Mapping Potato Productivity over the U.S. Eastern Seaboard using a Geospatial Crop Model

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USDA ARS

USDA-ARS, Crop Systems and Global Change Lab, Beltsville, Maryland

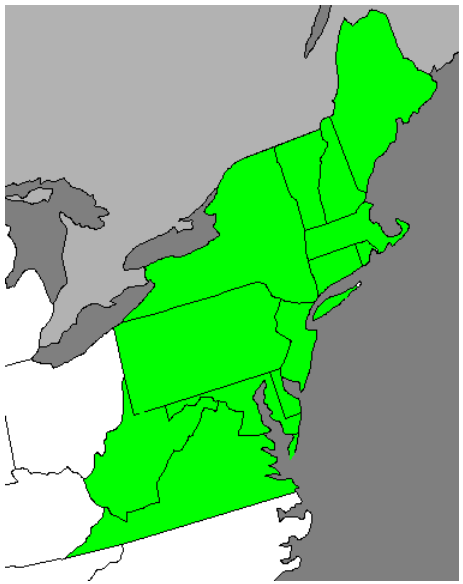
Applying Systems Theory To Complex Agricultural Problems

Topics of Discussion

1. Geospatial Crop Model Interface
   - Overview of Methods
2. Regional Crop Production Capacity
   - Water-limited and Non-limited Conditions
   - Current and Potential Land Use Scenarios
   - Biophysical Conditions (Climate, Soil)
   - Resource Requirements (Water, Nitrogen)
3. Possible Future Directions
   - Multiple Crop Yield Index (Potato, Corn, Wheat)
   - Climate Change Scenarios

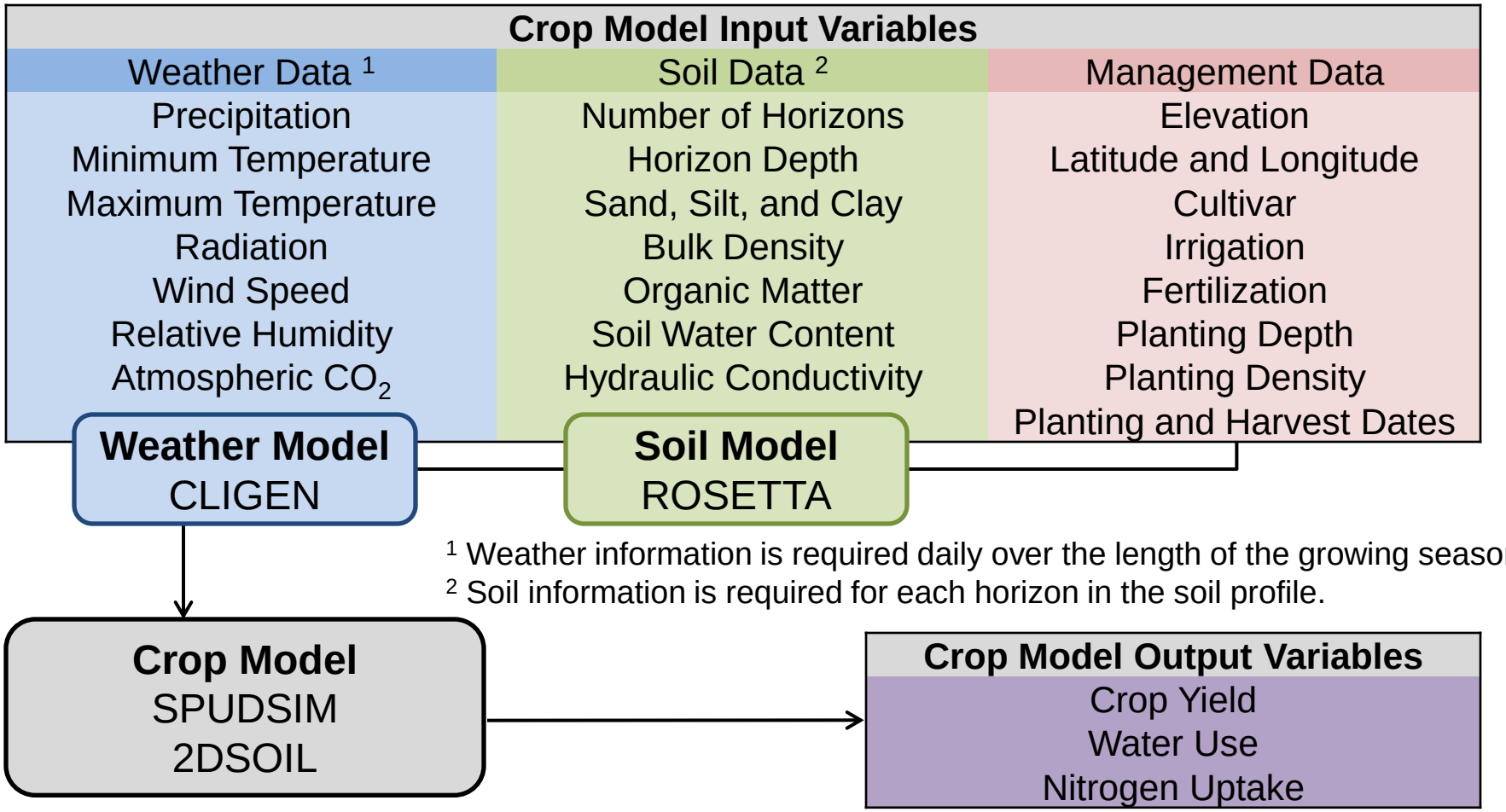
Interface Overview

1. Develop a Geospatial Crop Modeling tool for simulating crop production at a regional scale
2. Analyze the Potential Production Capacity (PPC) of the U.S. Eastern Seaboard Region (ESR)
   - Evaluate the current production
     - Compare with observed trends
   - Estimate potential production under various scenarios:
     - Different Management Practices
     - Limiting vs. Non-limiting Resources
     - Land Use Change
     - Climate Change



