

# ***Tracking the Fate of Deforested Land in the Tropics: Critical New Inputs for Ecosystem Service Evaluation***

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# Fate of Cleared Land: What does it tell us?

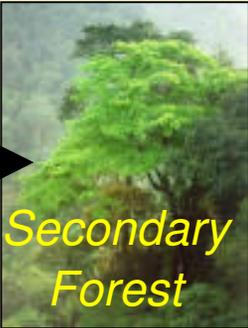
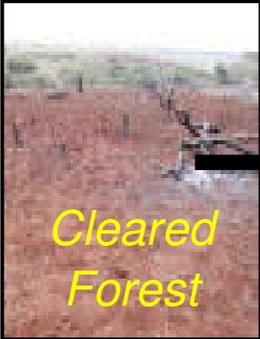
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## Four Key Topics

1. Critical to assess what happens after forests are cleared to evaluate ecosystem goods and services
2. Fate of cleared land significantly varies across tropics and between the 1980s and 1990s
3. Agricultural intensification in South America - Soybeans?
4. Need more than satellite data to fully track deforested land  
→ Early efforts to integrate ground-based and satellite data

# Fate of cleared land: Why does it matter?

Fate of cleared land = Land use following deforestation



# Fate of cleared land: Why does it matter?

Fate of cleared land = Land use following deforestation



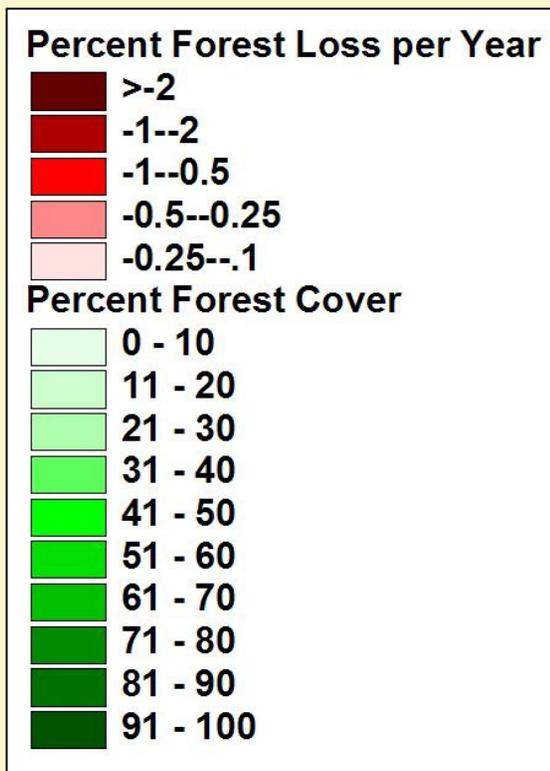
- ❖ *Just knowing the change in forest area is not enough*
- ❖ *Need to know what happens after deforestation to fully evaluate ecosystem services*

*Provides information on proximate causes of deforestation*

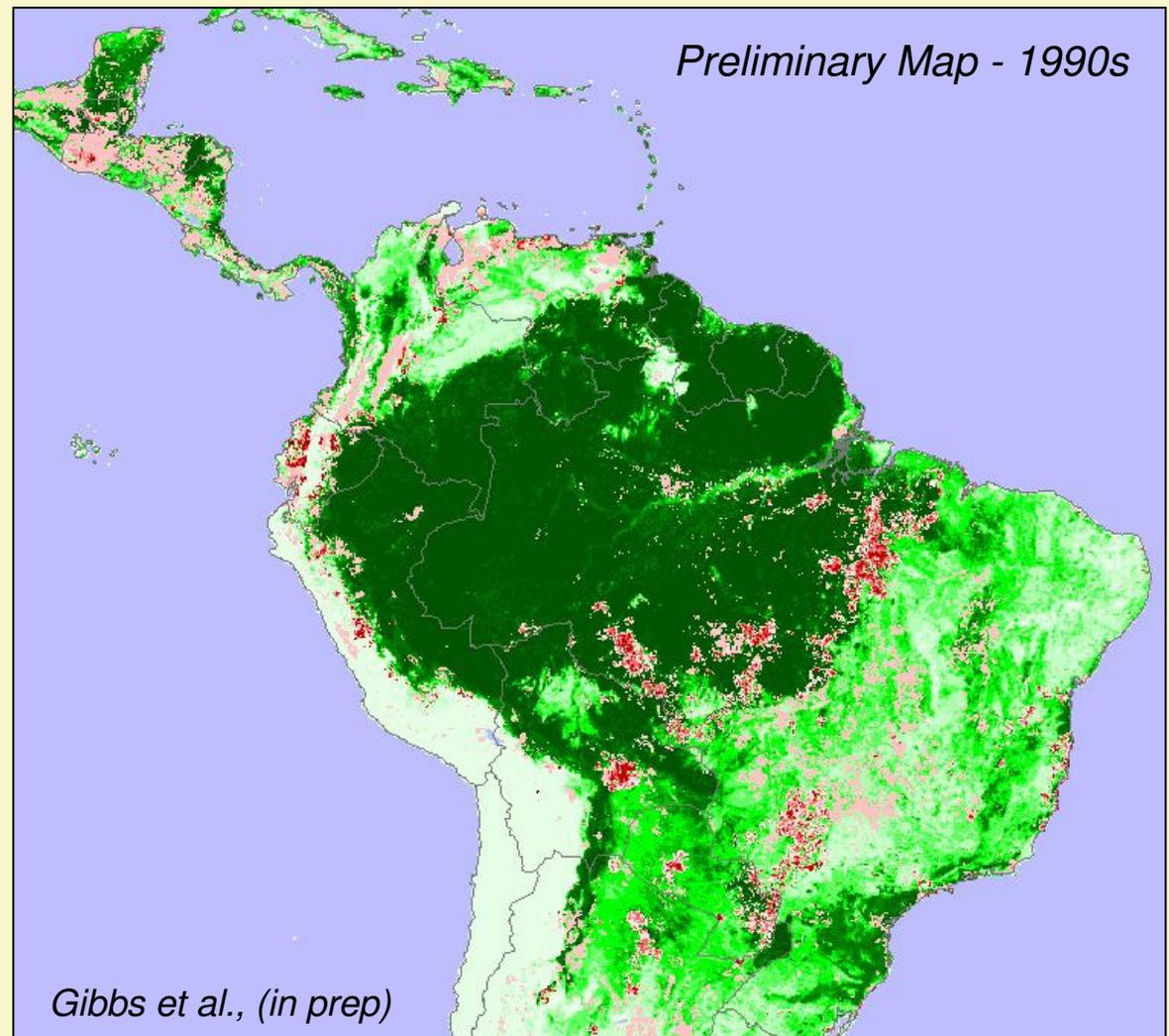
*→ What land uses are replacing tropical forests?*

