Land Conversion Databases and Methods

Land Cover Types Subgroup

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Photo from Rhett Butler

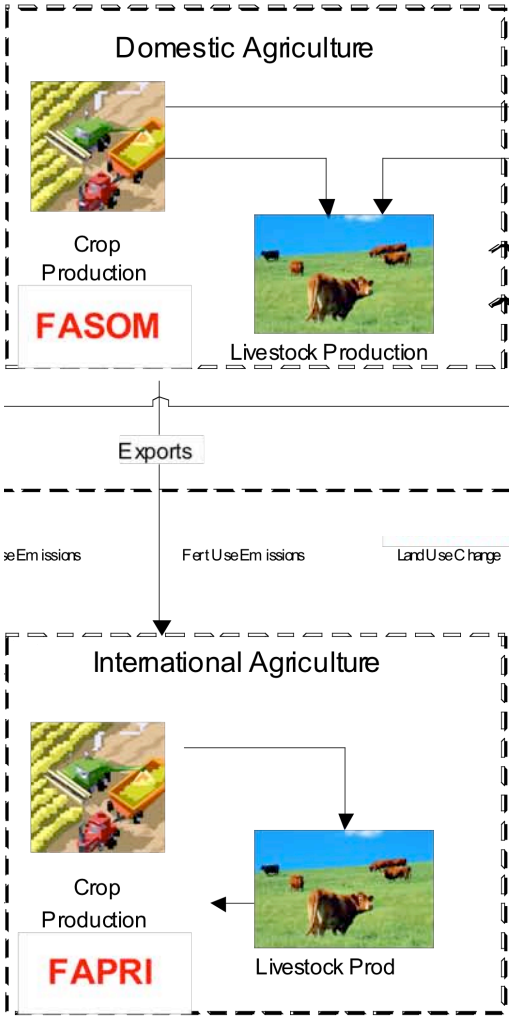
Land Cover Conversion Estimates?
Formidable task…

- Requires high resolution, global scale coverage of current conditions
- Most LUC science focused on net change in area of "forest" and "cropland"
  - Did not track land use transitions, needed for ILUC
- Challenging to distinguish types of agricultural land with satellite data
- "Land has long been neglected by global economics" Hertel (2009)

Focus on (Tropical) Land Cover Conversion Estimates

- Review methods and databases used by Searchinger, EPA and GTAP
- Dive into land conversion databases
- Future options and recommendations

Both Searchinger and EPA used FAPRI & FASOM models



- Used FAPRI / FASOM to identify the regions <u>where and how much</u> land use change would occur
- Used land databases to identify <u>what</u> types of land would be converted

Searchinger iLUC Estimate

Agricultural census data (WHRC)

- 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

WHRC database has land conversion estimates AND emissions factors -- GTAP only uses the emission factors

EPA iLUC Estimate

Satellite-based data (Winrock)

- Used global land cover maps with 0.5-1km spatial resolution to estimate LUC
- Second draft much improved but still needs work
  - Covered 2001-2007
  - Several land cover categories
  - **"Differencing Method" NOT true change detection**
    - **Leads to spurious changes between land cover categories**

(more on this later)

How Does GTAP Estimate Land Sources?

How Does GTAP Estimate Land Sources?

Must download GTAP model to really see what is happening

How Does GTAP Estimate Land Sources?

- CET function used to estimate the area of land cover types converted to cropland
- Then WHRC database is used to estimate the specific ecosystem types for each land cover type
  - Portion of broadleaf vs coniferous forest
- WHRC database also used to assign emission factors for each AEZ and region

