Land Cover Types Subgroup Preliminary Recommendations

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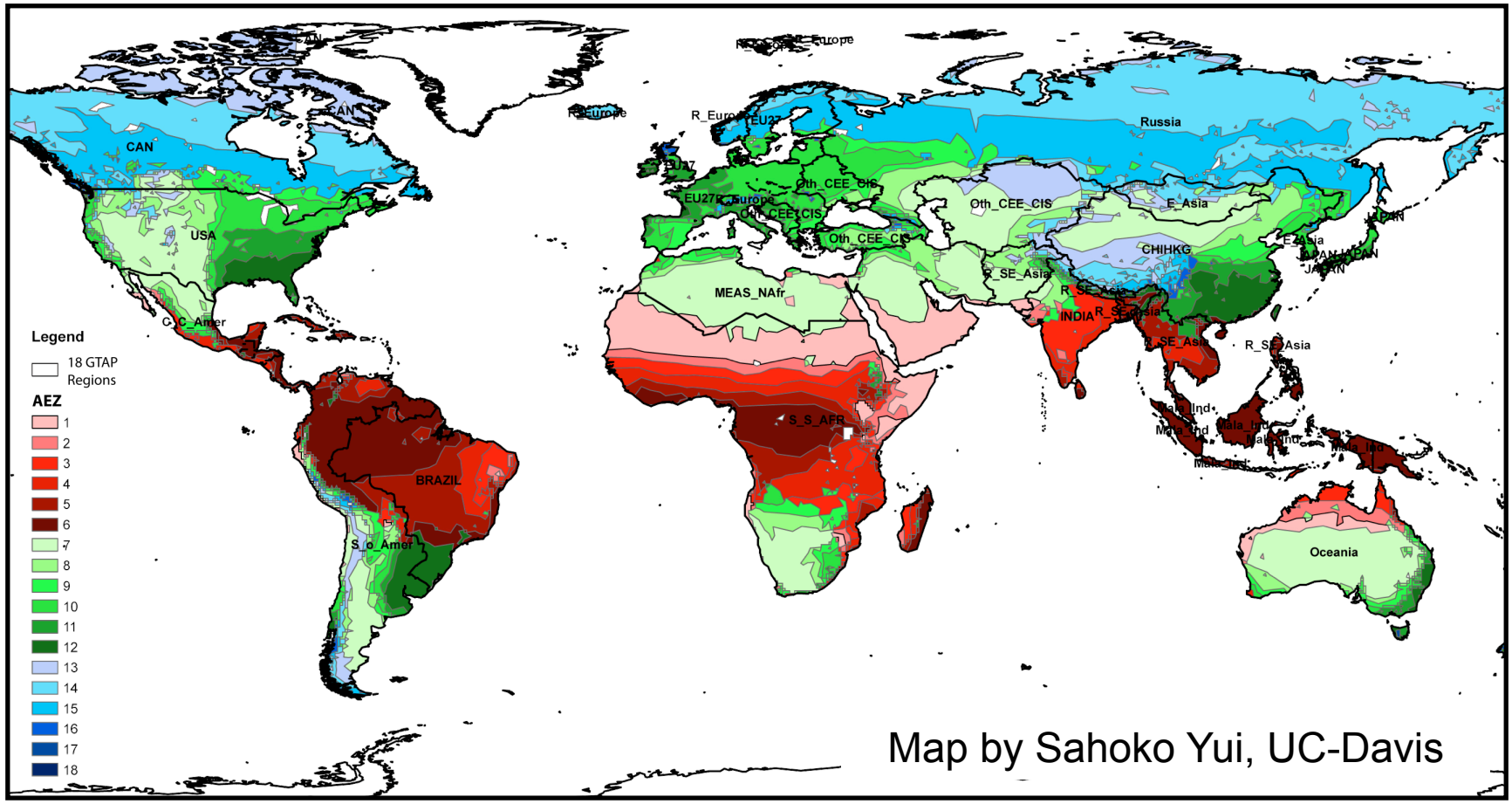
Focus on Land Conversion Issues

- ***How much land is needed? (JS)***
  - Yields of newly converted lands
- ***What types of lands are available in GTAP*? (HG)**
  - Existing land pools
  - Unmanaged lands & Inaccessible forests
  - Adding new land pools
- ***What types of land are converted*? (HG)**
  - CET Function
  - Ecosystem types & alternative data sources
- ***Environmental quality of land & conversions (RN)***
  - Improving marginal lands with cultivation
  - Defining marginal lands & related issues