# Need more than location of clearing..

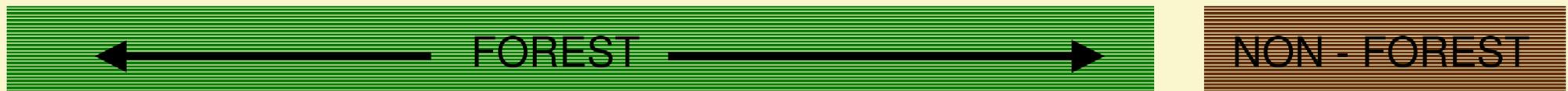
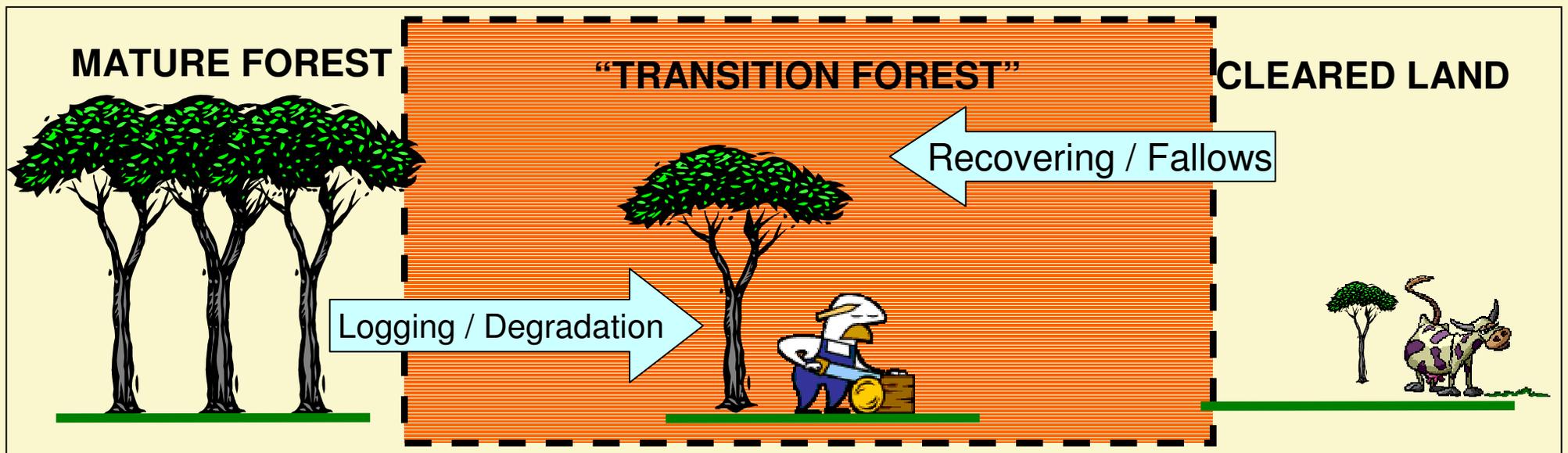
## Hybrid Estimate of *Net* Deforestation (poster presentation)



- ❖ 10km spatial resolution
- ❖ Both 1980s & 1990s

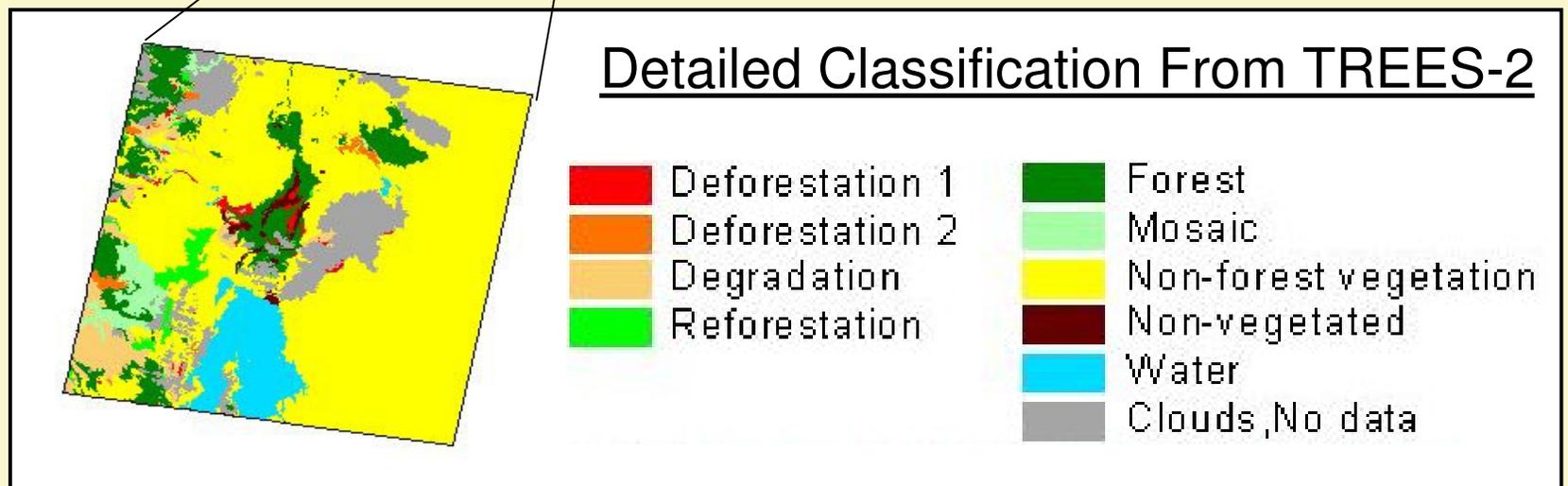
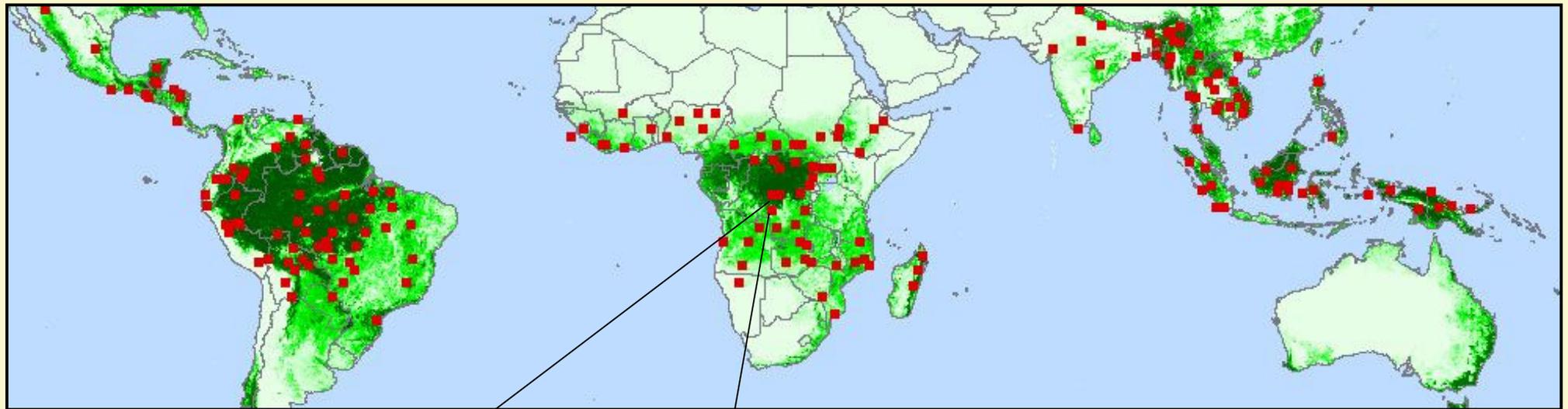


# Need more than deforestation rates..



- ✓ "Transition" Forest cover up to 40% of Total Forested Land (Brown and Lugo 1992)
- ✓ Area logged = Area Deforested in Amazon (Asher et al. 2005)
- ✓ Clearing of "Transition" Forest = Clearing of Mature Forest (Hirsch et al. 2005)
- ✓ 20-50% of Deforested Land is Recovering < 10yrs (Gibbs et al. in prep)

- ~600 co-registered Landsat scenes used to track deforested land
- Landsat manually classified by TREES and FAO



# Tracking the Fate of Deforested Land ...

## Using Landsat "Change Matrices"

<b>Land cover 1980</b>	Closed Canopy Forest	Open Canopy Forest	Long Fallow	Fragmented Forest	Shrubs	Short Fallow	Other Land Cover	<b>State in 1980</b>
Closed Canopy Forest	1115.9	12.1		8.9		2.5	3.8	1143.2
Open Canopy Forest	4.9	474.6		8.9		6.8	40.5	535.7
Long Fallow								
Fragmented Forest		1.9		449.3			12.8	464
Shrubs								
Short Fallow	5.3	4.8		0.5		68.4	2.1	81.1
Other Land Cover	1	0.5		1		1.4	485.4	<b>489.3</b>
<b>State in 1990</b>	<b>1127.1</b>	<b>493.9</b>		<b>468.6</b>		<b>79.1</b>	<b>544.6</b>	<b>2713.3</b>

