Estimating the Bioenergy Potential of the United States Using Satellite Observations of Vegetation Productivity

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1. Introduction

The United States (U.S.) currently supplies roughly half the world’s biofuel, with the Energy Independence and Security Act of 2007 (EISA) specifying an additional three-fold increase in annual production by 2022 (Figure 1).¹⁻³ Biofuel production in the U.S. has been increasing due solely to growth in corn ethanol production. Continuation of this trend could have significant detrimental impacts for global food prices.

2. Objectives

• Estimate the primary bioenergy potential (PBP) of the conterminous U.S. using satellite-derived net primary productivity (NPP) data as the most geographically-explicit measure of current vegetation growth capacity.¹

• Compare our capacity approximations to EISA energy mandates in an effort to evaluate the feasibility of current U.S. energy policy.³

3. Methods

Figure 2. Flow diagram for the quantification of landcover and primary bioenergy potential (PBP) pools.² Green indicates PBP pools while red indicates unavailable pools. Unavailable resources were defined to include current agricultural and forestry harvest (Hcep) as well as protected areas, wetlands, pastures, and low productivity regions.

4. Bioenergy Potential of the United States

Figure 3. Spatially explicit primary bioenergy potential (PBP) of the conterminous United States.² (a) Agricultural intensification (PBP), defined to include residual harvest (PBP_res) only. (b) Forestry intensification (PBP), including both additional harvest (PBPadh) and residual harvest (PBPres) only. (c) Agricultural extensification (PBP), including both managed harvest (PBP_m) and remote harvest (PBP_r) extensification. (d) Forestry extensification (PBP) defined to include remote extensification (PBP_r) only.

<table>
<thead>
<tr>
<th>Primary Bioenergy Potential</th>
<th>Area (Mkm²)</th>
<th>Mean Yieldb</th>
<th>Total PBP (EJ yr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Intensification</td>
<td>1.96</td>
<td>3.4-10.5</td>
<td>13.5 (1.6)</td>
</tr>
<tr>
<td>Managed Range (PBP_res)</td>
<td>0.27</td>
<td>3.8-6.3</td>
<td>4.3 (0.6)</td>
</tr>
<tr>
<td>Remote Range (PBP_res)</td>
<td>0.34</td>
<td>2.3-4.3</td>
<td>1.1 (0.3)</td>
</tr>
<tr>
<td>Agricultural Intensification</td>
<td>1.39</td>
<td>2.1-3.8</td>
<td>4.1 (1.0)</td>
</tr>
<tr>
<td>Residual (PBP_res)</td>
<td>1.21</td>
<td>3.5-11.9</td>
<td>9.2 (1.2)</td>
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<tr>
<td>Residue (PBP_res)</td>
<td>1.79</td>
<td>0.7-1.6</td>
<td>1.7 (0.8)</td>
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<tr>
<td>Total Average</td>
<td>5.46</td>
<td>2.3-5.6</td>
<td>22.2 (2.4)</td>
</tr>
</tbody>
</table>

²Mean Yield represents a range of one standard deviation. Values in parentheses represent parameter uncertainty.

5. Comparison With Current Literature Estimates

Figure 5. Cumulative maximum yield potential as a function of area.³ We show that a number of recent studies used yield potential values higher than maximum natural yield potentials, which we attribute to over-optimistic assumptions regarding management or to an incomplete consideration of biophysical constraints.⁴⁻⁷

6. Key Results

• Meeting EISA mandates under current technology will require large-scale changes in the U.S. agricultural landscape (Figure 6).³

• Future increases in U.S. agricultural yields are unlikely since rates of irrigation may already be unsustainable in many regions.⁴ Further, 70% of U.S. counties are likely to experience climate change-driven reductions in freshwater availability by 2050 (Figure 7).¹⁰

7. Conclusions

Acknowledgments

We thank M. Zhao for his valuable data acquisition and analysis expertise and A. Wolfe for her contributions to the initiation of this study. This work was supported by the Energy Biosciences Institute (grant 007.149), the NASA Earth Observing System MODIS project (grant NNX09AG87A), and the U.S. Geological Survey Energy Resources Group. Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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