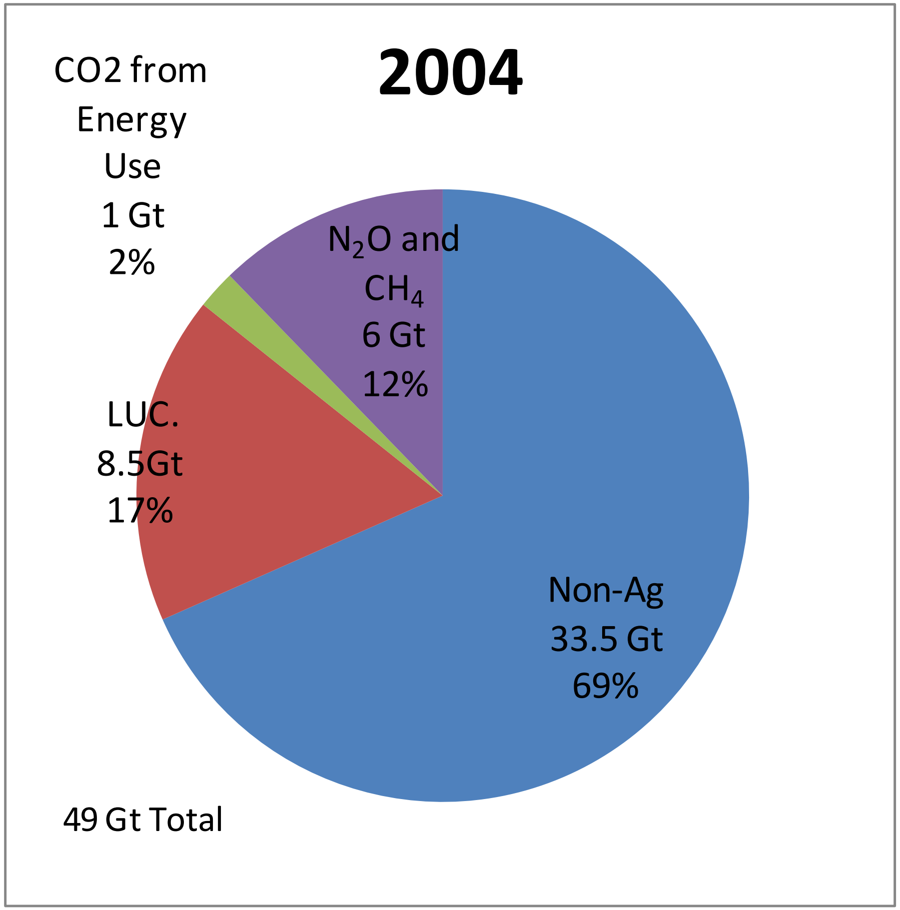
THE FOOD/FOREST CHALLENGE

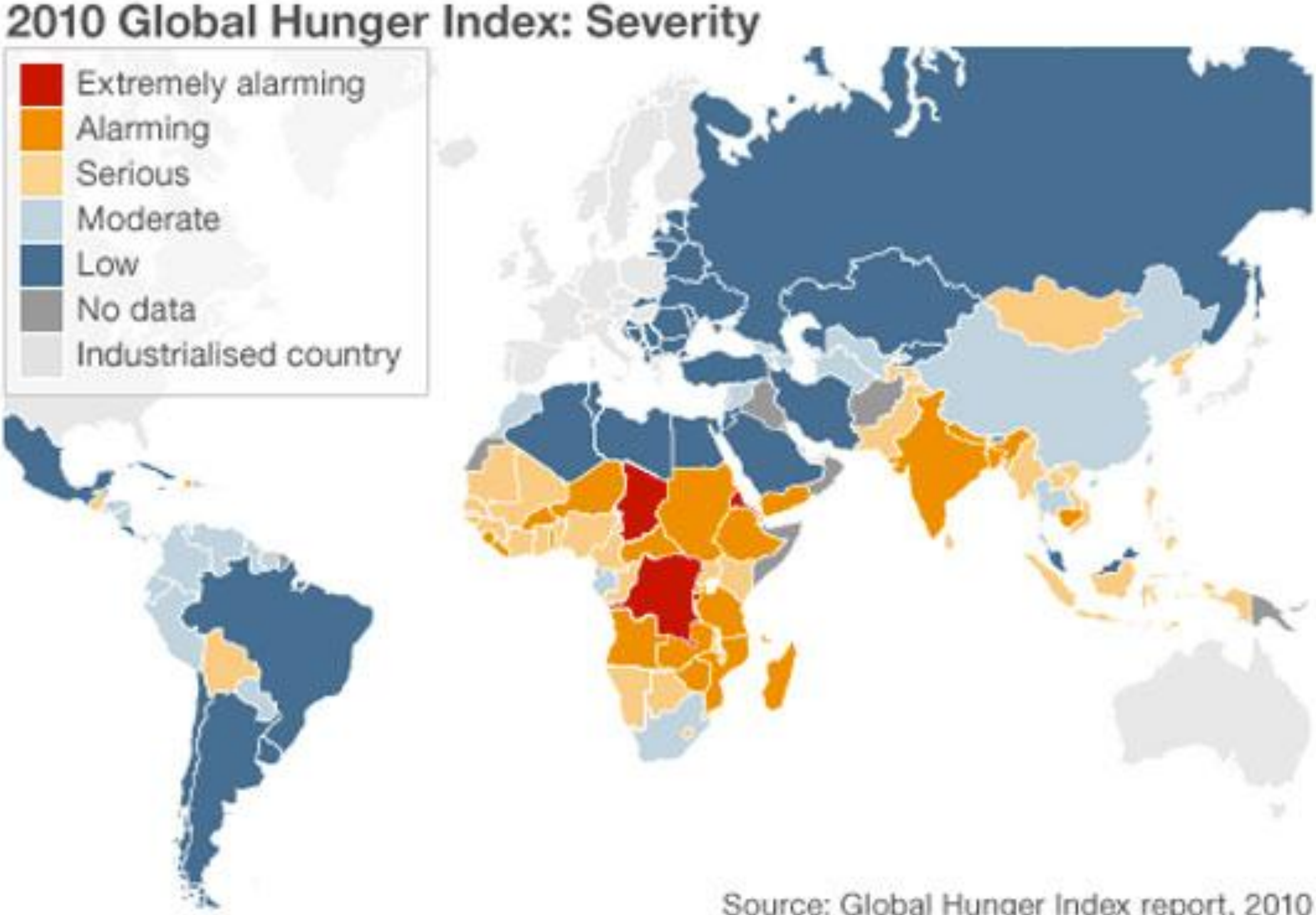
Presentation by: Tim Searchinger, Princeton University, tsearchi@princeton.edu

IPCC 2007: Ag & LUC Contribution to World Greenhouse Gases ~ 30%



- Nitrous oxide – livestock manure/urine, fertilizer, biomass burning
- Methane – livestock (enteric), manure, rice biomass burning
- Energy – fertilizer, machinery,irrigation
- 13 million acres/yr gross deforestation

(IPCC 2007; Bellarby 2008 , in CO_2 eq.)



IFPRI Analysis

Gross Forest Growth and Regrowth Sequesters 14.5 Tonnes of Carbon Dioxide Per Year

(Pan, Science 2011)

Control Supply v. Control Demand

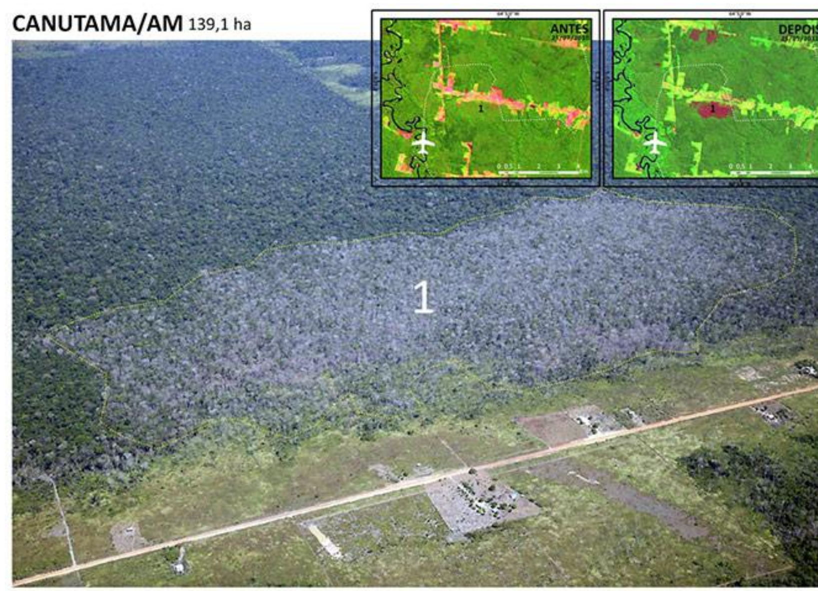
Supply Factors & Strategies

- Roads, concessions, certain kinds of research
- Tougher forest laws
- Fewer concessions
- Payments to protect forests
- Limited road access & preservation of areas along roads
- Prohibitions on purchases from newly cleared land

