Mapping Regional Production Capacity and Climate Change Sensitivity

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Applying Systems Theory To Complex Agricultural Problems

Abstract

The eastern seaboard region (ESR) imports over 70% of its fresh fruit and vegetables from outside the area. The stability of this distantly produced food supply is vulnerable to uncertainties posed by fuel and transportation costs, product safety, climate change, and other concerns. Food security and access can hypothetically be improved by promoting more reliance on locally and regionally derived production systems. The ESR has a robust natural resource base for this purpose, including ideal climate, rainfall, fertile soils, and land availability. However, the potential production capacity, as limited by biophysical constraints, has not been quantified. To this end, USDA-ARS corn and potato models MAIZSIM and SPUDSIM were integrated with a geospatial interface to study potential yields and resource requirements as influenced by soil properties, field management, land-use configurations, and historical weather patterns at a sub-county spatial resolution. The sensitivity of this baseline production potential over the 13-state region to mid-century climate change (including shifts in CO_2, mean daily air temperature, and rainfall) was also studied. Efficacy of using water management and planting dates as adaptation approaches was assessed. Results can be used by regional planners to study the viability of regionally based food systems as well as anticipate and respond to potential climate change risks.

This research was supported by the USDA-ARS Headquarters Postdoctoral Research Associate Program and the USDA-NIFA AFRI Grant #2011-68004-30057: Enhancing Food Security of Underserved Populations in the Northeast through Sustainable Regional Food Systems.

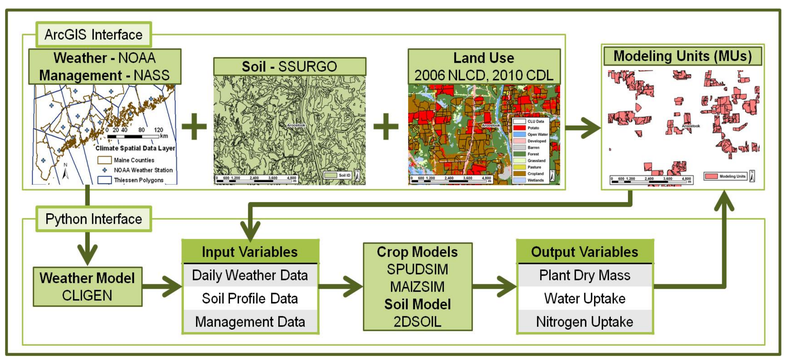
Objectives

- **Evaluate** the potential production capacity of the ESR.
- **Quantify** effects of climate change on production capacity.
- **Investigate** potential adaptation approaches.

Geospatial Crop Model Interface

1) Input data layers (weather, soil, management, land use) are georeferenced and organized in ArcGIS for the region of interest.

2) Spatially homogeneous modeling units (MUs) are created.

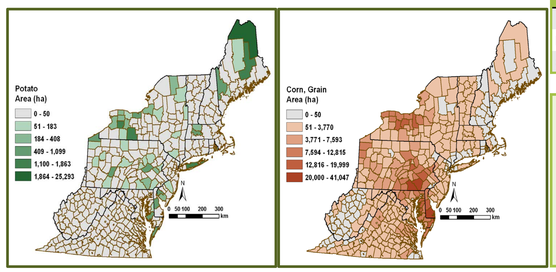


3) For each unique input combination, 30 independent growing seasons are simulated with SPUDSIM and MAIZSIM.

4) Output is spatially linked and aggregated to the county level. Models validated using published NASS statistics for selected years.

1. Potential Production Capacity

A. Observed Harvested Areas



Total Harvested Area (ha x 1000)

	Potato	Corn
NASS (County-level)	47.5	1,019
CDL (30-m) [a]	37.0	1,620

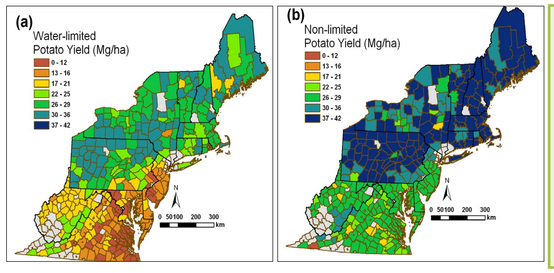
[a] CDL does not differentiate corn grain and silage

Harvested Area is the current or baseline area available for production.

What is ESR production capacity if more land were placed into agricultural production? Consider:

- Converting area from existing cropland (results shown below!)
- Adding unused marginal land
- Other changes in regional land use

B. Simulated Yields (potato) – Cropland Area



Potato Simulated Yield as projected on area basis for all land classified as cropland in NLCD database. Two scenarios:

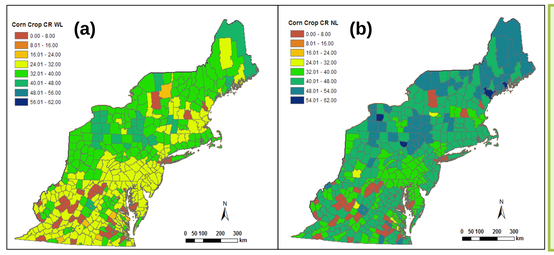
(a) rain-fed (water-limited, WL)

(b) fully irrigated (non-limited, NL)

Results suggest :

- Higher potential to increase potato production in northern states
- Increased irrigation can raise yields by up to 41% over baseline numbers

C. Simulated Yields (corn) – Cropland Area



Corn Simulated Yield as projected on area basis for all land classified as cropland in NLCD database. Two scenarios:

(a) rain-fed (water-limited, WL)

(b) fully irrigated (non-limited, NL)

Results suggest :