Land is aggregated to agro-ecological zones within each GTAP region

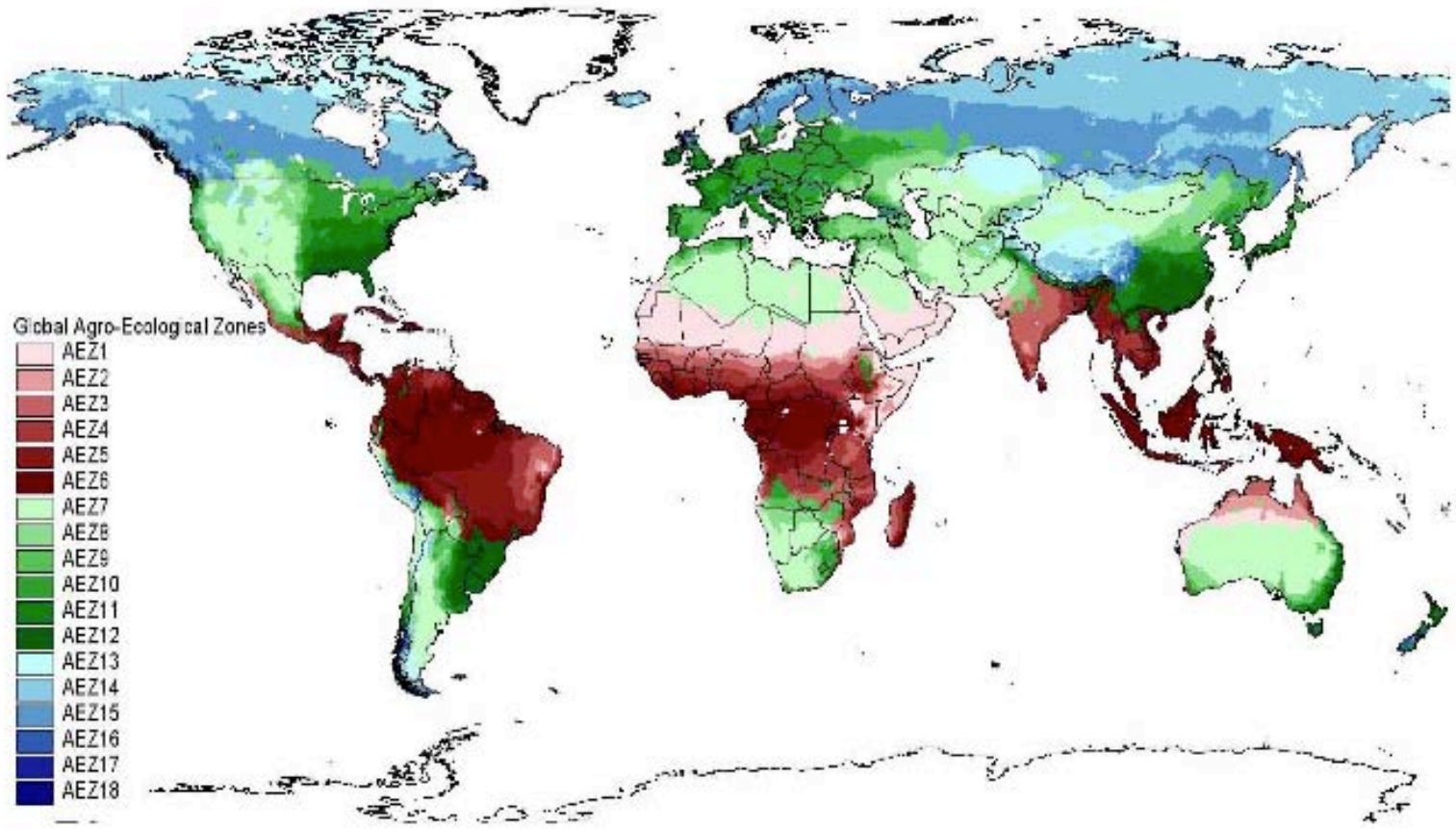


Figure 5. The SAGE global map of the 18 AEZs

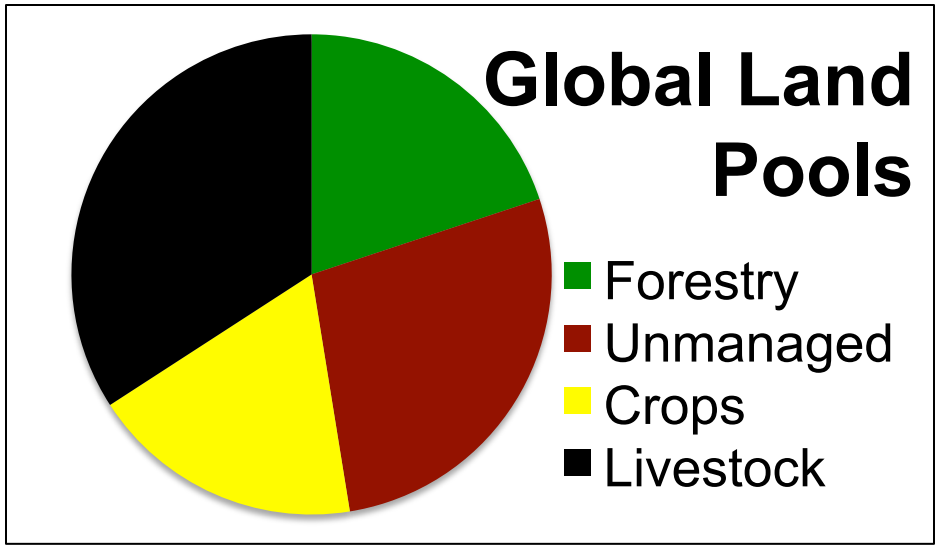
How Does GTAP Estimate Land Sources?

- **CET function determines land allocation** between three competing commercial uses → forestry, cropland and pasture
  - 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

GTAP Excludes Unmanaged Land

- Only considers “economically active” land
  - Excludes large pools of natural ecosystems and previously cleared land



Critical GTAP Fixes for iLUC

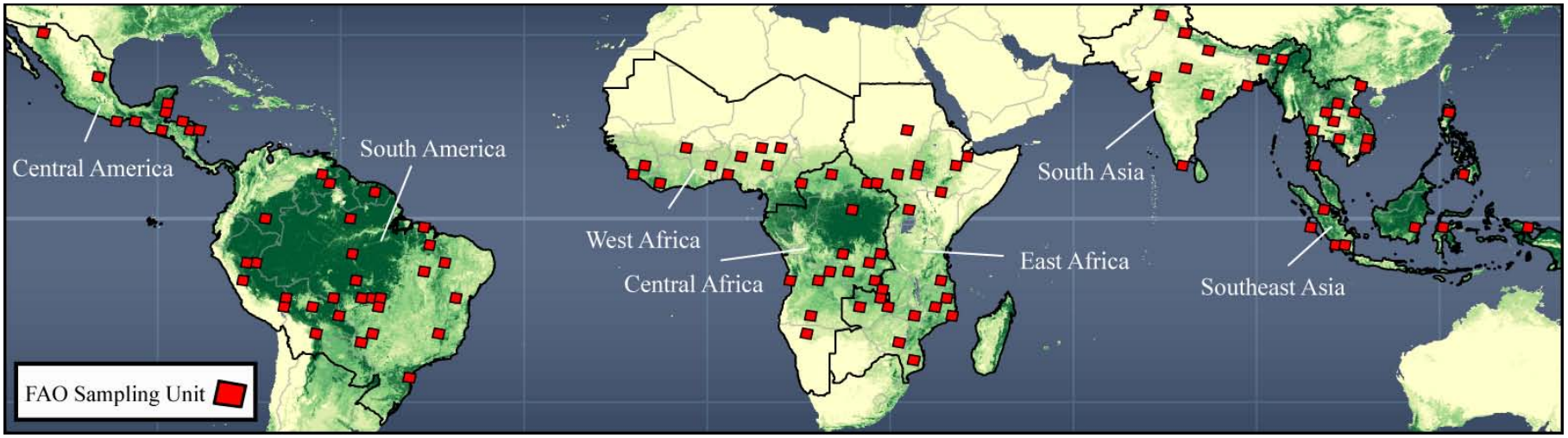
- **Incorporate "unmanaged land"**
- **Develop regional CET functions**
  - More than just economics
  - Land tenure, corruption, national policies..
    - Add non-economist land use scientist to team?
- **More detailed land source categories**
  - Degraded forest, grassland, savanna, subsistence agriculture, marginal and so on

Part 2: Other Land Conversion Estimates?