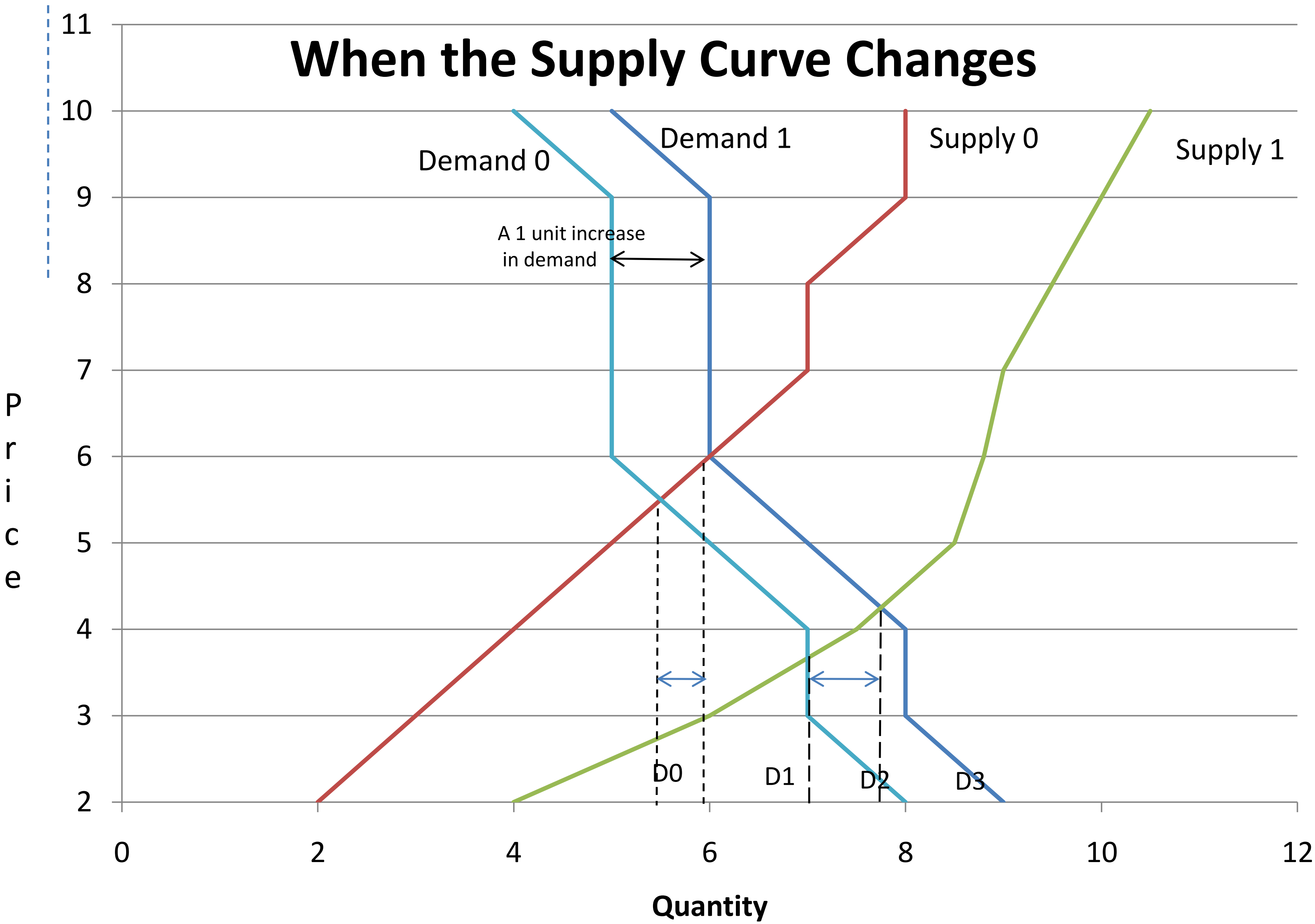
Demand Factors & Strategies

- Reduce population
- Limit meat & other proteins
- Yield gains
- Use of underproductive lands
- Limit biofuel demand

v.



Supply and Demand Both Count



Global Demand Factors Affect Land Use Change Even When Cropland is Shifting

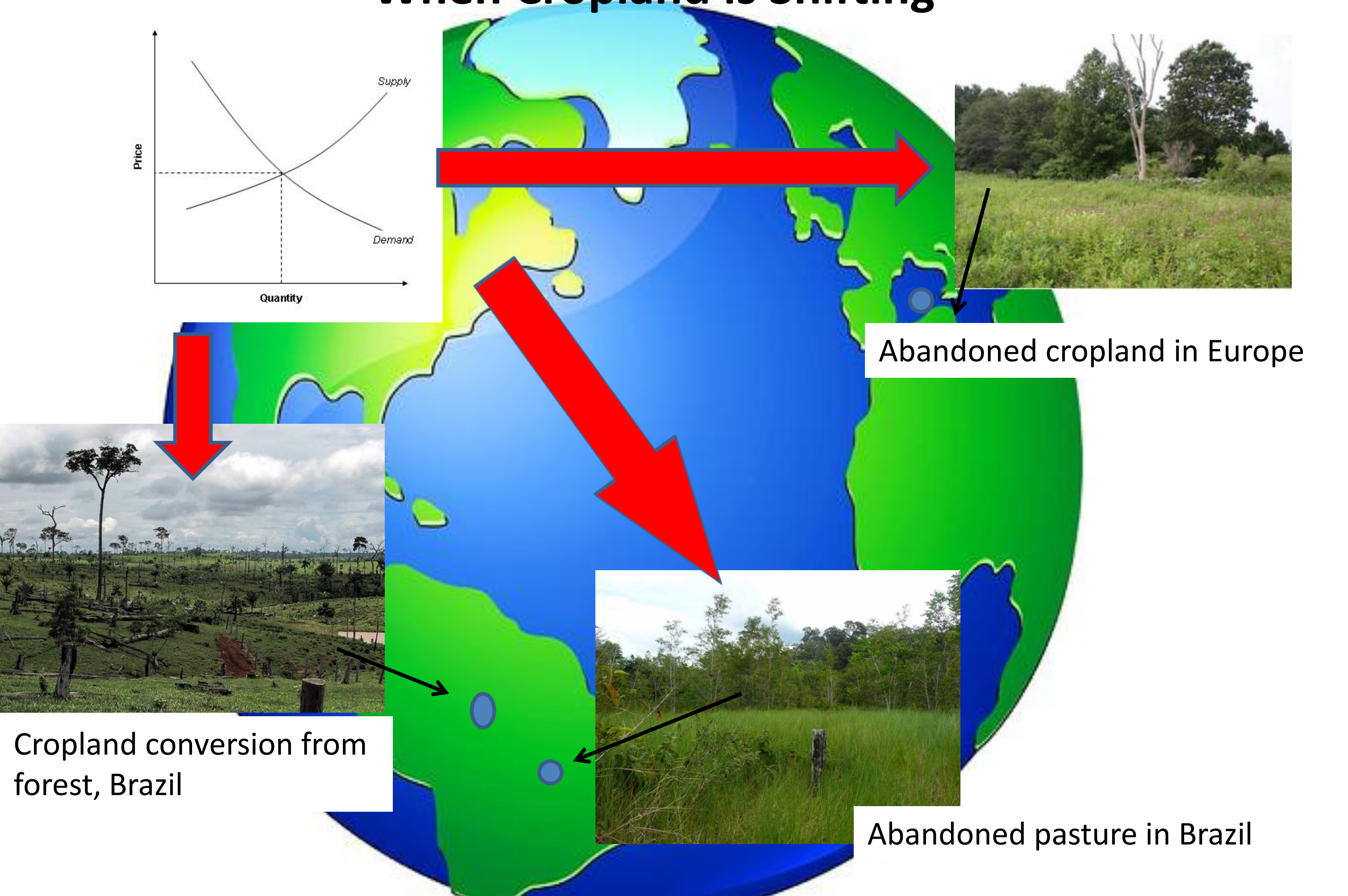
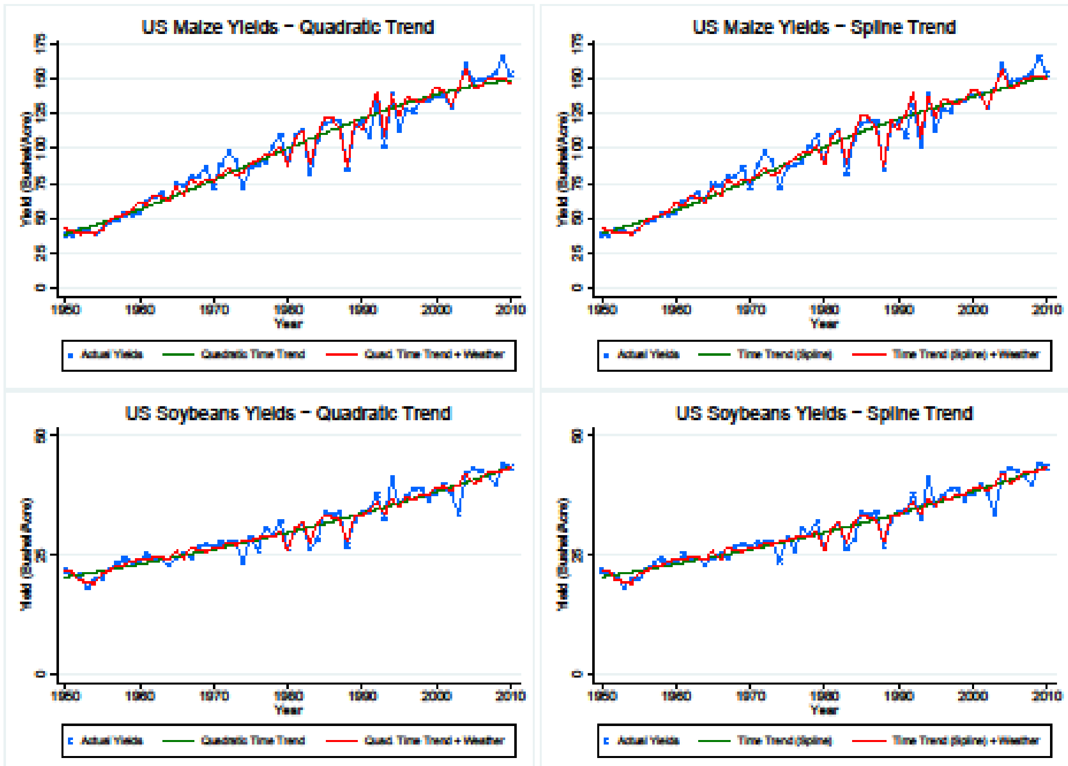


