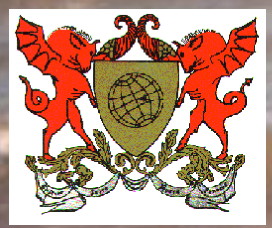
Investigating future trends in Amazon discharge and floodplain inundation

Michael T. Coe[1], Marcos Heil Costa[2], and David McGrath[1]

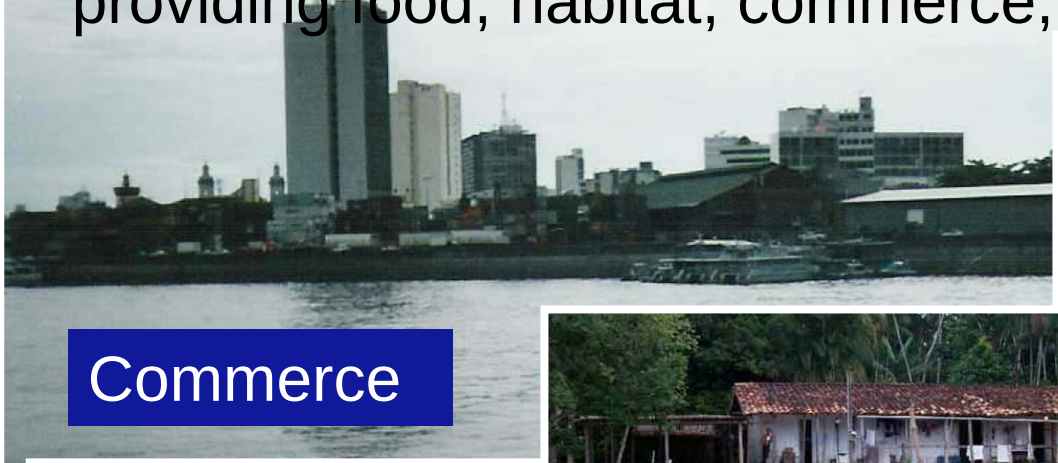
[1] The Woods Hole Research Center, Woods Hole, MA

[2] Universidade Federal de Viçosa, Viçosa Brasil

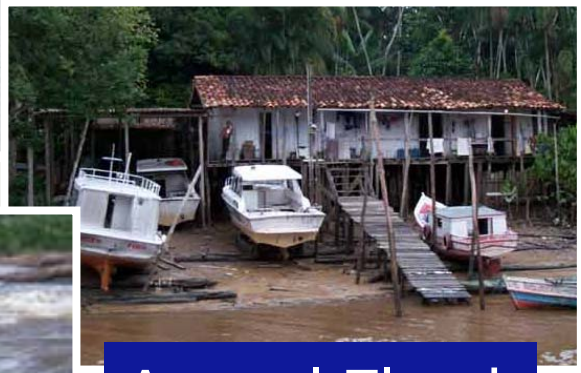


River is central to life in Amazonia

providing food, habitat, commerce, etc…



Commerce



Annual Flood

Ecotourism, travel

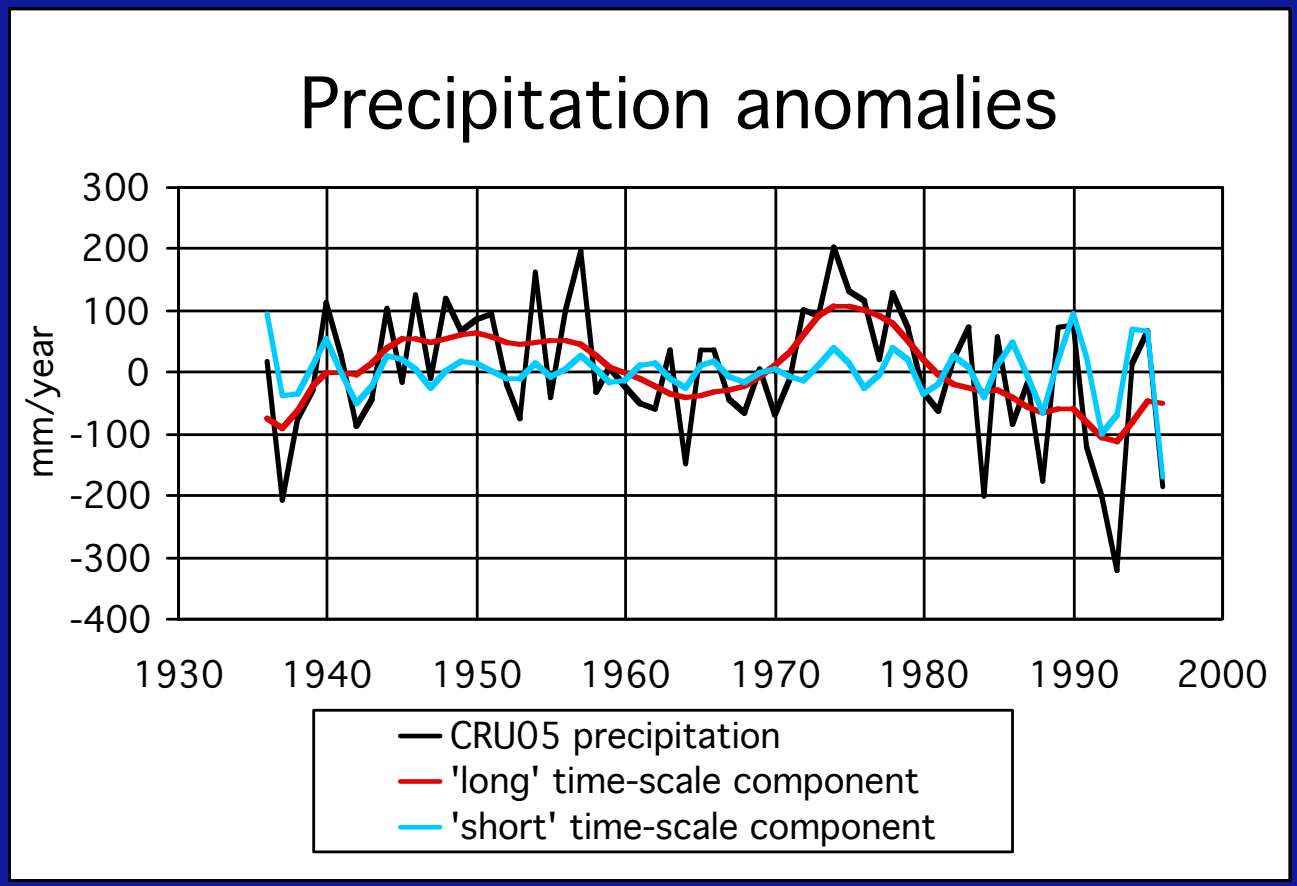
Fisheries

Future of River

Future will be influenced by combination of:

- Natural variability
- Direct human impacts
- Indirect human impacts

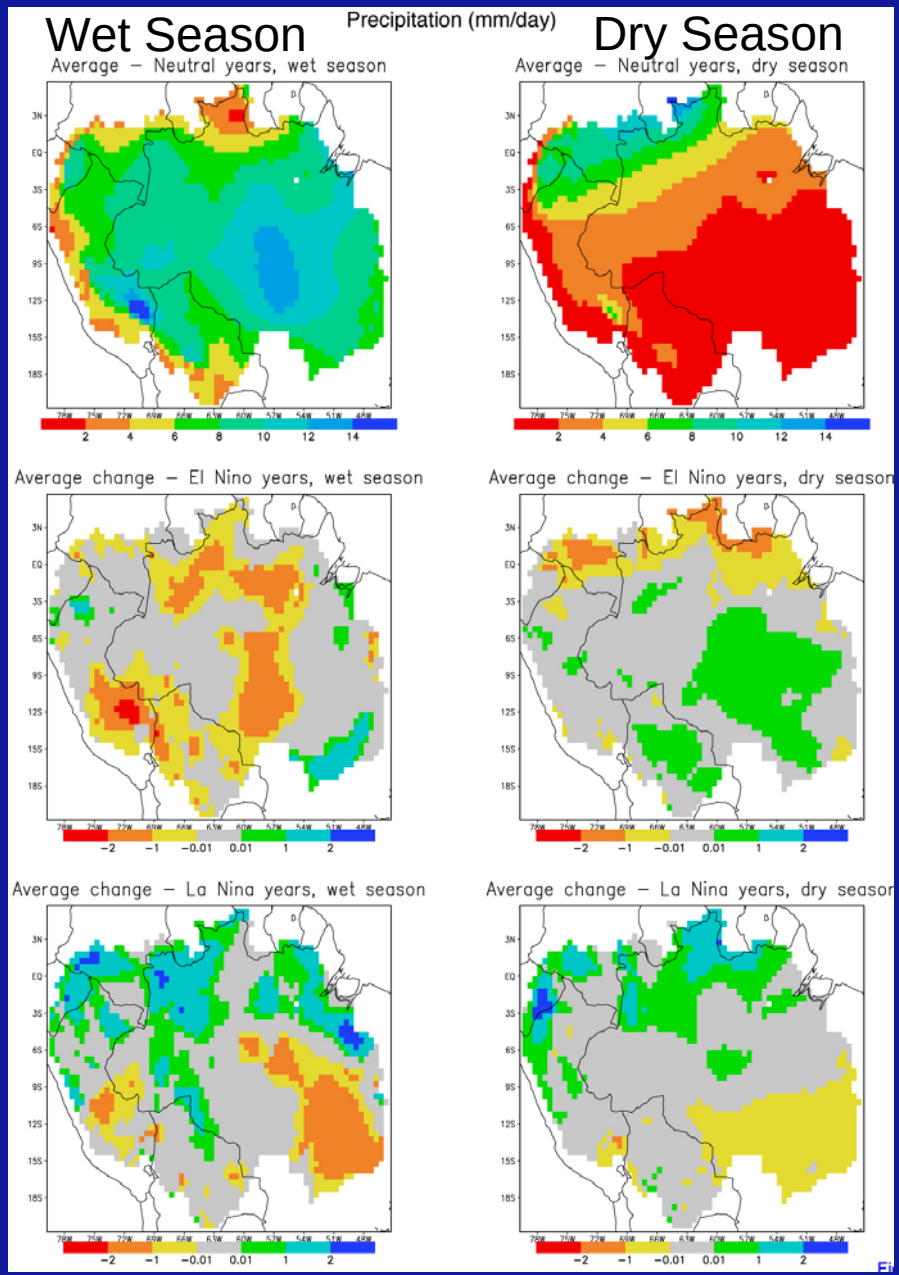
Natural variability



Botta et al. (2002)

- Long (26-year) and short (3-4 year) variability in precipitation
- Variability strongly influences surface water