# Tracking the Fate of Deforested Land ...

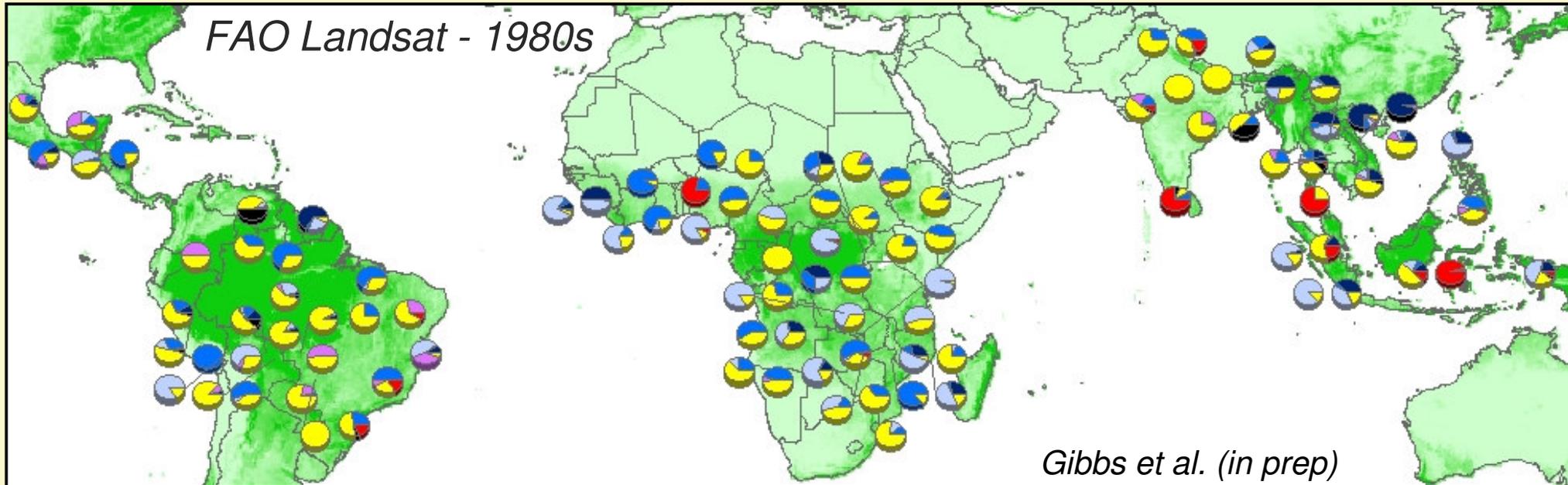
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→ Tracking new deforestation events, land cleared in 1980s/1990s

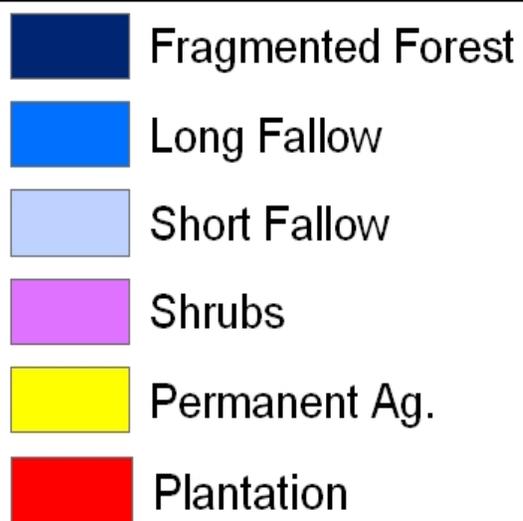
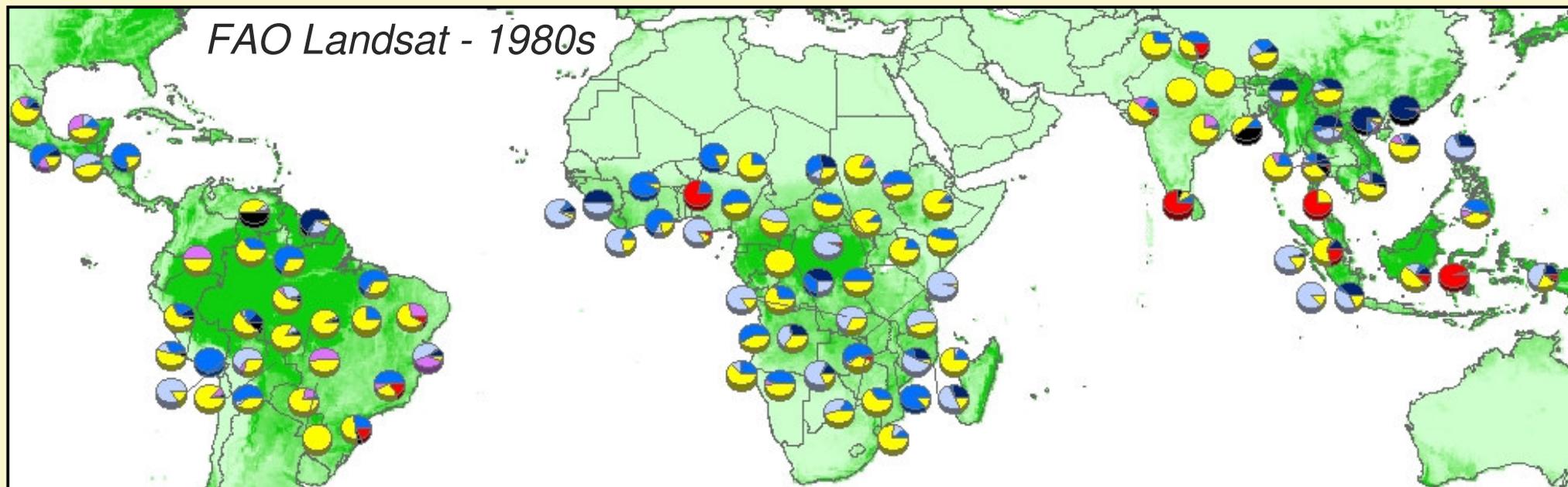
→ Not considering land cleared prior to 1980s or 1990s

# Fate of Deforested Land *Across Tropics*



	Fragmented Forest	= Mosaic of forest / non-forest
	Long Fallow	= Forest affected by shifting cultivation
	Short Fallow	= Agricultural land with short fallow cycles
	Shrubs	= Cerrado, savanna, scrubby vegetation
	Permanent Ag.	= Large-scale clearing, pastures / annual crops
	Plantation	= Forest or agricultural plantations

# *Fate of Deforested Land Across Pan-Tropics*



## Geographic Land-Use Patterns Following Clearing

*Latin Am* → pastures, shifting cultivation, logging, cash crops

*W Africa* → small-scale ag, cocoa plantations, “farmbush”

*C & E Africa* → small-scale ag, shifting cultivation, fuelwood

*S Asia* → fuelwood, small-scale ag

*SE Asia* → logging, shifting cultivation, plantations

# Tracking Deforested Land *Through Time?*

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Analyzed ~350 FAO Landsat Scenes