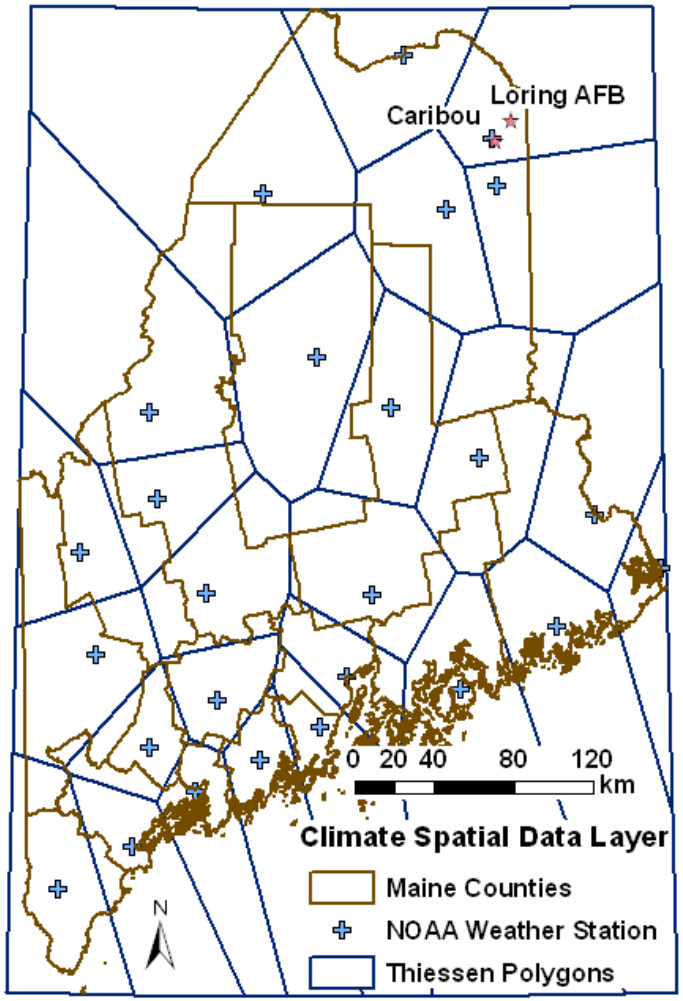
Crop Model Inputs and Outputs

- Explanatory, Process-based Crop Models



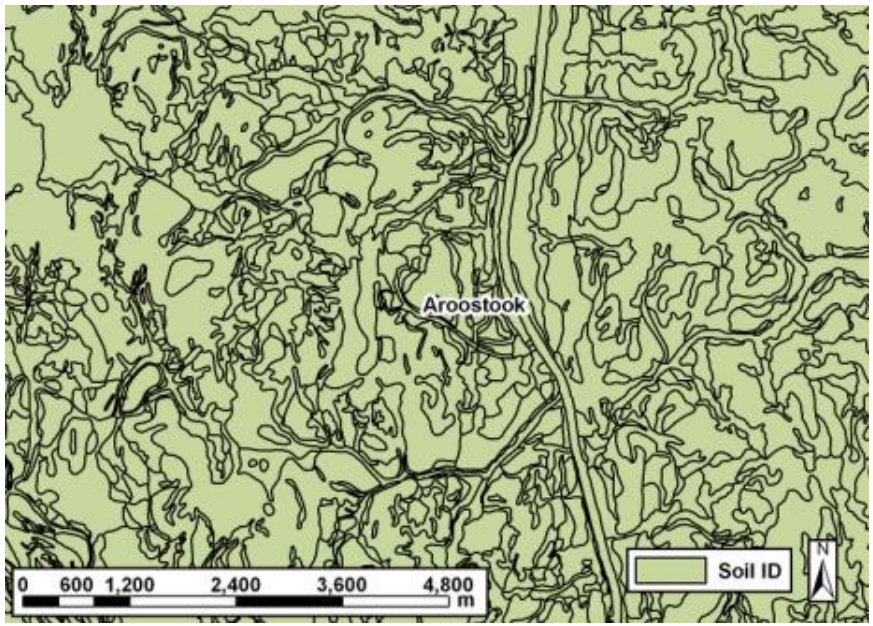
Weather Data

- National Climatic Data Center (NCDC) weather stations from NOAA
- At least 1 per county
- 30 years of daily data is simulated with CLIGEN
- Interpolated spatially with Thiessen Polygons
- Stored by Climate ID



Soil Data

- SSURGO soil profile texture properties
- Dominant soil component used for each map unit
- Data for each horizon
- Hydraulic properties estimated with ROSETTA
- Stored by Soil Map Unit Key

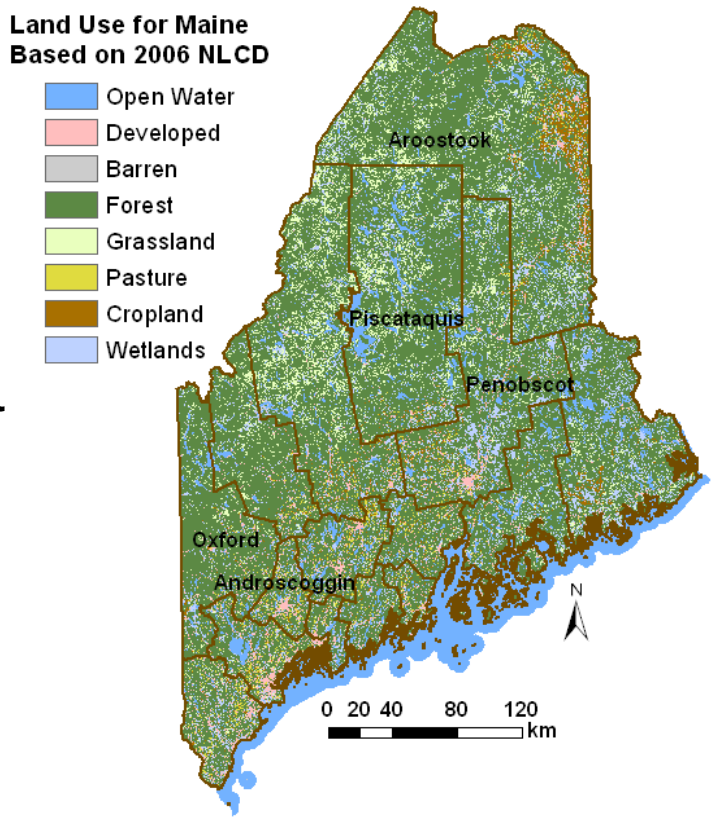


Management Data

- Averaged and stored at the county level
- 30-m NED used for elevation
- Planting and harvest dates, percent irrigated area, and observed yield from NASS
- All other management parameters constant
  - Cultivar (Kennebec)
  - Fertilization (Non-limiting)
  - Plant Density (6.9 pl/m^2)
  - Plant Depth (5 cm)

