Imperial College London

Bioenergy and food security: friend or foe? Evaluating the role of bioenergy in sustainable development through the LACAf and GSB projects

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The Royal Society
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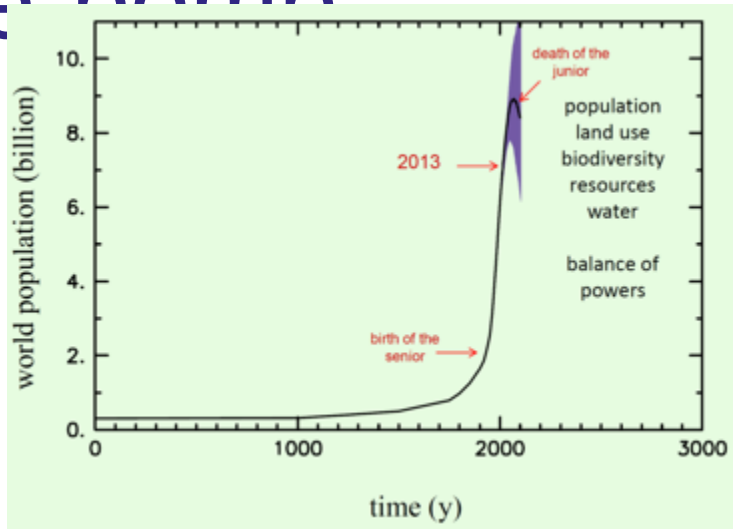
eit Knowledge & Innovation Community
Climate-KIC

How far can the biosphere be ‘pushed’ by human development?

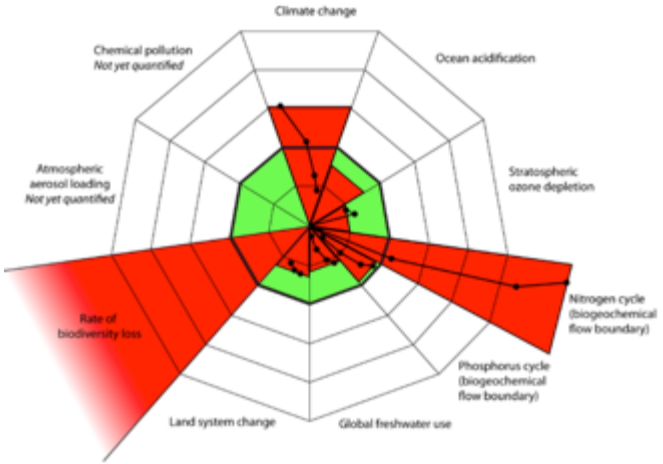
In the immortal words of Scotty to Captain Kirk…

How far can the biosphere be ‘pushed’ by human development? The population time bomb

- Population growth is unprecedented
- ‘Perfect storm’ of challenges (environmental, economic and social)
- ‘Planetary boundaries’ and footprints
- Also a time of spectacular technological and social innovation



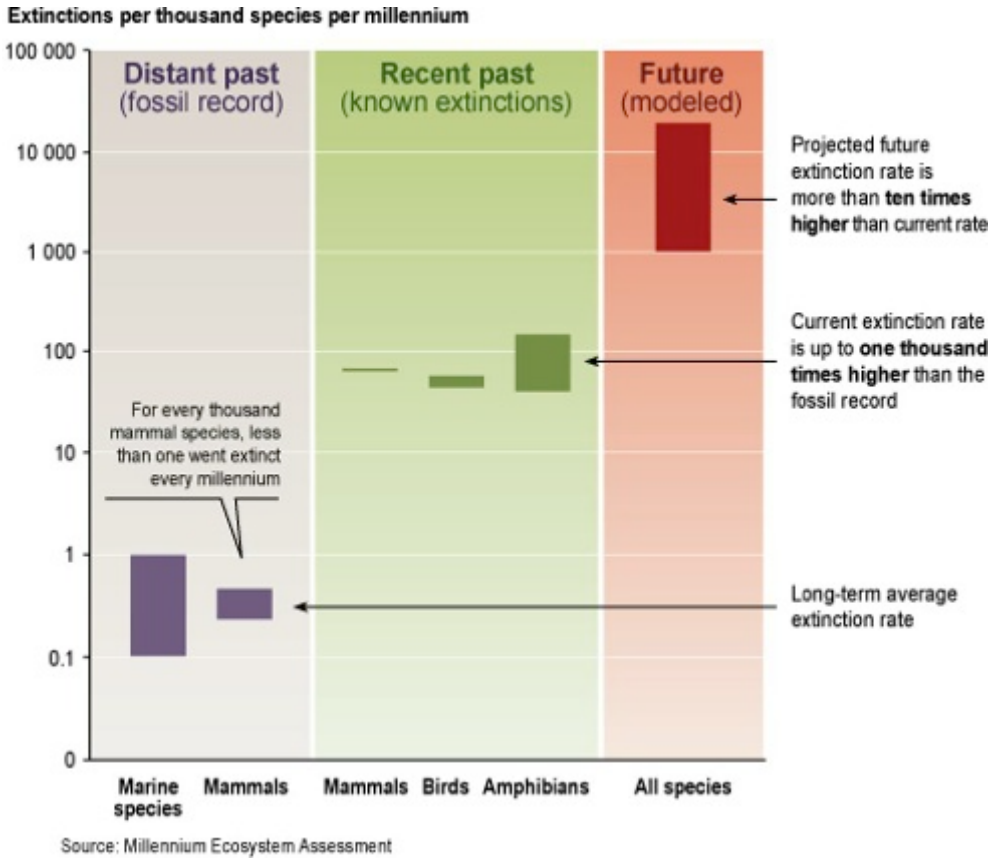
Corine Le Quere (2013) using Lutz et al (IIASA projections)



Rockström et al. (2009) Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecology and Society 14(2): 32.