ENSO Rainfall 1950-1996



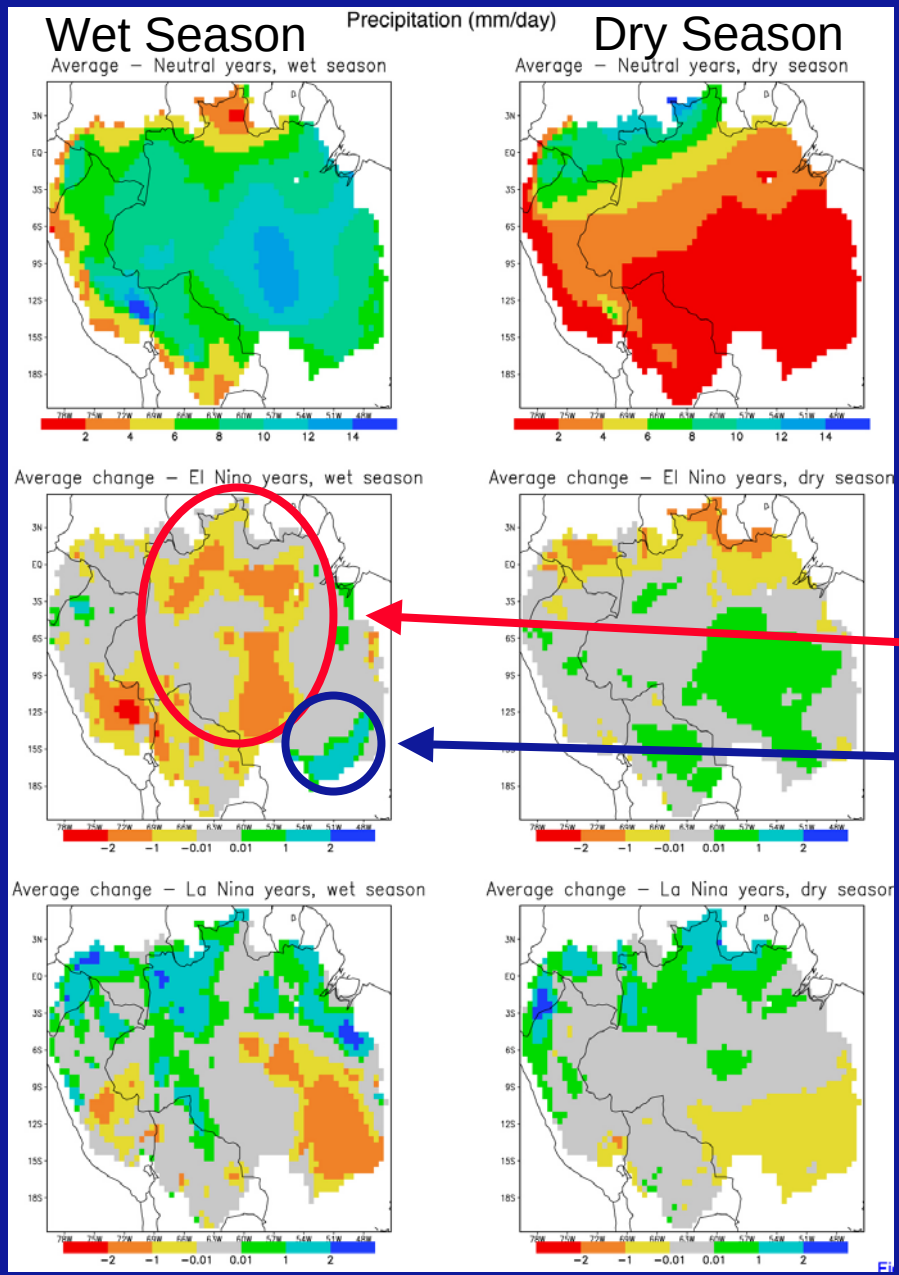
Non-ENSO

El Niño
Decreased in N, Central, increased SE

La Niña
Increased in N decreased SE

Foley et al., 2002

ENSO Rainfall 1950-1996



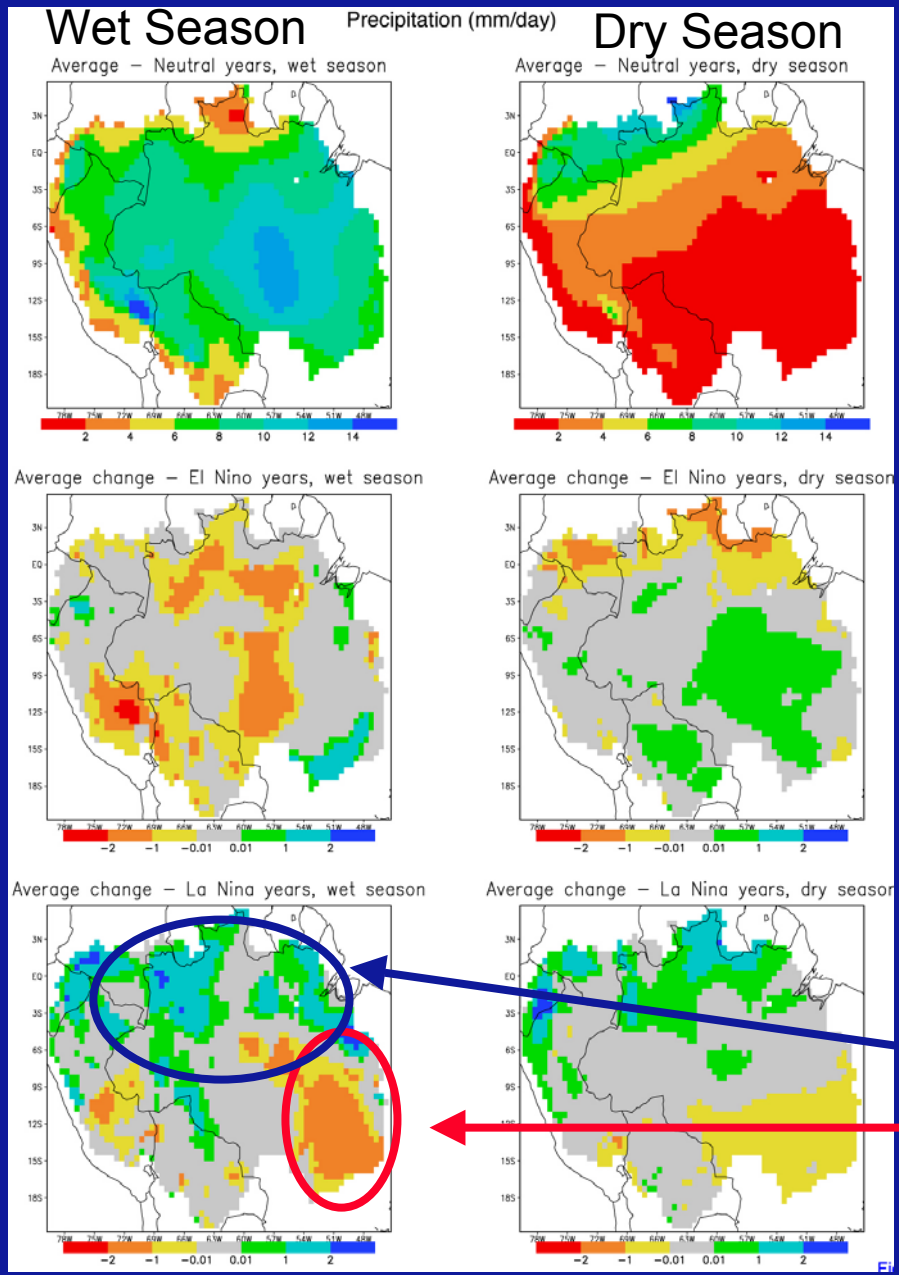
Non-ENSO

El Niño
Decreased in N, Central, increased SE

La Niña
Increased in N decreased SE

Foley et al., 2002

ENSO Rainfall 1950-1996



Non-ENSO

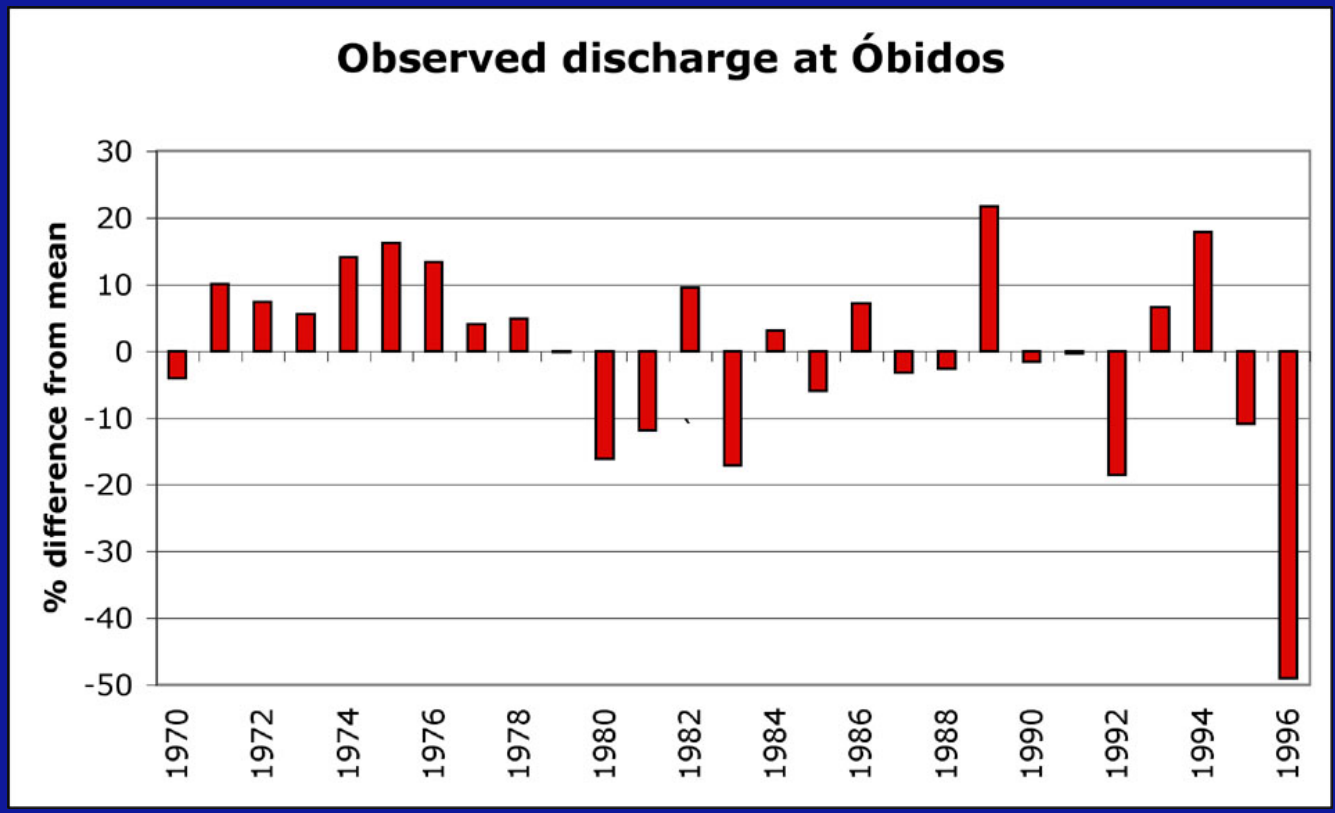
El Niño
Decreased in N, Central, increased SE