GTAP Spatial Resolution



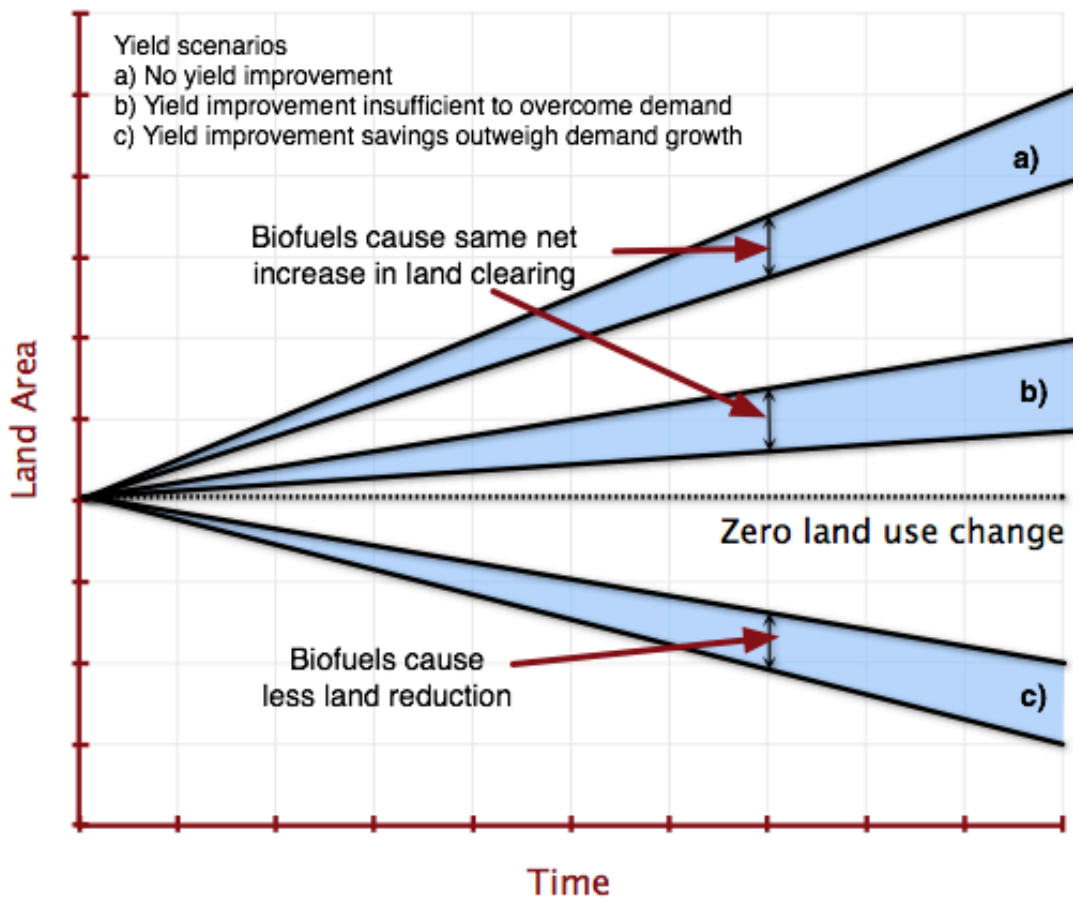
Coarse spatial resolution but reasonable because many regions have limited LUC data

How much land is needed?

- Yield across agriculture has a huge effect on the amount of new land required to support biofuels
- In the original analysis supporting estimates of indirect land use change's contribution to biofuels' carbon intensity, a number of simplifying assumptions have been made
- These assumptions fall into two categories—1) general agricultural yield trends, 2) yield on new versus existing land