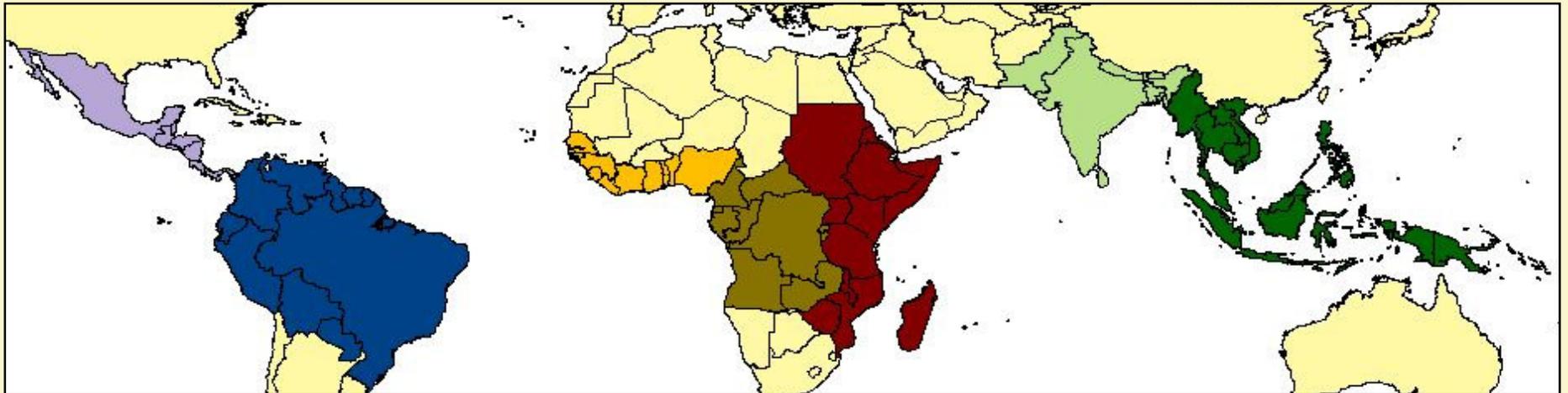
Time 1: 1980<sub>(i)</sub> → 1990<sub>(j)</sub>

Time 2: 1990<sub>(i)</sub> → 2000<sub>(j)</sub>

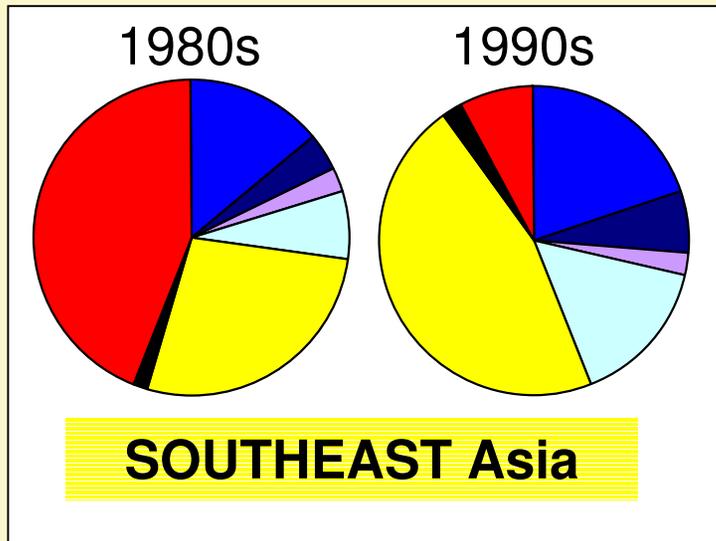
→ Tracking new deforestation events, land cleared in 1980s/1990s

→ Not considering land cleared prior to 1980s or 1990s

→ Ran paired t-tests to determine if the fate of cleared land changed between the 1980s and 1990 within the major land-use regions



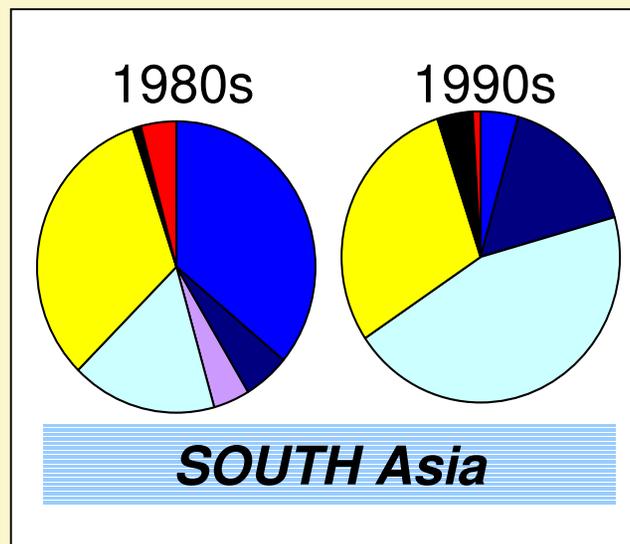
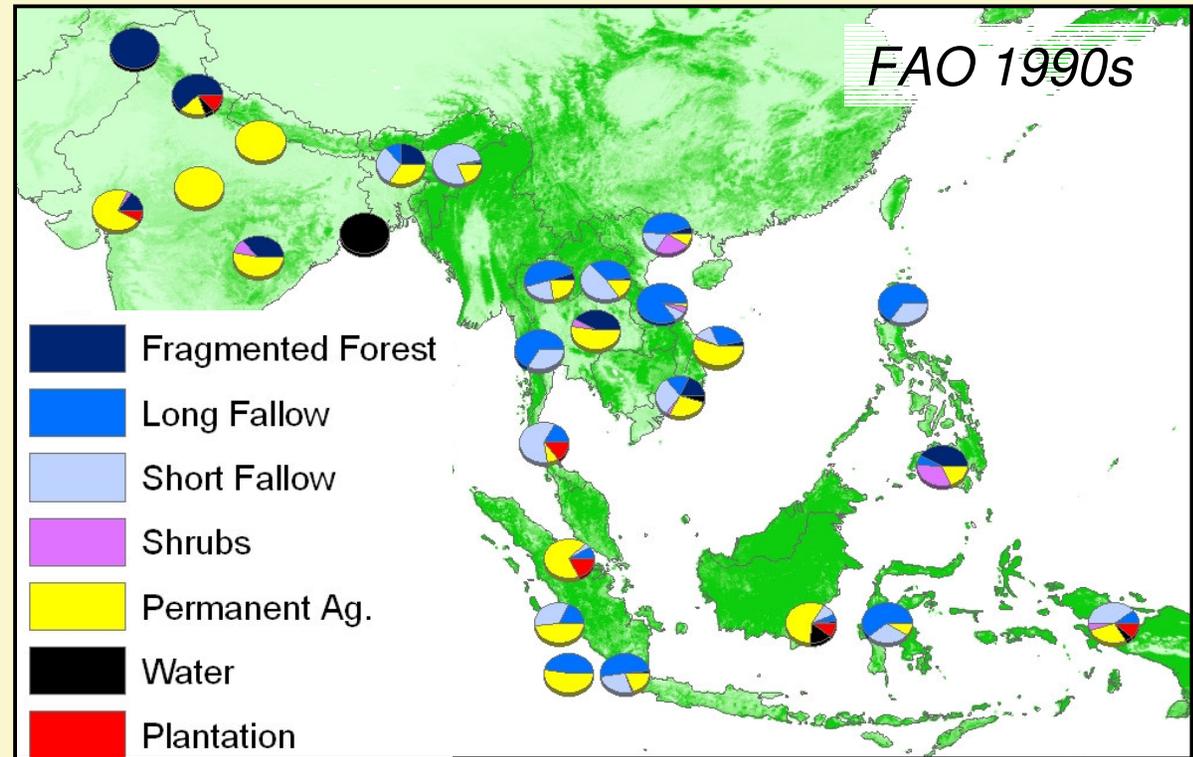
# The Changing Fate of Cleared Land: Tropical Asia