Significant, largely irreversible changes to species diversity (MEA, 2005)

- The distribution of species on Earth is becoming more homogenous
- Humans have increased the species extinction rate by as much as 1,000 times over background rates typical over the planet's history (*medium certainty)*
- 10–30% of mammal, bird, and amphibian species are currently threatened with extinction (*medium to high certainty)*



UK 'State of Nature' (2013) report:

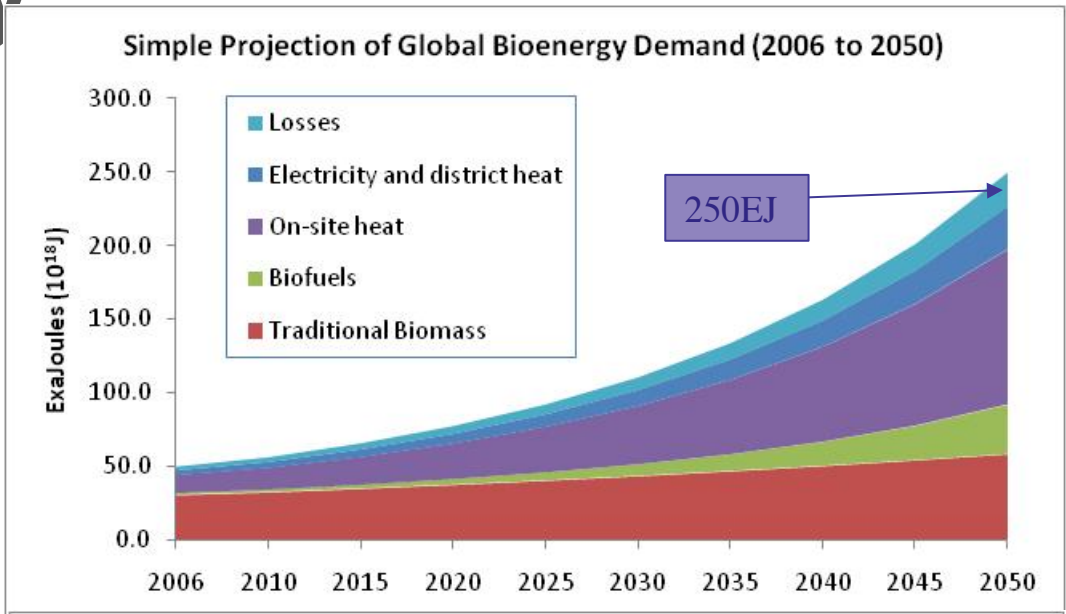
'We have quantitative assessments of the population or distribution trends of 3148 species. Of these, 60% of species have declined over the last 50 years and 31% have declined strongly.'

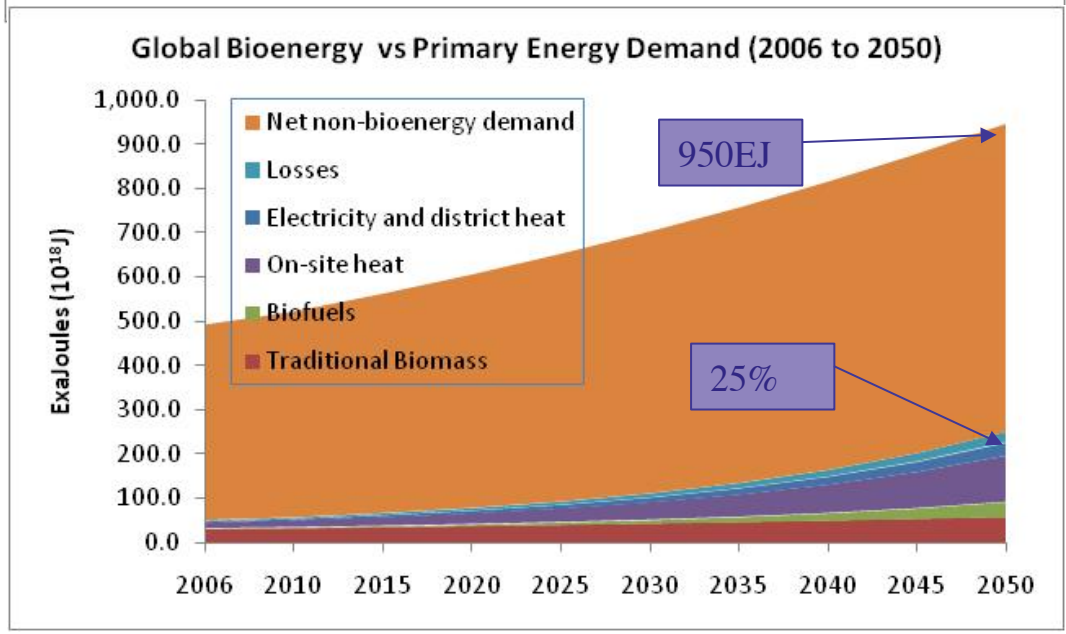
Particularly interactions with the global carbon cycle

THERE IS SUBSTANTIAL DISAGREEMENT ABOUT THE POTENTIAL SCALE AND IMPACTS OF BIOENERGY

Some really simple projections for global bioenergy

- Global primary energy grows at 1.5% CAGR (WEO, 2009)
- 5% CAGR for:
  - Electricity + district heat + On-site heat + biofuels
- c. 1.2% CAGR for Traditional Biomass
- At 5% CAGR bioenergy provides 250EJ of primary energy by 2050:
  - 13 Gt of dry biomass
  - Equivalent to 10% of current NPP (assumed to be 120 Gt biomass)