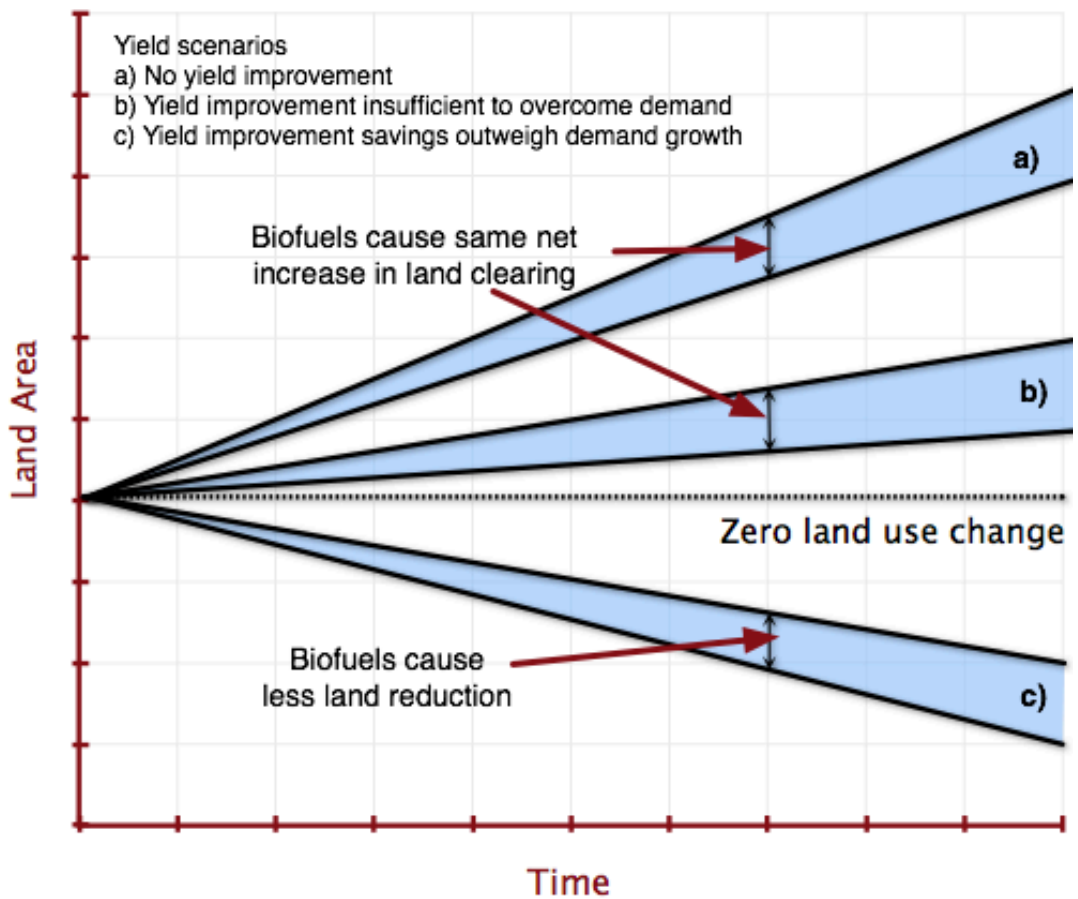
Yield trends as a background effect

- When demand outstrips yield savings, additional, yield has no effect on net clearing
- When yield savings outstrip demand, biofuels effect becomes an opportunity cost instead of a land clearing debt



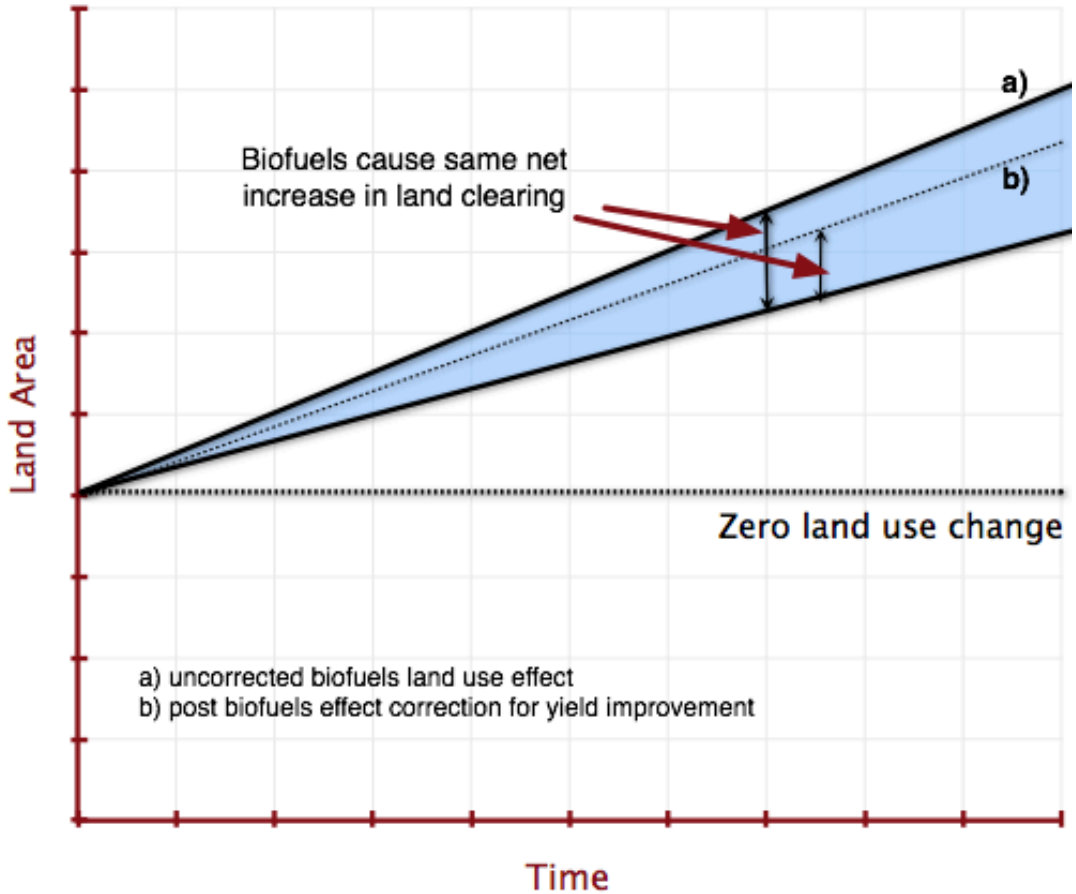
Yield trends as a background effect

- Thus, treating yield as a background factor that simply "cancels out" when subtracting baseline scenarios from biofuels scenarios is tantamount to assuming that land demand is always increasing



Yield trends as a post biofuels correction

- Correcting for yield improvement after the fact only reduces the magnitude of an implicit assumption of land demand growth