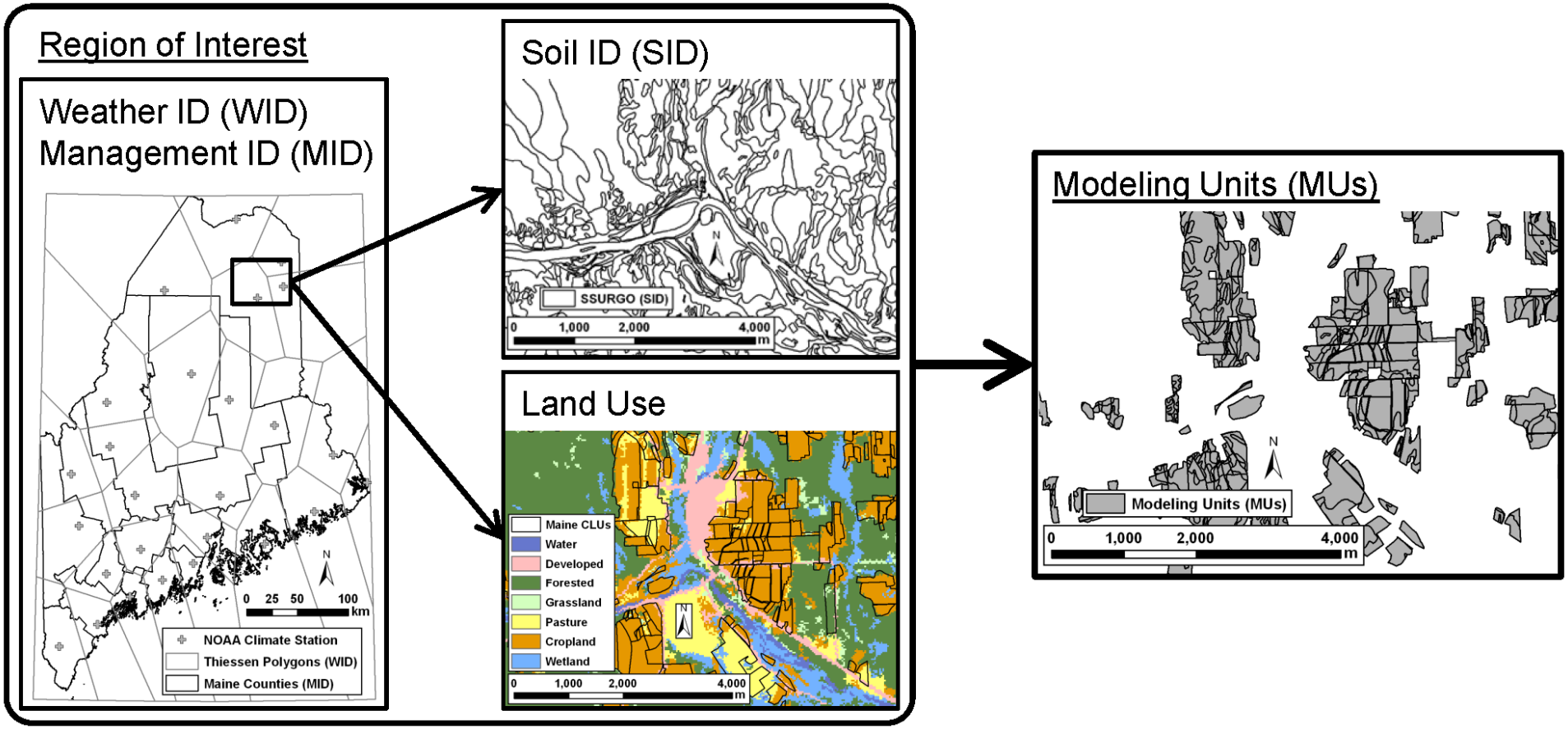
Land Use Data

- Common Land Unit (CLU) data to define field areas
- 30-m 2006 National Land Cover Database (NLCD)
- 30-m 2010 Cropland Data Layer (CDL)
- Combined raster and vector datasets; Used to identify areas to simulate



Field-scale Modeling Units

- Independent, Homogeneous Modeling Units



Potential Production Scenarios

Land Use Classifications

Current Production

1) Potato Cropland

Potential Production

2) All Cropland

More Potential Production

3) Pasture

4) Grassland / Scrub

Not Considered for Production

5) Forested

6) Developed / Barren

Off Limits to Production

7) Open Water / Wetlands

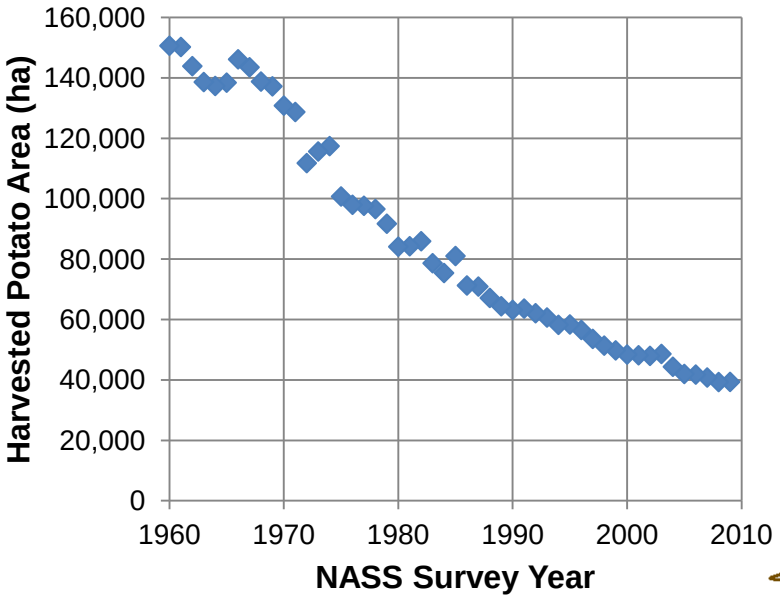
Decreasing Productivity?