Estimating the scale of impact(s) in 2050

	Units	Impact range
Energy provision	SRREN (EJ)	120 – 155[a]
	Van Vuuren (EJ)	78 – 139[b]
Biomass supply needed	Gt oven dry biomass	7 – 9[c]
	Gross market value to supply industry	$700 Billion
Mitigation potentials[1]	Gt CO_2eq abatement/yr (C-neut)	4.5 – 9.0[d]
	Gt CO_2eq abatement/yr (50% savings)	2.2 – 4.5[d]
Land area demand est	Mha	220 – 860[e]
	Share of 'Arable land and Permanent crops' (FAO)	14% - 56%

Notes:

a: median case scenario (IPCC SRREN. Chum et al. 2011)

b. van Vuuren et al 2012 (Cosust)

c. based on 18 GJ/odt biomass

d. mitigation potentials are estimated based on 1. 2009 energy and GHG emissions intensities (IEA ETP 2012) providing 2. an emissions factor for energy rated emissions of 58 million tonnes CO_2eq per EJ primary energy supplied in 2009. 'C-neut' = Carbon neutrality of bioenergy (savings of 58 MtCO_2eq/EJ Bioenergy); and '50% savings' = 29 MtCO_2eq/EJ savings c.f. 2009 baseline (note Table 2.13, Chum et al 2011 SRREN).

e. order of magnitude assumption based on Murphy et al, 2011. Low estimate is based on achieving 20odt biomass/ha (similar to current Brazilian sugarcane and eucalyptus yields @ 18 GJ/odt) to provide 78EJ. High estimate based on supply of 155EJ at yield of 10odt/ha. Note that net land demand estimates for bioenergy are complex and uncertain due to likely use of low value biomass derived from residues and wastes and that could be generated by more efficient use of biomass in alternative sectors and from traditional bioenergy and through technological innovation. In practice, in our opinion, net land demand is likely to be at the lower end of the scale above and could be lower than the low estimate provided

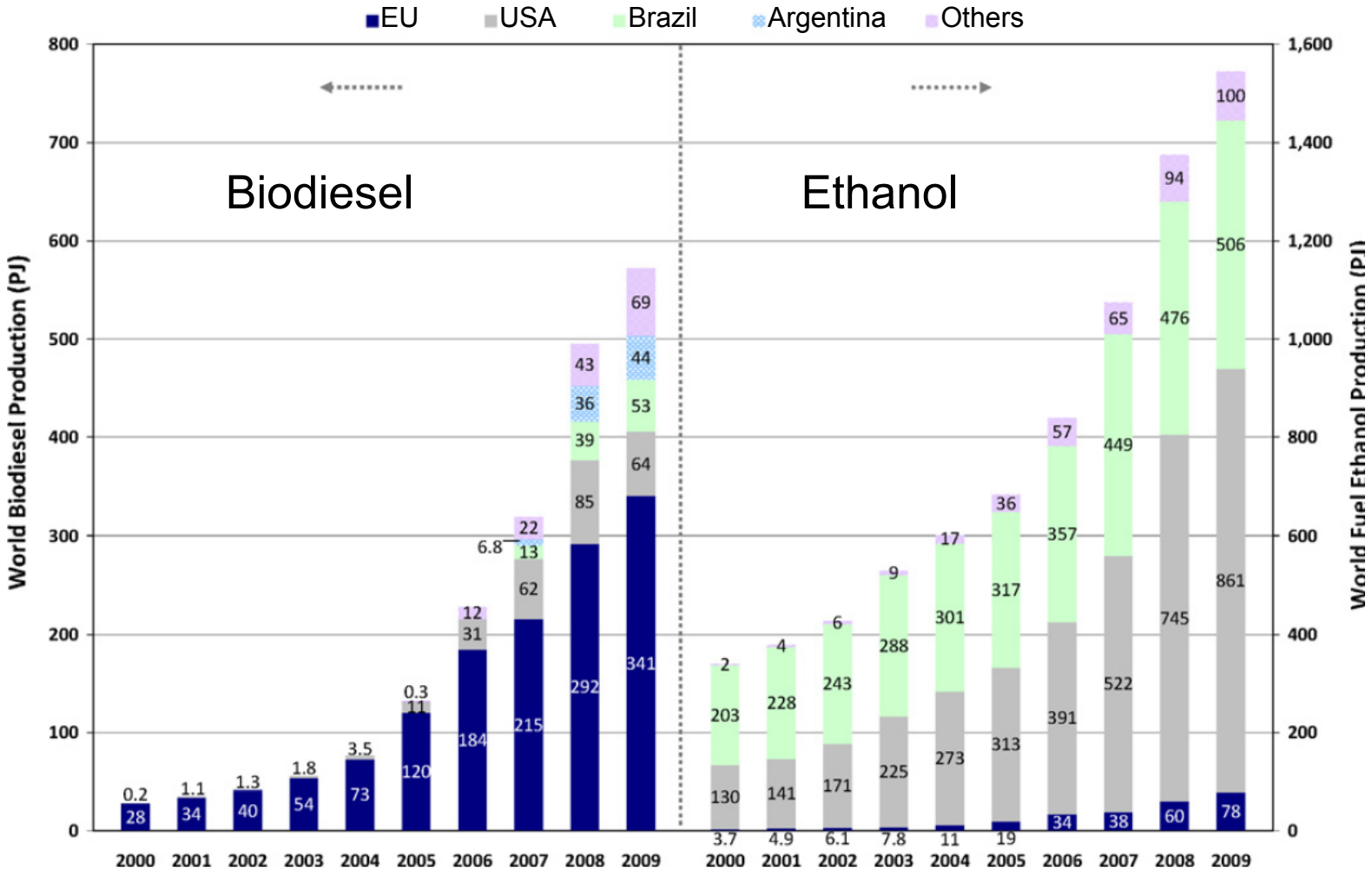
[1] Note: Chum et al (IPCC SREN, 2011) state; 'Carbon mitigation potential. The mitigation potential for electricity generation from biomass reaches 1,220 Mt CO2eq for the year 2030, a substantial fraction of it at costs lower than USD2005 19.5/t CO2. From a top-down assessment, the economic mitigation potential of biomass energy supplied from agriculture is estimated to range from 70 to 1,260 Mt CO2eq/yr at costs of up to USD2005 19.5/t CO2eq, and from 560 to 2,320 Mt CO2eq/yr at costs of up to USD2005 48.5/t CO2eq. The overall mitigation from biomass energy coming from the forest sector is estimated to reach 400 Mt CO2/yr up to 2030.

