Using Landscape Typologies to Model Socioecological Systems

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Using landscape typologies to model socioecological systems: Application to agriculture of the United States Gulf Coast.
Submitted to Environmental Modeling and Software

U.S. DEPARTMENT OF ENERGY
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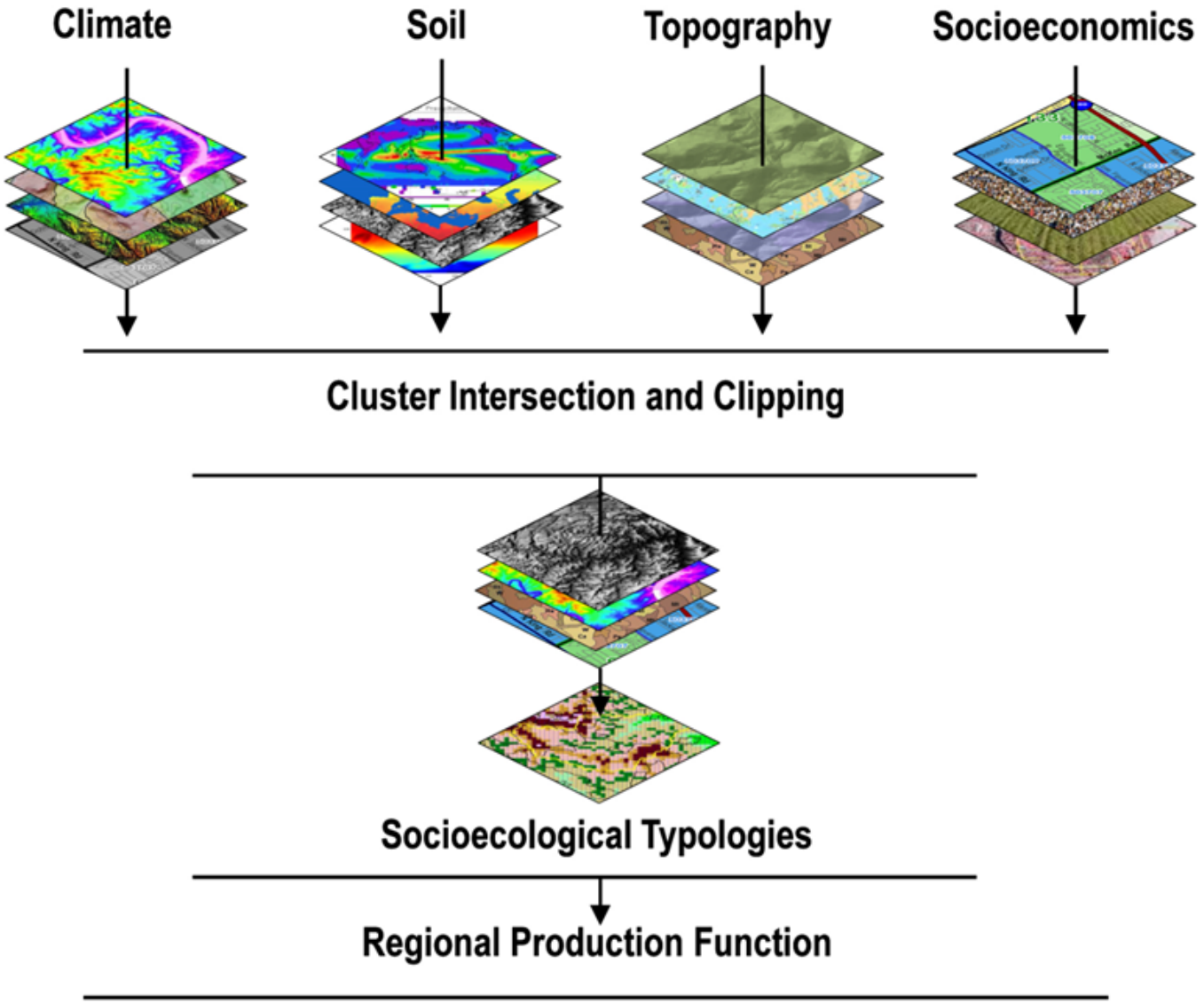
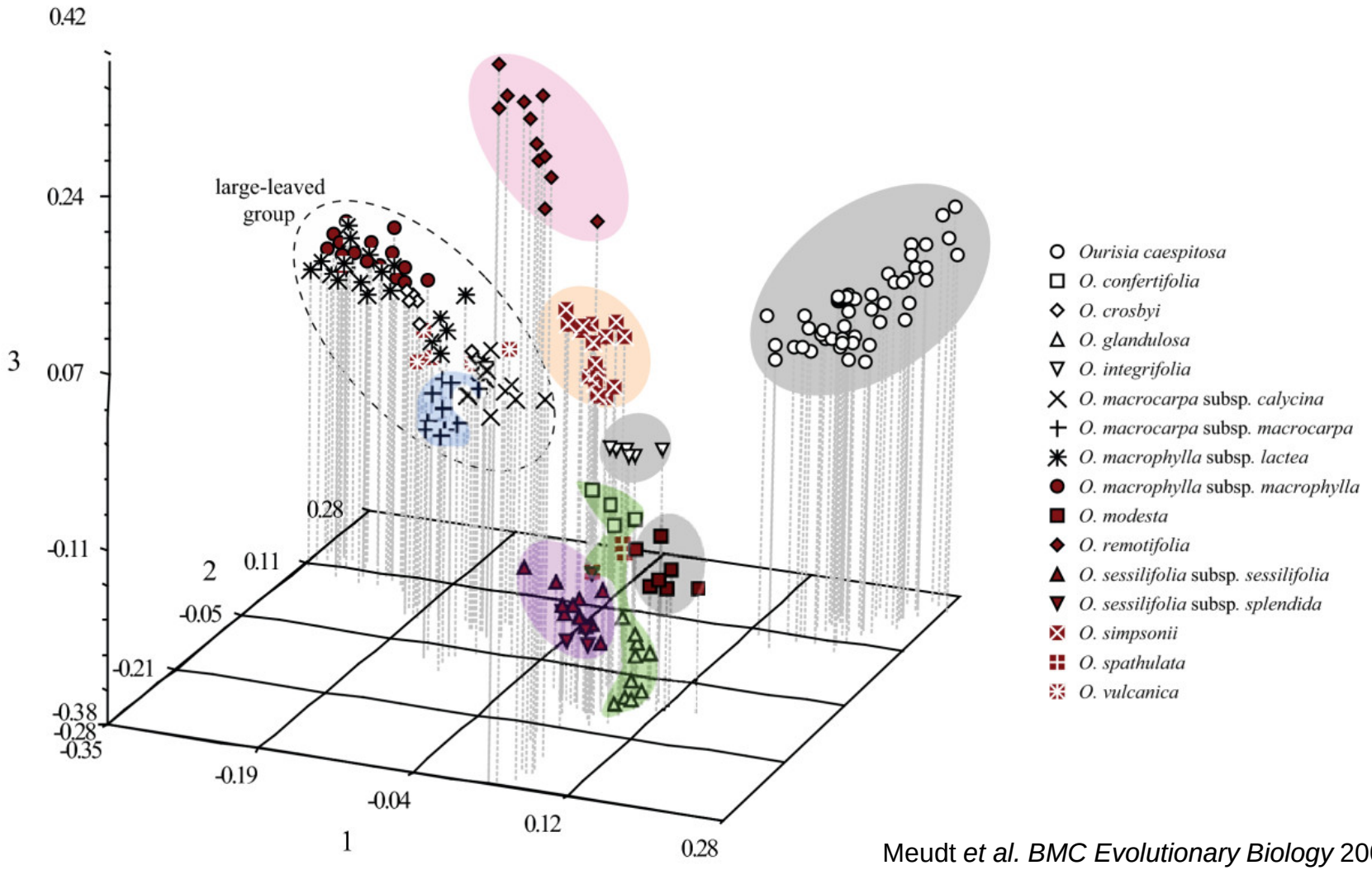
Hierarchical clustering to create typologies