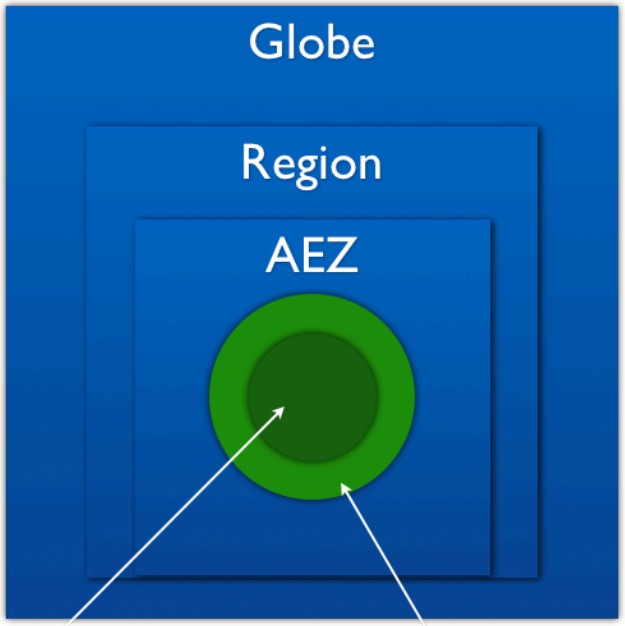
Yield on new land

- The original analysis of carbon intensity for biofuels assumed that yield on new land was only 2/3 of yield on existing land
- The a priori assumption of such a yield penalty is not necessarily appropriate

Yield on new land

- While not perfect, new analysis that attempts to assess new land productivity using natural ecosystem models is more methodologically defensible

$$\text{Eta} = \frac{Y_{delta}}{Y_0} = \frac{NPP_{delta}}{NPP_0}$$

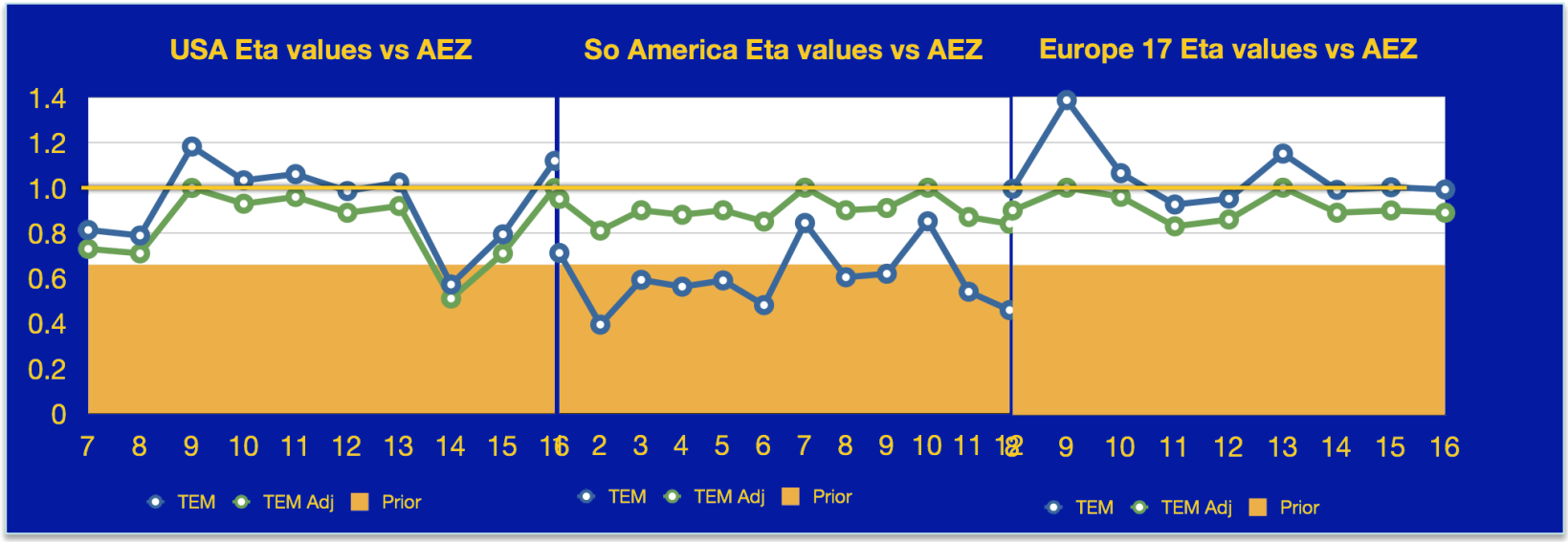


Current cropland with yield Y_0

New cropland with yield Y_{delta}

Yield on new land

- Yields on new land could be as high as yield on existing land
- Need to understand why high yielding land is not in use



Short term recommendations - YIELDS

- Incorporate estimates of time-dependent yield improvement in all land calculations
- Incorporate TEM (Terrestrial Ecosystem Model) methodology for estimating yield on new land introduced as a result of biofuels

Long term recommendations - YIELDS

- Incorporate more robust approaches to estimating food demand and future yield improvements
- Allow for scenarios of yield improvement reflecting both technology improvement and closing of the yield gap across climate-similar areas of the world
- Statistical approach to yield as f(climate, management, etc)

GTAP Land "Pools" Database

- **Older SAGE land cover data determines available land pools for each AEZ / region**
  - Non-agricultural lands based on SAGE land cover map circa 1992 (Ramankutty and Foley 1998)
  - Livestock and cropland area circa 2000 based on earlier version of SAGE crop maps (Leff et al. 2004)
  - Much improved "SAGE data" circa 2000 now available that uses county level yield and area data (Ramankutty et al. 2007, Monfreda et al 2007)

What lands are excluded from land pools database?