→ Forests cleared for plantations decreased by 80% { $p=0.12$ }

→ Forest conversion to long fallow decreased { $p=0.05$ }

→ Forest converted to permanent agriculture increased by 22%



→ *Forest cleared for permanent agriculture decreased { $p=0.0003$ }*

→ *Fragmented forest and fallow increased*

→ *Deforestation also decreased by 50%*

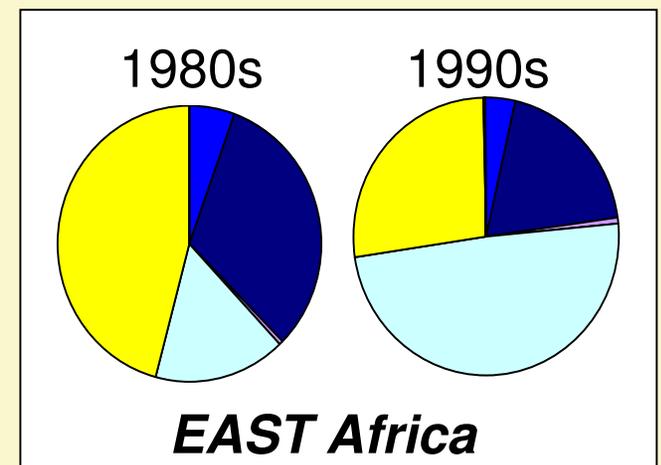
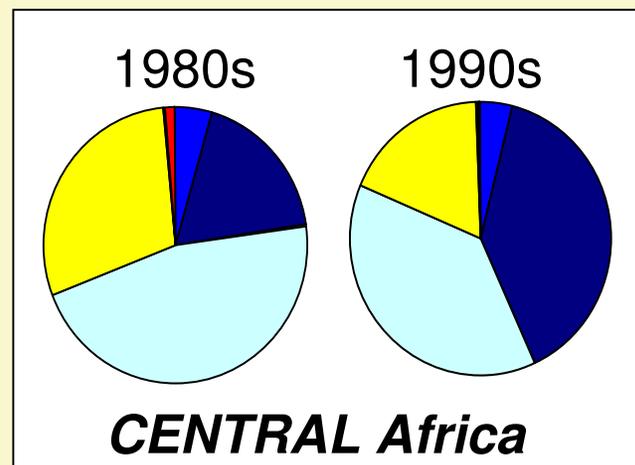
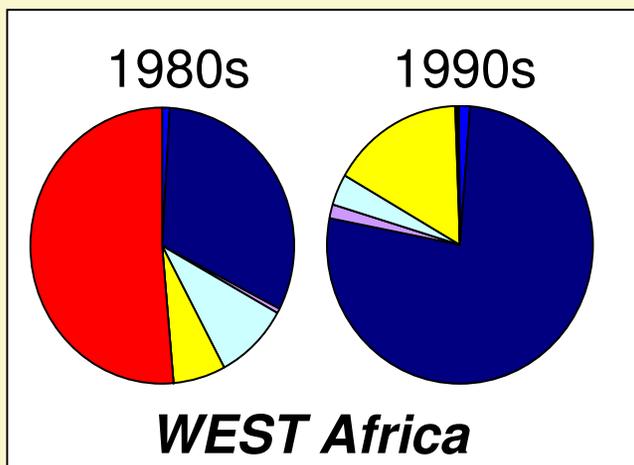
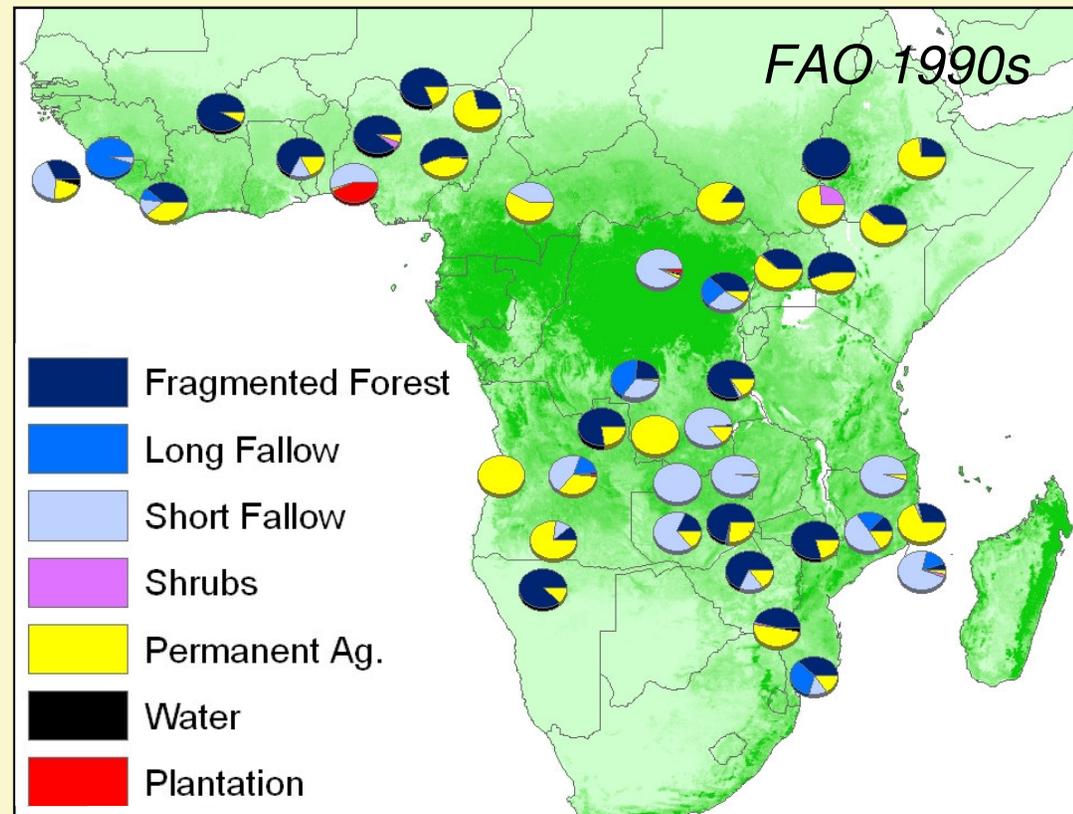
# The Changing Fate of Cleared Land: Tropical Africa

*All Regions* → Fragmented forest increased {p ~0.06}

*West Africa* → Permanent agriculture increased {p ~0.02} while plantations decreased

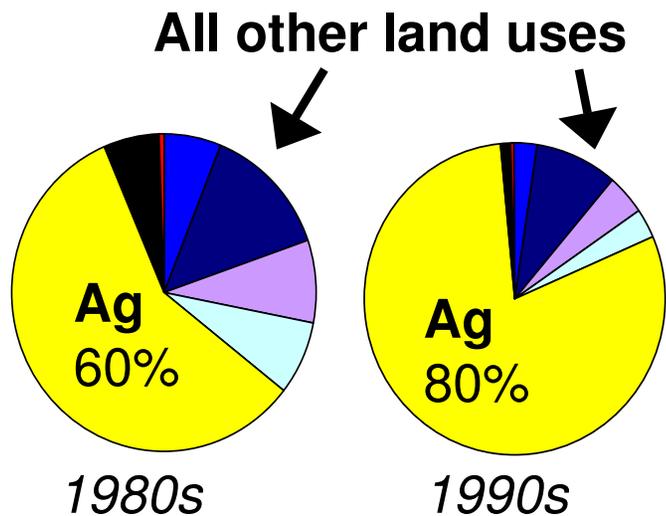
*East Africa* → Permanent agriculture decreased {p ~0.02} while short fallow increased