+ data comparison

Analyzed library of Landsat images from FAO

→ Detailed satellite data with 30m by 30m spatial resolution

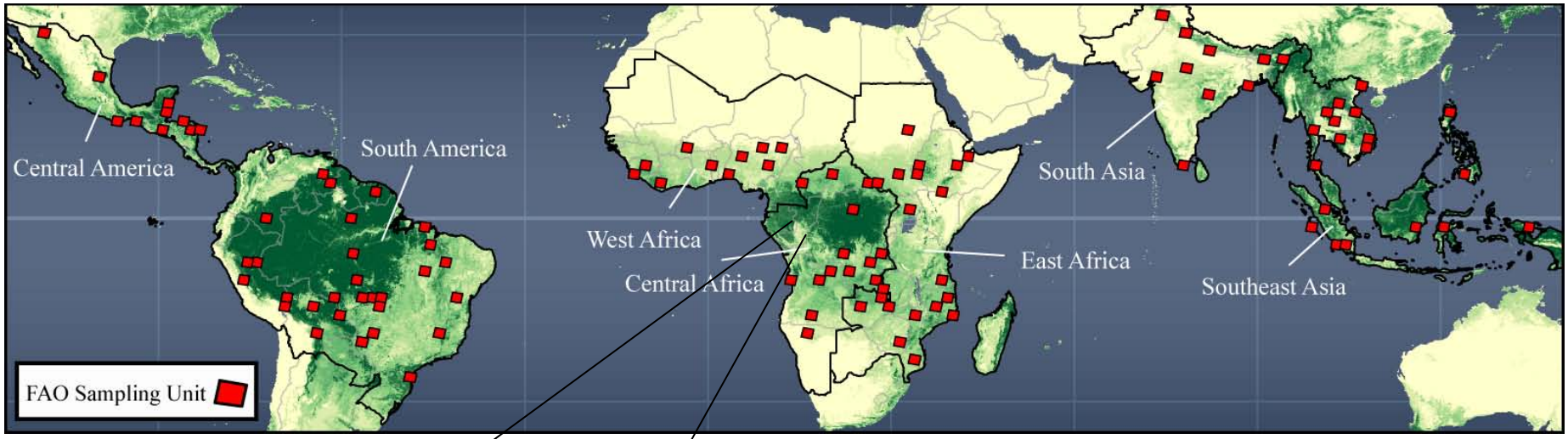


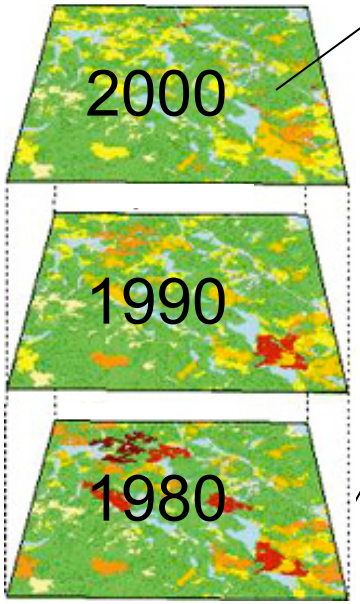
- Random sample of Landsat locations or "sites"
- "Snapshots" of land cover for 1980, 1990 and 2000
- Detailed image processing tracks land transitions