Clustering to create typologies



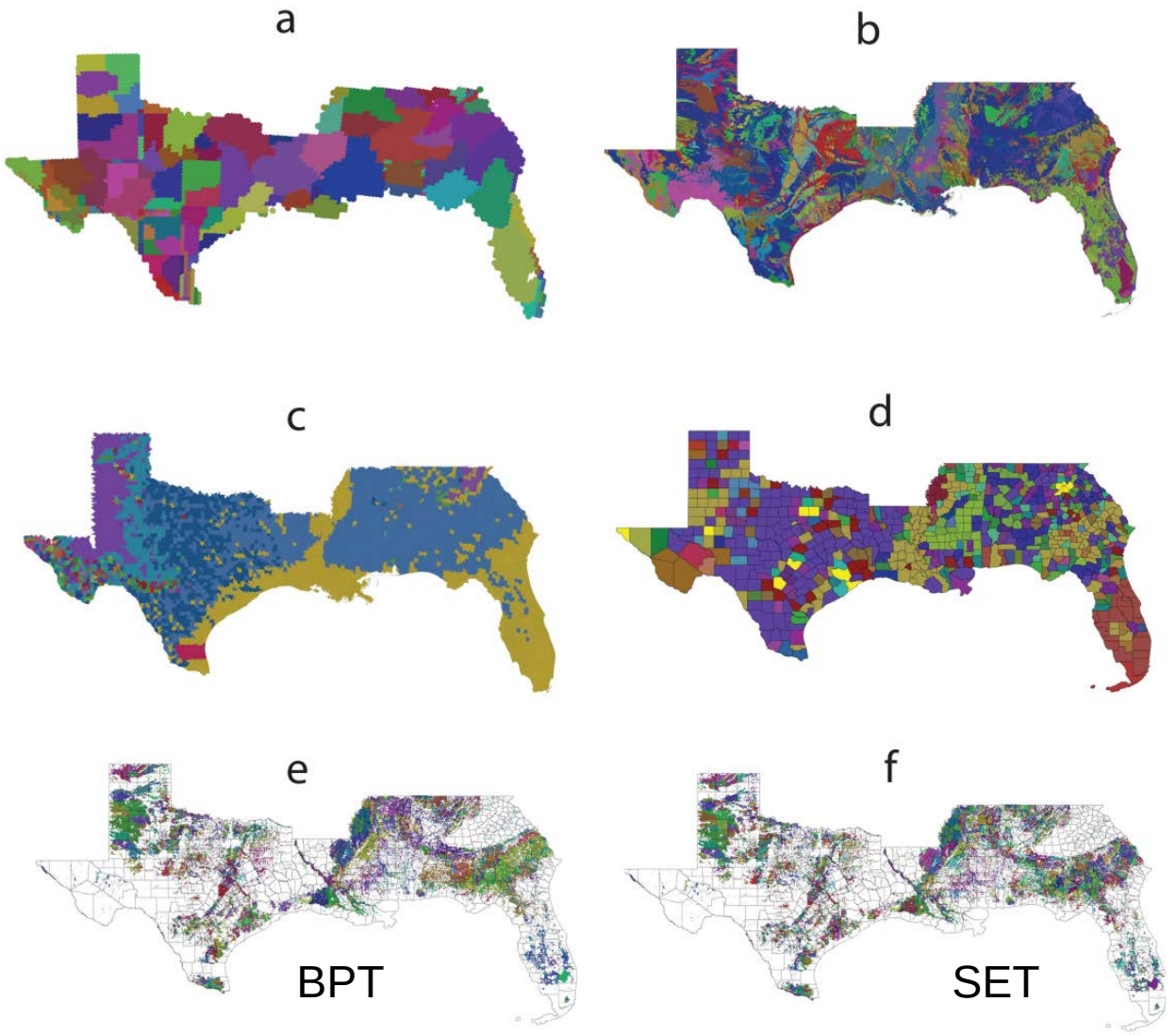
Meudt *et al. BMC Evolutionary Biology* 2009 **9**:111 doi:10.1186/1471-2148-9-111

Input variables for clustering

Variables	Time Span	Data Source
Climate (30 years monthly, growing-season and annual mean and standard deviations at 18 km^2 grid)	1981-2010	DayMet
Soil (Components in map unit key)		STATSGO
Topography (Average and standard deviation HUC-12 watersheds)		NED, USGS

Socioeconomic Variables (County)		
Size of farm holding	1982-2007	Agriculture Census, USDA
Farm production intensity	1986-2010	NASS-USDA and US BEA
Farm specialization	1986-2010	NASS-USDA and US BEA
Total factor productivity	1986-2010	InSTePP Database
Population and population density	1986-2010	US Census Bureau
Road connectivity	1990-2010	US Census Bureau
Household income	1986-2010	US Census Bureau, American Community Survey
Unemployment	1986-2010	US Census Bureau
Education	1986-2010	US Census Bureau