*Central Africa* → remained stable

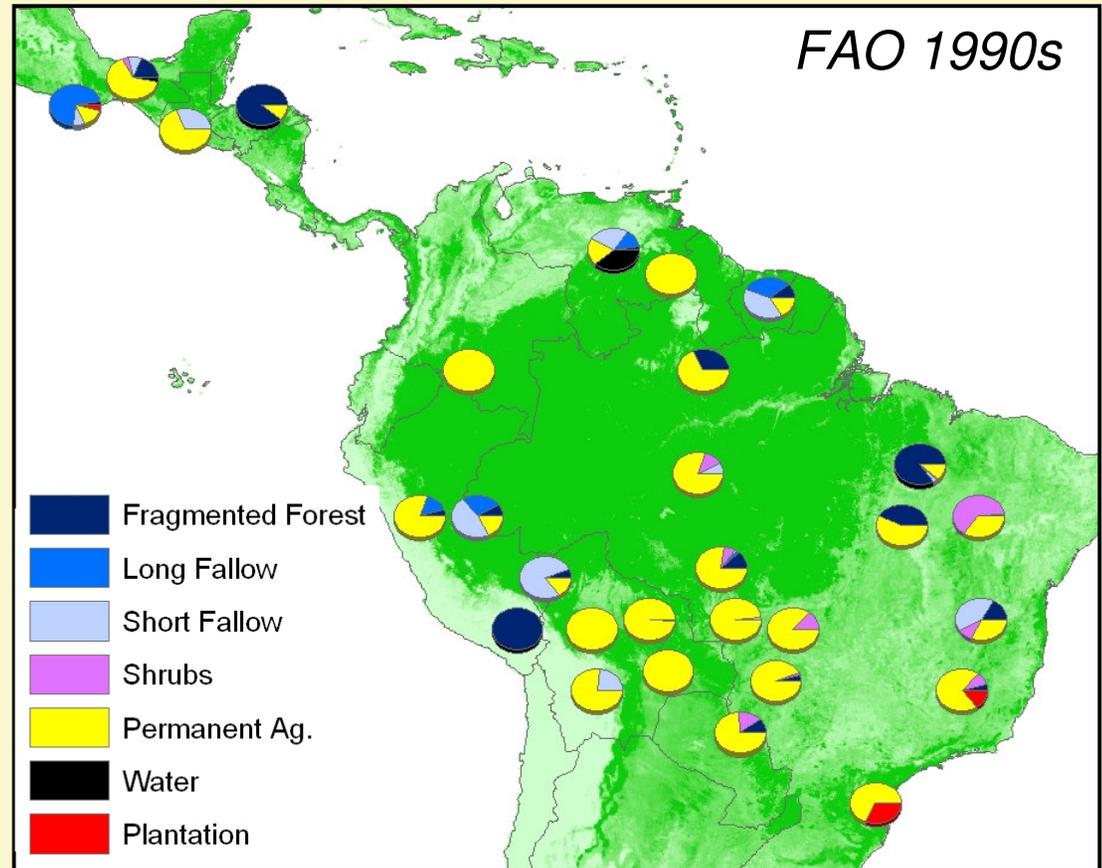


# The Changing Fate of Cleared Land: South America

- ✓ Clearing for permanent agriculture increased while all other land uses decreased
- ✓ Agricultural Intensification?



**Ag = Large-scale clearing for pastures or annual crops**

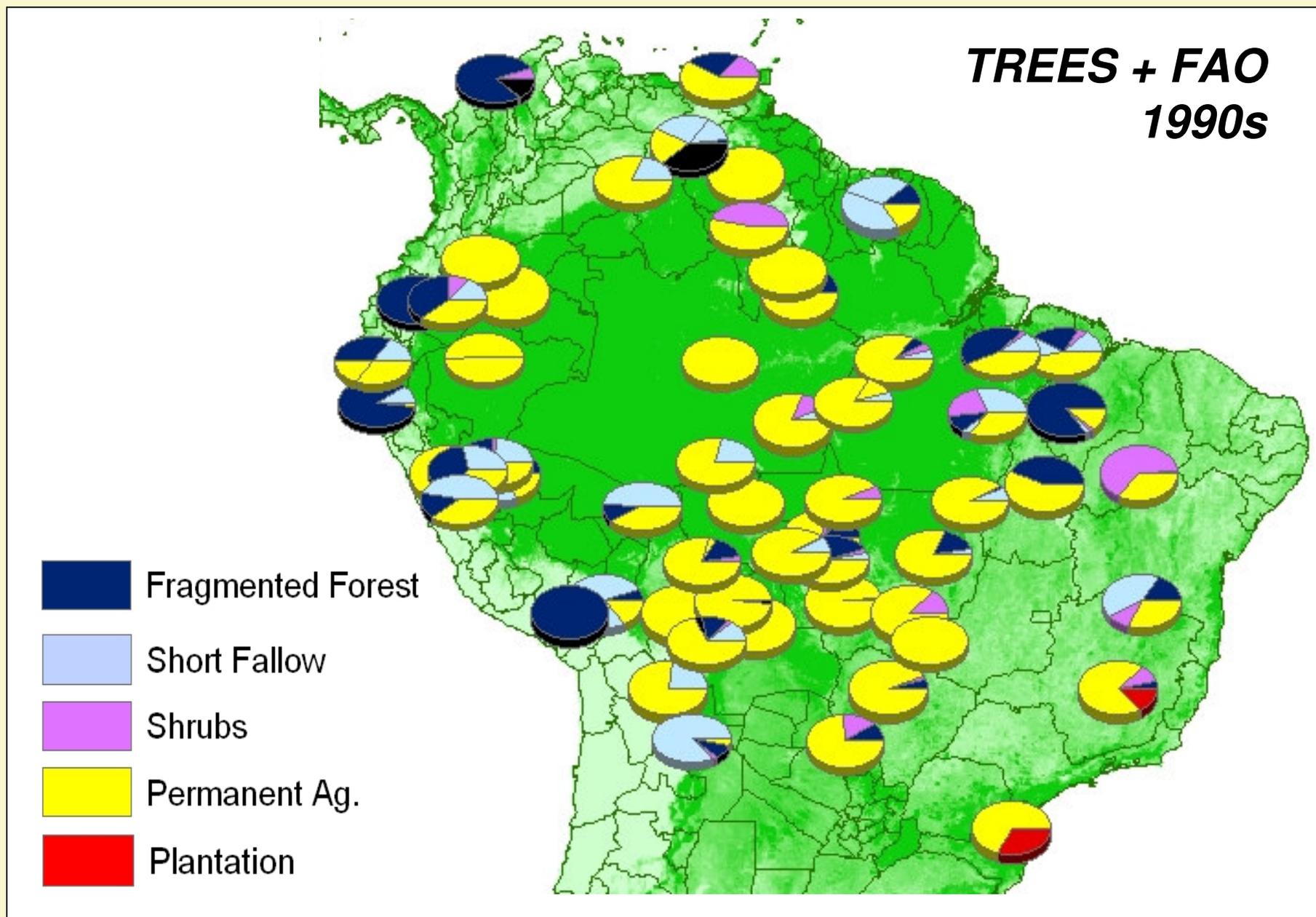


Secondary Forest Regrowth ↓ { $p = 0.02$ }

Deforestation for Short Fallow ↓ { $p = 0.03$ }

Deforestation for Permanent Ag ↑ { $p = 0.02$ }

# The Changing Fate of Cleared Land: South America



# *Agricultural intensification in Amazon Basin?*

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❖ More deforested land transformed for permanent agriculture { $p=0.06$ } while all other land uses decreased



More forests converted to pastures? Soybeans?

***What was the source of new agricultural land in the 1980s? 1990s?***

Mature forests? Secondary forests? Pastures?