La Niña
Increased in N decreased SE

Foley et al., 2002

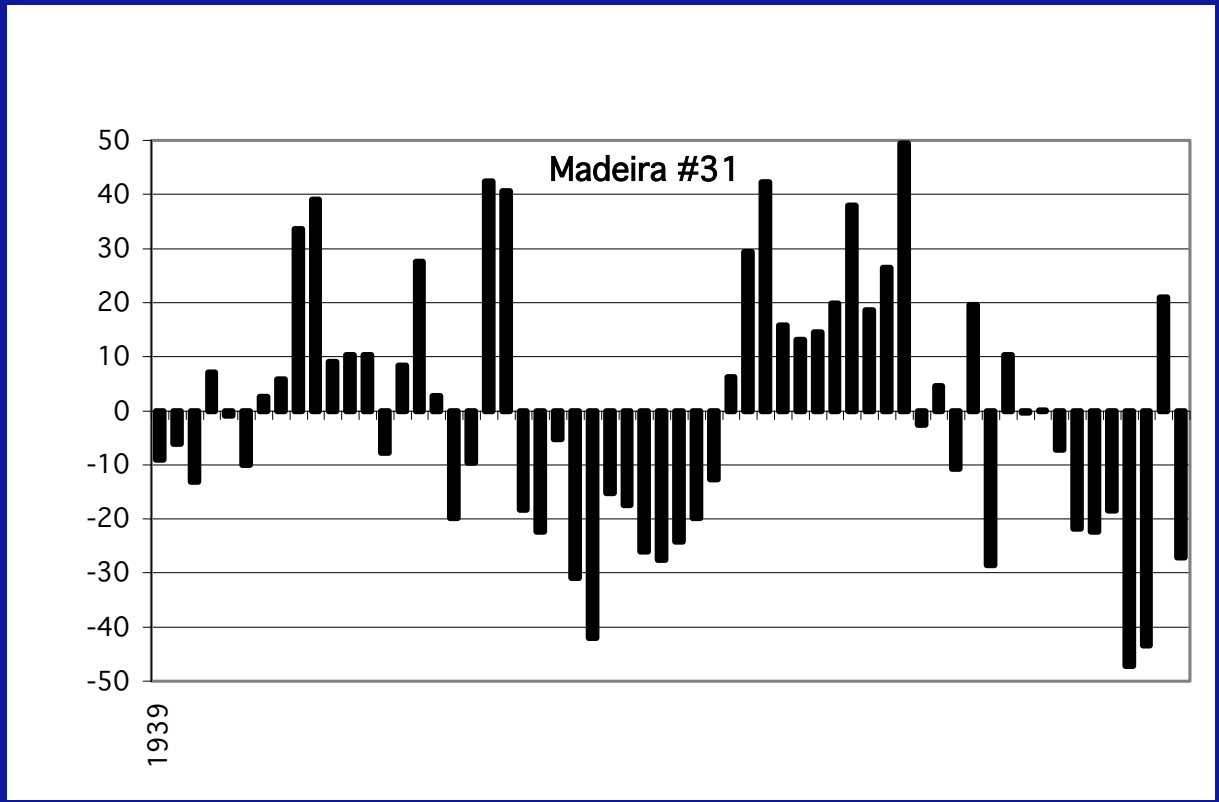
Natural variability

Observed Discharge



Natural variability

Simulated Discharge



Human Influences

- Indirect
  - Feedbacks from surface changes (altered regional climate)
  - Climate change (greenhouse warming)
- Direct
  - Changes to vegetation and land use (altered surface energy, water, and biogeochemical balances)
  - Changes to river structure (reservoirs, channelization)

Direct influences

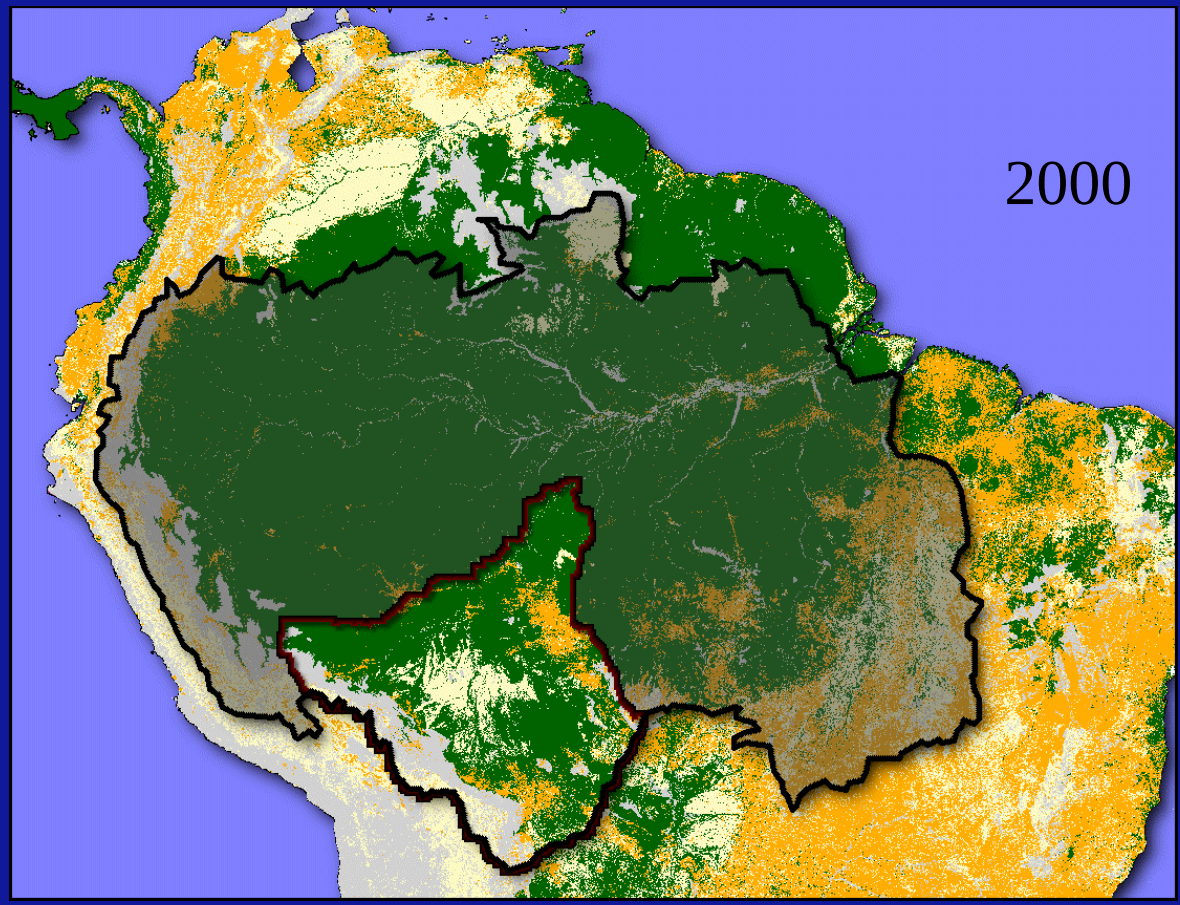
Land use and land cover changes alter flow and chemistry

Numerous local studies have shown that deforestation often results in:

- Decreased evapotranspiration
  - Decreased rooting depth
  - Decreased LAI
  - Less soil infiltration
- Increased runoff and river discharge in wet and dry seasons
- Changes to chemical input to streams

