**SUPPORTING INFORMATION (Figures, Tables, Equations)**

Specific equations, tables and figures for more detailed data and analysis are presented in the online supporting information.

**Figure S-1.** Trends in New York State milk production efficiency

**Figure S-2.** Soil and climate suitability for crop growth represented by the National Commodity Crop Productivity Index.

**Figure S-3.** Cost relative to production potential of bioenergy feedstocks in New York **for 2020**

**Table S-1.** Constraints applied to account for sustainability

**Table S-2.** Land use/land cover (LULC) in New York State

**Table S-3.** 2007, 2013 & 2020 actual and regression estimates of predominant NYS crops

**Equations S-1 to S-4:** Linear regression of agricultural and dairy production efficiencies

**Equations S-5 to S-8:** Projected yield and production of dedicated bioenergy crops

**Figure S-1.** Trends in New York State milk production efficiency



**Figure S-2.** Soil and climate suitability for crop growth represented by the National Commodity Crop Productivity Index (NCCPI)

**Figure S-3.** Cost relative to production potential of bioenergy feedstocks in New York for 2020.

**Table S-1**. Constraints applied to account for sustainability

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Forest | Herb. Land | Water | Air | Other |
| NYS Forests will stay as forestsNo forestland is converted | x |  | x | x | x |
| Existing herbaceous landcover will remain herbaceous |  | x |  |  |  |
| Not all herbaceous lands are practical to harvest (slope > 15% or field size < 5 acres) |  | x |  |  | x |
| Federal or State protected lands are not considered | x | x | x | x | x |
| Existing equine landuse is not considered |  |  |  |  | x |
| Idle and “Fallow” crop land is considered available (Note that “fallow” is included in the national database, but fallow is not important in crop rotations in the region) |  | x |  |  |  |
| Not all land landowners want to use their land for energy feedstock (Sustainable yield models related to site conditions and demographics = ~50% adoption across available lands, varying with population density) | x | x |  |  | x |
| Crop yield and dairy milk production efficiencies will increase based on analysis of existing trends |  | x |  |  | x |
| Existing use of crop residues are not considered | x | x | x |  | x |
| Only perennials will be considered to reduce erosion and N loss to air and water, and increase soil carbon storage and wildlife habitat. |  | x | x | x | x |
| Replacement P and K used to maintain soil |  | x |  |  |  |
| Forest harvest for existing wood products were maintained | x |  |  |  | x |
| Harvest of forest land never exceeds net annual growth rate in each county | x |  | x |  |  |
| Dead trees and 35% of tops were not collected to maintain nutrients and biodiversity | x |  |  |  | x |
| Stover harvest was reduced for soil and water quality |  | x | x |  | x |

**Table S-2.** Existing Land-Use/Land Cover (LULC) in New York State.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land Cover Type (from NLCD)** *a* | **Land Area (hectares)** | **Land Area (%)** | **Existing Crop, Forage, and Hay LULC** *b* **(hectares)** | **Existing Non-Farm Equine LULC** *c***(hectares)** |
| Forest land *d* | 6,759,119 | 53.7% |  |  |
| Pasture, Hay & Grass land | 1,866,636 | 14.8% | 794,245 | 323,099 |
| Developed land | 1,096,093 | 8.7% |  |  |
| Crop land | 1,068,903 | 8.5% | 691,033 |  |
| Wetlands | 993,055 | 7.9% |  |  |
| Open water | 411,919 | 3.3% |  |  |
| Shrub & Scrub land | 355,383 | 2.8% |  |  |
| Barren land | 23,718 | 0.2% |  |  |
| Other | 2,446 | 0.0% |  |  |
| **TOTAL** | 12,577,272 | 100.0% | 1,485,277 | 323,099 |

a These land cover categories are aggregated from the National Land Cover Database (NLCD)19.

b LULC categories are from the 2007 Census of Agriculture23. Crop land includes grains, oilseeds, vegetables, and fruit. Forage land includes all forages used for livestock. Hay includes all types.

c Equine land includes all land used for horses (399,424 hectares)24 minus the amount of equine land on farms that is already counted elsewhere (76,324 hectares)

d The value presented here for forest land is derived from the NLCD19 and is based on the area of forest cover in rural parts of the state. This database was used as a starting point for analysis of land cover. However, more detailed data on forest area are available based on survey data from the USDA Forest Service Forest Inventory and Analysis (FIA)2 program, which conducts surveys of forests in cooperation with State agencies. For analysis of forest feedstocks, these more detailed FIA data were used.