Mapped typologies

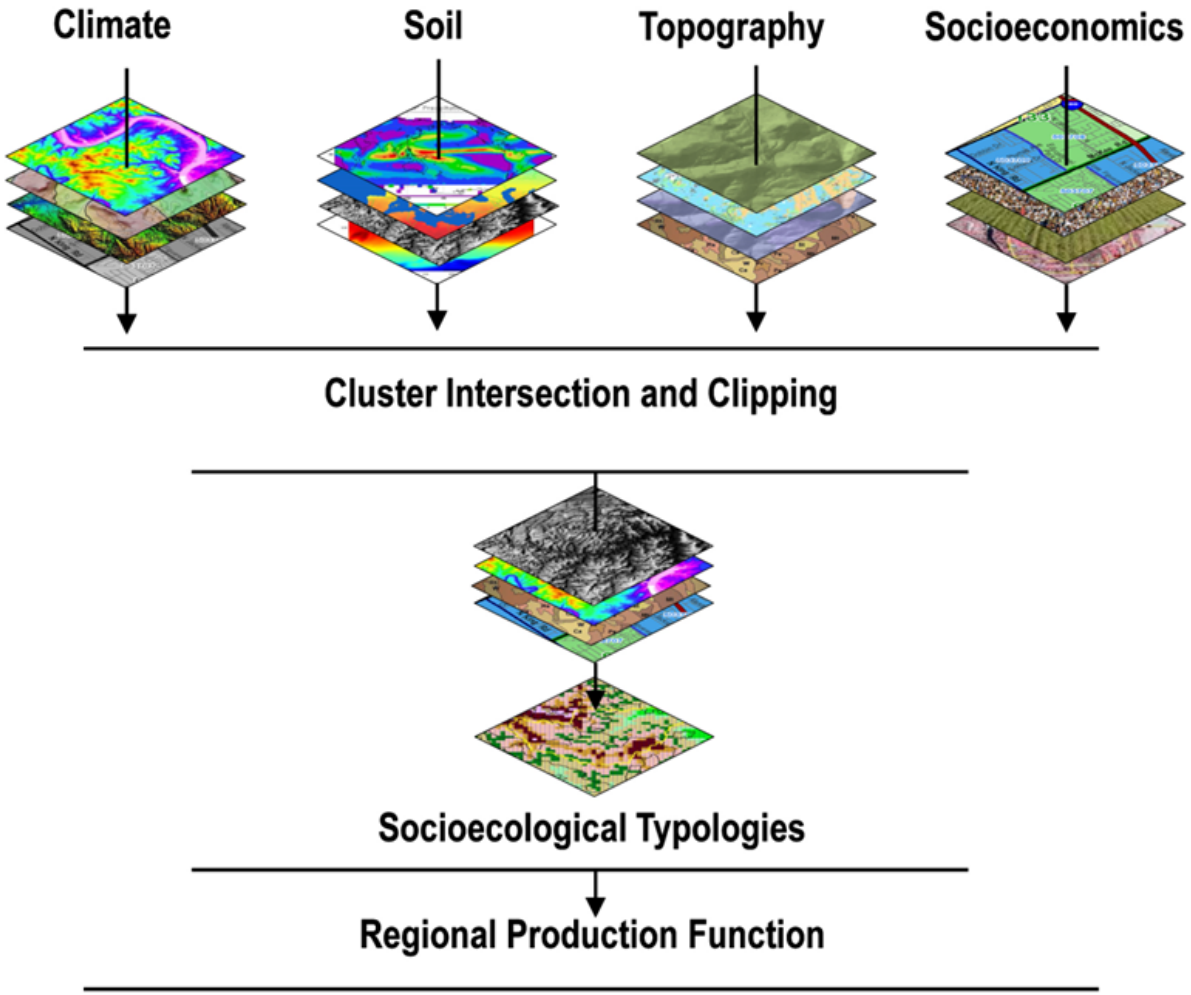


Typologies

a. **Climate**
b. **Soil**
c. **Topography**
d. **Socioeconomic**
e. **Bio-Physical (BPT)**
f. **Socio-Ecological (SET)**

2,410 unique BPT types
4,429 unique SET types

Regression modeling with types as predictor variables



$Y_{corn} = F_{linear}(types)$

BPT model

SET model

Results from BPT and SET models for corn yield

Property	BPT	SET
Adjusted R^2	0.72	0.89
Share of typologies[†] (%)		
Climate	55	38
Soil	33	17
Topography	12	8
Socioeconomic		37
Number of types dropped from BPT and new types added to SET		
Climate	6	18
Soil	4	3
Topography	3	1
Socioeconomic		37
Friedman's Two-way Analysis of Variance[‡]		
Observed Corn Yield	19.92	0.05
BPT vs. SET	13.92	
Partial F test[†††]	114.44	