GTAP Land "Pools" Database

EXCLUDES "INACCESSIBLE" FORESTS

- **GTAP → Sohngen → FAO to determine area of inaccessible forests**
  - FAO provides estimates of the proportion of accessible vs inaccessible forests for each country
    - For tropics, based on distance to roads

  - **Overestimates area of inaccessible forests**
    - Poor mapping of roads, many are unofficial / temporary
    - Absence of roads does not necessarily mean forests will not be converted

GTAP Land "Pools" Database

EXCLUDES UNMANAGED / UNPRICED LANDS

- Unmanaged land = SAGE grassland, shrubland, and savanna classes
  - Excludes large areas where croplands likely to expand

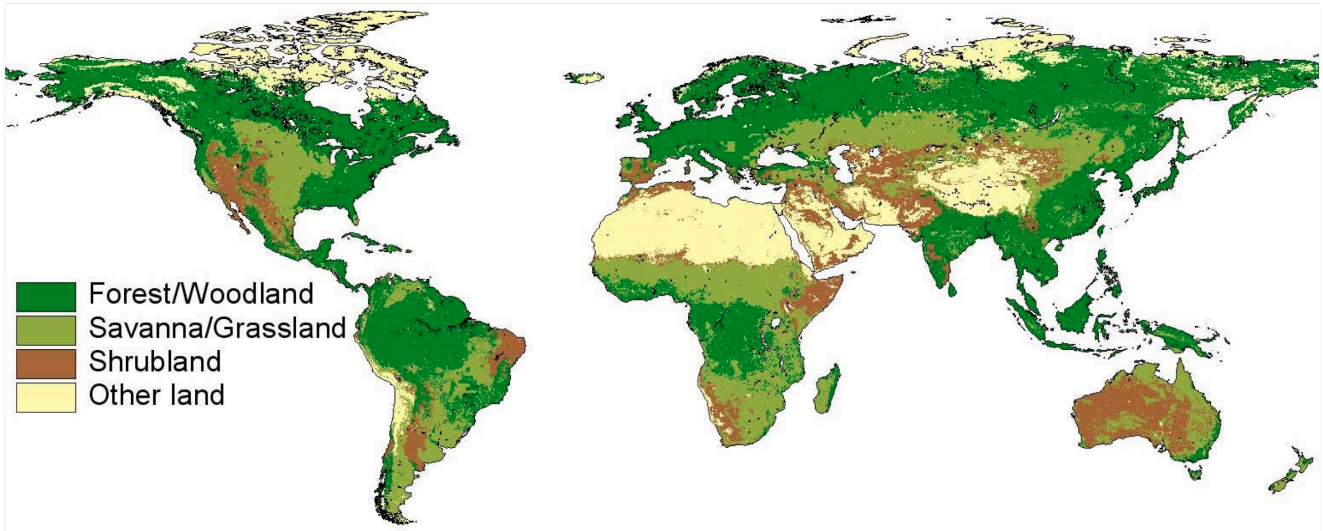
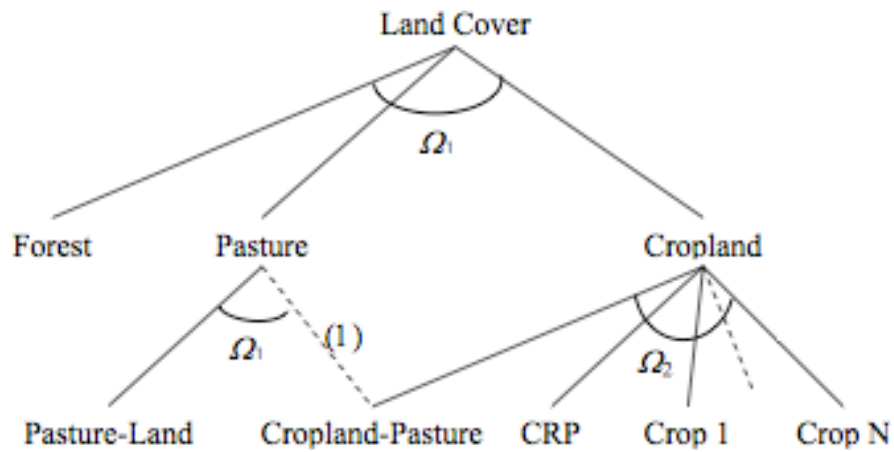


Figure 3. SAGE global land cover map (the original 15 classes have been merged to 4 classes used in GTAP)

