Simulating Potential Production Capacity of Corn and Potatoes in New England using a Geospatial Crop Model

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Objectives

1. Evaluate the potential production capacity for the region of New England

   A. Determine the land available for production under various land use scenarios

   B. Simulate crop yield under both water-limited and unlimited water use scenarios

   C. Calculate the natural resource requirements (land, water, nutrients) for production
Potential Production Capacity

• What is the capacity of a region for food production?
  – Can I grow X crop in Y location?
  – What are the natural resource constraints?
  – What is the sensitivity of production?
  – What is the potential under various scenarios?
  – Can we support a growing population with locally grown food?

• Land Use Change Scenarios
  – Current Production
    (Crops currently grown in the region)
  – Potential Production (Areas not currently being used)

• Water Use Availability Scenarios
  – Water-limited, Rain-fed, No Irrigation
  – Not Water-limited, Irrigated to Full Potential
Study Area

- Loss of local production due to the loss of the agricultural land:
  - Soil erosion
  - Urbanization
  - More food will need to be imported to support the growing population!
Crop Modeling

• Explanatory, Process-based Crop Models

Crop Model Input Variables

- Weather Data:
  - Precipitation
  - Minimum Temperature
  - Maximum Temperature
  - Radiation
  - Wind Speed
  - Relative Humidity

- Soil Data:
  - Number of Horizons
  - Horizon Depth
  - Sand, Silt, and Clay
  - Bulk Density
  - Organic Matter
  - Soil Water Content
  - Hydraulic Conductivity

- Management Data:
  - Elevation
  - Latitude and Longitude
  - Cultivar
  - Irrigation
  - Fertilization
  - Planting Depth
  - Planting Density
  - Planting and Harvest Dates

Crop Model Output Variables

- Crop Yield
- Water Use
- Nitrogen Uptake

1. Weather information is required daily over the length of the growing season.
2. Soil information is required for each horizon in the soil profile.
Geospatial Crop Modeling

1) Organize Data Layers
   - Weather: NOAA
   - Land Use: CLU, NLCD, CDL
   - Management: Various Sources
   - Soil: SSURGO

2) Create Modeling Units
   - Modeling Units (MUs)
     - Weather: WID
     - Soil: SID
     - Management: MID
     - Land Use

3) Select Modeling Units
   - Land Use Classifier
   - Min Area Threshold
   - Apply Variability
     - Land Use Change
     - Soil or Climate Change
     - Management Scenarios

4) Simulate Production
   - MUs
     - Yield, Water, Nitrogen

5) Aggregate Results

SPUDSIM

CLIGEN
- 30 Gen. Years

List of Unique Combinations of Parameters (PID)
- WID
- SID
- MID
- 1
- 2
- n
Field-scale Modeling Units

Region of Interest

Weather ID (WID)
Management ID (MID)

Soil ID (SID)

Land Use

Modeling Units (MUs)
Potential Production Scenarios

Land Use Classifications

**Current Production**
1) Potato / Corn Cropland

**Potential Production**
2) All Cropland
3) Pasture
4) Grassland / Scrub

**Not Considered for Production**
5) Forested
6) Developed / Barren

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?

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## Current Land Use - Potato

<table>
<thead>
<tr>
<th>State</th>
<th>County</th>
<th>Observed (NASS)</th>
<th>Simulated (SPUDSIM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ave.</td>
<td>Std.</td>
</tr>
<tr>
<td><strong>Water-limited</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maine</td>
<td>Aroostook</td>
<td>30.73</td>
<td>1.07</td>
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<td></td>
<td>Penobscot</td>
<td>27.13</td>
<td>1.70</td>
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<td></td>
<td>Oxford</td>
<td>32.39</td>
<td>0.85</td>
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<tr>
<td></td>
<td>Piscataquis</td>
<td>25.11</td>
<td>1.77</td>
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<tr>
<td></td>
<td>Androscoggin</td>
<td>29.15</td>
<td>2.49</td>
</tr>
<tr>
<td><strong>Non-limited</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Massachusetts</td>
<td>Hampshire</td>
<td>27.88</td>
<td>2.27</td>
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<tr>
<td></td>
<td>Franklin</td>
<td>29.05</td>
<td>3.52</td>
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<td>Rhode Island</td>
<td>Newport</td>
<td>26.76</td>
<td>5.26</td>
</tr>
</tbody>
</table>
Land Use Comparison

![Graph showing land use comparison across different states. The graph compares observed yields (NASS) with simulated yields aggregated by land use and state. Categories include potato, cropland, pasture, and grass.]
Water-limited vs. Potential Yield

(Preliminary Results - Potato - Simulated Over All Cropland)

Average Simulated = 26.20 Mg/ha
Average Simulated = 36.80 Mg/ha
Average Observed (NASS) = 28.88 Mg/ha
New England Corn Yield

(Preliminary Results - Simulated Over All Cropland)

May 26 Planting Date
Raid-fed Yield (Mg/ha)

- 8.07 - 8.57
- 8.58 - 10.21
- 10.22 - 11.31
- 11.32 - 12.99
- 13.00 - 15.77
- Maine MDs

Simulated Corn Yield (Mg/ha)

Simulated Potato Yield (Mg/ha)

y = 0.8074x - 10.516
R² = 0.5471

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Regional Production Capacity

(Preliminary Results - Potato - Simulated Over All Cropland)

NOAA Weather Stations

Simulated Potato Yield (Mg/ha)

- 0.00 - 10.00
- 10.01 - 22.00
- 22.01 - 23.69
- 23.70 - 25.38
- 25.39 - 27.91
- 27.92 - 31.89

0 75 150 300 450 km

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Conclusions

• More research is needed to evaluate the availability of specific land areas, but this initial analysis shows potential for crop production growth in the region

• The field-scale geospatial crop model generates high-resolution results to allow analyses into the regional infrastructure

• The results demonstrate highly productive areas to focus on over more marginal land
Future Work

• Perform further validation / ground-truthing
• Explore uncertainties in the model
  – Parameter variability (e.g. planting date)
  – Weather data interpolation
• Expand land availability to other variables:
  – Rockiness of the soil
  – Soil Slope
• Evaluate other scenarios e.g. climate change