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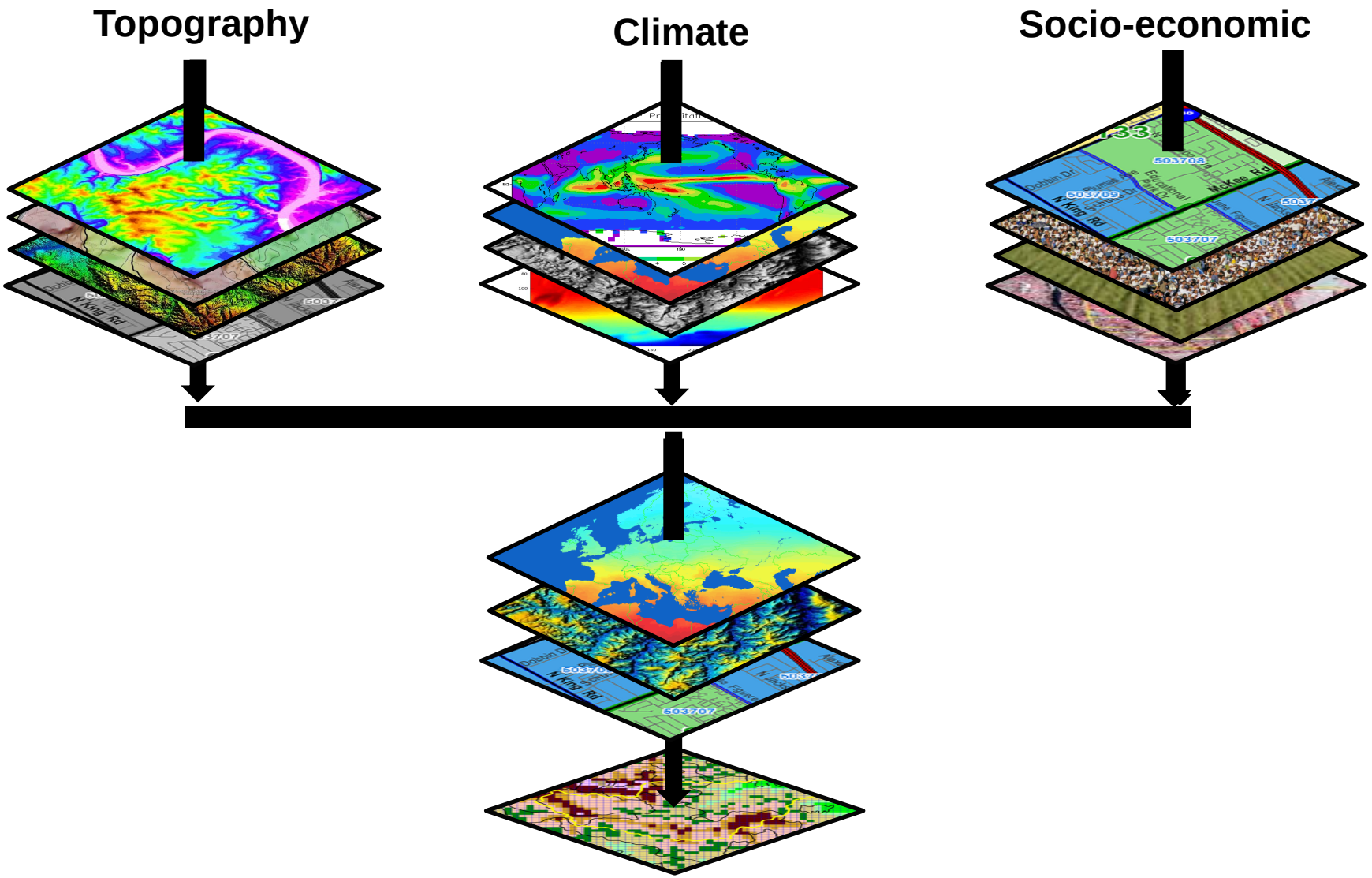
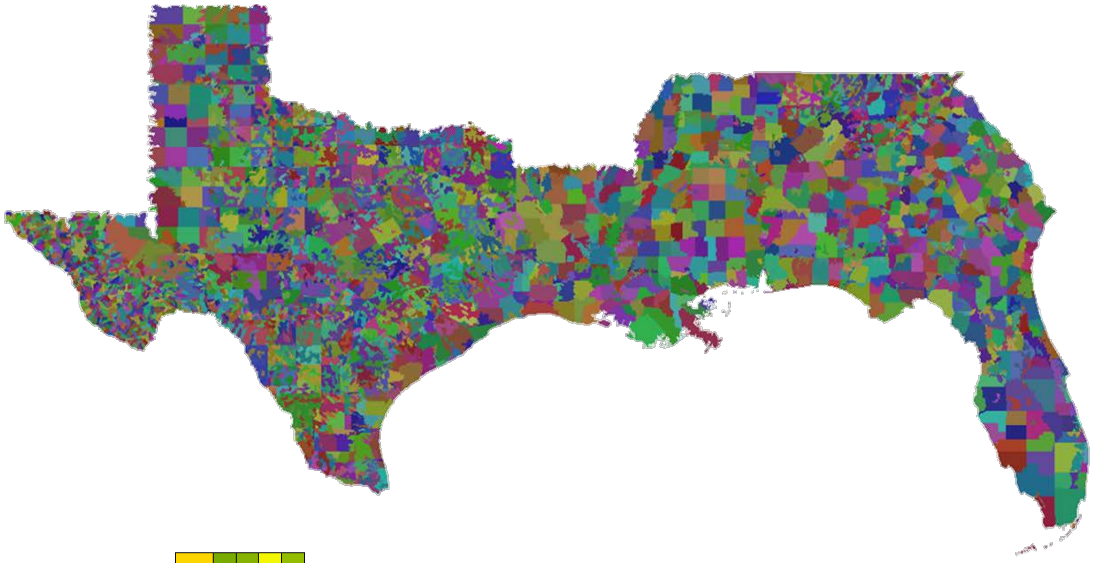
Including socioeconomic variables explained more of the regional spatial variation in 25-year mean corn yields