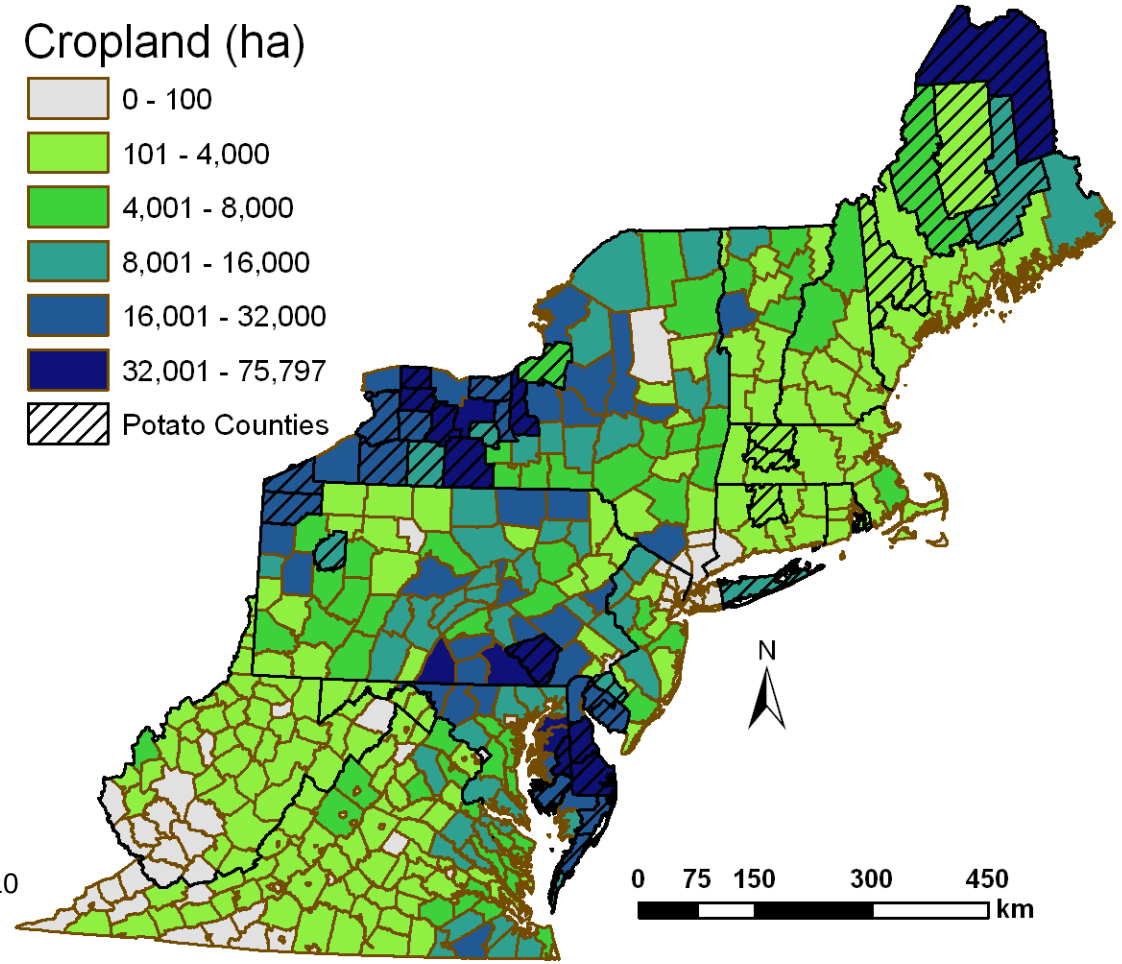
Increasing Conversion Likelihood?

If we were to increase production
How much land is available?
Where is the potential yield greatest?
What is the potential production range?
What are the resource requirements?
What are the biophysical constraints?

Study Area

- Loss of local production due to the loss of the agricultural land
- Food will need to be imported or produced locally to support the growing population