GTAP Land "Pools" Database

ADDITIONAL LAND POOLS

- CRP and Croplandpasture land pools added by Tyner et al.
- CRP not accessed

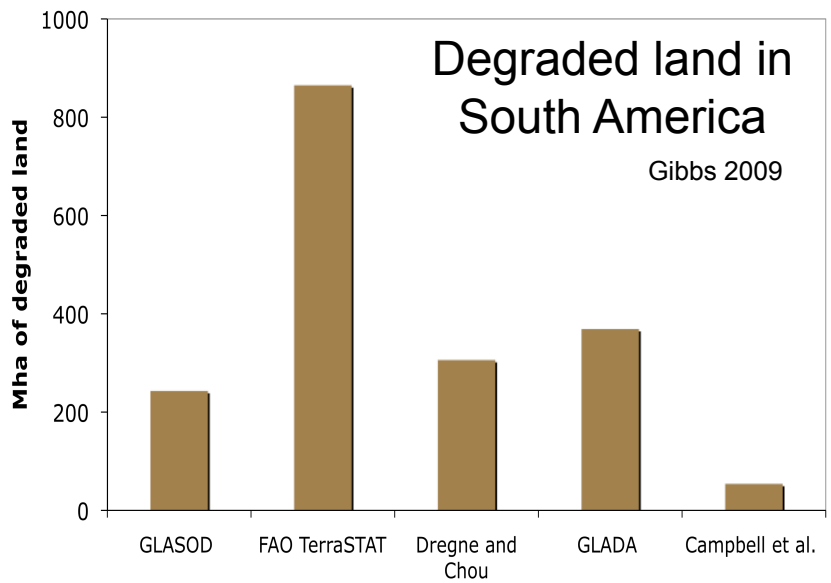


(1) To create this link we introduced an industry into the GTAP framework which uses only cropland-pasture as an input and sells its output (land) to the livestock industry.

GTAP Land "Pools" Database

ADDITIONAL LAND POOLS – MARGINAL LAND

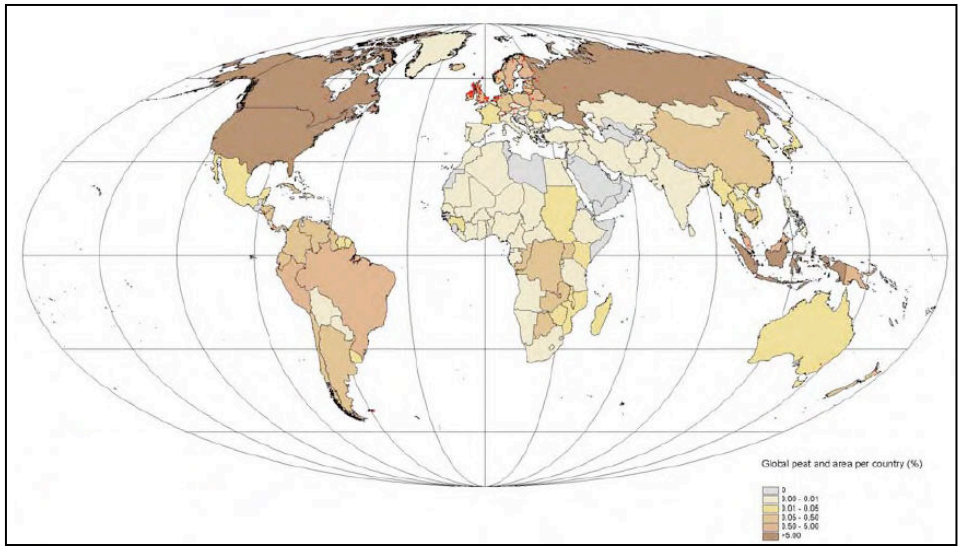
- Marginal land important but challenging land class to include
  - Uncertain mapping, controversial definitions
  - Cultivation costs vary widely



GTAP Land “Pools” Database

ADDITIONAL LAND POOLS -- PEATLANDS

- Peatlands, particularly in SE Asia, are critical land cover types to include
  - Large soil carbon emissions from draining
  - Routinely drained and used for oil palm



Recommendations – LAND POOLS

- **Short term**
  - Update to contemporary land cover map
  - Update to improved SAGE / M3 cropland and pasture data
  - Reconsider area of inaccessible forest
  - Include more unmanaged land
  - Access CRP classes
- **Long term**
  - Add new land pools including marginal lands and peatlands

What types of land are converted?

- **CET function used to estimate area and type of land pool converted to cropland**
  - BIG impact on emissions
  - Endogenous to model, harder to modify
- **Then WHRC database is used to estimate the specific ecosystem types**
  - Proportion of broadleaf vs coniferous forest available
  - Smaller impact on emissions
  - Only needed to estimate C emissions
  - Exogenous to model, easier to modify

CET function determines land allocation between three competing commercial uses → forestry, crops and livestock

- Based on detailed land use transitions and price data for U.S. to determine land owners response to price changes. (Lubowski 2002)

- Estimates of land sources for entire world are based on land owner decisions in U.S.
- Practices in other countries not considered

Challenging to improve CET function

- Limited data outside developed world
- Land use practices vary by region
- Decision to convert land in tropics determined by both economic and non-economic factors
  - Logging profits
  - Limited governance in forest frontiers
  - Land concessions for forests in Indonesia
  - Non-forest lands may be “inaccessible” because they are inhabited by communities
  - National policies

GTAP Ecosystem Types

Agricultural census data combined with map of potential vegetation (WHRC)

- Estimated the current area of ecosystem types by subtracting out the cropland area from a potential vegetation map
  - Net changes at national scale from FAO
  - Inconsistent between years and countries
- Used coarse assumptions to make the best of available data
  - Assumed forest was the land source if forest cover decreased while cropland increased

GTAP Ecosystem Types – Two issues

- **Area and type of ecosystems**
  - Can be updated using satellite-based land cover maps (e.g., GLC2000, MODIS)
  - Allows for estimates at AEZ / Region level that can also be matched to C stocks
- **Probability of ecosystem conversion**
  - Based on availability of each ecosystem type or something else?
  - Need more data..