Global human appropriation of NPP doubled in the 20thC (Krausmann, Erb, Haberl, Searchinger et al, PNAS 2013)

A 250 EJ/y bioenergy scenario by 2050 would increase HANPP from 27-29% to 44% and caution against a further increase. Conclude that:

- ***Bioenergy at levels contemplated by the International Energy Agency and in IPCC-SRREN would have a transformative effect on the planet. As the world faces large new demands for food and timber products, that experience suggests caution in refocusing the energy economy on bioenergy, and stresses the importance of developing improved practices for sustainable intensification of land use.***

Global biodiesel & fuel ethanol production 2000-2009



(Source: Lamers et al., RSER, 15 (2011) 2655– 2676)

The Economist – 24th Feb 2011

The Economist

A special report on feeding the world

Plagued by politics

Biofuels are an example of what not to do

Feb 24th 2011 | from the print edition

"THIS is the craziest thing we're doing," says Peter Brabeck, the chairman of Nestlé. He is talking about government biofuels targets which require a certain proportion of national energy needs to be met from renewable fuels, most of them biofuels (ie, ethyl alcohol made from crops, usually maize or sugar).

The targets are ambitious. Brazil, Japan, Indonesia and the European Union all say biofuels must supply 10% of energy demand for transport by 2020. China's target for that date is 5%. America aspires to meet 30% of such needs from biofuels by 2030.

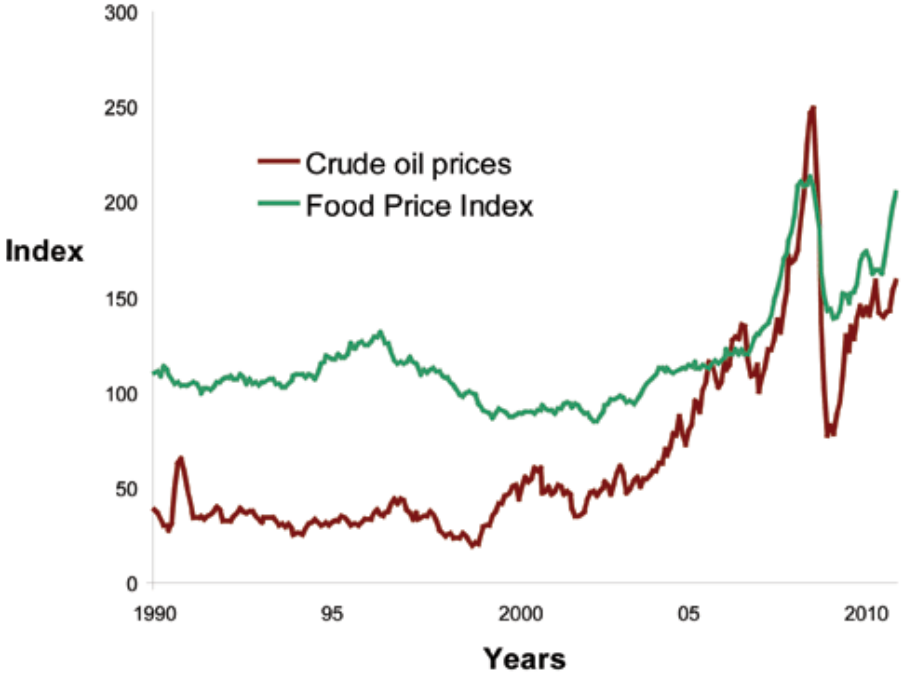
Did biofuels or rising oil prices drive the food price spike in 2007/8?

Many blamed biofuels for the food price spike of 2007/08 but:
the increasing price of oil (and energy inputs to agriculture and food supply chains) was a more likely and significant culprit. Baffes & Dennis, 2013 (World Bank)

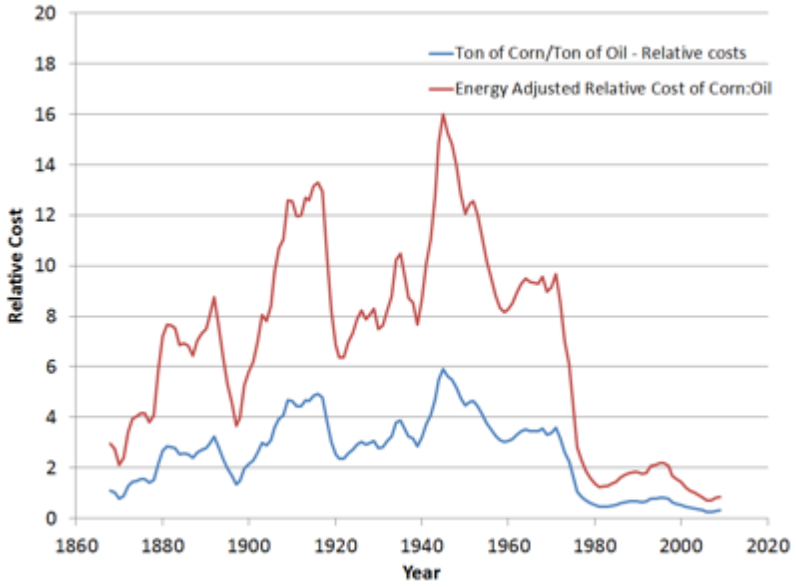
If so new thinking is urgently required about how to increase food crop production in light of increasing energy prices.