Social Vulnerability: loss to climate hazards

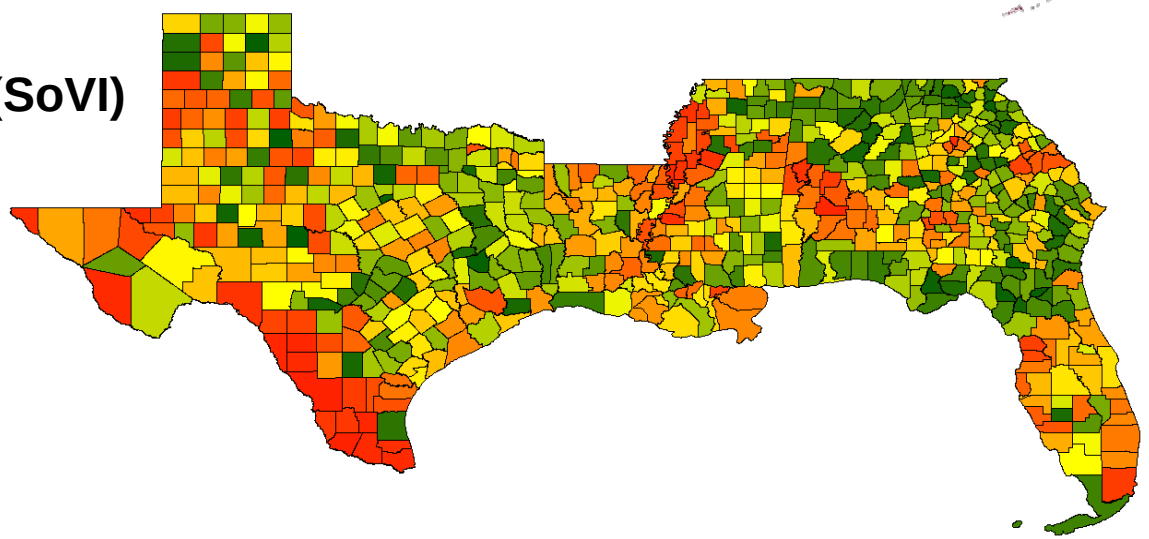


Social Vulnerability

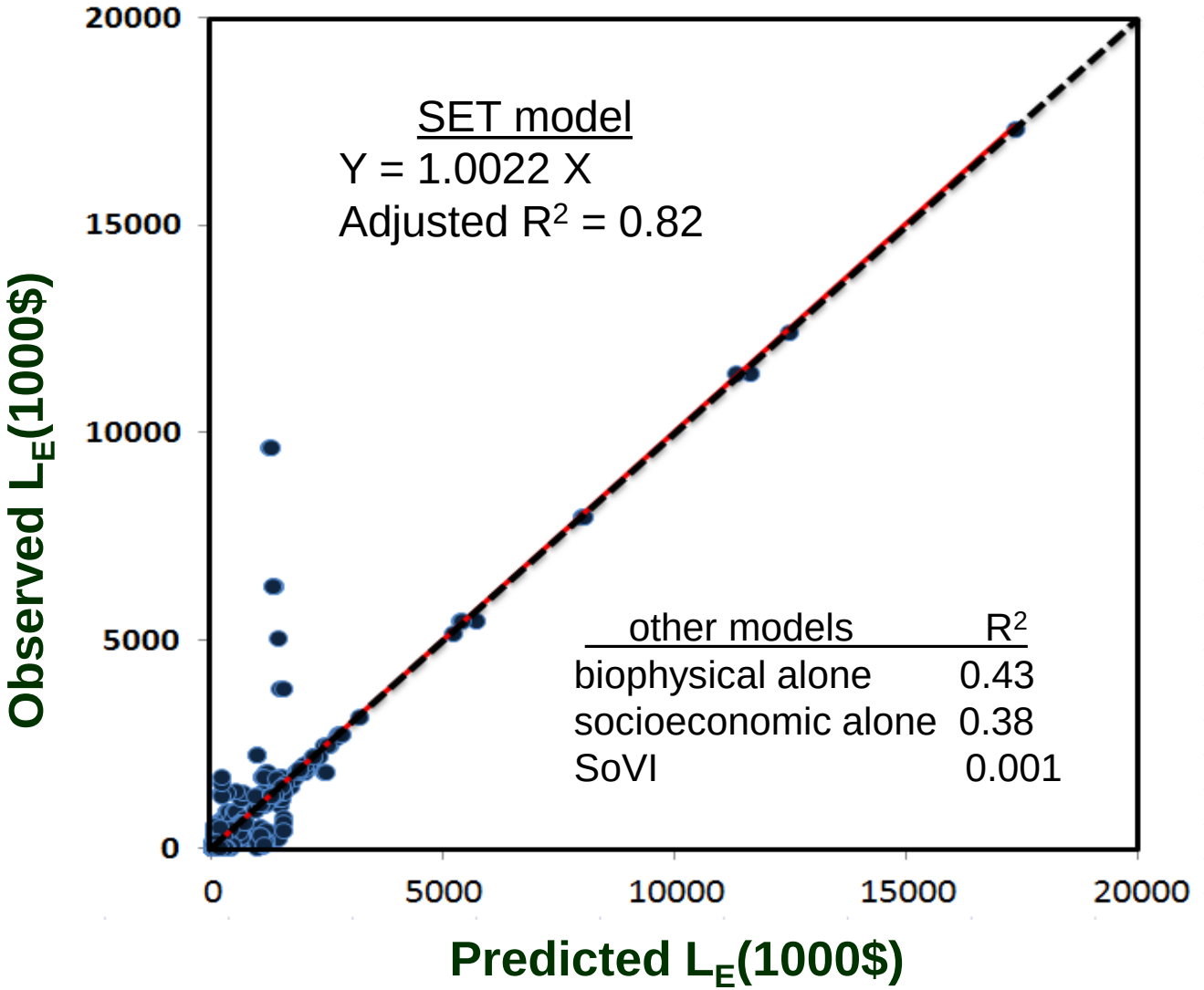
Socioecological Typology



Social Vulnerability Index (SoVI)



Predicting economic loss from climate hazards (L_E)



So…

So... typologies and CESM

1. **Attribution might inform choice of variables for:**
   a. **Scenarios of future socioeconomic forcings**
   b. **Endogenous variables in CESM >2**

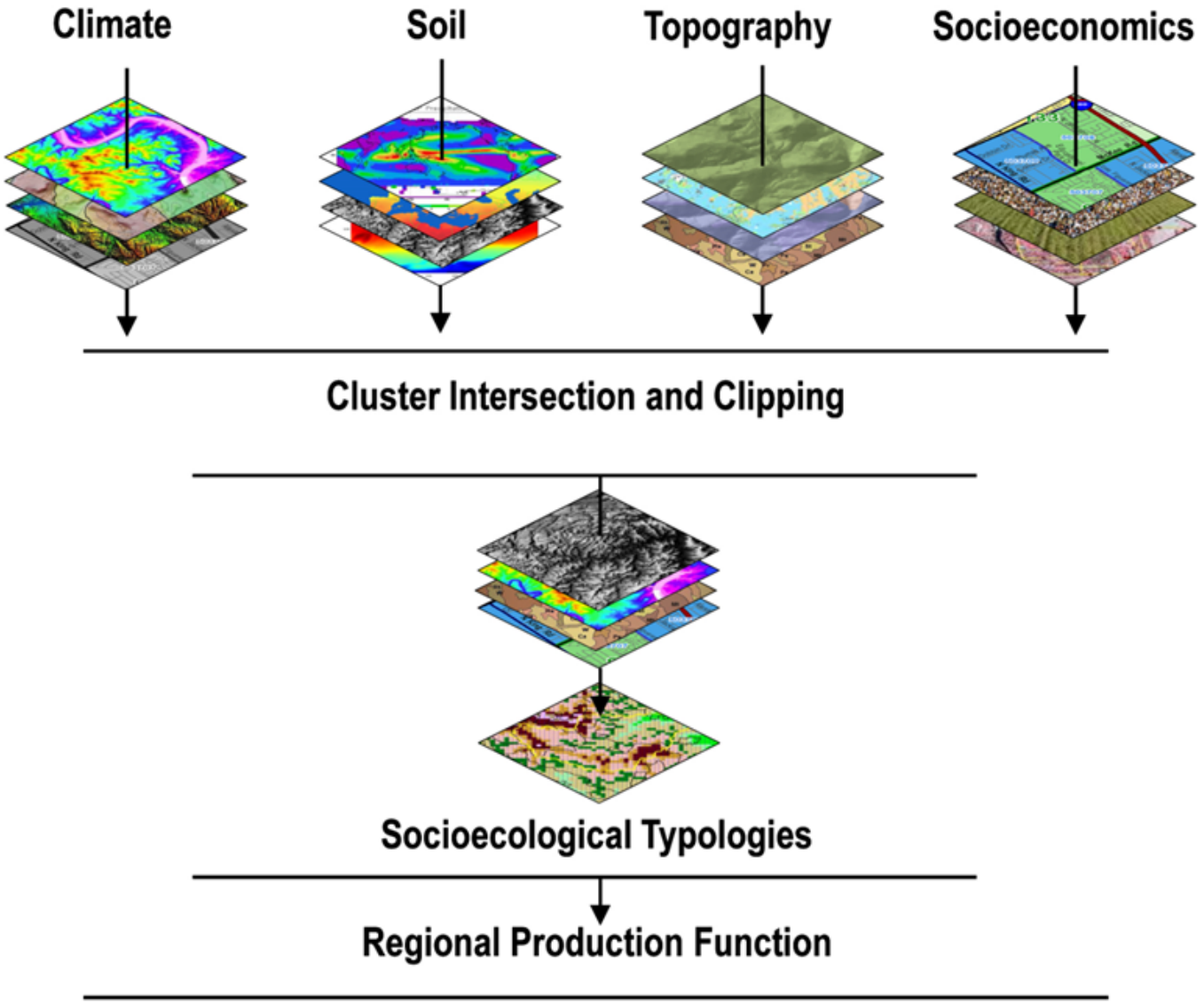
2. **Post processing of CESM projections:**
   a. **Typological differences**
      --- how does a future typology compare with the historic BPT straightforward, but future SET will be constrained by projection of socioeconomic variables
   b. **Use future typology with the historical empirical model to project future values for the target variable**
   c. **Evaluate functional responses --- does the relationship between target variable and typology in the future match the historical**

3. **Use types within CESM --- analogous to plant functional types**

Relevance to SDWG

- Fostering dialogue ✔
- Needs for CESM development (CESM >2)
  - expanded socioeconomic scenarios
  - endogenous socioeconomic variables
- Relevant CESM simulations (if used in post-processing/analysis of results):
  - those with projected agricultural yields
  - any with future extreme events/hazards
- New CESM linkage code ?

