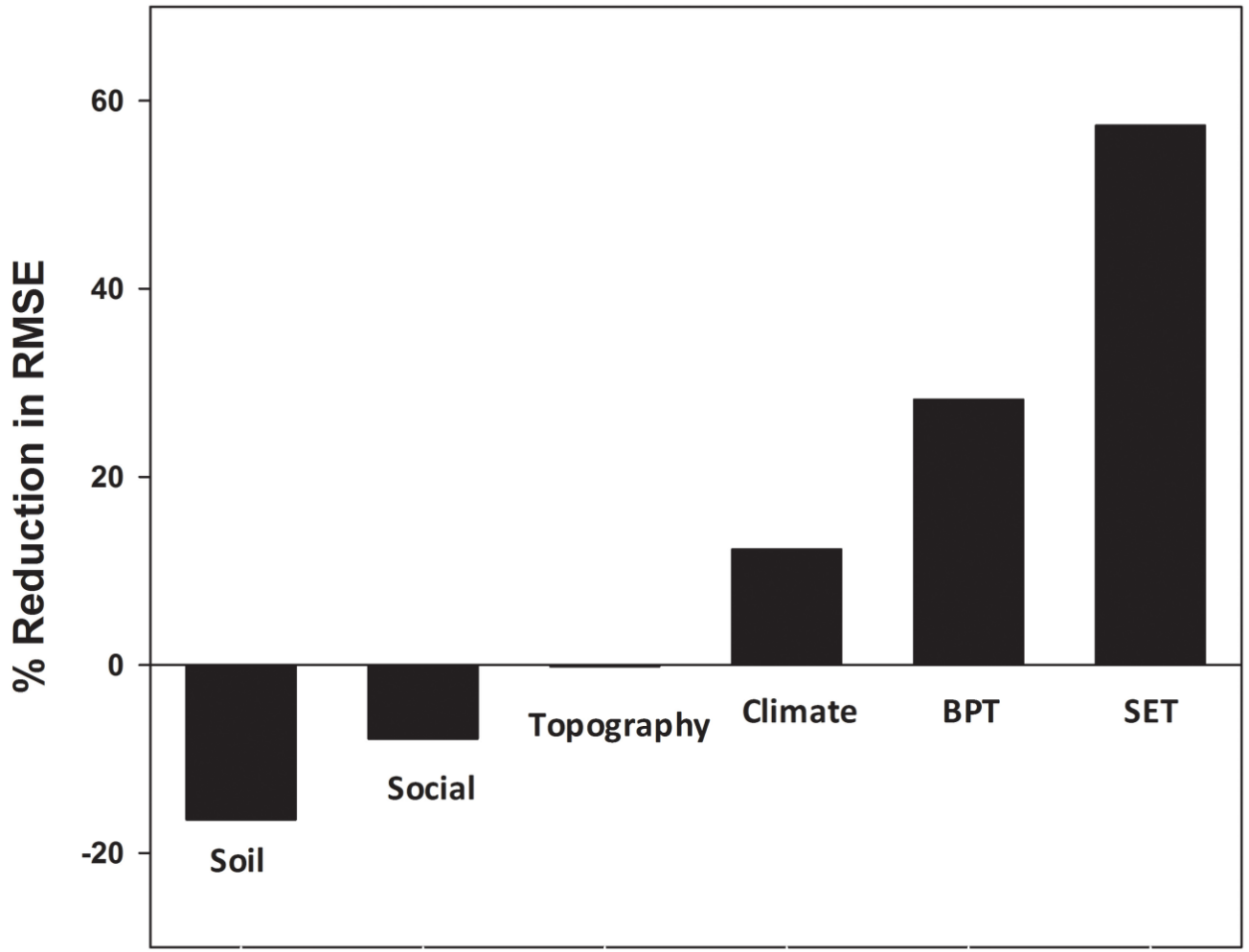
Soybean


y = 1x
R2 = 0.87
Observed yield (Bushels acre-1)
Predicted yield (Bushels acre-1)
0
10
20
30
40
50

Cotton


y = 1x
R² = 0.84
Observed Cotton Yield (LB per acre)
Predicted Cotton Yield (LB per acre)
0
300
600
900
1200
1500