Rather than being a threat to food production, locally produced bioenergy might be a crucial supporting mechanism

Global food and oil price trends (1990 – 2010)
UNEP Global Environment Alert Service, April 2012



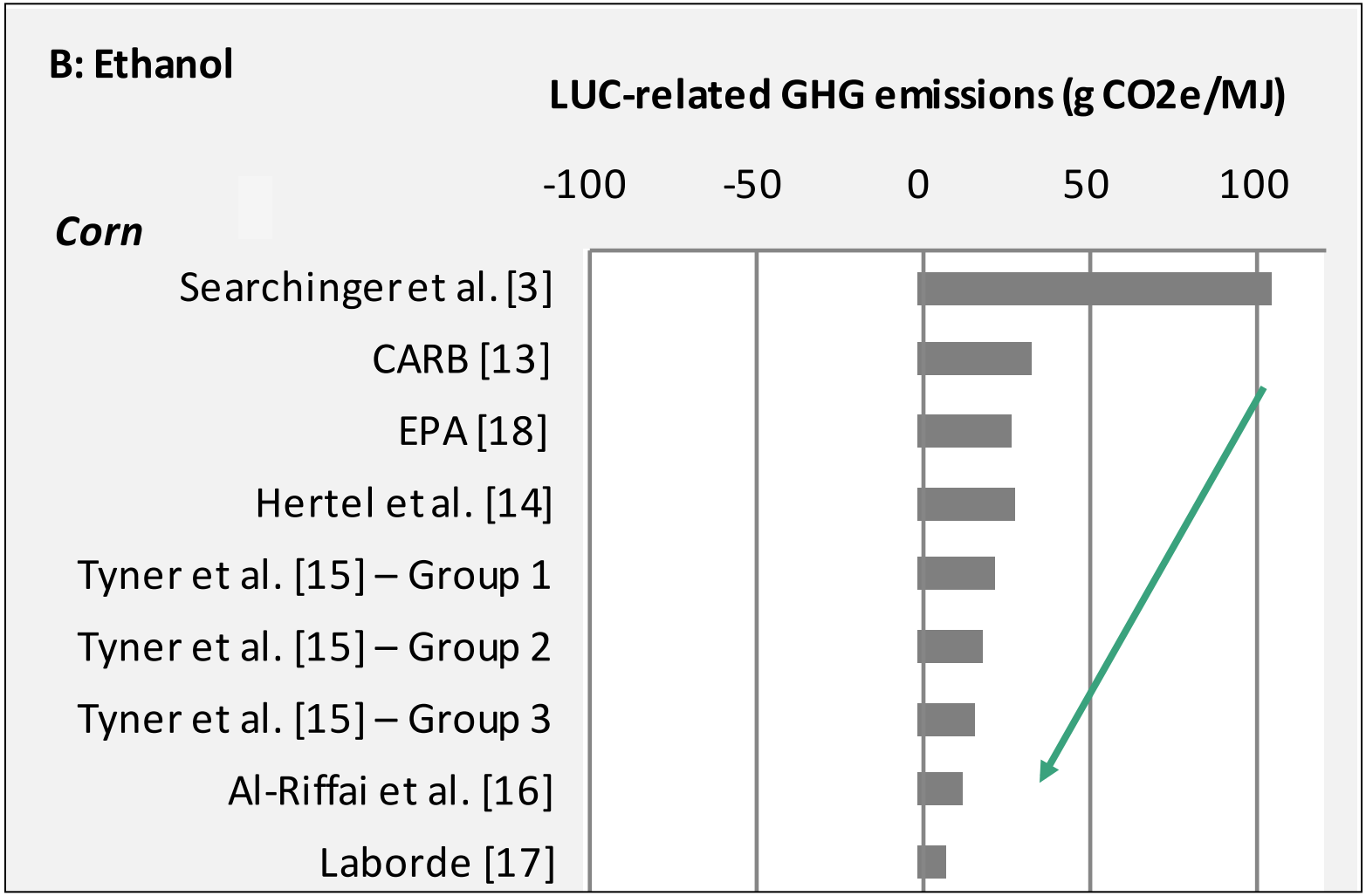
Biomass and sugars are increasingly competitive feedstocks – and are material at large scale (slide courtesy of John Pierce; 2013)



Very complex, sometimes competitive, sometimes symbiotic, relationships exist between bioenergy and agriculture. The net impact of bioenergy (particularly biofuels) is much disputed

A FUNDAMENTAL CHANGE OF PERSPECTIVE IS NEEDED

Example: Corn ethanol
Results from PE & CGE models



[Wicke et al., Biofuels, 2012]

Looking for indirect impacts in the US 'corn ethanol' program

- Cannot find competitive impacts of biofuels on cereal (or oilseed) production and trade in global data sets as predicted (and needed by) Indirect Land Use modelling
- Increased yields (rather than land area expansion dominate)
- For example, see:
  - US: Kim & Dale (2011), Oladosu et al (2011),
  - Brazil: Sousa and Macedo (2010), Seabra et al. (2011)
- Note the Zambian example mentioned above, (Jayne, GFS 2012)
- Indirect effects are largely invisible so far in the places they should be most visible!