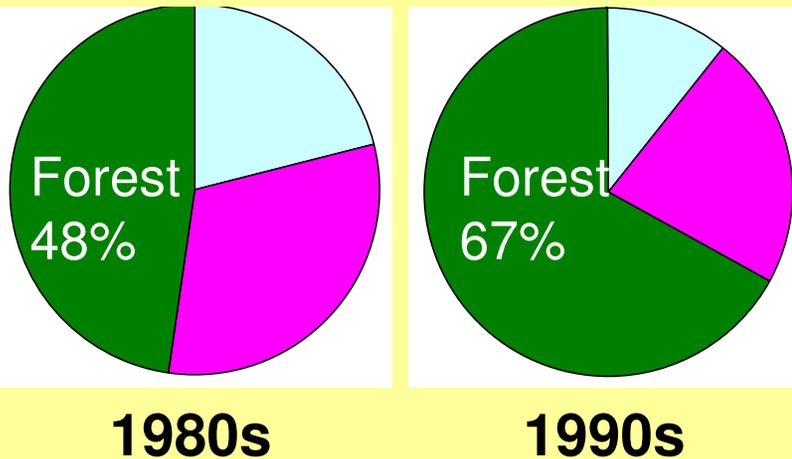
# Tracking the Source of New Agricultural Land

<b>Land cover 1980</b>	Closed Canopy Forest	Open Canopy Forest	Long Fallow	Fragmented Forest	Shrubs	Short Fallow	Agriculture	<b>State in 1980</b>
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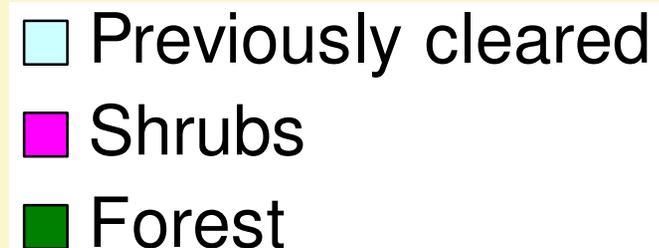
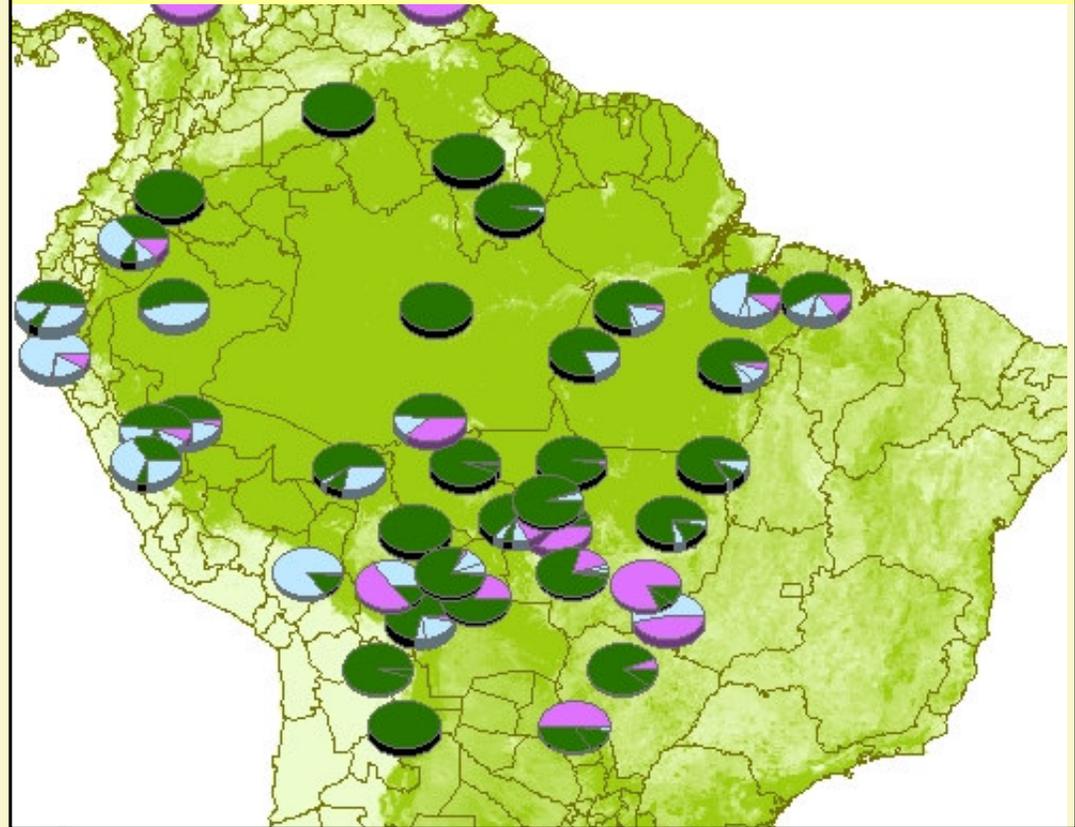
# Land cover replaced by agriculture in South America?

❖ Expansion of agricultural land into closed forest increased between the 1980s and 1990s { $p=0.11$ }

## Land Converted for New Ag.



## Source of new agricultural land in 1990s



# Is Soybean Expansion Increasing Deforestation?

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→ Our results indicate ~70% of *permanent agriculture* expansion during the 1990s came from forests

→ *However*, “agricultural land” includes both annual crops and pastures...

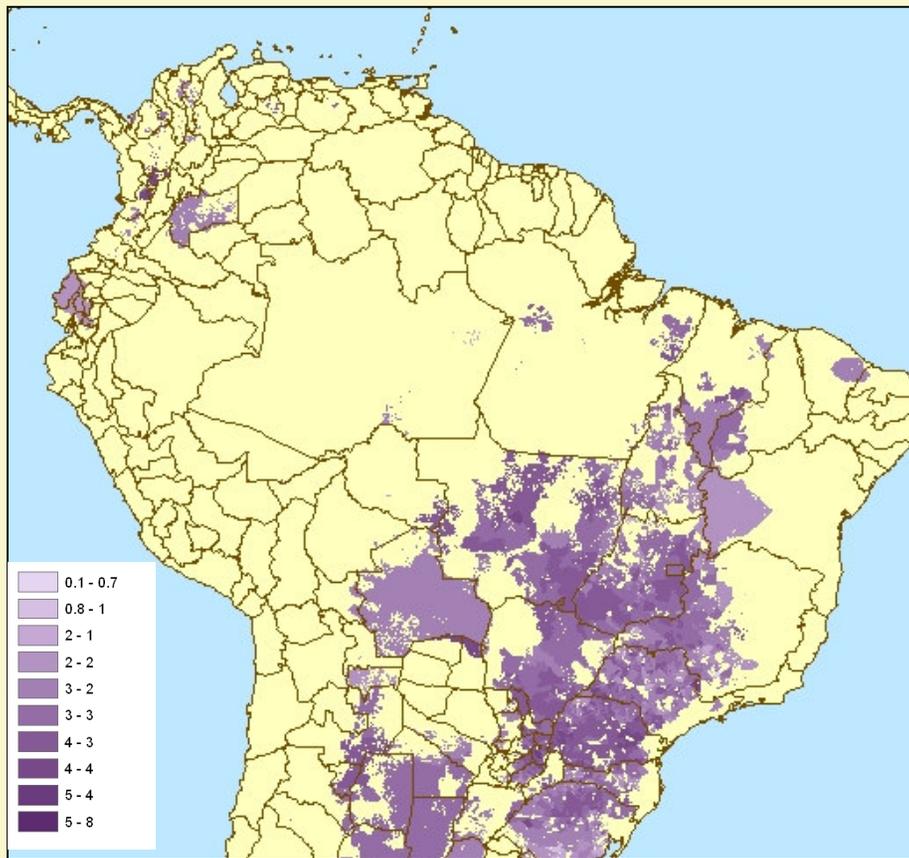
❖ *TREES / FAO Landsat scenes do not identify conversions of pasture / corn / rice to soybean fields*

❖ *Need ground-based data to identify increases in specific crop types and full land-use transitions*

