The Global Potential for Biomass Energy on Abandoned Agriculture Lands

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Abstract

Converting forest lands into bioenergy agriculture could accelerate climate change by emitting carbon stored in forests, while converting food agriculture lands into bioenergy agriculture could threaten food security. Both problems are potentially avoided by using abandoned agriculture lands for bioenergy agriculture. We found that the global potential for bioenergy on abandoned agriculture lands to be less than 8% of current primary energy demand, based on historical land use data, satellite-derived land cover data, and global ecosystem modeling. Our estimated global area of abandoned agriculture is 376 to 472 million hectares, or 65% to 110% of the areas reported in previous preliminary assessments.

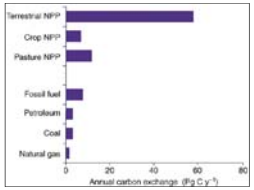


Fig.1. Fossil fuel energy systems already release more carbon annually than that fixed by all the world's croplands but much less than all the world's terrestrial plants.

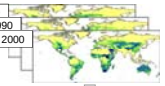
Objectives

•Spatially-explicit estimate of area of land that was formerly agriculture and is not currently classified as forest or urban.

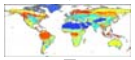
•Determine range of potential plant production on these lands.

Methods

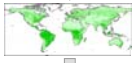
Abandoned Agriculture: Time series analysis of historical agriculture databases (5'). Gridded crop and pasture land cover every decade from 1700 to 2000 (HYDE, SAGE).



Available Abandoned Area: Overlay abandoned lands with current global land cover to exclude land currently in forests and urban (MODIS/Terra Land Cover Types MOD12C1, 3').



Potential Plant Production: Net Primary Production (kg C m^{-2}) of natural ecosystems (CASA, 1').



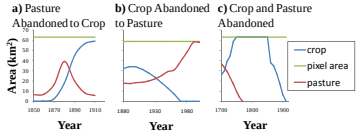
Geographical Biofuels Potential: Product of available area and plant productivity for each grid cell. Reported as the energy heat content (~40 kJ/gC) of above-ground portion of NPP (~50%) available for harvest.

Abandoned Agriculture Area

The historical land cover provided a geographical time series of crop and pasture data. We calculated abandoned crop area for each grid cell as the difference between the historical maximum crop area (from 1700 to 2000) and the current crop area. The same approach was also used to estimate abandoned pasture area. We used two independent approaches to provide an upper and lower estimate of the abandoned area:

High Assumption: Abandoned agriculture area cannot exceed (pixel area - current agriculture area)

Low Assumption: For each decade and pixel, a simultaneous increase of crop and decrease of pasture is a conversion of crop to pasture and vice-versa.



Global Abandoned Areas

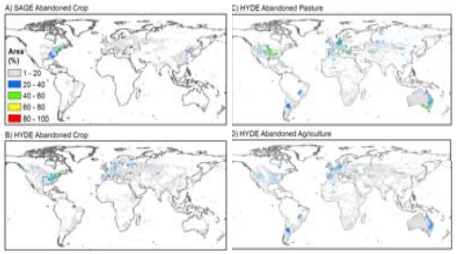


Fig. 2. Global land areas of crop and pasture abandonment.

•269 Mha of crop lands have been permanently converted to land uses other than cropping (Fig. 2b), while 479 Mha of pasture lands have been converted to land uses other than pasture (Fig. 2c).

•HYDE-based abandoned crop area is somewhat higher than the 210 Mha of abandoned crop area from the SAGE crop data (Fig. 2a).

•Our low and high approaches to estimating the area of abandoned agriculture (crop and pasture) yield global total areas of 474 Mha and 579 Mha

•Overlaying the MODIS land cover data, we found that the abandoned agriculture, excluding forest and urban areas, was 377 Mha to 472 Mha (Fig 2d)

Potential Plant Production

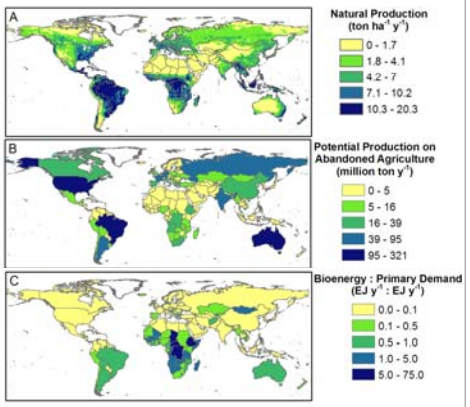


Fig.3. Biomass production potential on abandoned agriculture lands.

•Natural above-ground production of biomass on all lands determined from the CASA model, assuming 50% of the biomass is above-ground and the ratio (by mass) of biomass to carbon is 2.2. The energy content of biomass is assumed to be 20 kJ g-1.

•The area-weighted mean production of above-ground biomass is 3.8 tons ha^{-1} y^{-1}, in contrast to estimates of up to 10 tons ha^{-1} y^{-1} in previous assessments.

•The energy content of potential biomass grown on 100% of abandoned agriculture lands is less than 10% of primary energy demand for most nations in North America, Europe, and Asia, but it represents many times the energy demand in some African nations where grasslands are relatively productive and current energy demand is low

Table I Biomass production potential on abandoned agriculture lands.

Land Cover	Area (Mha)	Average NPP (ton ha^{-1} y^{-1})	Total NPP (billion ton y^{-1})
Urban	17 - 18	5.4 - 5.5	0.5 - 0.6
Forest	71 - 89	6.9 - 7.1	0.09 - 0.1
Savannah, Grassland, Shrubland	376 - 472	3.6 - 4.0	1.5 - 2.1

Country Potential

Country	Abandoned Area (Mha)	Geographic Potential (10^9 ton biomass / yr)	Bioenergy : Energy Demand
United States	67	321	3.6
Brazil	33	275	8.7
Australia	73	256	3.1
Argentina	26	95	2.9
Russia	25	67	2.2
France	9	57	6.7
India	14	51	3.0
Germany	9	49	4.7
Spain	9	38	3.9
China	23	38	1.6
South Africa	10	34	3.6
Canada	7	28	3.0
Congo, DRC	3	26	10.1
Ethiopia	5	25	5.2
Italy	5	25	3.6
Angola	4	20	6.4
Zambia	3	16	7.5
Kazakhstan	13	15	1.0
Ukraine	4	15	4.0
United Kingdom	3	13	2.1

Conclusions

•Area-weighted mean production of above-ground biomass is 3.8 tons ha^{-1} y^{-1}, in contrast to previous estimates of up to 10 tons ha^{-1} y^{-1}.

•Globally, the bioenergy potential is a small but meaningful fraction of primary consumption.

•Regionally, bioenergy potential is many times current fossil fuel demand in parts of South America and Africa due to relatively productive land availability and small fossil fuel demand.

Literature cited

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Acknowledgments

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