Impacts of the US Corn Ethanol Program

Oladosu et al (2011)

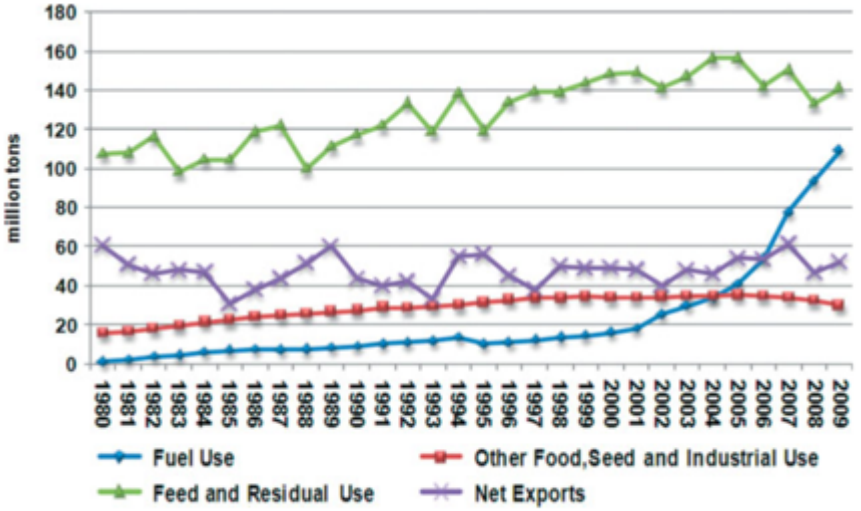


Figure 4. Patterns of corn uses in the United States: 1980–2009.

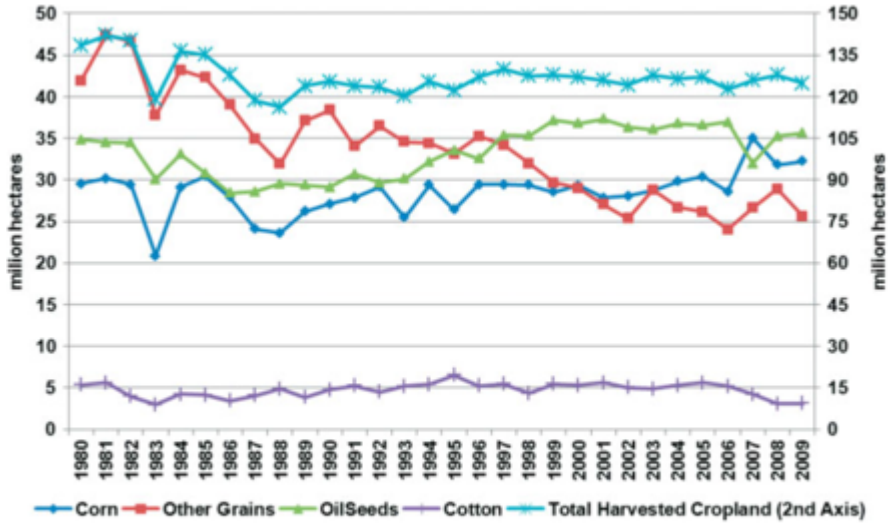


Figure 3. Cropland area harvested for major crops and total cropland harvested in the United States: 1980–2009.