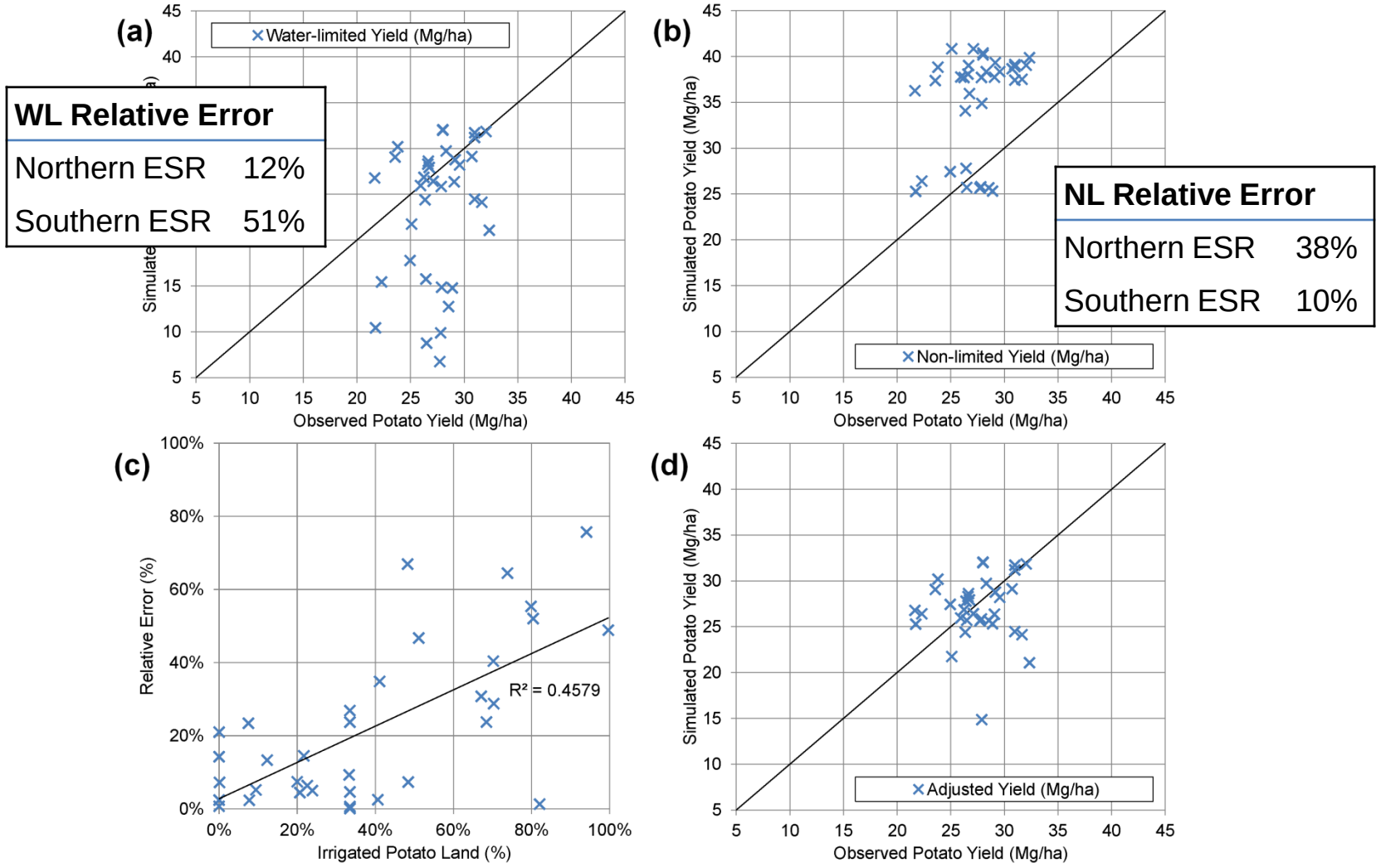
Current Land Use - Potato

(Simulated Over Potato Cropland)

	Observed (NASS)			Simulated (SPUDSIM)			
	Irrigated Area	Yield (Mg ha^{-1})		WL (Mg ha^{-1})		NL (Mg ha^{-1})	
State	(%)	Ave.	Std.	Ave.	Std.	Ave.	Std.
Northern ESR / Fall Growing Season							
Maine	12%	30.40	2.56	28.81	1.54	38.76	1.29
Massachusetts	20%	28.89	3.18	26.06	1.38	37.72	0.60
Rhode Island	21%	28.08	3.79	27.93	0.81	35.96	0.59
New York	33%	30.97	2.20	27.76	1.49	38.09	0.51
Pennsylvania	22%	26.98	3.42	27.61	2.19	38.78	0.75
Southern ESR / Summer Growing Season							
New Jersey	74%	27.80	2.98	7.62	1.46	25.66	0.47
Maryland	67%	26.59	6.49	15.11	1.78	25.86	0.73
Delaware	70%	26.42	4.08	17.45	1.24	27.49	0.68
Virginia	53%	23.29	3.96	11.21	3.22	25.41	0.60

Current Land Use - Potato

(County-level Averages)