Figure 1: US Maize and Soybean Yields



Notes: Figure displays actual yields (blue), a time trend (green) as well as yield predictions (red) from a model using the same weather variables as in Table ?? and Table ??. The top row displays the results for maize, the bottom for soybeans. The left column uses a quadratic time trend, while the right column uses restricted cubic splines with 3 knots.

From Berry & Schlenker 2011 (in press)

Indonesia/Malaysia Forested Peatlands

Yale environment360
Opinion, Analysis, Reporting & Debate

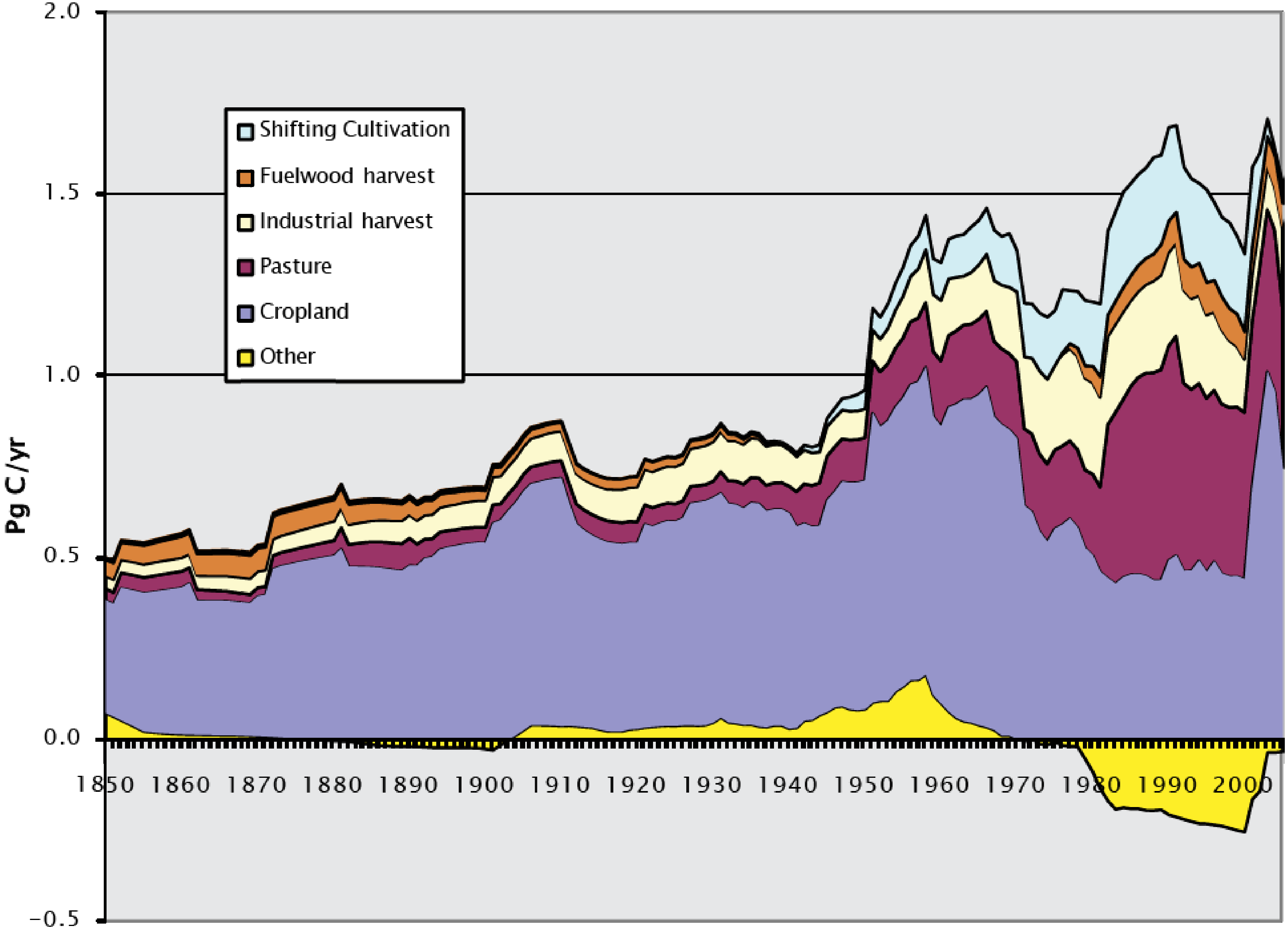
Agribusiness Boom Threatens Key African Wildlife Migration

(March 7, 2011)

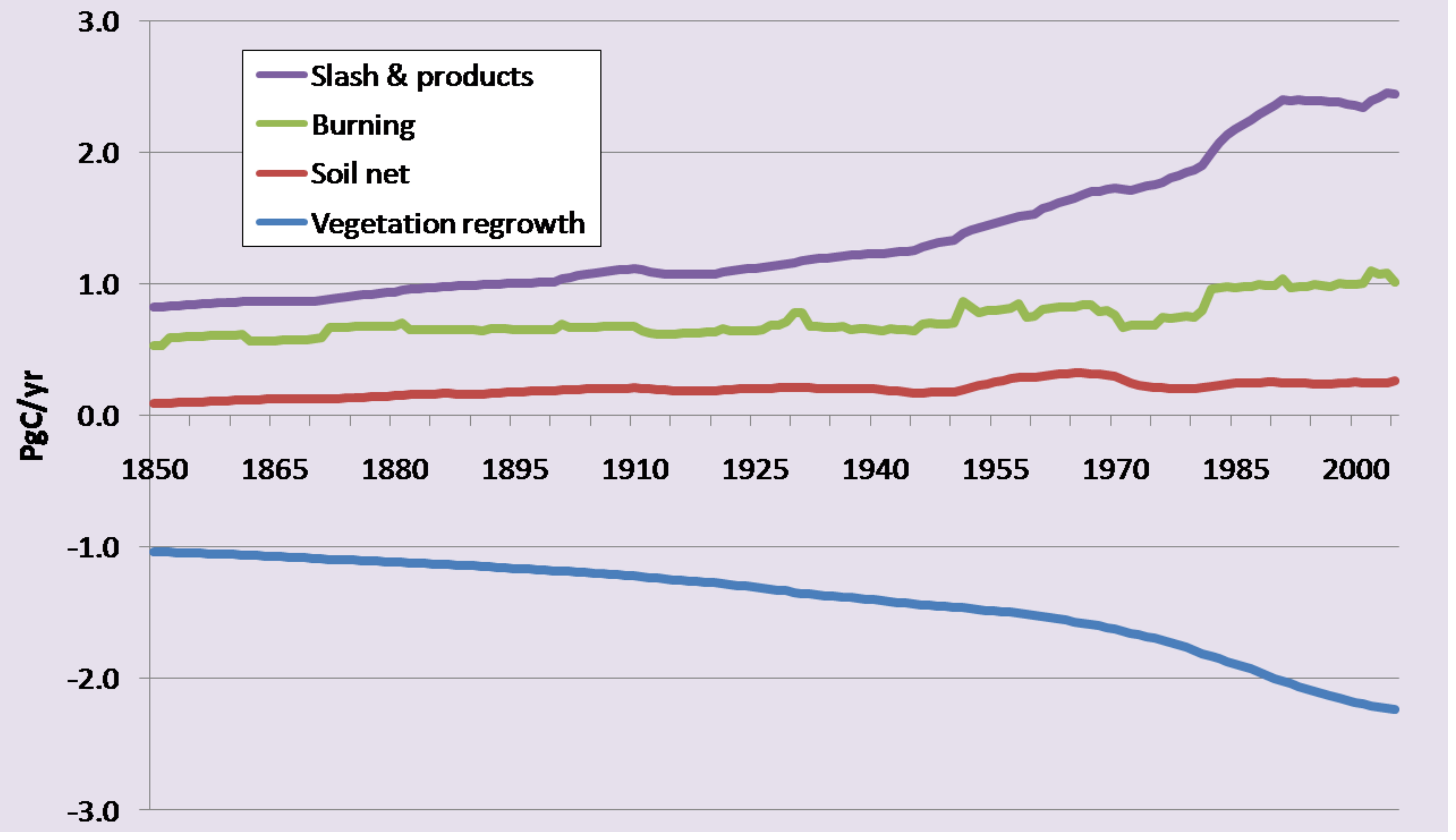
World Bank, Awakening the Sleeping Giant (2008)?