Improve CET function & ecosystem type conversion probability?

- **Very data constrained with few studies aiming to identify pathways of cropland expansion**
  - Agricultural census data
  - Coarse resolution satellite data products
  - Landsat databases for 1980s and 1990s
  - Regional data products & literature

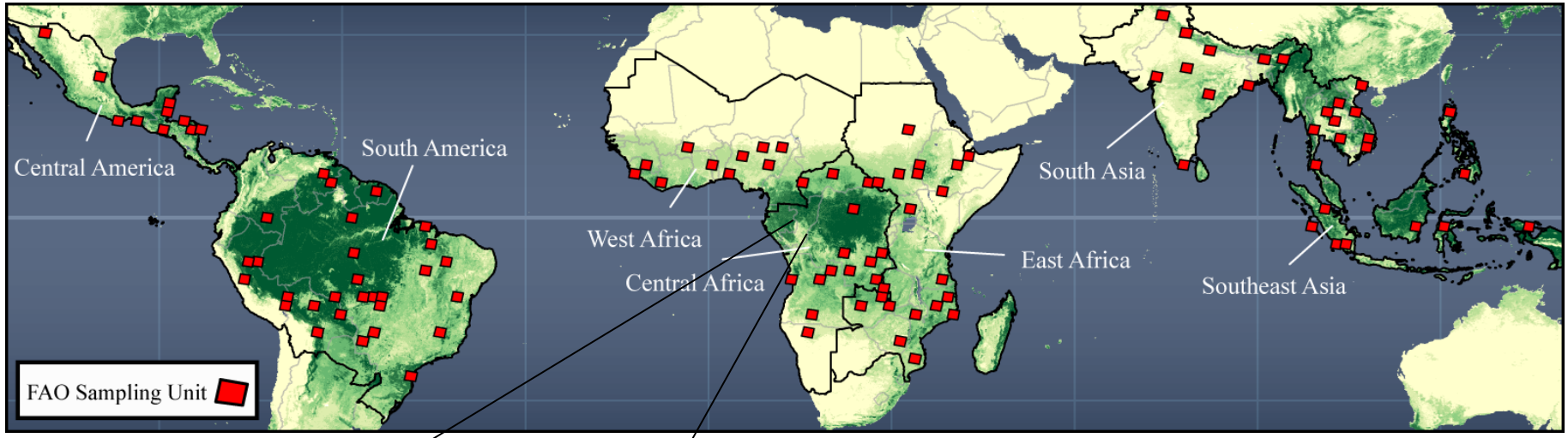
EPA iLUC Estimate

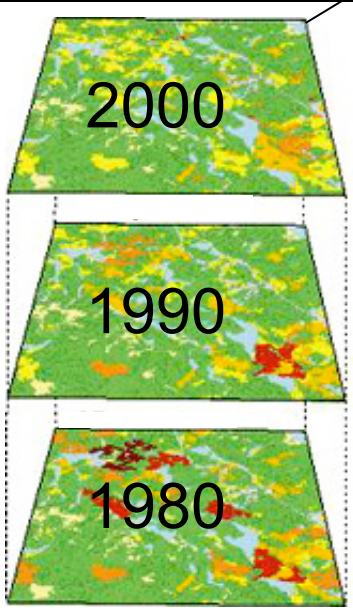
MODIS Global Land Cover Maps (Winrock)

- Subtracted global land cover maps with 0.5-1km spatial resolution to estimate LUC
- “Differencing method” is not true change detection and leads to inaccurate results