Hierarchical clustering to create typologies



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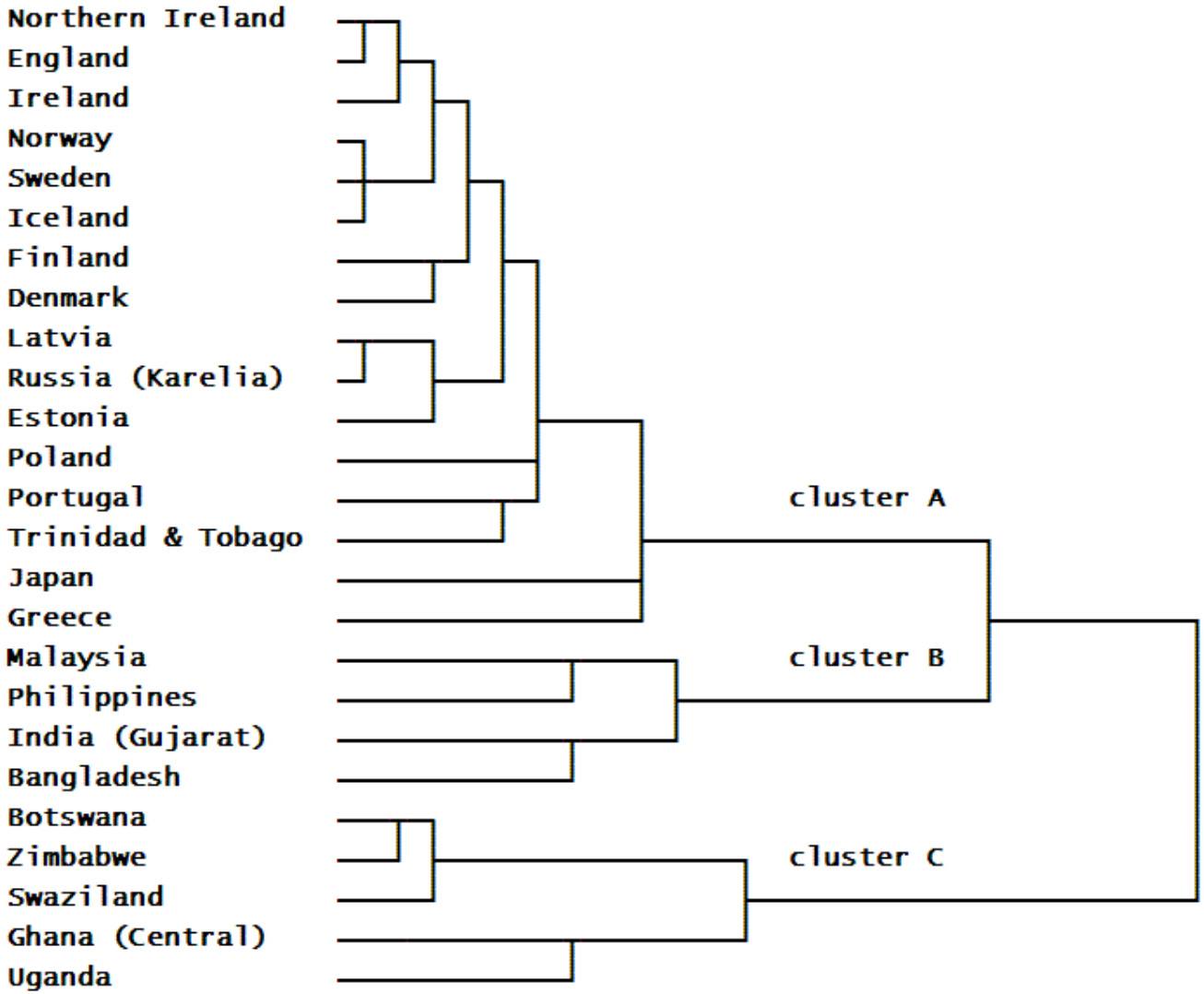
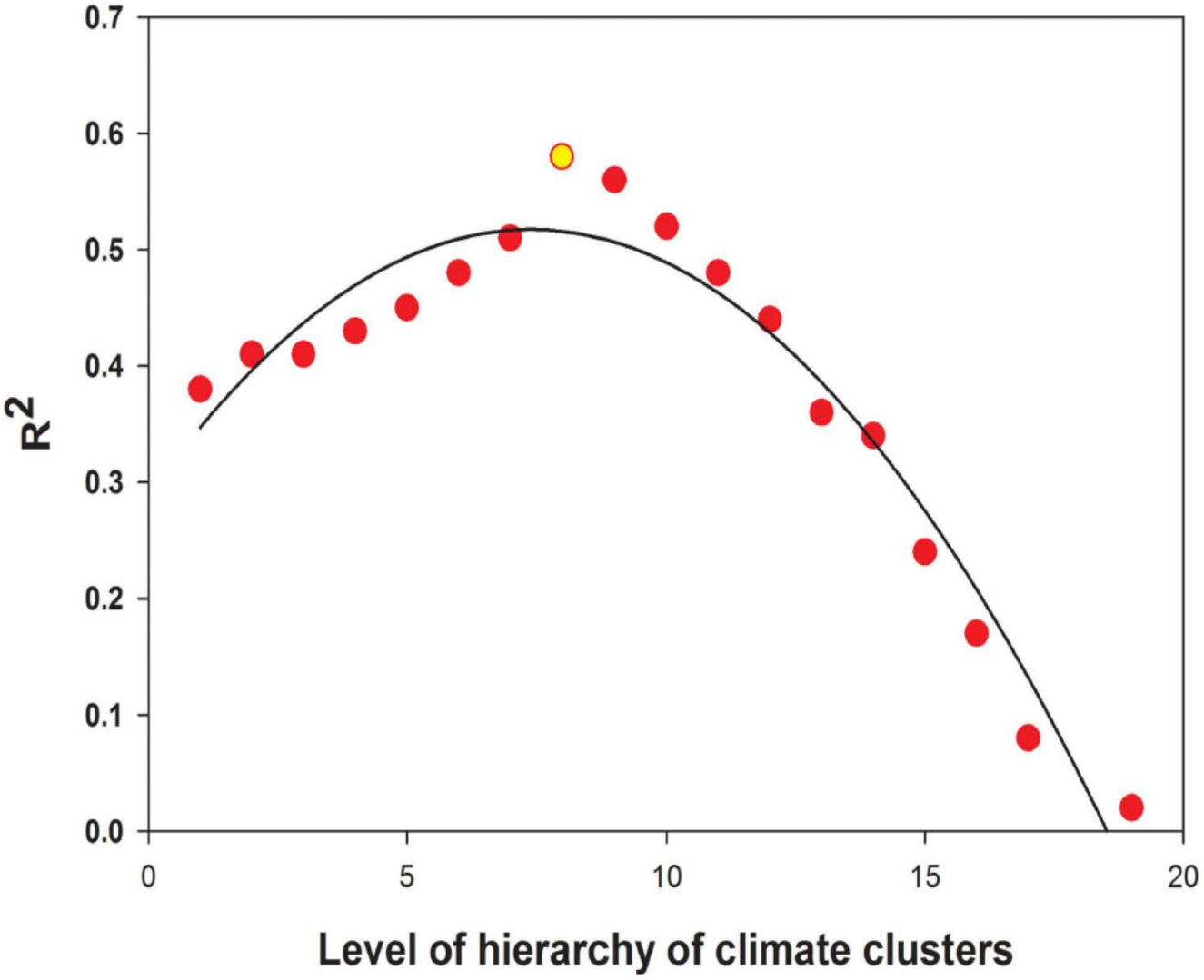