Zambian Miombo Woodlands

Net flux by type of land use



Components of the land-use flux



R.E. Houghton

Consequences of Netting

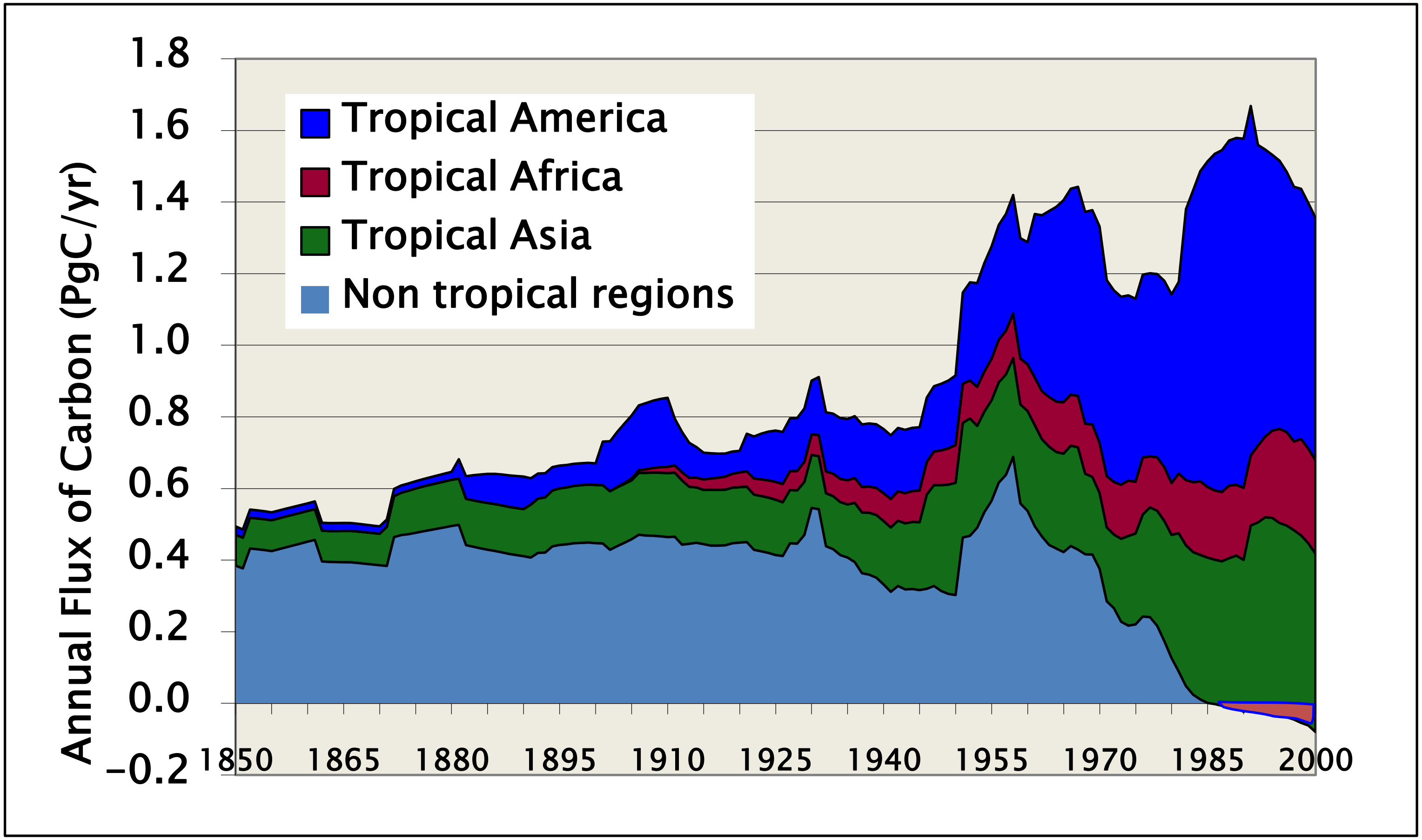
- Underestimates LUC from tropical deforestation

- Diverts attention

from

  – Logging
  – Developed and transitional countries
  – Carbon sink

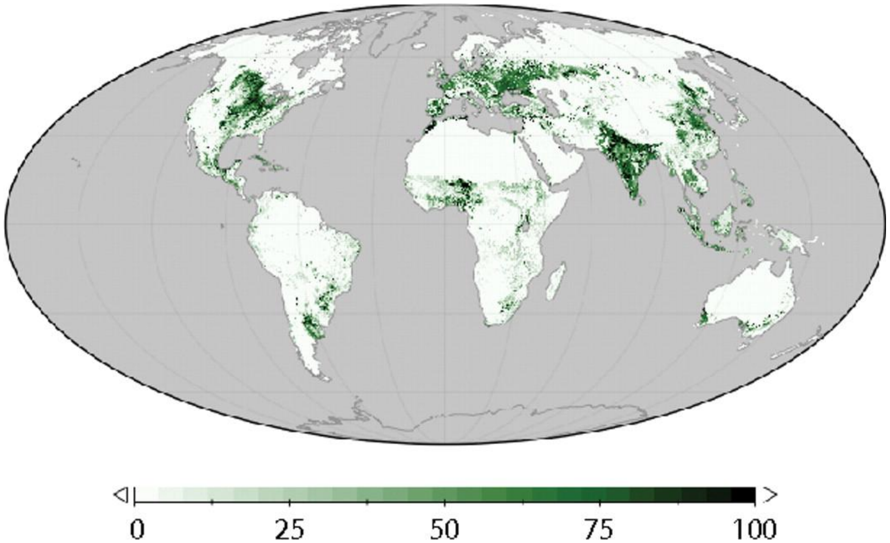
Net flux by region



	Tropics	Non-tropics
Long term	60%	40%
1990s	100%	0%

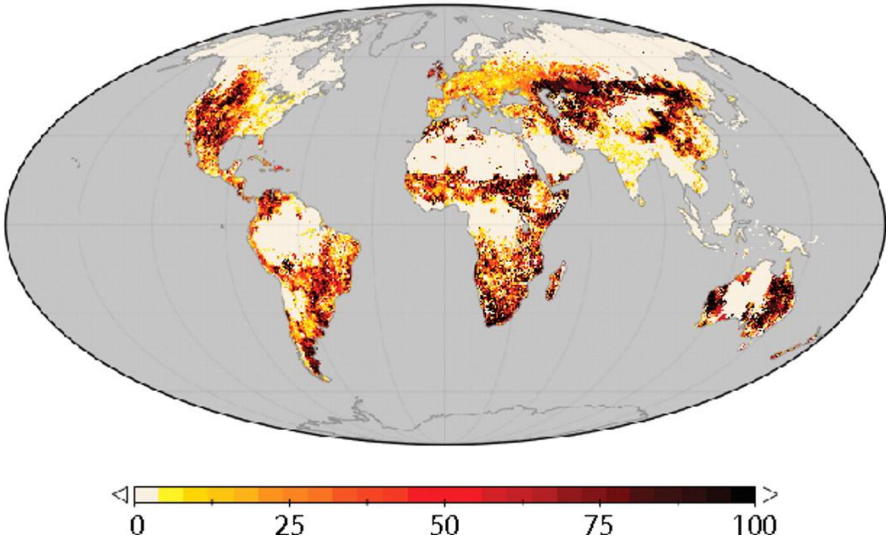
Courtesy of R.E. Houghton

Can We Avoid Land Use Change for Food?