FRA 1990, 2000

Used Landsat to track agricultural expansion

→ Detailed satellite data with 30m by 30m spatial resolution



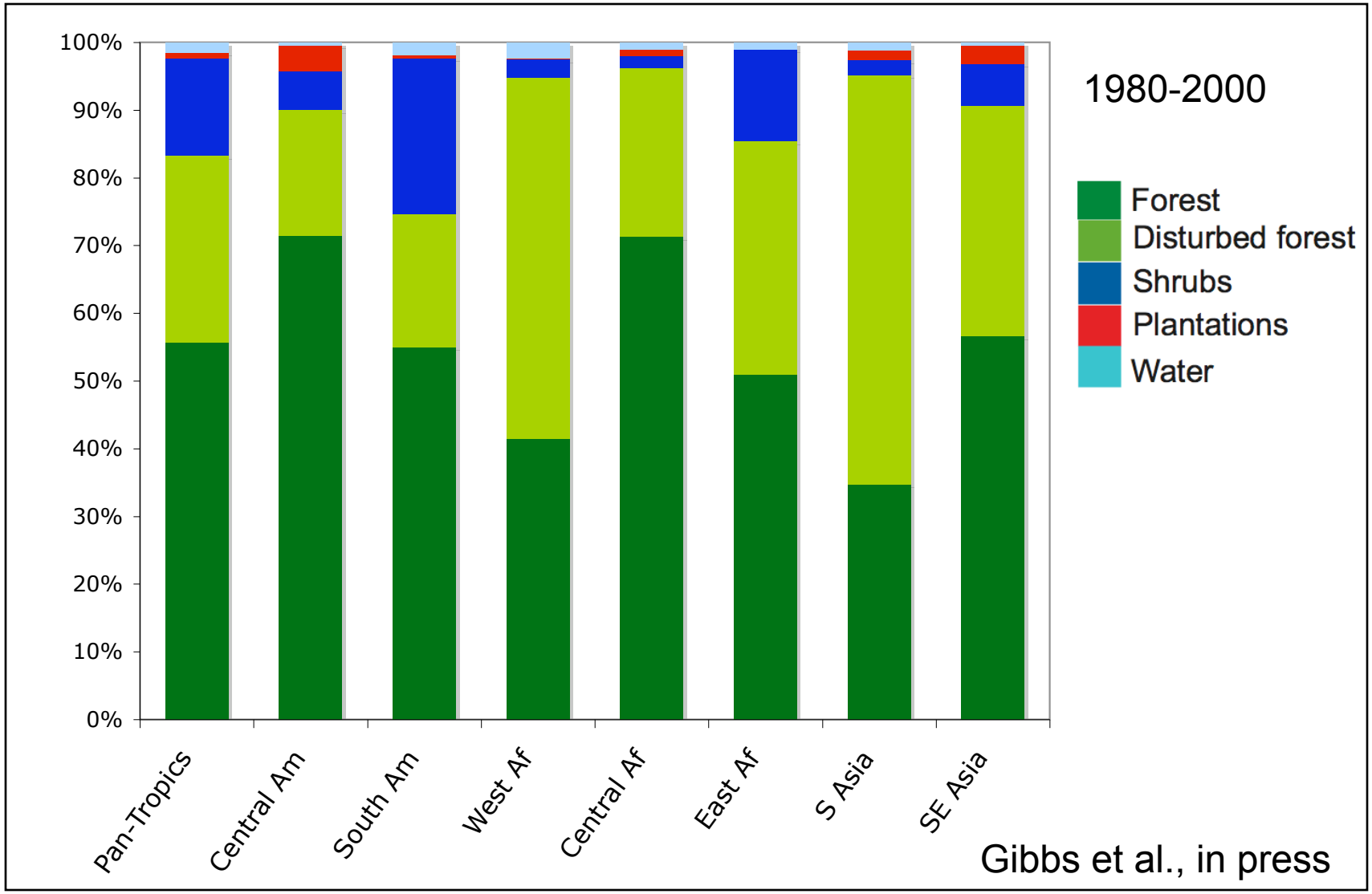


Land Cover Types

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

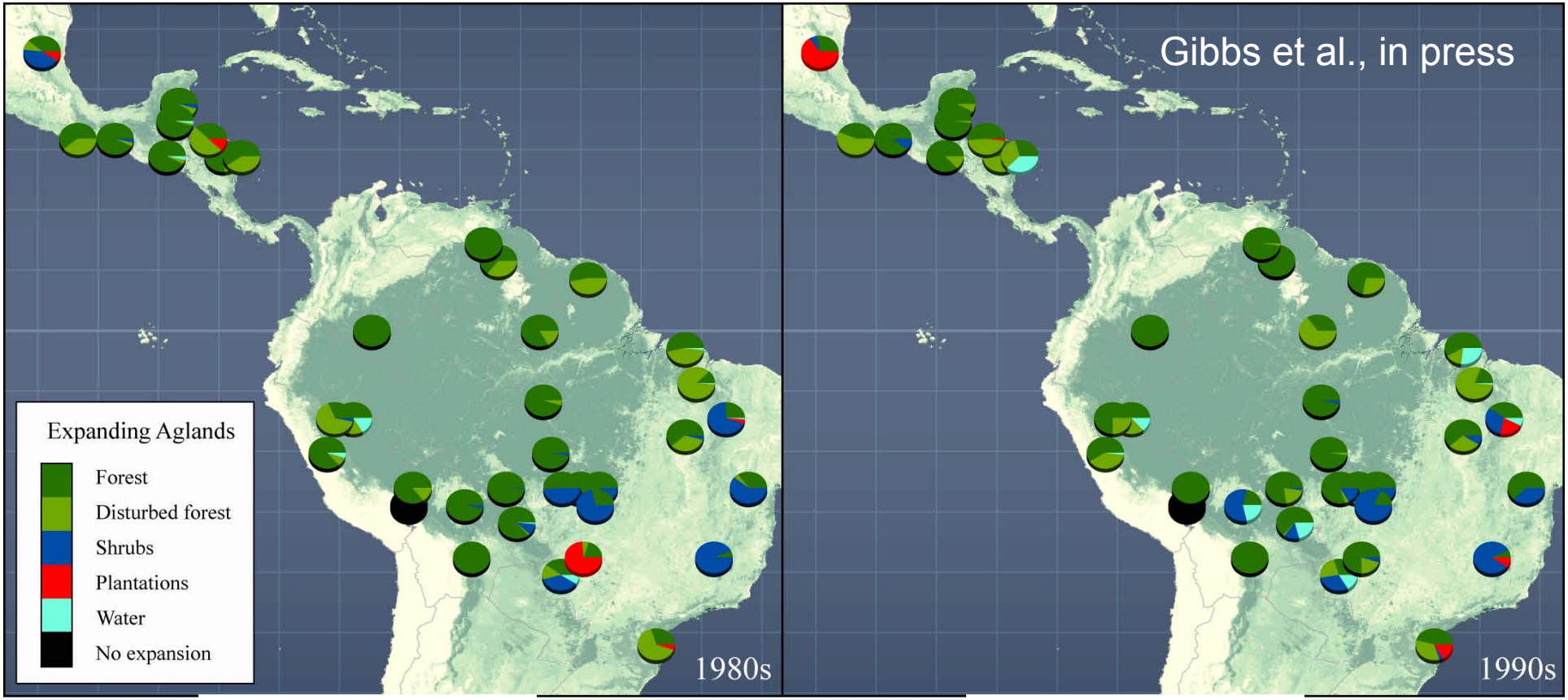
FRA 1990, 2000

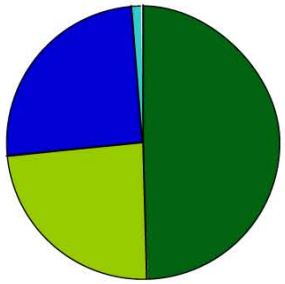
Land Sources *Across* the Tropics?