Comparison with county-fixed effect model



Predicted corn yield –BPT vs SET models

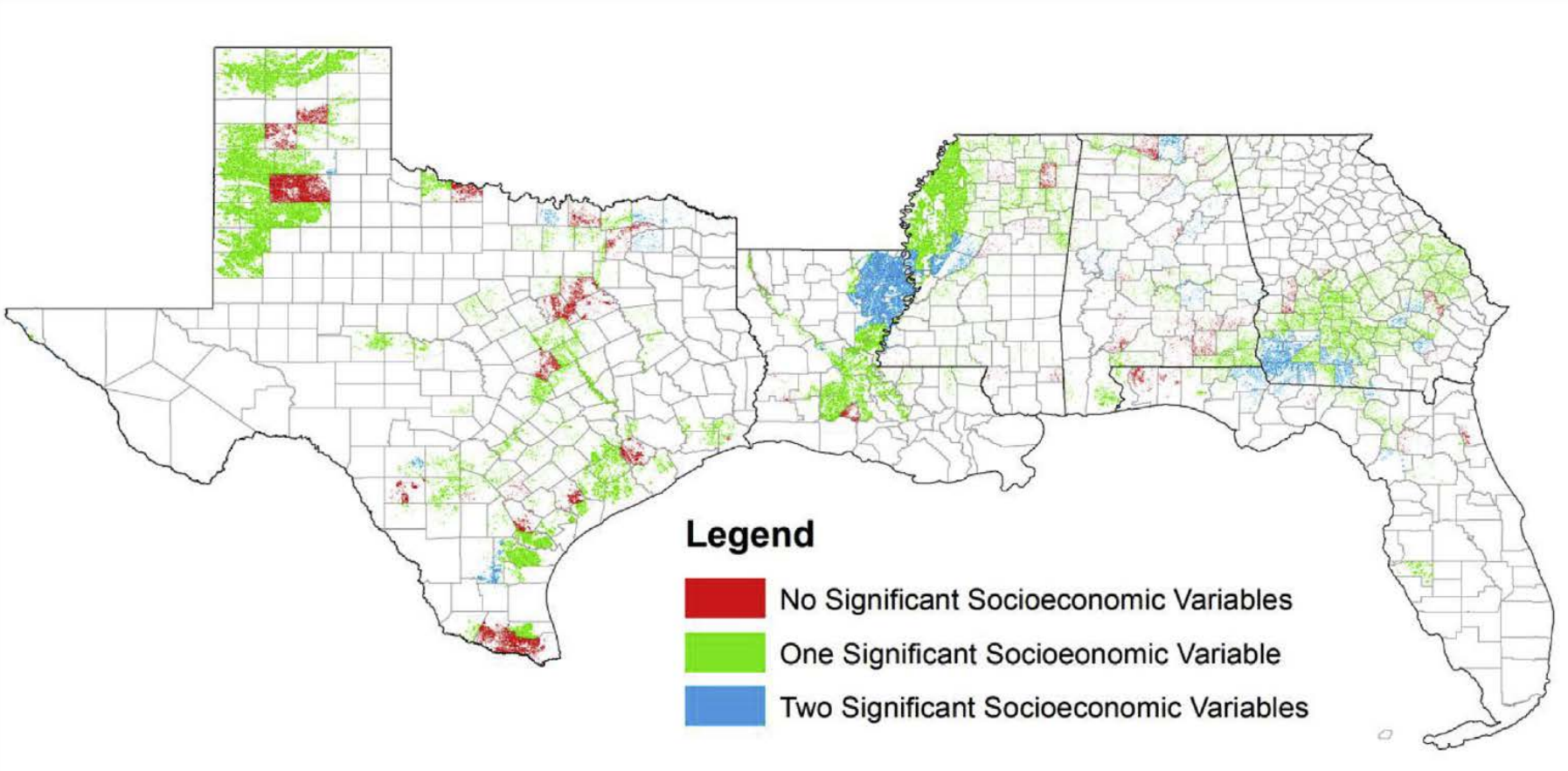
BPT model was significantly different from both observed corn yield and the prediction of the SET model

Estimated regression coefficients of the SET model with those of the BPT model using a t-test.

- 86 percent of topography types,
- 66 percent of climate types and
- 58 percent of soil types

89% of the SETs, socioeconomic types, were significant

Pattern of socioeconomic determinants



$$\mathrm{Y_j} = F\left(C_{jc}, S_{js}, T_{jt}, SE_{je} * V_{le}\right) \quad j \in c, s, t, e$$

Variable	Single variable	Single Variable in combination with a second Variable							
		FSp	FInt	TFP	Edu	PDen	HIn	Rlength	Total
FSize	1004	21	38	78	54	41	1	0	1237
FSp	94		0	0	0	0	0	0	94
FInt	62			0	24	0	21	0	107
TFP	750				28	0	53	0	831
Edu	845					0	45	11	901
PDen	169						1	0	170
HIn	590							0	590
Rlength	124								
Total	3638								3930

FSize: Farm size; FSp: Farm Specialization; FInt: Farming Intensity; TFP: Total Factor Productivity; Edu: Education; PDen: Population Density; HIn: Household median Income; Rlength: Road Length. Total number of SETs = 4429. Unemployment is not significantly determining the corn yield in any of the socioeconomic typology, so not included in Table-6.