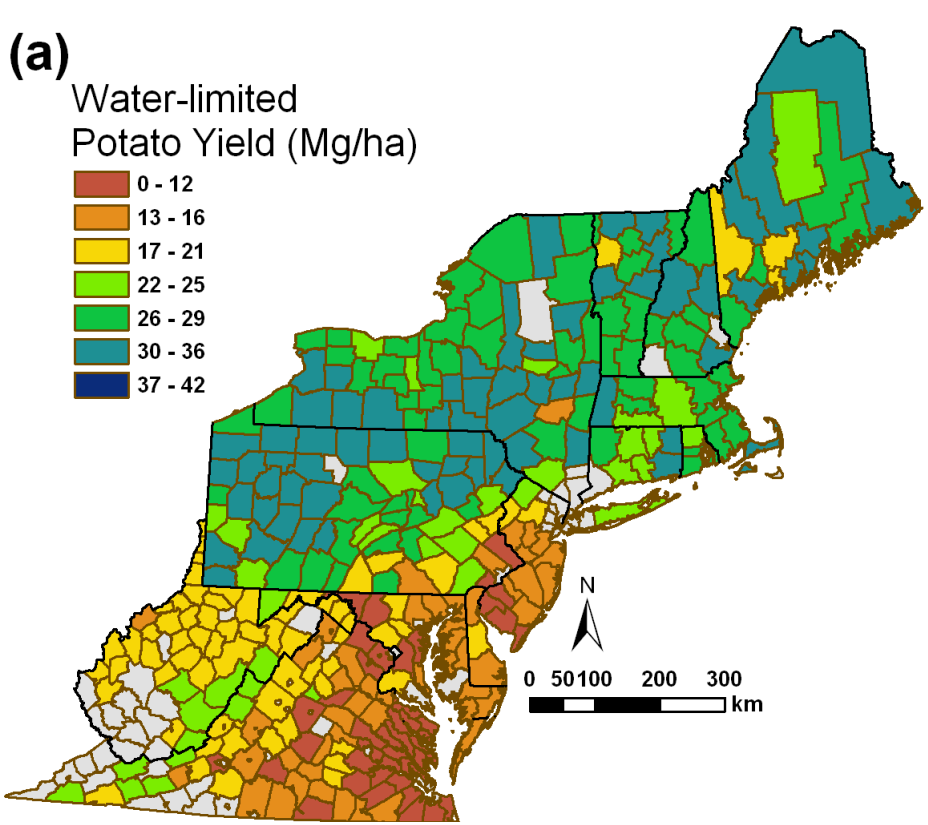


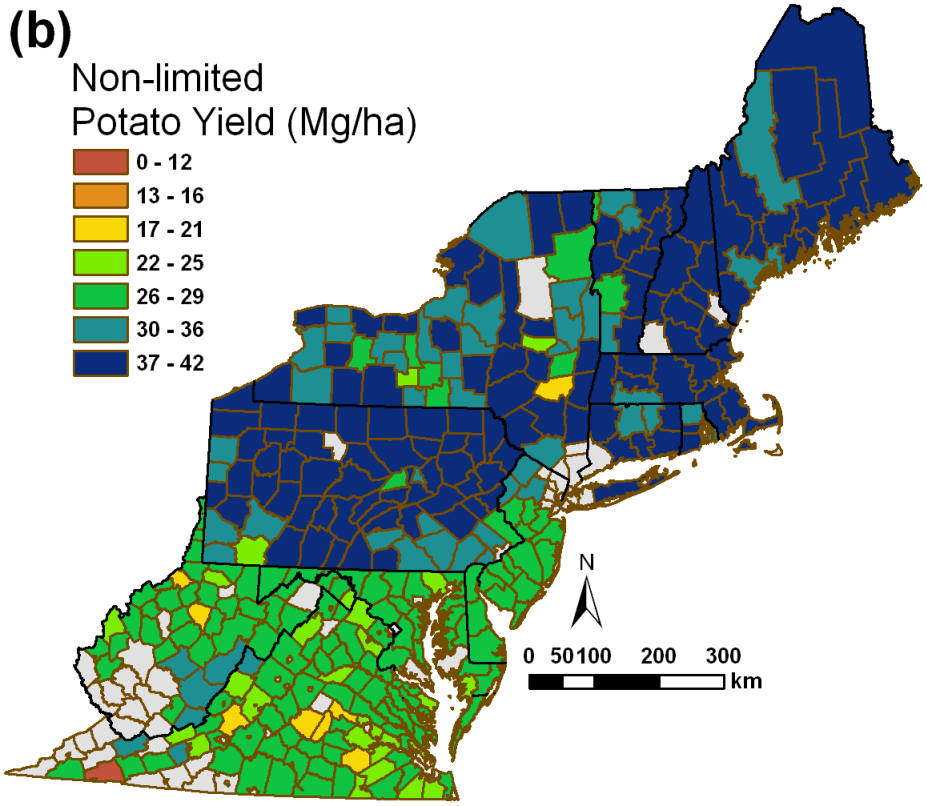
WL Relative Error	
Northern ESR	12%
Southern ESR	51%

NL Relative Error	
Northern ESR	38%
Southern ESR	10%

Potential Land Use - Cropland

(Simulated Over All Cropland)





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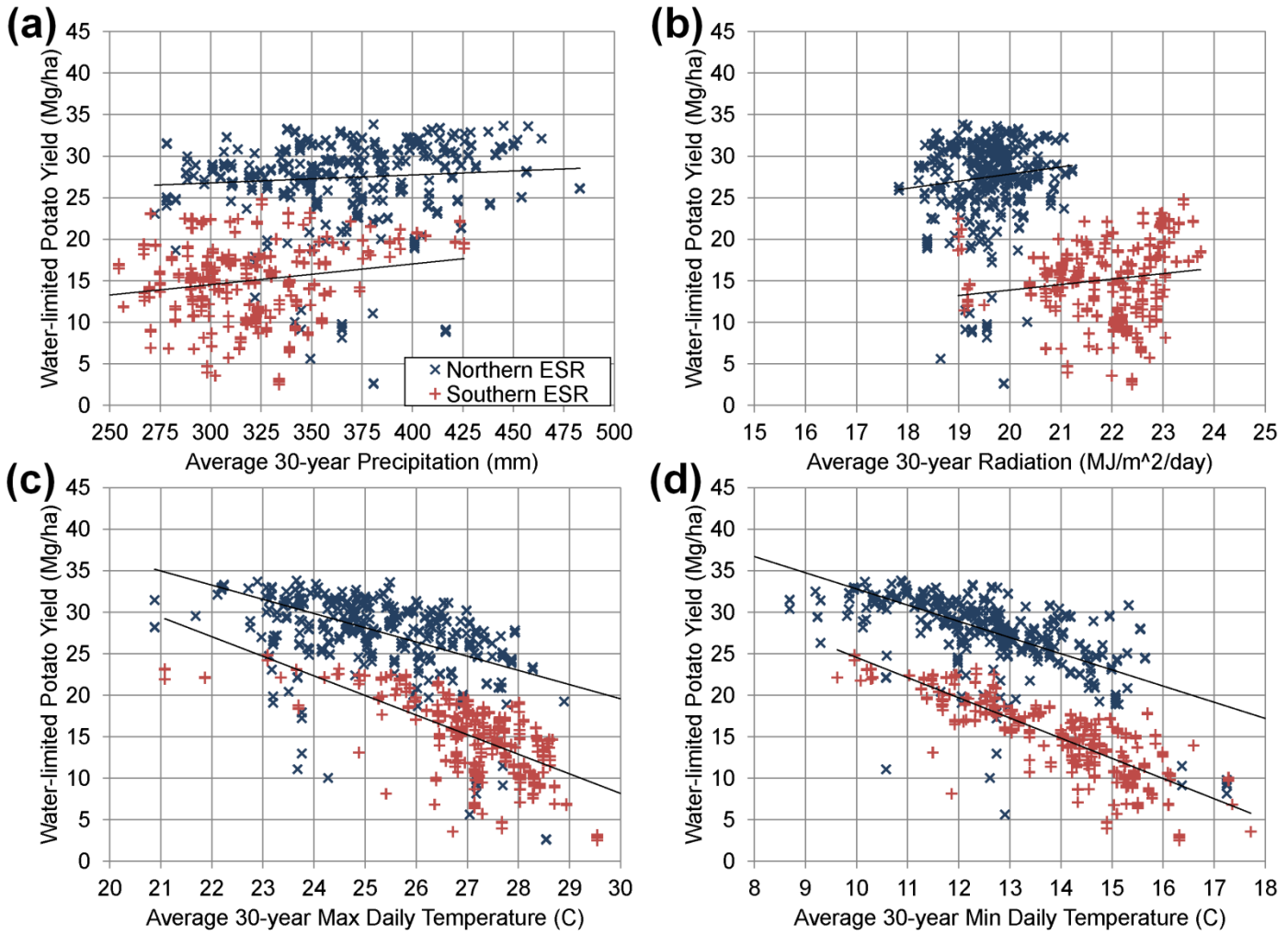