**Table S-3**. 2007, 2013 & 2020 actual and regression estimates of predominant NYS crops

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   | units | 2007 Census of Ag (actual) | 2013 NASS NYSa (actual) | 2013b c calculated | % increase of actual from calculated | 2020b calculated |
| Milk | kg/cow | 8,706 | 10,024 | 9,400 | 6.6% | 10,210 |
| Maize grain | kg/ha | 7,925 | 1,420 | 1,414 | 0.4% | 1,549 |
| Maize silage | Mg/ha | 37.9 | 38.1 | 41.0 | -7.0% | 44.6 |
| Soybean | kg/ha | 2,771 | 3,231 | 3,127 | 3.3% | 3,542 |
| Wheat | kg/ha | 3,820 | 4,577 | 4,037 | 13.4% | 4,289 |

a Actual yield from National Agricultural Statistics Service8

b Using regression analysis derived from historical Census of Agriculture data

c To note, 2010 NASS actual production exceeded all 2013 calculated; specifically maize silage production was 42.6 Mg/ha.

**Equations S-1 to S-4.** Linear regression of agricultural and dairy production efficiencies

Where: (1 bushel maize = 56lbs or 25.4kg; 1 bushel soy/wheat = 60lbs or 27.2kg; 1 acre = 0.405 hectare; 1lb = 0.45kg)

**Equation S-1.**

*Maize silage: y=0.229x -442.7 (R2=0.625) where y = yield in tons/ac and x = year*

**Equation S-2.**

*Soybean: y = 0.881x-1727 (R2=0.343) where y = yield in bushels/ac and x = year*

**Equation S-3*.***

*Wheat: y=0.536x-1019 (R2=0.322) where y = yield in tons/ac and x = year*

**Equation S-4.**

*Milk Production: y=254.95x-492,509 (R2=0.9734) where y = milk production in lbs/cow and x = year*

**Equations S-5 to S-8.** Projected yield and production of dedicated bioenergy crops

We used the draft NCCPI for maize to predict above-ground yield of maize, warm season grasses, and willow across a variety of soil and climate conditions (Equation S-5).

**Equation S-5*.***

*Maize grain yield in 2002 (bu/ac) = (50.5 + 119\*NCCPI)*

 *Where: NCCPI = average NCCPI value for maize*

Regression Equation S-5 explained 60.4% of the variance. Maize yield was estimated based on average yields from 1998 to 2007, thus it represents the year 2002. To make a prediction of maize yield for years subsequent to 2002, yield should be increased by 1.275 bu/ac/yr based. Accounting for this yield trend, Equation S-6 shows the predicted yield for 2020.

**Equation S-6.**

*Maize grain yield in 2020 (t/ac) = (50.5 + 119\*NCCPI+1.275\*18)\*0.028*

*Where: Annual yield increase (bu/ac) = 1.275*

 *Years after 2002 = 18*

*Short tons per bushel = 0.028*

We adapted the maize yield model to represent aboveground biomass of grasses across the Northeast as shown in Equation S-7. Adjustments were made to account for aboveground biomass from grain yield data, and to account for reduced yields during the first three years of a projected 10-year stand life.

**Equation S-7.**

*Grass yield 2020 (odt/ac) = (50.5 + 119\*NCCPI+1.275\*18)\*0.028\*2\*0.845\*0.825*

 *Where: Years after 2002 = 18*

*Short tons per bushel = 0.028*

 *Adjustment from grain to aboveground maize yield = 2 (harvest index of 0.5)*

 *Adjustment from 15.5% moisture to oven-dry = 0.845*

 *Adjustment for years 1 to 3 (10-yr stand life) = 0.825*

Due to the high establishment costs for planting willow, we adapted the perennial grass model to represent willow yield adjusted to the 22-year stand life of willow with reduced yield during the first rotation as shown in Equation S-8.

***Equation S-8****.*

*Willow yield 2020 (odt/ac) = (50.5 + 119\*NCCPI+1.275\*18)\*0.028\*2\*0.845\*0.9273*

 *Where: Years after 2002 = 18*

 *Adjustment for years 1 to 3 (22-yr stand life) = 0.9273*