Land Cover and Chemistry of Ji-Parana

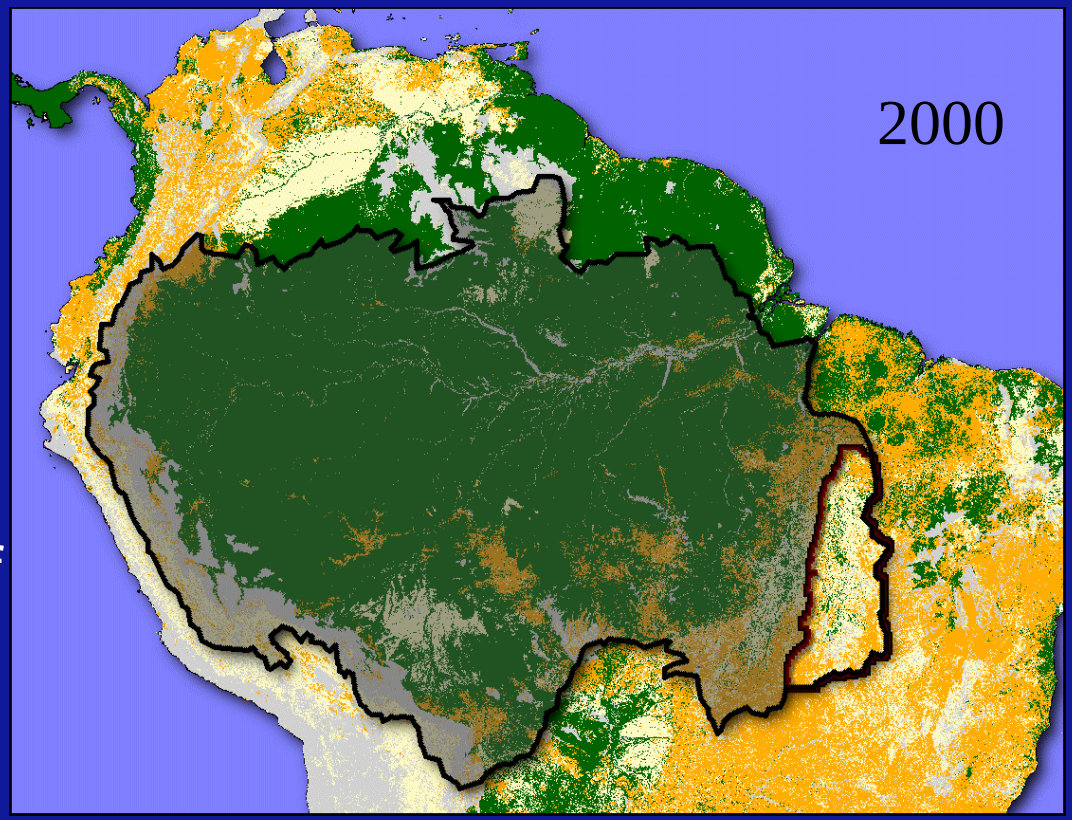
- Deforestation, ranching, and urban populations in Rondonia are associated with increased sulfate, potassium, sodium, and chloride in streams.



Biggs et al., 2002, Ballester et al., 2003

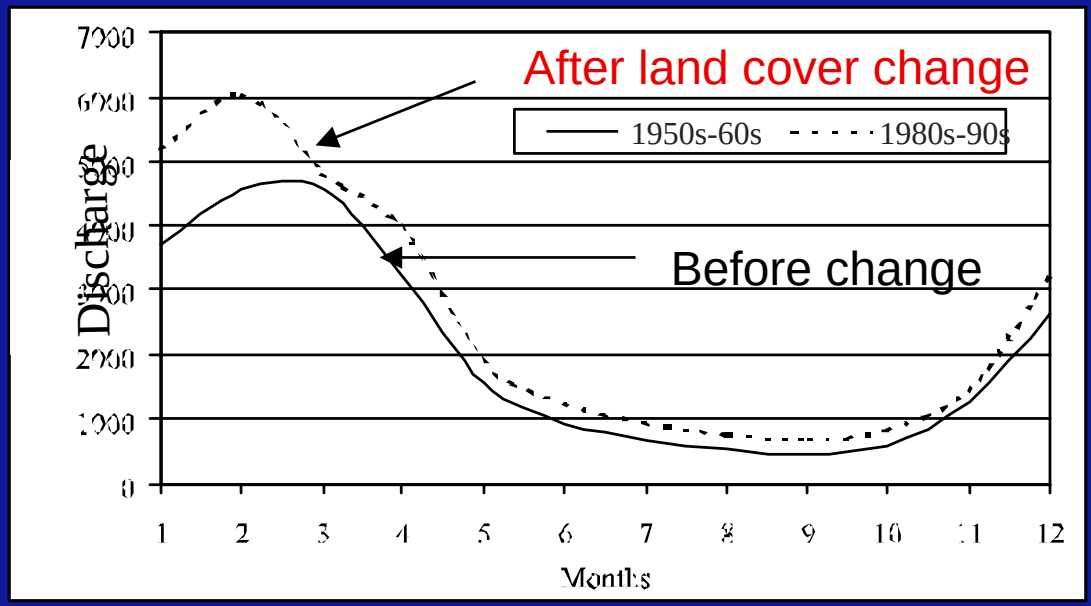
Land Cover Change and Tocantins -- Costa et al., 2002

- 175000 km^2
- Compared two periods 1949-1968; 1979-1998
- Cropland and pasture increased from 30% of basin in 1960 to 50% of basin by 1995



Costa et al., 2003

Discharge of Tocantins Before and After Change

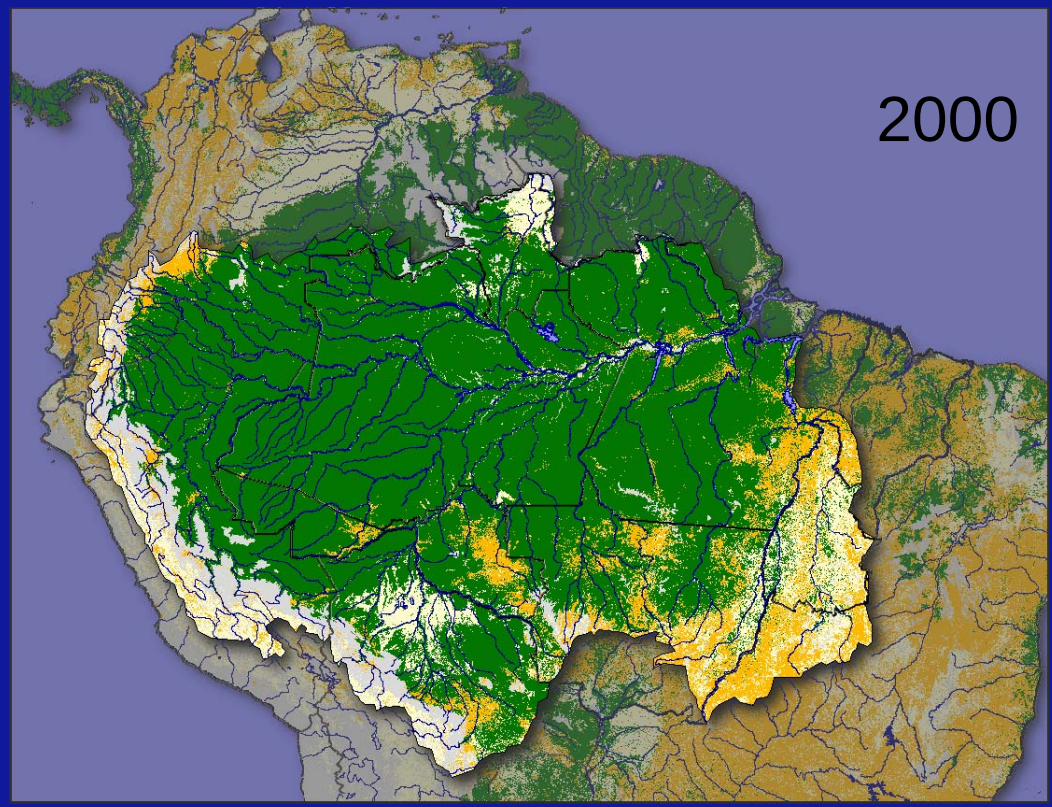


- Observed 30% increase in discharge in wet season with no change in rainfall
- Found maximum discharge to be one month earlier

Costa et al., 2003

Land Cover Change

- About 15% of basin is currently deforested, mostly in SE
- Demand for agricultural and forest products is currently very high
- Possibility exists for large increase in the deforested area.