Use Landsat database to track croplands

→ Visual change detection provides more accurate results



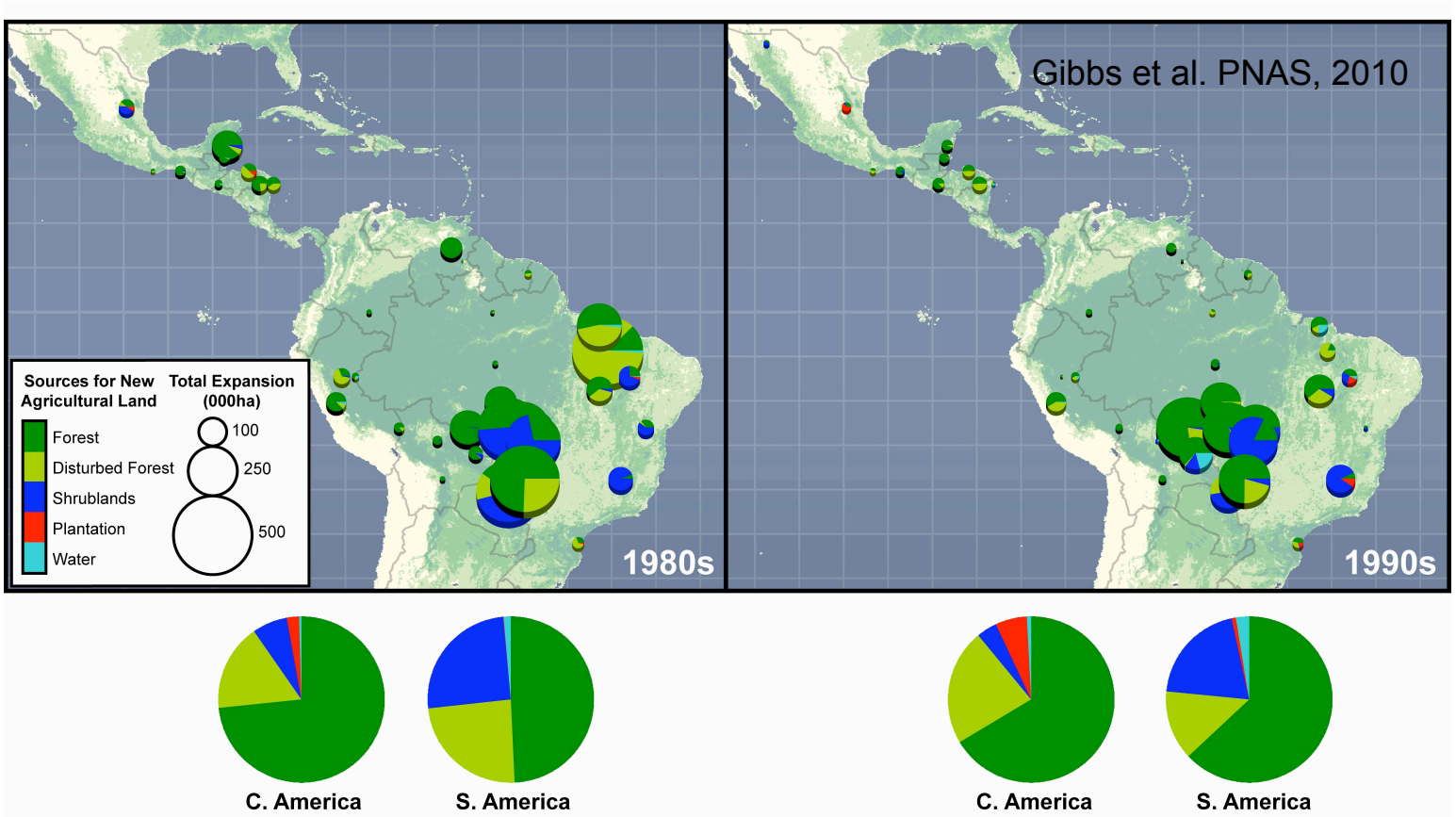


Land Cover Types

- Closed Forest
- Open Forest
- Fragmented Forest
- Shrubland
- Long Fallow Systems
- Smallholder Agriculture
- Permanent Agriculture

Gibbs et al. 2010, FRA 1990, 2000

Use Landsat database to track croplands



Landsat database could also help identify likelihood of clearing for specific ecosystem types (Gibbs et al, in prep)

Short-term recommendations – LAND CONVERSION

- **Develop hybridized ecosystem type database**
  - Rely on satellite data for area & types of ecosystems
  - Account for relative likelihood of conversion
  - Add more ecosystem types (peatlands, logged forest, marginal land, etc)
- **Develop regional look-up-tables or modifiers that can help adjust CET function results**
  - Account for critical non-economic factors in specific regions (e.g., forest concessions in Indonesia)
  - Help account for peatland conversion

Long term recommendations – LAND CONVERSION

- **Develop CET functions for each region**
  - Synthesize available econometric data outside USA
  - More than economics… corruption, national policies, land tenure

Environmental quality of land & land conversions

- Marginal lands for bioenergy =
  cropland-pasture, idle cropland, possible degraded lands, rangeland, uncultivated areas, CRP, etc.

— Soil and water quality improvements on these lands may be able to be made with respect to crop selection (herbaceous, select commodity crops, etc.), landscape diversity, cropping rotation, field management practices, etc.

— NLCD with sub-categories of grassland/rangeland, pasture, cultivated cropland, and scrub/shrub can provide a “first cut” as to what environmental quality improvements could 1) potentially be expected, and 2) what lands are “out-of-bounds”

Short-term Recommendations – Environmental Quality

- Determine how soybeans (and other crops) are accounted for and moved around in GTAP and does their movement onto other lands make agronomic sense?
- Investigate what can be done to really improve the "detail" of the model especially with respect to US production
  - Investigate what it would take for GTAP to incorporate environmental quality parameters and land cover types from SSURGO and the NLCD into the internal workings of GTAP

Long-term Recommendations – Environmental Quality

- Get a much better definition of what does and what does not constitute 'marginal' acreage with respect to geo-climatic parameters as well as land-based agronomics

- Look at yields of the major crops more closely and investigate the ETA of select land groups and land types in the US at least on a more refined regional scale

SUMMARY OF RECOMMENDATIONS

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