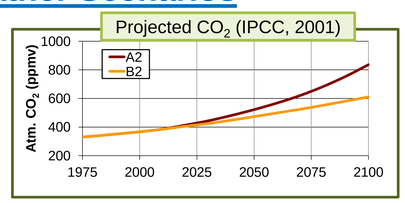
- Potential for higher corn production is roughly the same for most states
- Increased irrigation can raise yields by up to 31%

2. Climate Change – Weather Scenarios

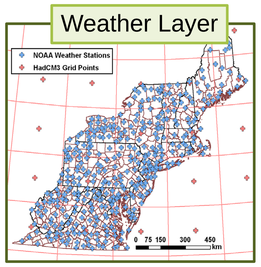
Baseline vs. **Future** Climate

- **Baseline** - 1970 to 2000 (NOAA)
- **Future** - 2050 to 2080 (HadCM3)
  - **A2** - Economic Development
  - **B2** - Ecological Sustainability

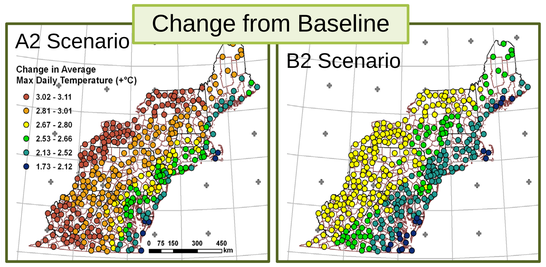
Projected CO_2 (IPCC, 2001)



Weather Layer



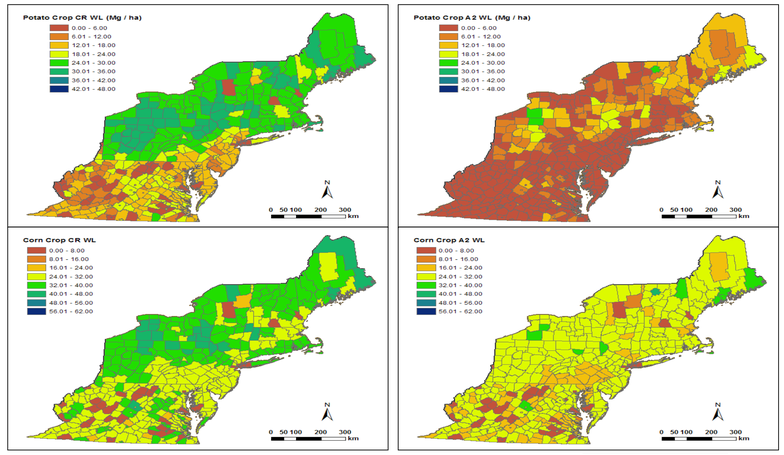
Change from Baseline



- GCM future climate change predictions were downscaled to monthly NOAA weather station parameters.
- In general, the trend of increasing temperatures due to climate change was greater west from the Atlantic coast.

2. Climate Change – Simulations (A2 scenario)

A. Rainfed Comparisons



Percent Yield Declines		
	Potato	Corn
State	Rainfed	
ME	-50	-23
VT	-55	-24
RI	-80	-20
NH	-59	-19
MA	-66	-20
CT	-76	-19
NY	-72	-21
PA	-87	-20
NJ	-71	-18
DE	-90	-14
WV	-79	-22
VA	-76	-17
MEAN	-70%	-17

Potato and Corn simulated yield as projected on land area basis. Left-side yield maps are current or baseline projections. Right-side yield maps are mid-century A2 climate change results for rainfed scenario only. Yield impacts were summarized for both rainfed (left) and irrigated (right) production as indicated:

Rainfed

Irrigated

Percent Yield Declines		
	Potato	Corn
State	Irrigated	
ME	-10	13
VT	-8	9
RI	-20	5
NH	-12	9
MA	-16	10
CT	-20	8
NY	-9	3
PA	-25	-17
NJ	-21	-17
DE	-21	-14
WV	-20	-16
VA	-21	-14
MEAN	-17	-3

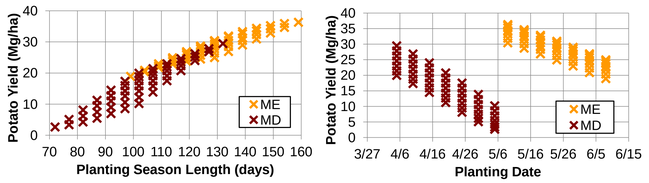
- Climate change had a larger impact on potato as compared with corn. There was also disparity between northern and southern states. On average, **rainfed** potato yield decreased 70%, and corn by 17%, as compared with baseline data. **Irrigated** comparisons fared much better, with a decline of 17% for potato and 3% for corn.

3. Adaptation Responses

A. Water management

- Increasing irrigation could alleviate some climate change impact on corn and potato in the ESR. For potato, moving from rainfed to irrigated improves yield loss from -70% to -17%. For corn, the improvement is from -17% to -3%. The use of irrigation as a realistic adaptation response will depend on availability of water resources.

B. Planting / Harvest Dates



Example of shifting planting and harvest dates on potato yield in Maine and Maryland. Other states very considerably in type and effectiveness of response.

- Adjusting planting and/or harvesting dates can reduce yield loss from -70% down to an average -38% for potato. For corn, the improvement in yield loss can be from -17% to -11%.
- There is considerable variation from state to state. Southern states show less adaptation potential with respect to growing season duration (adjusting harvest dates) than northern states.

Conclusions

- ESR has a large capacity for increasing regional food production. This is closely tied with irrigation and land-availability.
- ESR will be sensitive to climate change; however the degree of sensitivity is specific to different crops and latitude.
- Both irrigation and planting/harvest date adjustments may be effective adaptation strategies for future climate change impact.