Croplands

Agriculture occupies 45% of ice and desert free surface



Grazing lands

Foley J A et al. PNAS 2007;104:12585-12586

Some Projections to Feed World by 2050

Globiom

- 266 million additional hectares cropland
- 121 million hectares grassland
- 343 million hectares decline unmanaged forest (offset by 103 million hectares of plantations)
- 168 million hectare decline "other" natural vegetation

FAO

- 120 million hectares increase in cropland in tropics
- 50 million hectare decrease in developed countries
- Effective increase of 93 million hectares through higher cropping intensity

Change in Rate of Worldwide Yield Growth Projected by FAO

Crop	Annual Yield Growth 1961/63 to 2005/07 (in kilograms/ha/year)	Projected Yield Increases 2005/07 to 2050 (in kilograms/ha/yer)	Rate of Increase by Comparison with Prior Rate
Wheat	36	23	64%
Rice	48	27	56%
Maize	62	30	48%
Soybeans	26	31	119%
Barley	23	18	78%
Pulses	6	10	167%

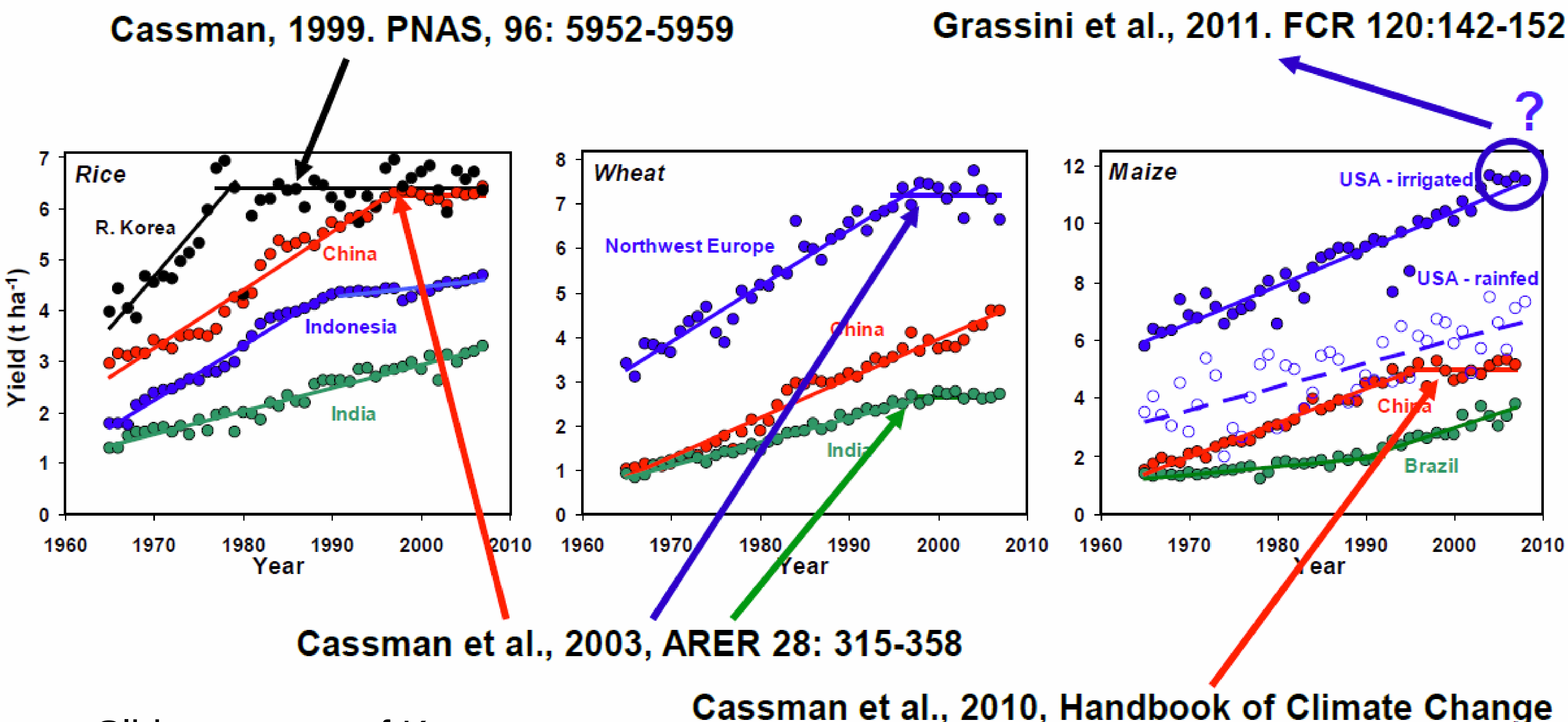
Source: Bruinsma, The Resource Outlook to 2050 (FAO 2009), Table 11

Change in Rate of Yield Growth Needed to Avoid Any Cropland Increase

	Yield Growth/y 61/63 to 05/07	Needed Yield Growth/y to 2050	Change in Rate
All cereals	**42**	**27**	**65%**
Soybeans	**26**	**71**	**275%**

WHY SLOWER YIELD GROWTH?

Yield plateaus are evident for several cereal crops in some major producing countries: Korea and China for rice, wheat in northwest Europe and India, maize in China and……..perhaps also for irrigated maize in the USA.

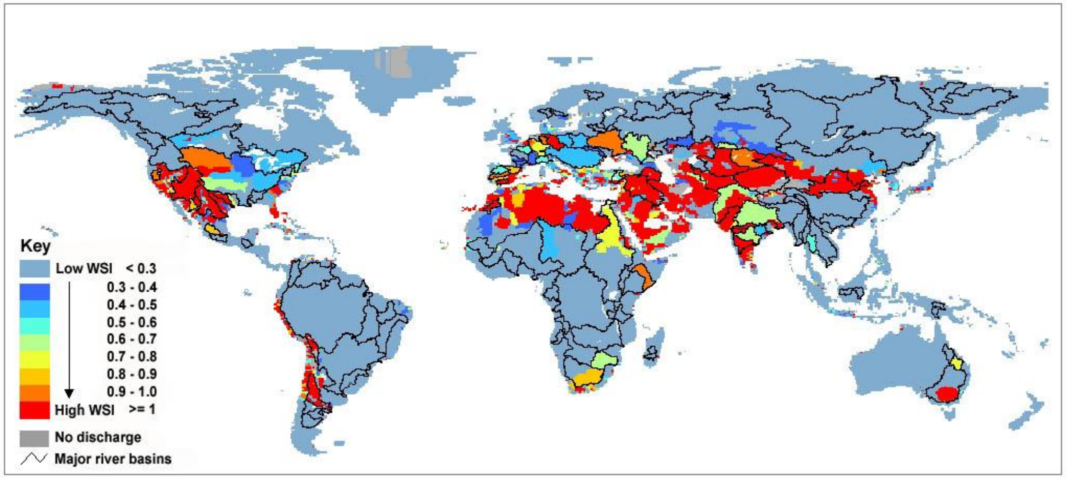


Slide courtesy of K. Cassman

Irrigation

Irrigation growth decline (from ‘61 to ’05 increased from ~120 to ~240 hectares but projected to increase only by 33 hectares by 2050)

Areas of Water Stress (IIASA)



Feeding Sub-Saharan Africa in 2050:

Population growth from 856 million in 2010 to 1.96 billion (medium estimate UN)

	Current	2050 - Current consumption and % of Imports	2050 - FAO projection & self-sufficient production (2830 kcal)
Cropland needed at current yields for domestic food consumption (hectares)	**154 million**	**357 million**	**488 million**
Cereal yield needed to avoid new land clearing	**1.23 t/ha**	**2.81 t/ha**	**4.33 t/ha**

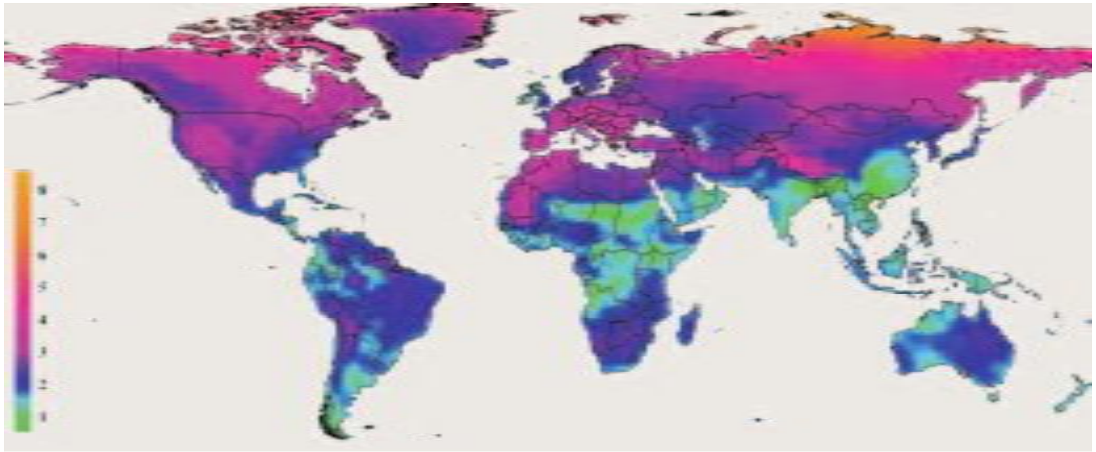
FAO Cropland Increase 74 million ha; Globiom 182.5 million ha