Summary and Conclusions

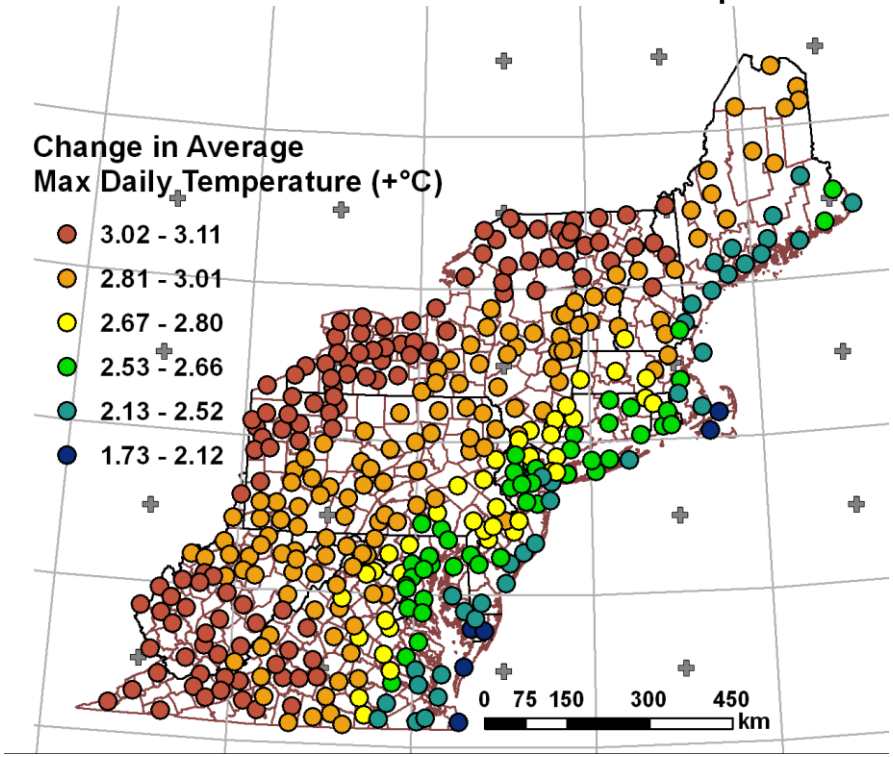
- Potato yield mainly limited by temperature, but deficits can be offset by irrigation.
- Production greatest in northern areas where there is already potato cropland, but there is potential in areas like WV.
- The geospatial method used here takes advantage of higher-resolution climate and soil data to get a better understanding of the spatial and temporal variability.

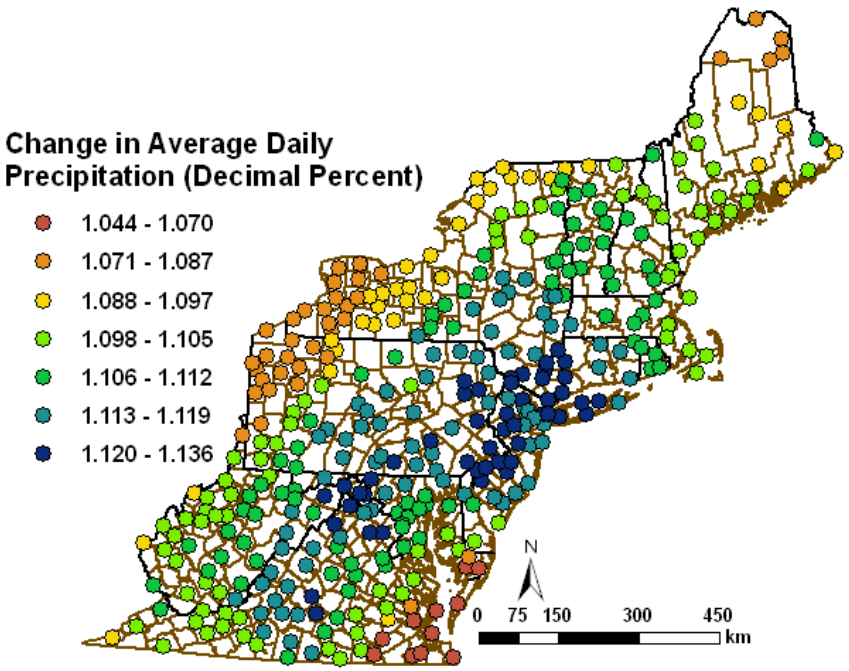
Future Directions

- Expand analysis of current and potential production to include corn and wheat to create a overall yield-index for productivity
- Study the sensitivity of the region to different scenarios such as climate change and land use change as well as potential adaptation

Climate Change Scenarios

- Uses IPCC Scenario and the HadCM3 GCM Model
- Monthly parameter changes from the GCM are downscaled using IDW method to the NOAA CLIGEN monthly parameters and then daily data is generated
- Future predictions are averaged over the time frame 2050 to 2080
- Climate Scenarios = A2 (Focus on Economic Development, High CO_2 ~600 ppmv)
- Weather Parameters = Max Temp, Min Temp, Precipitation, and CO_2