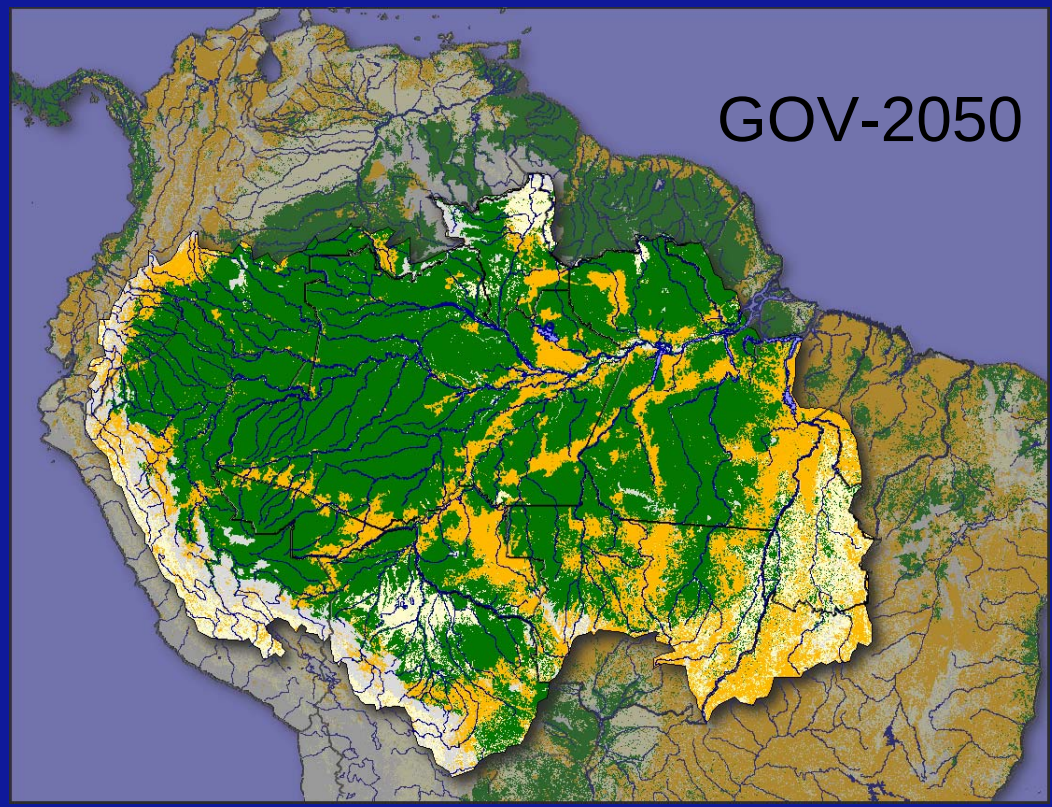


Eva et al., 2000

Figure: Paul Lefebvre

Land Cover Change

- Soares-Filho et al., 2004 developed model scenarios of future deforestation
- Prescribed governance rules limiting deforestation in individual locations



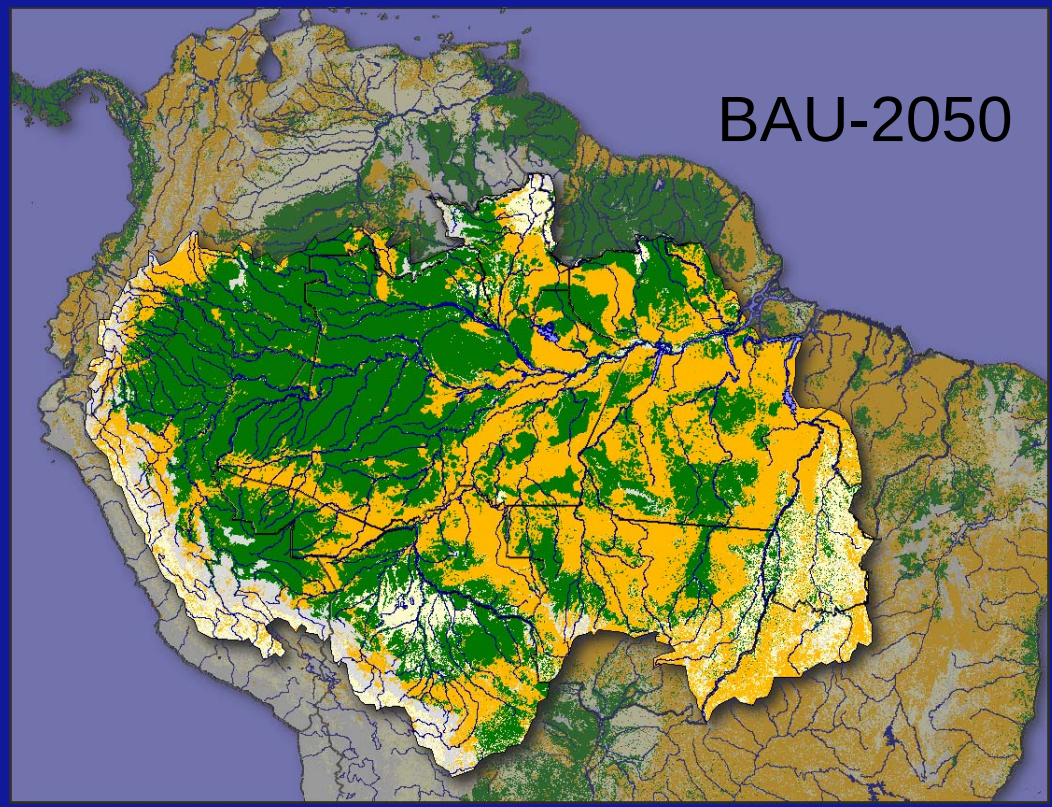
About 36% of basin deforested by 2050

Soares-Filho et al., 2005

Figure: Paul Lefebvre

Land Cover Change

- Soares-Filho et al., 2004 developed model scenarios of future deforestation
- Business-as-Usual where current trends are extrapolated to future with no control on total deforestation