http://www.ied.edu.hk/apfslt/v6_issue2/foreword/foreword4.htm

Selecting the typology (level of clustering)



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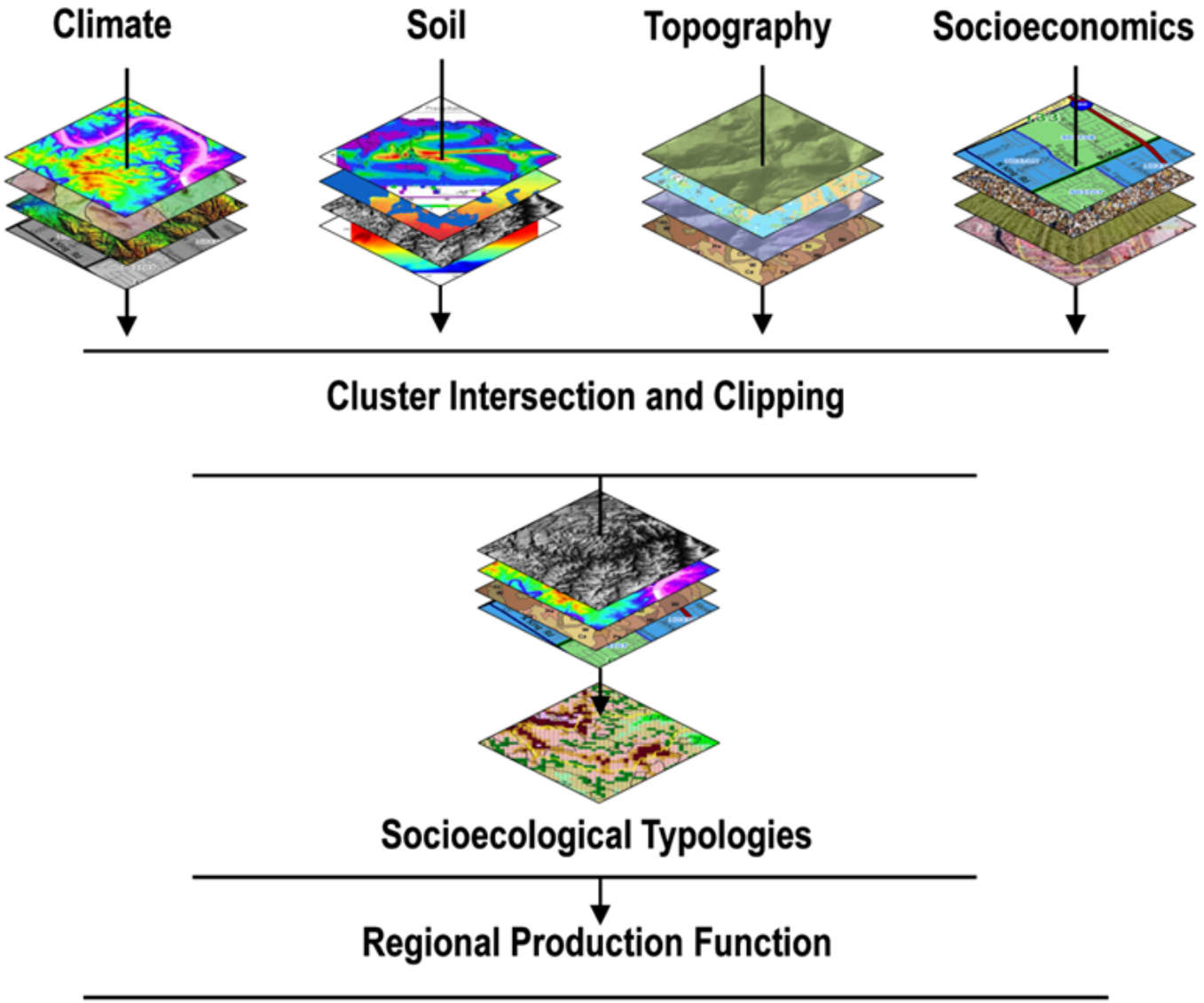
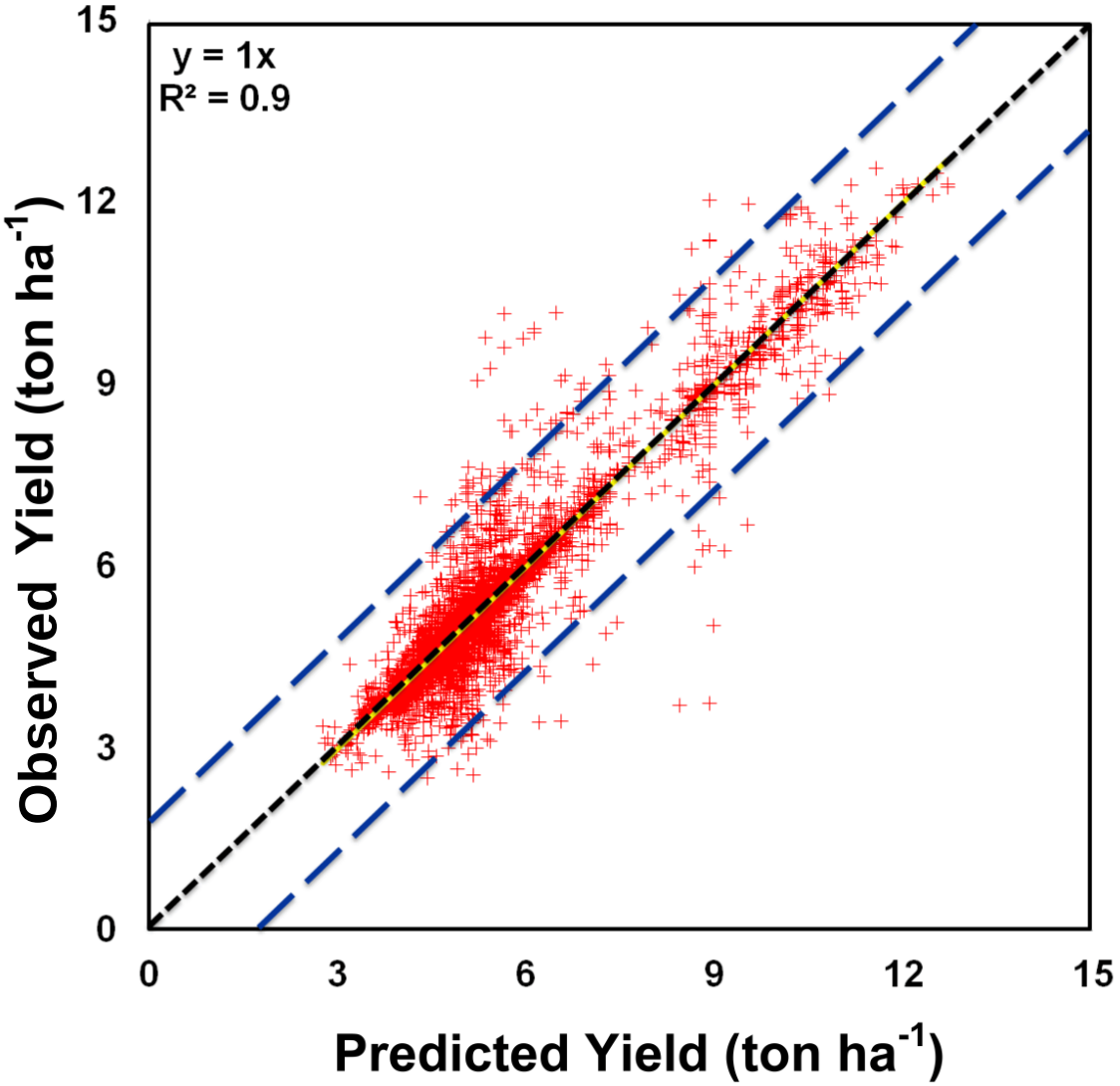
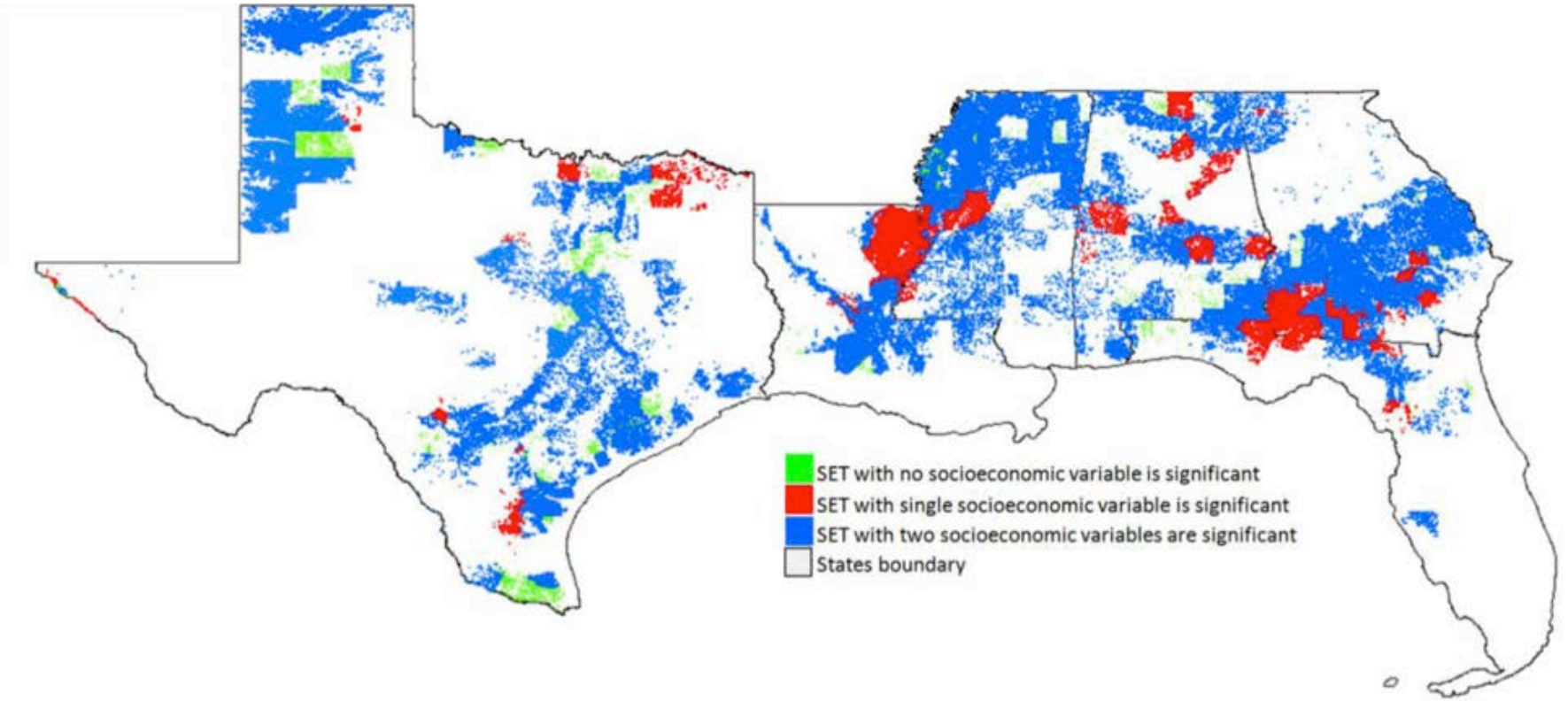


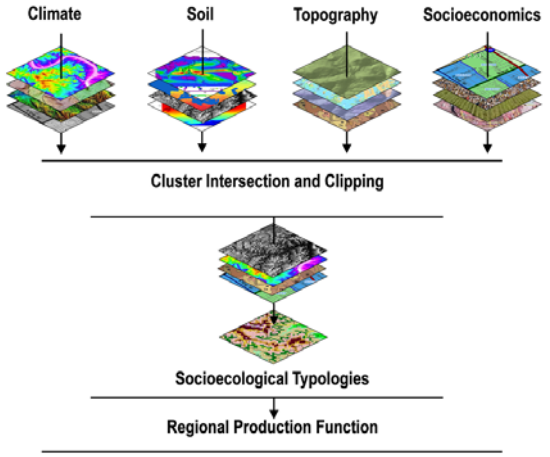
Predicted versus observed corn yield



Significant socioeconomic variables



Significant socioeconomic variables

Variable	Single variable	Single Variable in Combination with a Second Variable							Total
		FSp	FInt	TFP	Edu	PopDen	PerIn	RdDen	
FSize	1,004	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	3,638								3,930

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.