How robust is SE control on regional corn yield variation?

$$Y_j = F(C_{jc}, S_{js} * V_{ls}, T_{jt}, SE_{je}) \quad j \in c, s, t, e$$

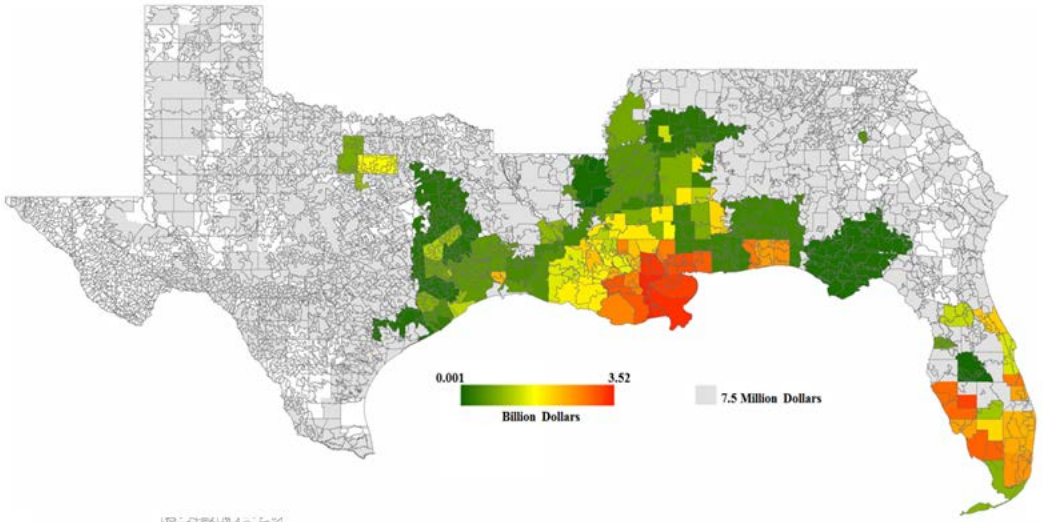
$$Y_j = F(C_{jc}, S_{js}, T_{jt} * V_{lt}, SE_{je}) \quad j \in c, s, t, e$$

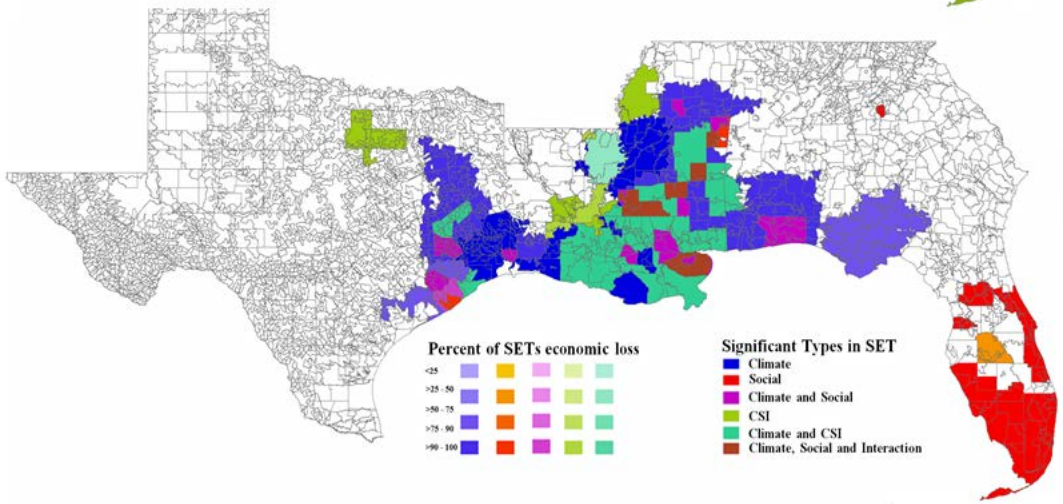
$$Y_j = F(C_{jc}, S_{js}, T_{jt}, SE_{je} * V_{le}) \quad j \in c, s, t, e$$

$$Y_j = F(C_{jc}, S_{js} * V_{ls}, T_{jt} * V_{lt}, SE_{je}) \quad j \in c, s, t, e$$

The predictive skill of other alternative SET “interaction” models for soil typology or/and topographic typology was noticeably reduced whenever, and only when, the socioeconomic typology was not included in the model

Application 2:
Economic losses from extreme events





On going work

A general socioecological typology – US and Global – with Ben

Urban Typology for US – with Tony

Human Agent Types – with Melissa and team

Conclusion

_Landscape typologies are useful for identifying local (finer-scale) similarity and preserve the intrinsic heterogeneity

_Landscape typologies are useful for predicting agricultural outcomes at local to regional scales and attributing those outcomes to underlying biophysical and socioeconomic determinants

_Ignoring socioeconomic drivers in analysis will lead to misattribution of sources of crop yield variability.

_Conventional use of agro-ecological zones/county based impact assessment may be biased

Thanks