About 46% of basin deforested by 2050

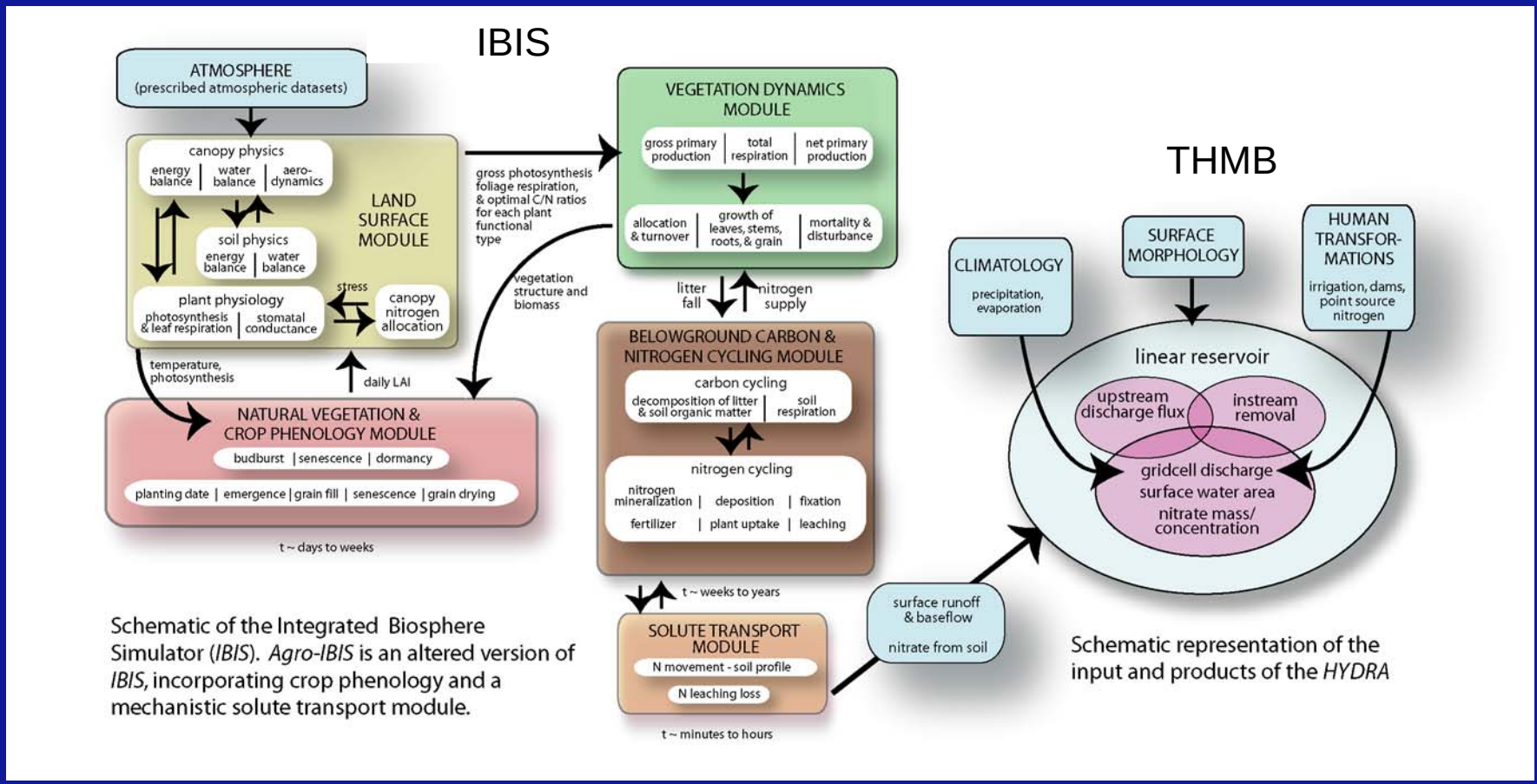
Soares-Filho et al., 2005

Figure: Paul Lefebvre

Questions

- What affects could land cover change have on the river in the future --locally and downstream?
- Are these changes to the energy and water balance of potentially important scale?
- Are there significant differences in future scenarios for the River?

IBIS-THMB models



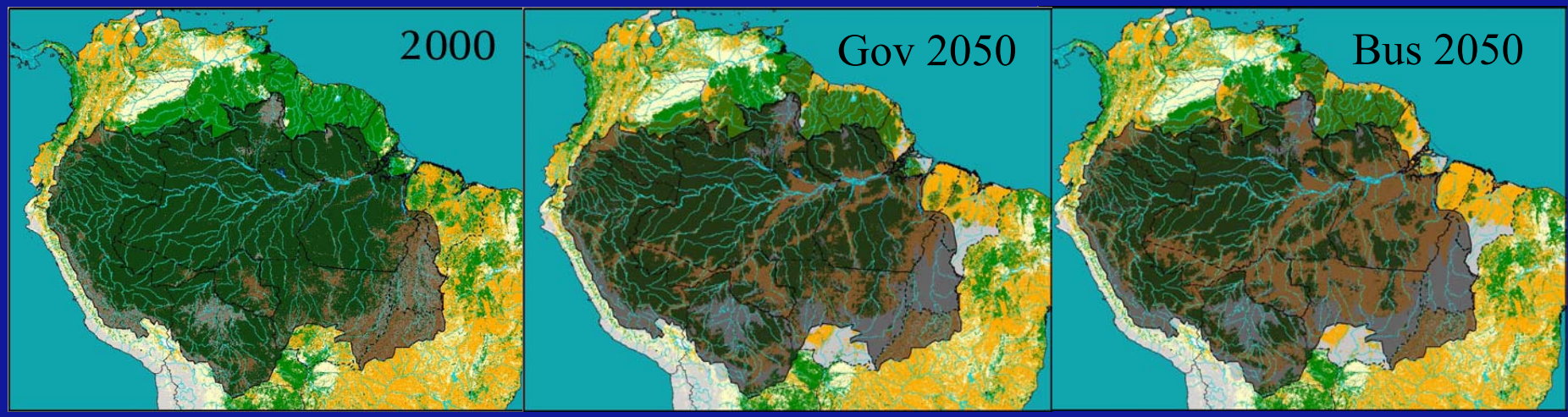
Schematic of the Integrated Biosphere Simulator (*IBIS*). *Agro-IBIS* is an altered version of *IBIS*, incorporating crop phenology and a mechanistic solute transport module.

Schematic representation of the input and products of the *HYDRA*

- Empirically derived estimates of changes in evapotranspiration
- Mechanistic models of plant and soil functioning
- Partitions incoming precipitation and radiation
- Routes runoff across landscape to simulate rivers, lakes, and wetlands

Kucharik et al., 2000; Coe et al., 2002

Sensitivity of hydrology to land cover changes



Eva et al., 2000

Britaldo Soares

- Simulate change in runoff with RisQue and IBIS models
- Simulate change in discharge and flooded area with THMB