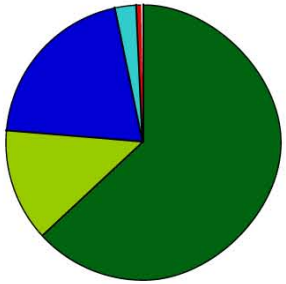
Forests and disturbed forests are primary land sources

Land Sources for New Agricultural land?





S.America



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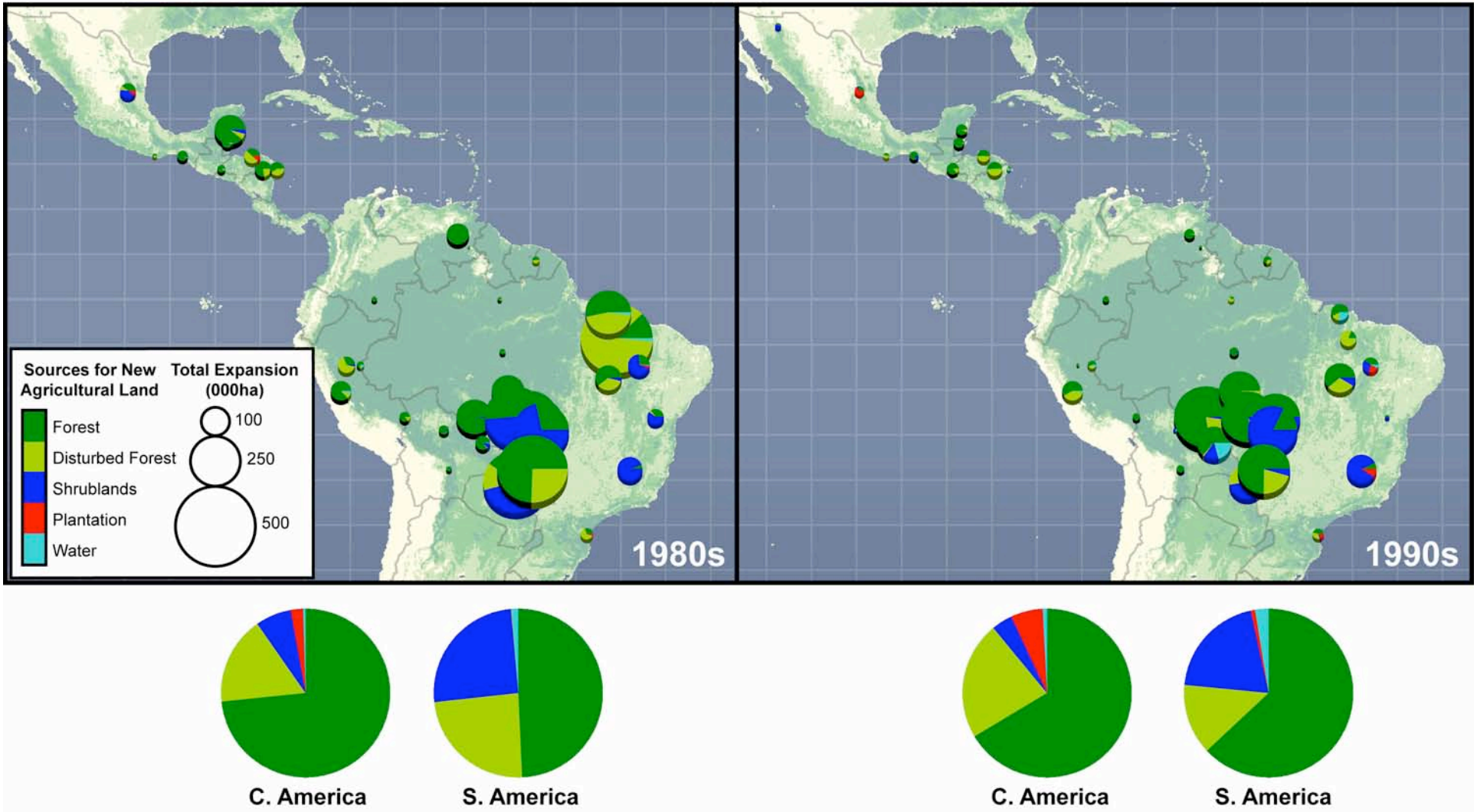


Gibbs et al. PNAS, in press

Main GTAP output for Brazil, 2001-2006

Scenario	Forest	Pasture	Cropland
C1	-24031	-10740	34821
C2	-16846	1602	15256
C3	-24619	595	23982

Winrock 2010 Estimates for Brazil, 2001-2007

Land Source	ha	% of total cropland
Forest	1,217,596	6
Mixed	6,593,064	30
Savannah	8,884,278	41
Shrub	238,857	1
Grassland	4,928,192	23

Percentages are important

Winrock LUC Data Problematic

Estimated changes are likely spurious

How much of each land cover type changed between T1 and T2?