# Option 1: Integrate with county-level census data?

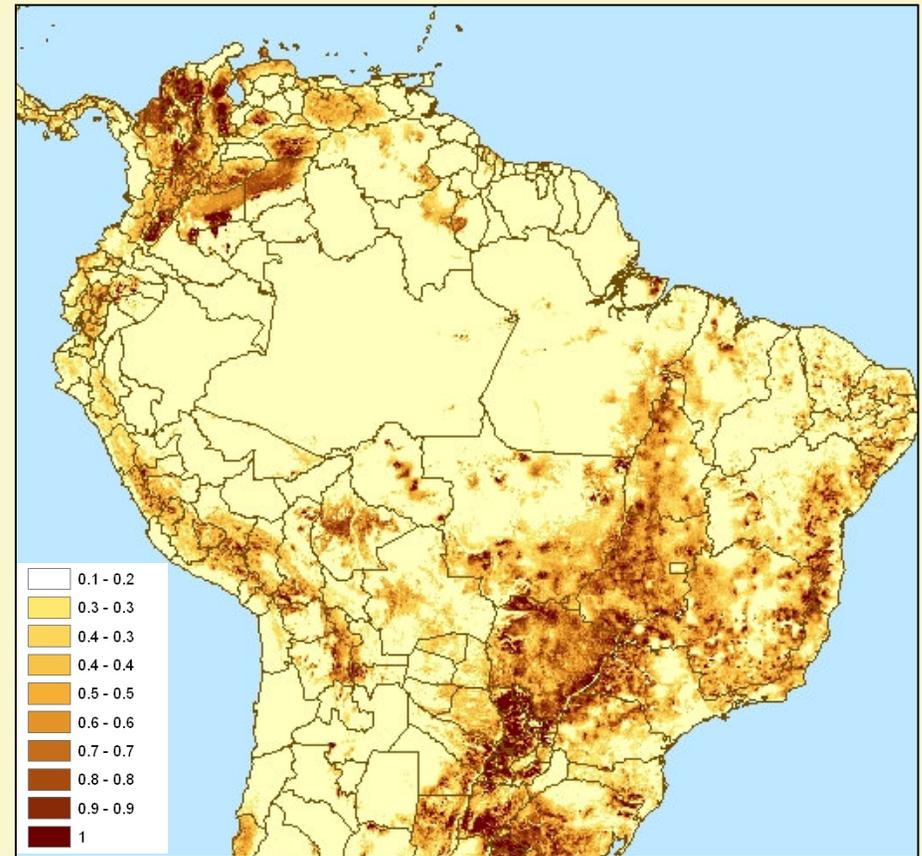
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*Soybeans ?*



*Monfreda et al. (submitted GBC)*

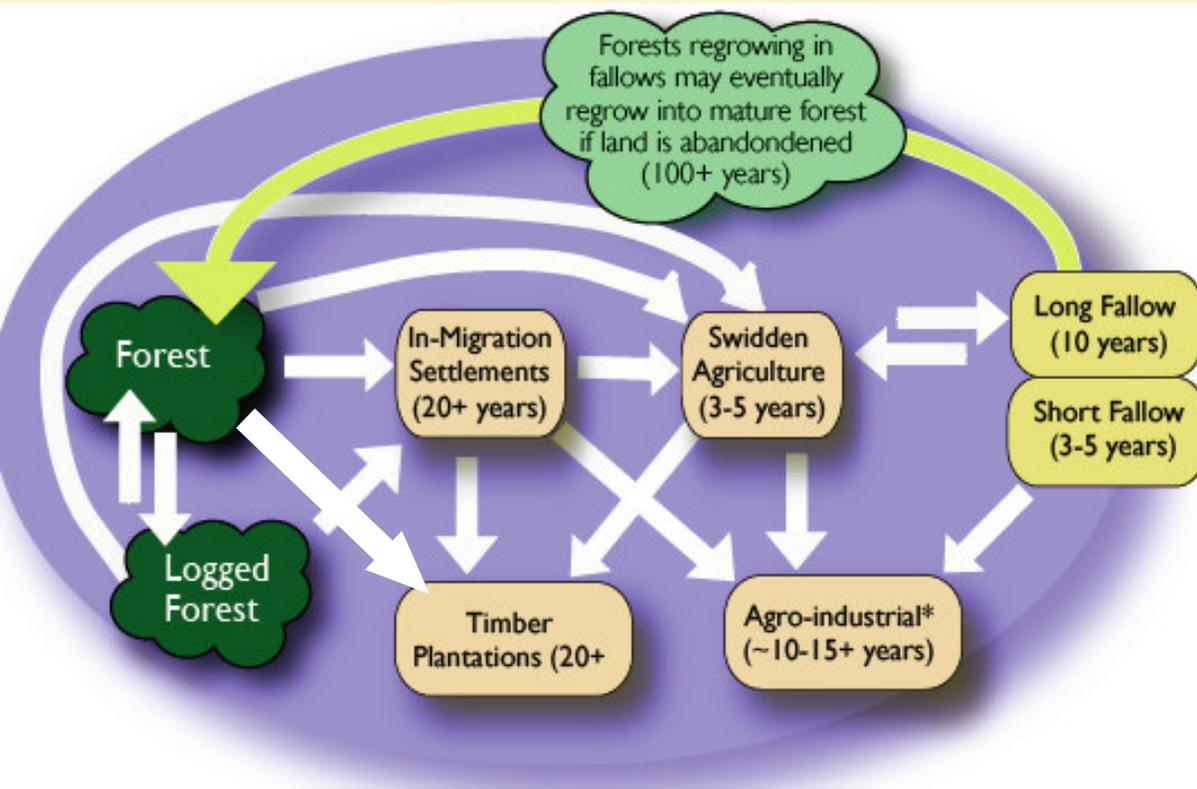
*Pastures ?*



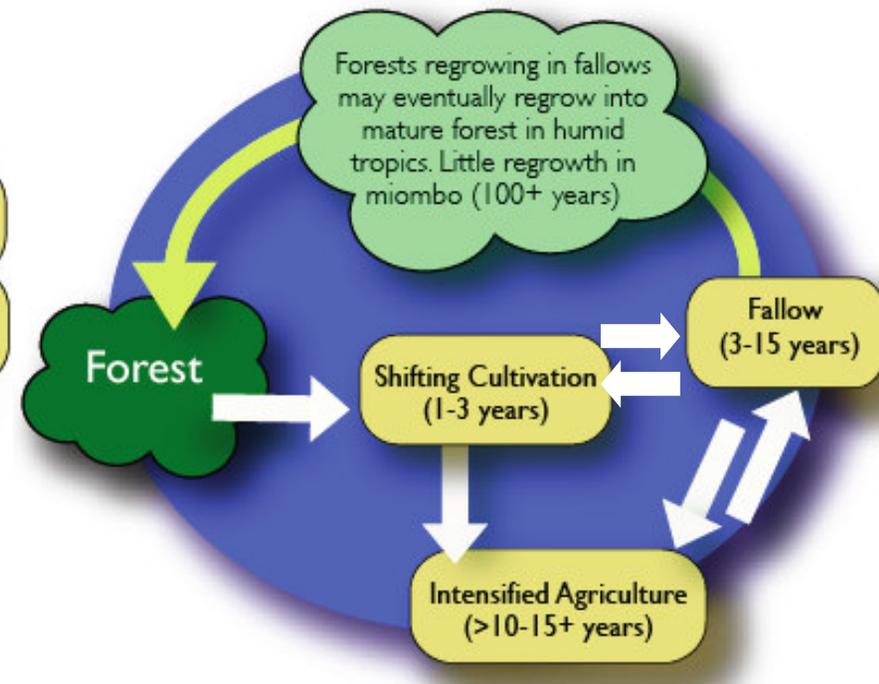
*Ramankutty et al. (in review, GBC)*

# Option 2: Integrate with “bottom-up” socioeconomic data?

*Land-use transition models synthesized from place-based literature to provide more complete view of land-use dynamics*



*Southeast Asia highlands during 1990s*



*West Africa lowlands during 1990s*

## Conclusions:

- ✓ Fate of cleared land varies across the tropics and between the 1980s and 1990s
- ✓ More forest cleared for large-scale agriculture in 1990s than in 1980s
- ✓ Need more than just location of change to assess impacts of land use on ecosystem goods and services

## Next Steps:

1. Integrate full land-use transitions into new global model
2. Assess impacts of tropical land use on carbon emissions

# *Questions?*

# Need full land-use transitions to accurately evaluate ecosystem goods and services