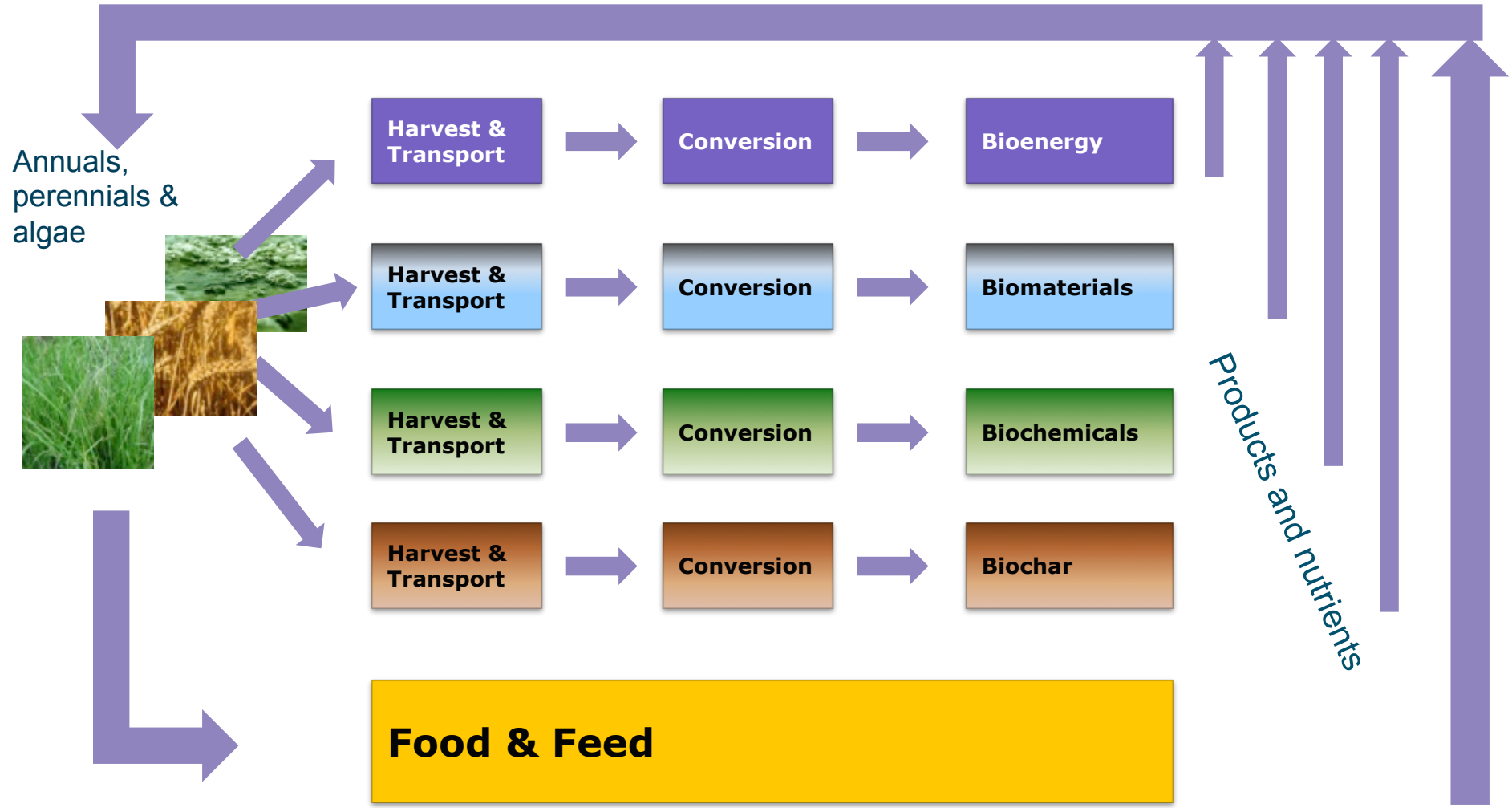
Four ways to expand biomass supply

1. **Increase the area of land used to grow biomass**
2. **Increase the yield of crops**
3. **Exploit 'waste'**
4. **Increase efficiency / resilience**

An integrated land management perspective and tools are urgently need that integrate social, economic and environmental dynamics on both supply and demand sides.

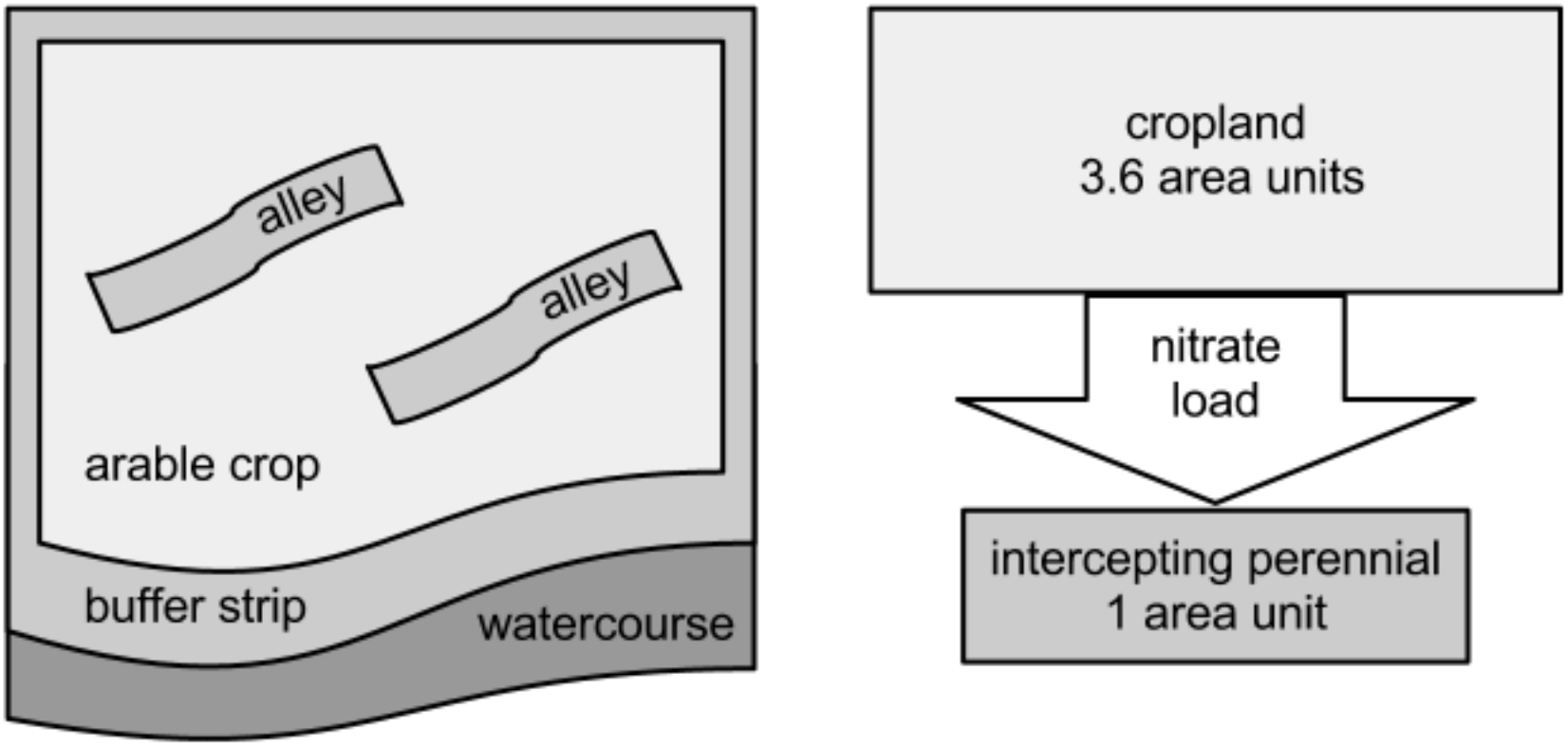
Most existing assessments focus on '1' or '2': in practice will be a combination of all four options:
E.g. Zambia, 2010, 2011 and 2012 (Jayne, GFS 2012):
'In 2010, 2011, the government of Zambia spent 2-3% of GDP stabilising food prices. In 2012, Zambia had a 1.5 million tonne maize surplus… however it only has the capacity to export 70k tonnes per month, taking 20 months to export the 1.5 million tonnes by which time most would be unsuitable for human consumption…'