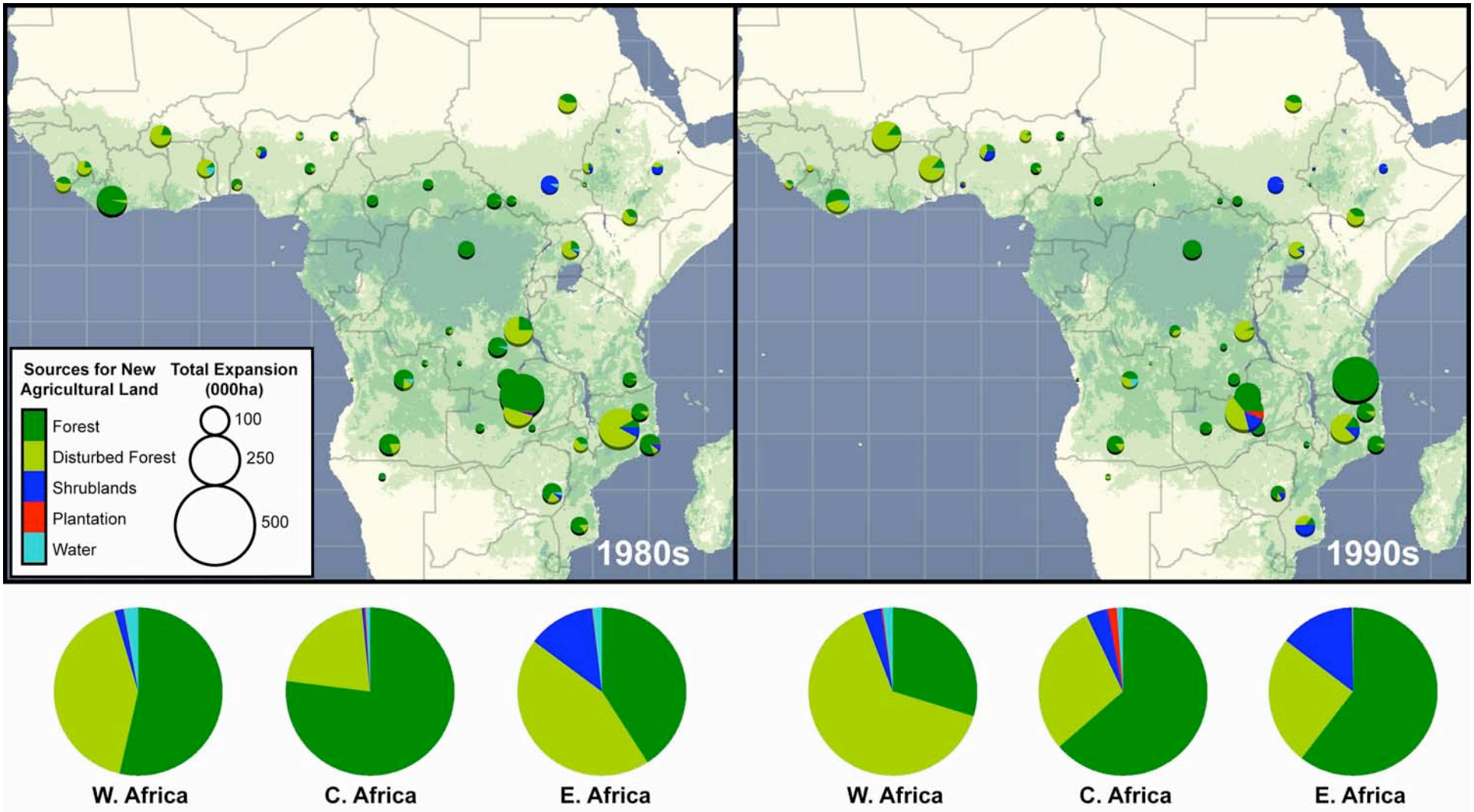
DIFFERENCING METHOD
Winrock 2001-2007

Land Cover	% changed
Forest	9%
Mixed	59%
Savannah	16%
Shrub	94%
Grassland	80%
Cropland	54%

TRUE CHANGE DETECTION
Gibbs / FAO, 1990-2000

Land Cover	% changed
Forest	5%
Dist. Forest	13%
Shrubland	9%
Cropland	4%

Land Sources for New Agricultural land?