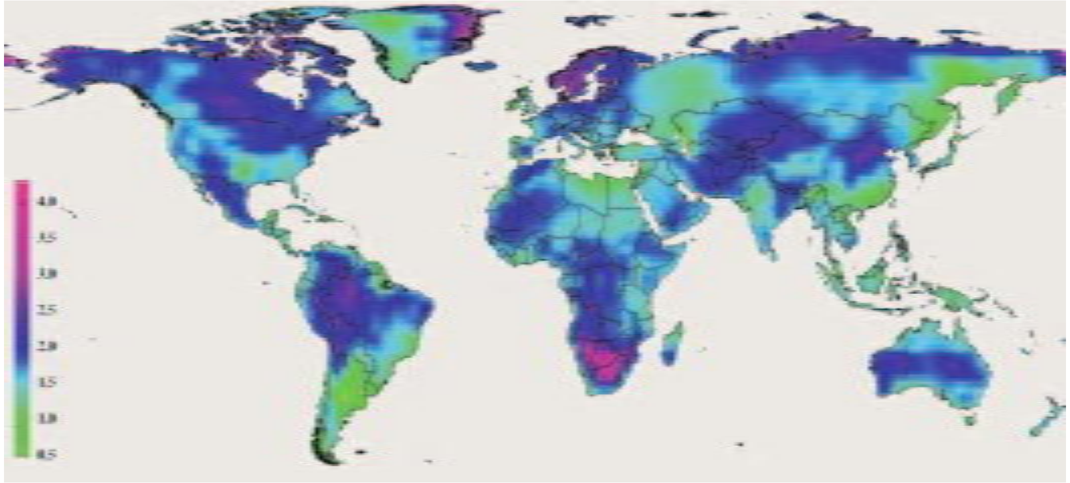
Impacts on Yields of Climate Change Itself

Change in average maximum temperature (oC), 2000–2050 top is CSIRO; bottom is NCAR

Nelson et al., Climate Change Impact on Agriculture (IFPRI 2009)

With no crop fertilization effect , by 2050:
–rice yields decline by 14 – 18% in developing countries
- Irrigated wheat declines 28-34%





Additional Land Demands

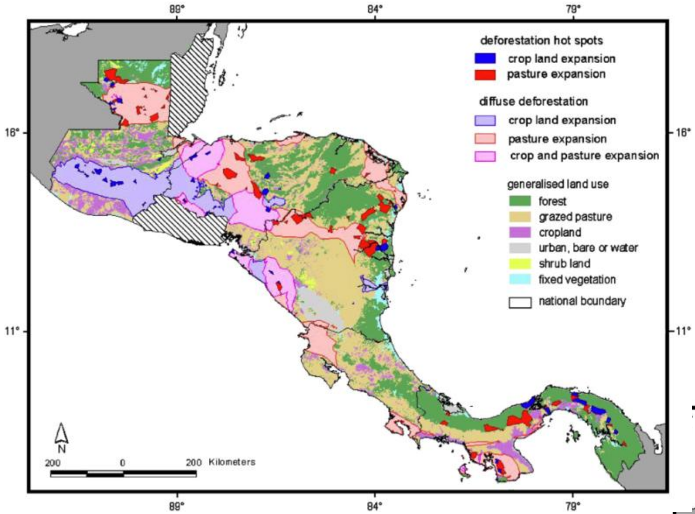
- 100 million hectares of agricultural loss to urban expansion (FAO 2002)
- Demand for industrial use
- Saw timber growth 1.4% per year (72% by 2050) & 3% paper

(Smith 2010)

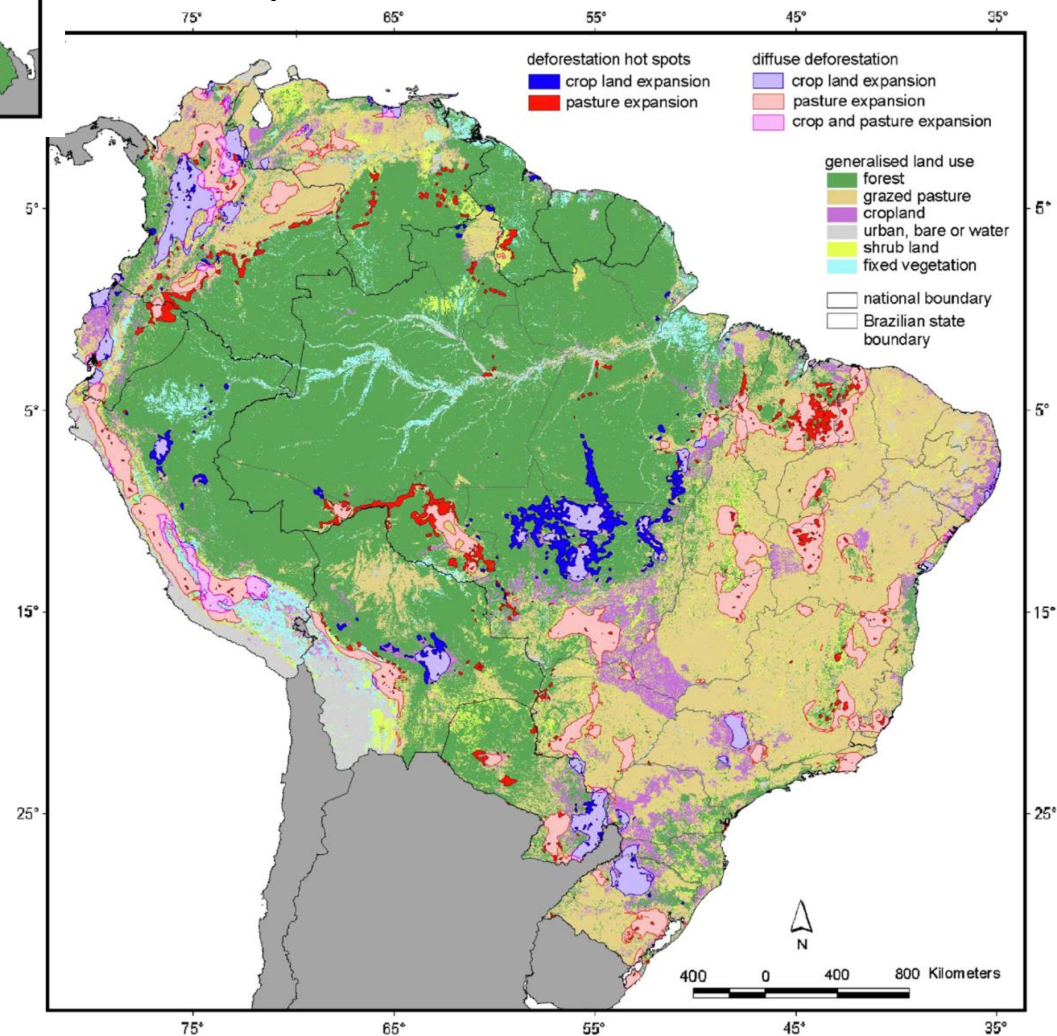
- Potential high pop.

of 10.6 billion (UN)

Pasture Expansion



FAO: Net cropland increase
1961-2005 = 166,000 hectares
Net pasture increase = 295,000



Predicted 2000-2010
Pasture
& Cropland Expansion
in Latin America

Wassenaar et al., Global Env. Change 17:86-104 (2007)

One Lesson: Be Prudent

Bioenergy is a form of land-based carbon offset

Land grows plants whether for bioenergy or not:

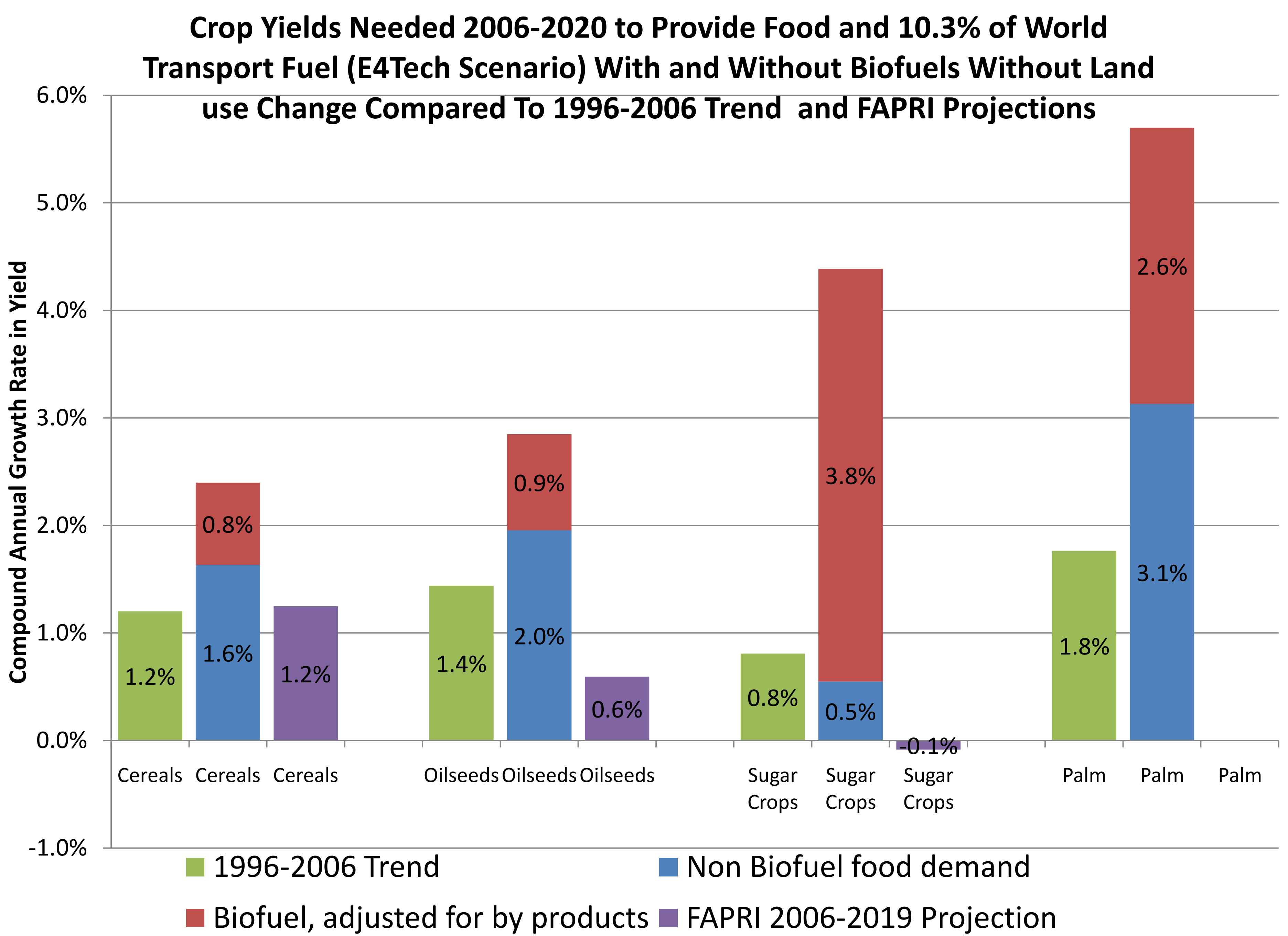
* forest
* food

Only ADDITIONAL plant growth helps or REDUCED other emissions

Importance of Food Consumption Reduction in LCAs for Biofuels

Model and Type of Ethanol	*Food Consumption Reduction (exclusive of by-products), CO_2 savings from reduced respiration and % of gasoline emissions*
GTAP US Maize	**52% = 56 g/MJ =67%**
Impact US Maize	**36% = 39 g/MJ = 47%**
IMPACT EU Wheat	**47% = 50 g/MJ = 60%**
FAPRI CARD EU Wheat	**34% = 36 g/MJ = 43%**
GTAP EU Wheat	**46% = 49 g/MJ = 59%**

from JRC 2010



Crop Yields Needed 2006-2020 to Provide Food and 10.3% of World Transport Fuel (E4Tech Scenario) With and Without Biofuels Without Land use Change Compared To 1996-2006 Trend and FAPRI Projections
Compound Annual Growth Rate in Yield
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
-1.0%
1.2%
1.6%
0.8%
1.2%
1.4%
2.0%
0.9%
0.6%
0.8%
0.5%
3.8%
-0.1%
1.8%
3.1%
2.6%
Cereals
Cereals
Cereals
Oilseeds
Oilseeds
Oilseeds
Sugar Crops
Sugar Crops
Sugar Crops
Palm
Palm
Palm
1996-2006 Trend
Non Biofuel food demand
Biofuel, adjusted for by products
FAPRI 2006-2019 Projection

Large Bioenergy Potential Studies

- Most potential arable land – IPCC 2007 chapter 8 - 1.3billion hectares and/or
- All forest growth in excess of harvest (Smeets 2008)and/or
- All "abandoned" cropland (Hoodwijk 2005) and/or
- Hundreds of millions of hectares of "grazing" or "other" land – savannah (Fischer 2001; Smith 2007)

Recounts existing forest, forest re-growth, net terrestrial carbon sink, land counted for grazing

To produce 20% of world energy demand by 2050 (IEA target), world would have to potentially double harvest of plant material

World Plant Harvest Today – from Haberl, European Environmental Agency Presentation (October, 2010) (below) (energy content of biomass converted from biomass use quantities in Haberl et al., PNAS (2007))

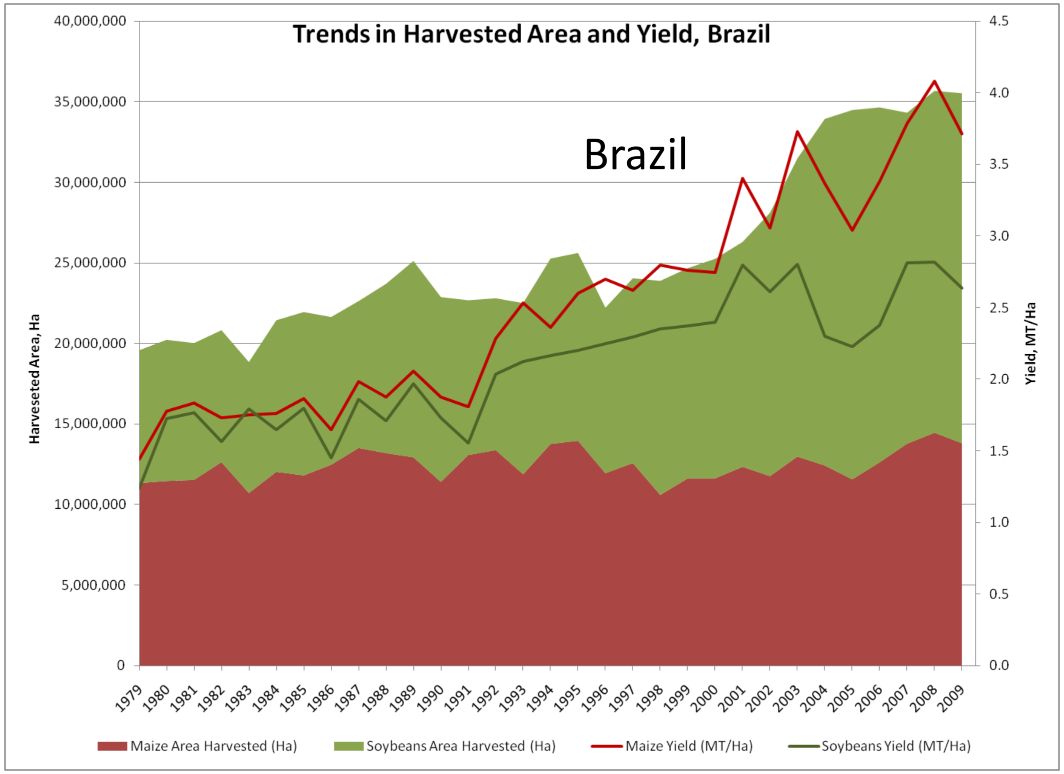
Above-ground biomass production (NPP) -	Exajoules/year
Natural vegetation	1,309
Human-induced reduction	68
Current total	1,241
Human harvest (2000)	
Primary crops	64
Harvested crop residues	54
Biomass grazed	71
Wood removals (FAO)	36
Possible uncounted fueld wood	*12*
Total	***225-237***

Do Higher Yields Spare Forests?

Borlaug

v.

Angelsen & Kaimowitz



*Ewers , Gl. Ch. Bio. (2008)
* Rudel PNAS (2009)

Why Might Yield Gains Not Spare Lands

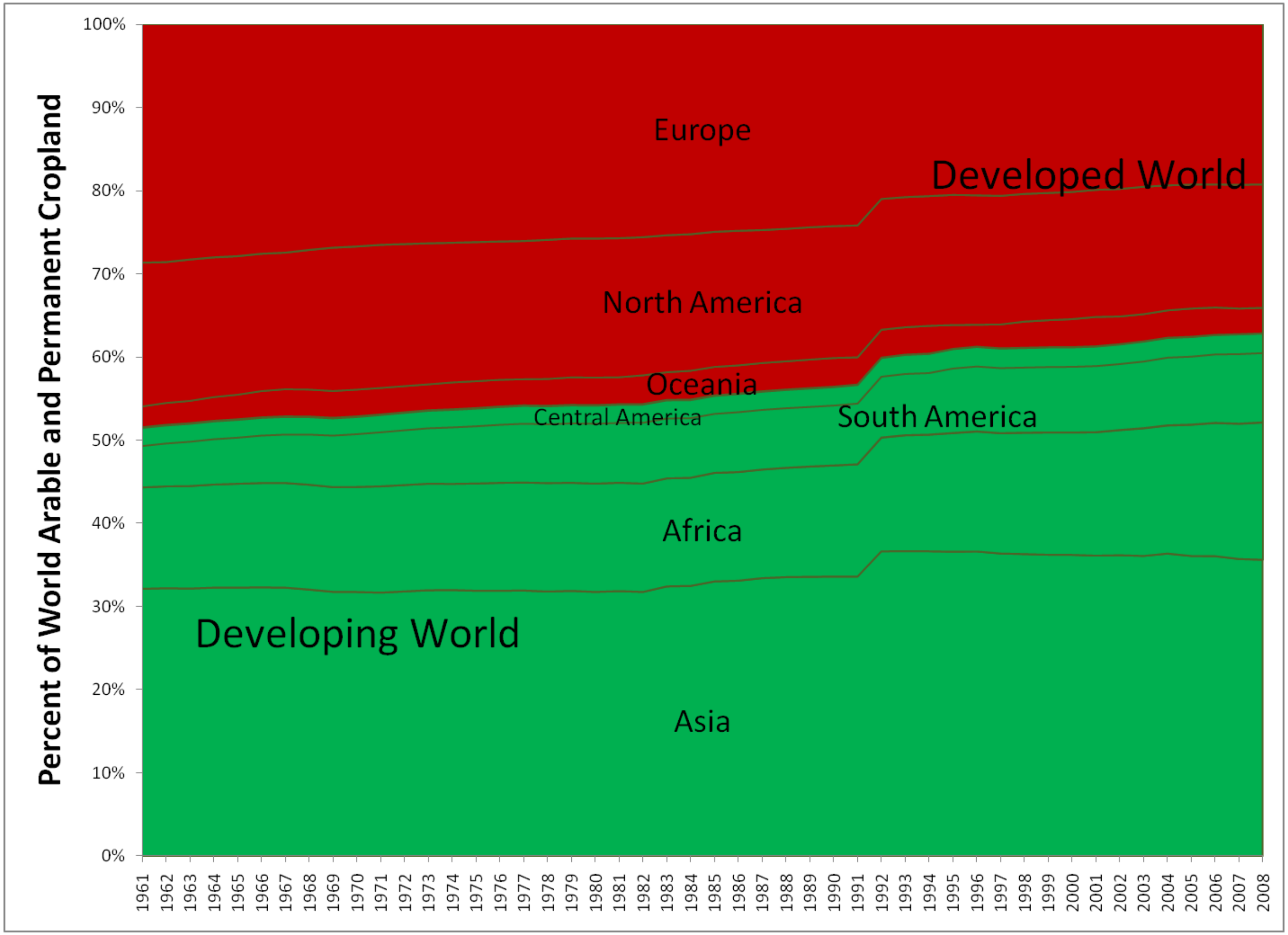
- Socieconomic Factors – Labor Displacement
- Capital
- Demand Increases