Opportunities: Integrating Biomass supply chains (food + non-food) adds flexibility, efficiency, resilience and reduces waste



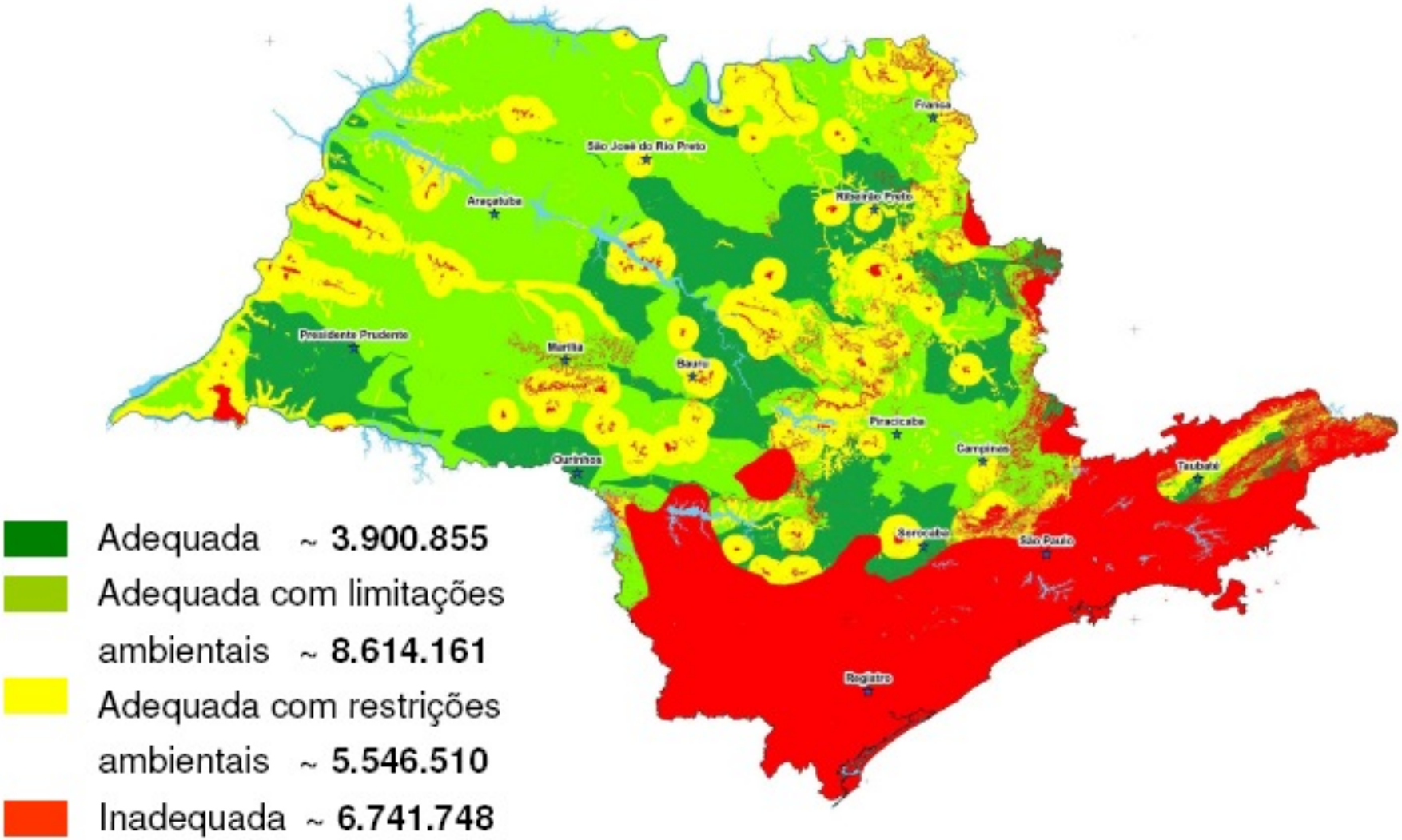
ADMIT Biorenewables, 2012 (www.climate-kic.org)

How could bioenergy systems be deployed to close the Nitrogen cycle in the UK?



Alongi Skenhall, S., Berndes, G., and Woods, J. (2013), Integration of bioenergy systems into UK agriculture - new options for management of nitrogen flows. *Biomass and Bioenergy* 54:219-226. Doi: j.biombioe.2013.04.002

Zoneamento Agroambiental para o Setor Sucroalcooleiro do Estado de São Paulo



Conclusions

- **Food security: investment urgently needed in energy service provision into agriculture – bioenergy can be an enabler for food security (Lynd & Woods, A new hope for Africa. *Nature;* 2011)**
- **'Sustainable Intensification' = New tools + perspective urgently needed to enable farmers to manage land sustainably.**
- **Agricultural landscape integration is a major opportunity for innovative farming and new markets in both Developed and Developing countries.**
  - **How translatable are Brazilian agri-developments, sugarcane ethanol (plus CHP) and Integrated crop–livestock zero tillage systems (ICLZT; Landers, FAO, 2007), to Latin American (Columbia and Guatamala) and African (Mozambique and South Africa) contexts?**
- **The linked LACAf and GSB projects are developing integrated modelling (spatially explicit bio-physical / environmental, economic and social methodologies and models**
- **Instead of seeing bioenergy as a threat it needs to be developed and implemented firstly as a tool to solve the fundamental problems with intensified food production whilst acknowledging its intrinsic importance in energy and climate security**

Thank You

My research group: Nicole Kalas, Alexandre Strapasson, Mireille Rack, Rembrandt Koppelaar
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The Economist, 24th June 2010

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