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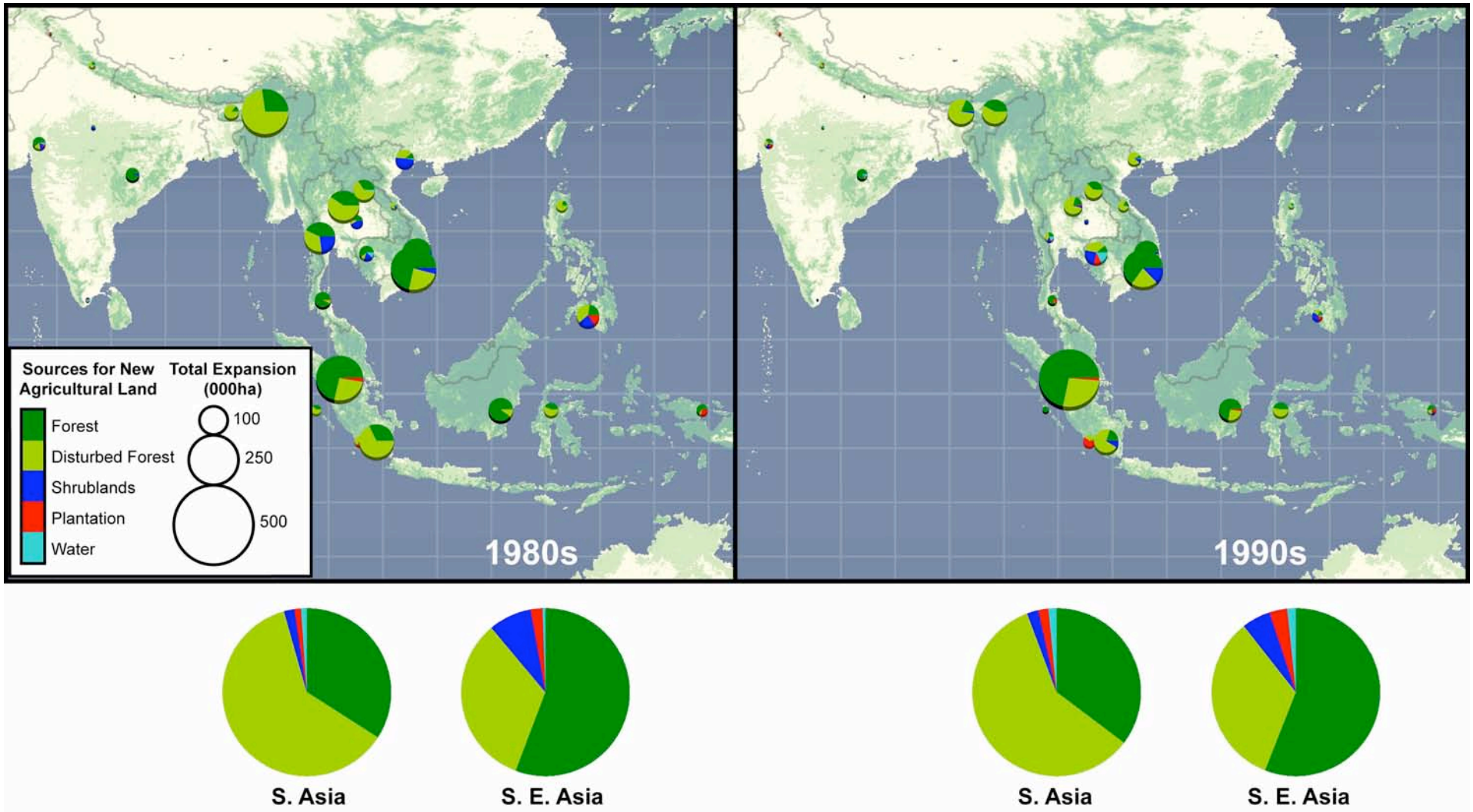
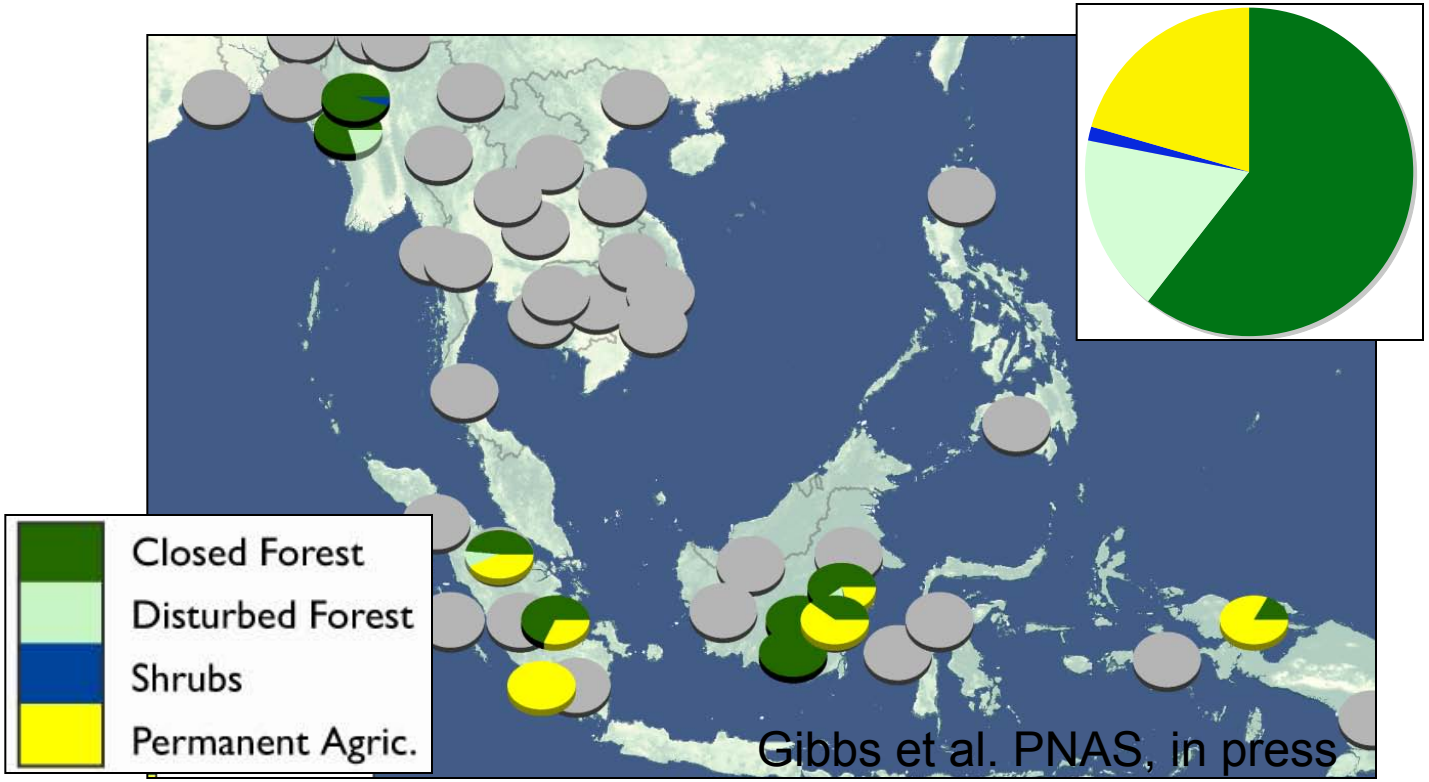


Gibbs et al. PNAS, in press

Land Sources for New Plantations?