Are yield gains likely to increase demand enough to wipe out land savings?

	Rent as share of cost of production (USDA ERS Crop Budgets)	Elasticity of Demand for cereal calories from Roberts & Schlenker 2010	Increased demand assuming only cost reduction from yield gain alone
Maize	24.5%	-.01	2.5%
Soybeans	36%	-.01	3.6%
Wheat	21%	-.01	2.1%
Tomatoes	4%	-	

But note: Productivity gains can reduce costs in ways that are additional to yield gains and land savings

Big Issue: Global v. Local Land Savings



All efficient use is good

- Whatever the use
- When is changing use good?
  - Carbon efficiency index?

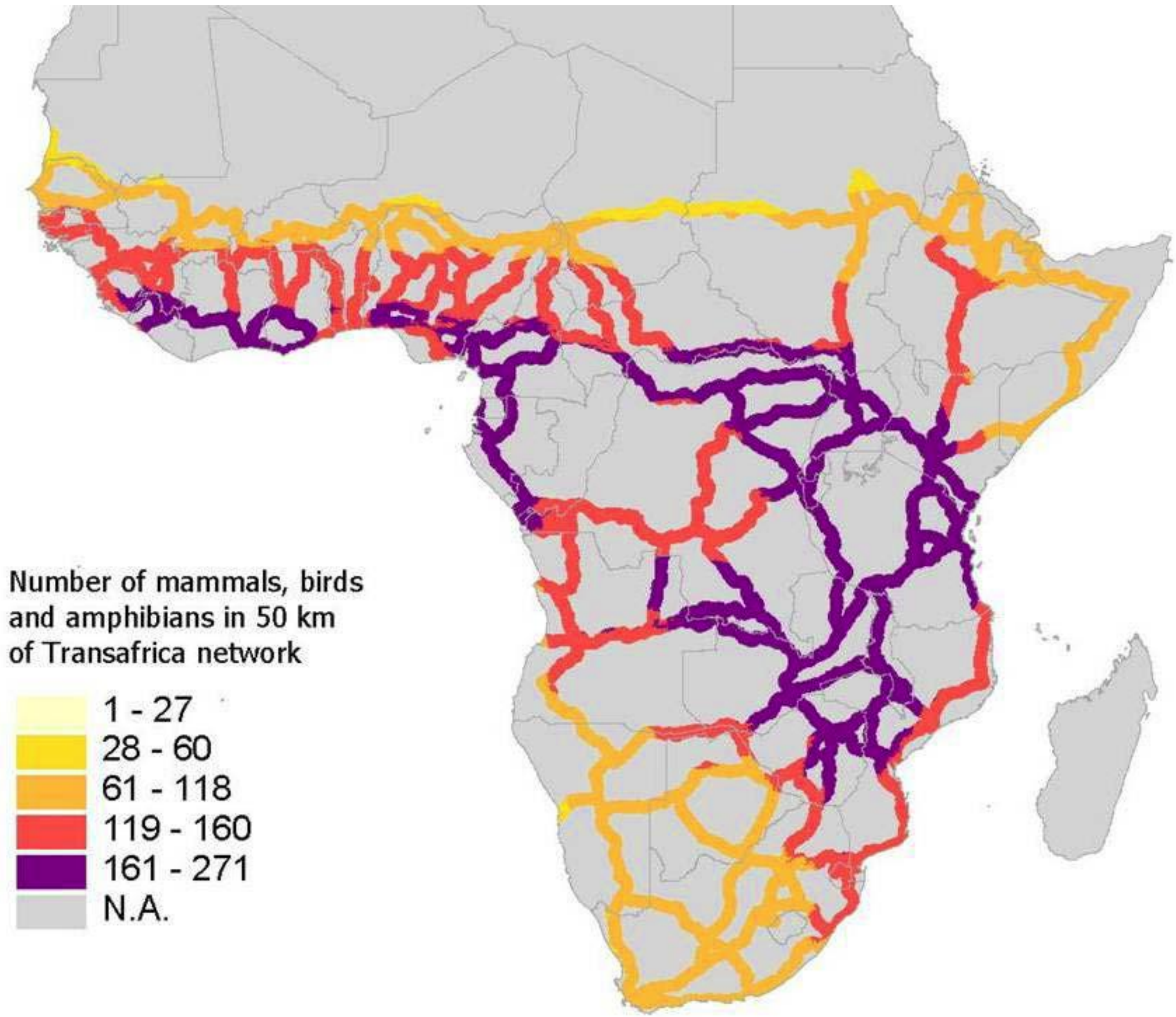
All Demand and Land Shifts Count

- Wetlands and savannas
- Biofuels
- Timber products demand
  - How to hold down demand
  - How best to satisfy demand
- Worldwide gross land use change

Africa

- Focus domestic use of staple crops; export tropical crops
- Enhance yields from existing farmland and existing farmers
- Focus yield improvement on shifting agriculture

Sub-Saharan Africa Road Network Suggested by World Bank Study (Buys 2006)

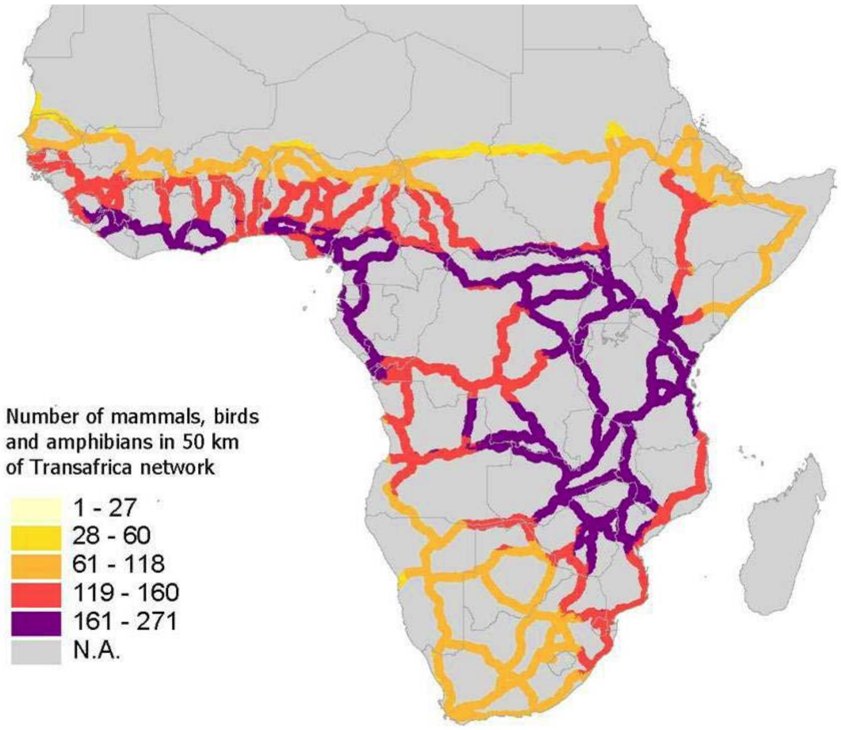


Fix the Accounting Errors

- Bioenergy
- Forest carbon sink

REDD

- Integrate REDD with yield gains
- Preserve areas along transportation corridors



Sub-Saharan Africa Road Network Suggested by World Bank Study (Buys 2006)

Underutilized land

- Intensify wet tropical forest pasture
- Imperata grasslands
- Unutilized "arable" land

Roundtables & Purchasing Standards

- Not just what you don’t use but what you use
- Intensification/efficiency goals

Research Needs

- Carbon efficiency index
- Pasture intensification opportunities
- Benchmarks for meeting demands without natural area conversion
  - Yield gains, different livestock growth and feeding efficiency, pasture intensifcation, use of "degraded" lands, non-food demands
- Better understand unutilized "arable" land
- Identify ideal African conversion lands