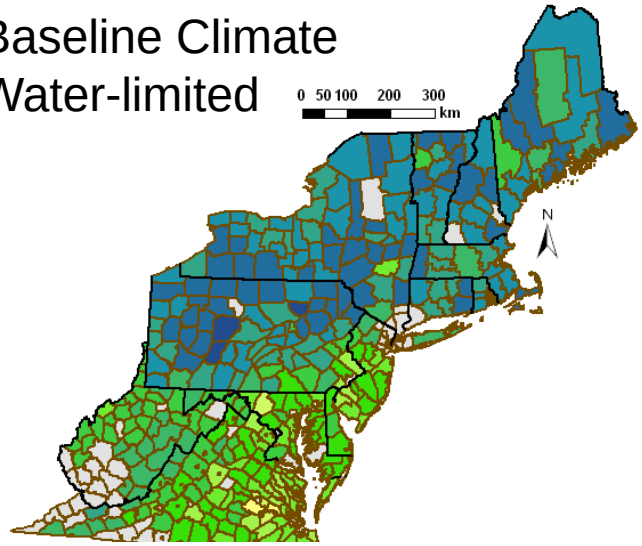


Climate Change Scenarios

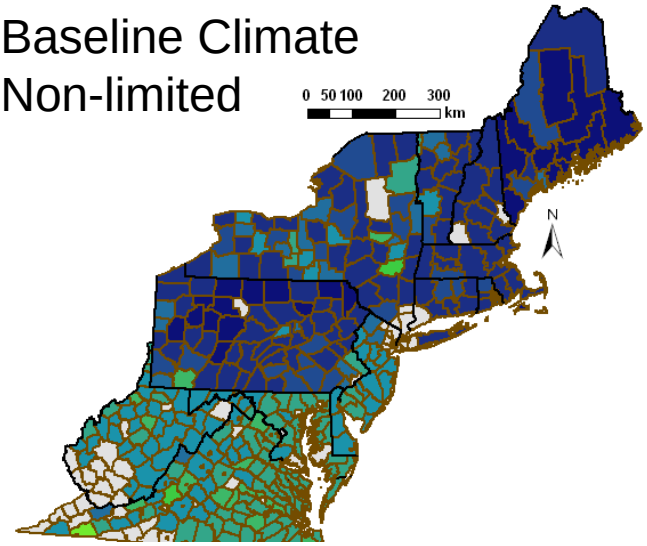
Potato Yield (Mg/ha)

- 0.00 - 3.30
- 3.31 - 6.60
- 6.61 - 9.90
- 9.91 - 13.20
- 13.21 - 16.50
- 16.51 - 19.80
- 19.81 - 23.10
- 23.11 - 26.40
- 26.41 - 29.70
- 29.71 - 33.00
- 33.01 - 36.30
- 36.31 - 39.60
- 39.61 - 42.00

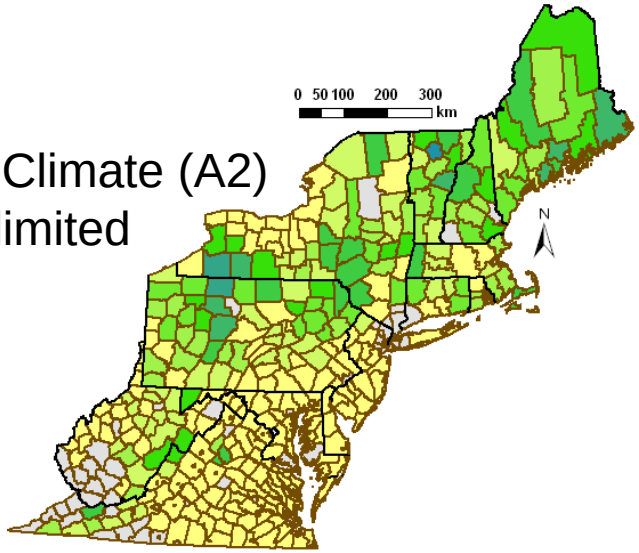
Baseline Climate
Water-limited



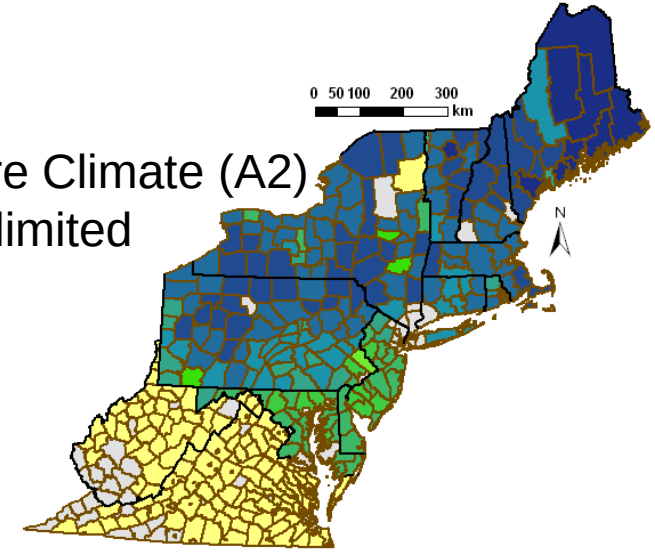
Baseline Climate
Non-limited



Future Climate (A2)
Water-limited



Future Climate (A2)
Non-limited



(WV/VA Scenarios Not Complete)

Questions?

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The CSGCL Geospatial Analysis Cluster Computing Center

A MASSIVE CROP SIMULATING FORCE

Maryland – Post-Doctoral Researcher

The USDA-ARS Crop Systems and Global Change Laboratory in Beltsville, MD is seeking a postdoctoral associate for a 2-year appointment. **QUALIFICATIONS:** Recent Ph.D. in one of the following fields: Agricultural Engineering, Agronomy, Plant Physiology, Soil Science, or related discipline. Knowledge of crop responses to biophysical constraints, simulation models for plant growth, and GIS is highly desirable. **HOW TO APPLY:** Submit resume or curriculum vitae to Dr. David H. Fleisher, USDA-ARS, (david.fleisher@ars.usda.gov).

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