- Winrock estimates 39% of cropland from forests in Indonesia and 52% in Malaysia (per E4tech)
- But not clear that MODIS able to capture plantations

Main GTAP output for SE Asia

Scenario	Forest	Pasture	Cropland
C1	3143	-2851	-294
C2	-10939	-643	11597
C3	21453	-2247	-19199

Pasture → Forest is unlikely

- Most pasture is degraded imperatta grasslands
- Regeneration near impossible
- Very expensive for plantations

Potential of Gibbs et al. for iLUC Applications?

Limitations

- Sampling scheme
- Aggregated cropland and pasture classes
- From 1980s and 1990s

Strengths

- High spatial resolution
- Detailed change detection
  - Tracks individual parcels of land
- Covers entire tropical forest belt

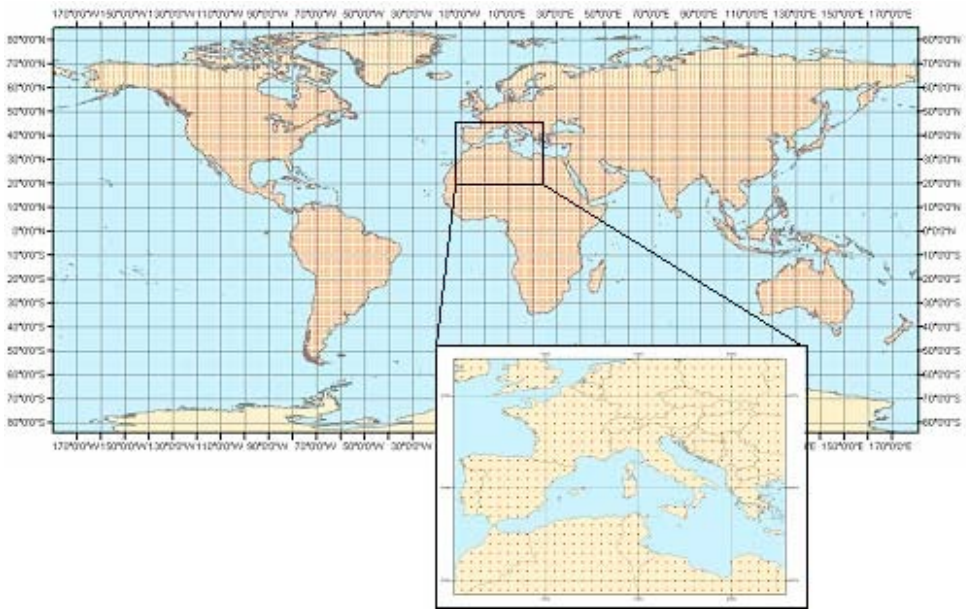
Part 3: Future options?

Ideal Land Conversion Data?

- 6+ year long baseline within this decade
  - monitoring every 3 years
- Detailed land cover classes
  - Distinguish cropland, pasture, degraded lands and crop types
  - Range of natural ecosystem types
- Track full land use transitions with careful change detection
- Connected to price data??

Near term data improvements?

- FAO will have new Landsat database available for 1975, 1980, 1990, 2000 and 2005 that covers all global land



VERY limited use though because only has forest and non-forest classes

Near term data improvements?

- Ask MODIS / Landsat science teams to create a “change product” focused on agricultural expansion?
  - 500m MODIS will miss key changes
  - Not likely to capture cropland ←→ pasture
- Hybridized databases?
- Targeted regional studies

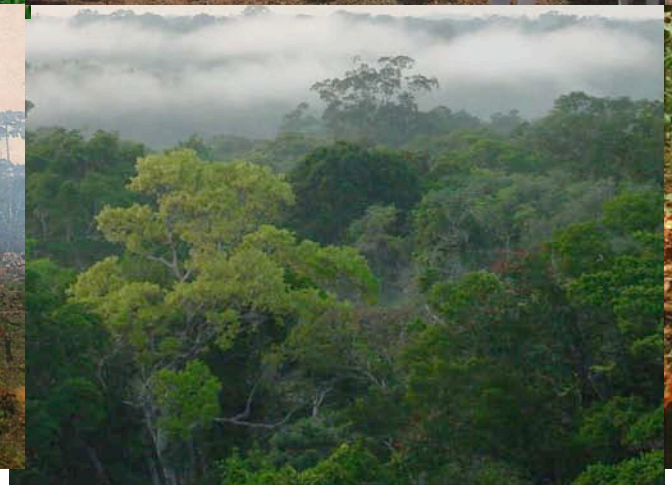
Way forward? Longer term..

- **Create new satellite data products** tracking expanding agricultural land and patterns of crop substitution

- Improve understanding of the potential and location of **degraded land** around the world

- More attention on **GTAP CET** function – what options are there to improve? How can we best identify likelihood of land conversion?
  - Synthesize available econometric data outside USA
  - Methods to add in non-economic variables?

In closing…

- Critical to get conversion estimates right
  - Error between pasture vs forest has larger influence than carbon stock / emission estimates
- Moving target for land conversion and emissions factor databases
  - “Hybrid approach” to use best available data while encouraging improvements
- ILUC must be evaluated in light of current, on the ground realities and not theoretical or idealized conditions
  - More than economics needed

Land sources for expanding crops?