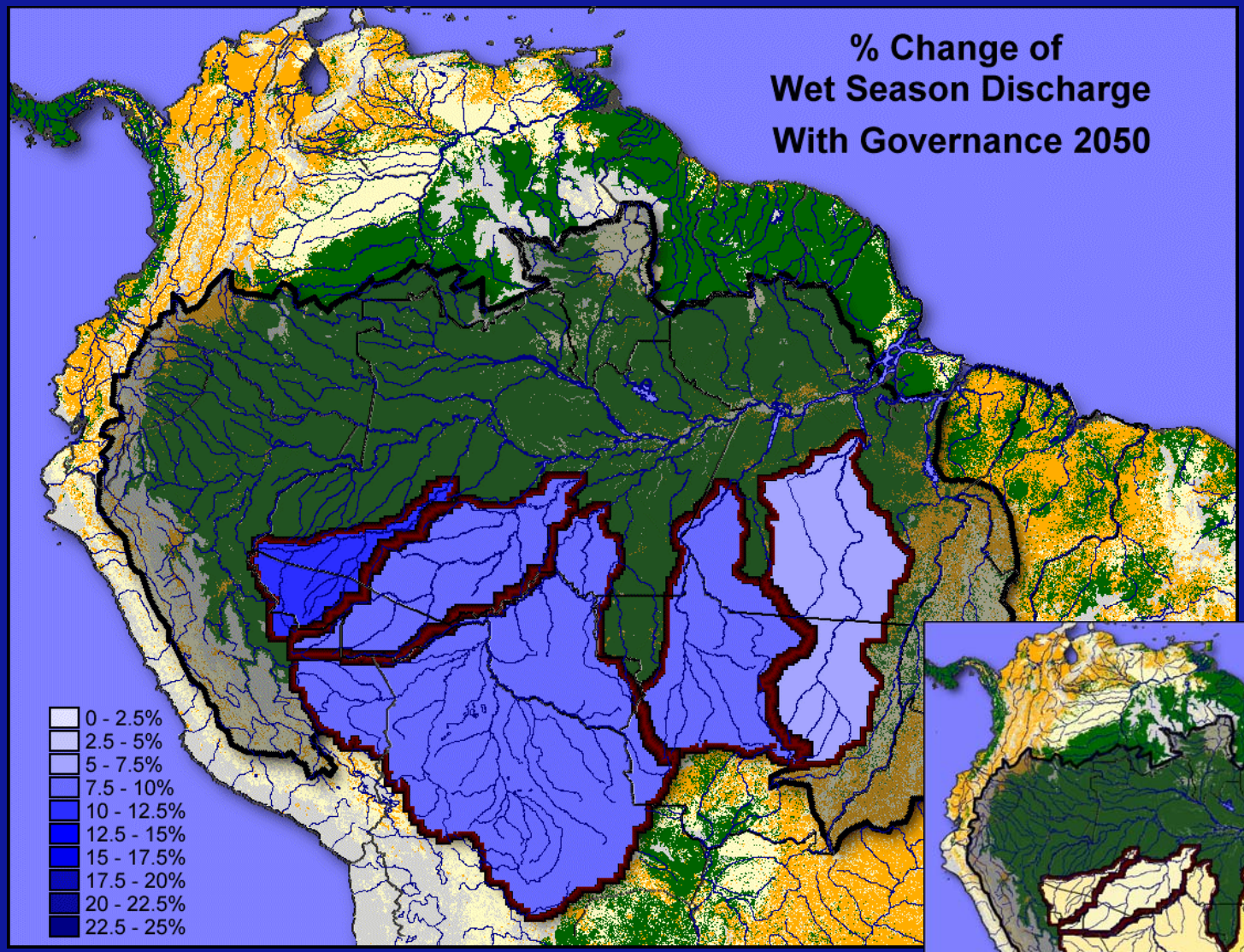
Figure: Paul Lefebvre

Discharge -governance

20-30% of basins deforested

Figure: Paul Lefebvre

Discharge -governance



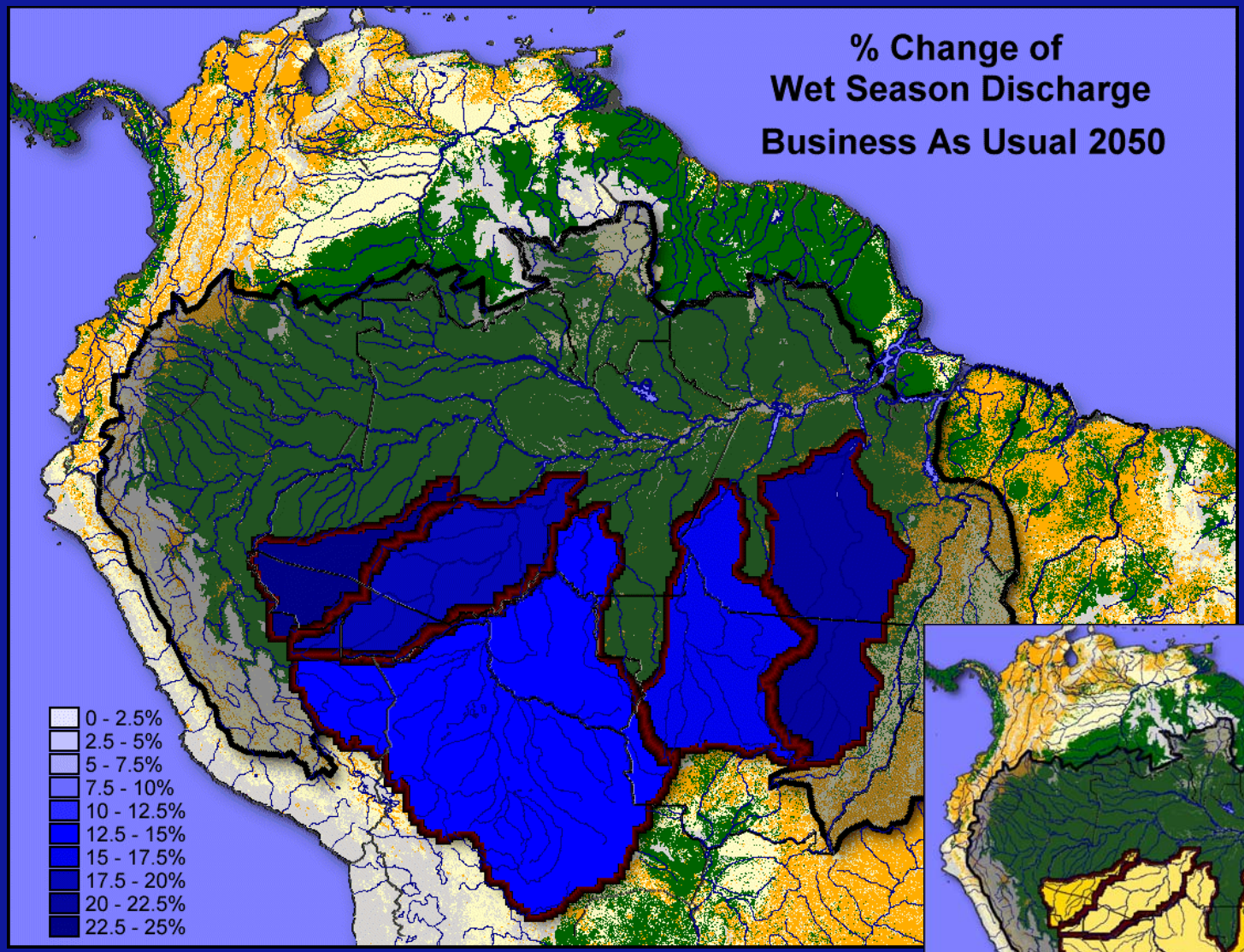
5-15% increase in discharge

Discharge -business as usual

30-55% of basins deforested

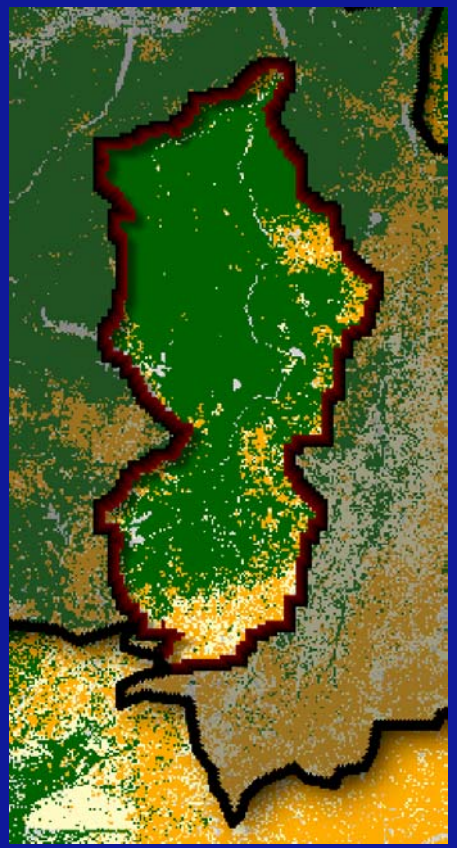
Figure: Paul Lefebvre

Discharge -business as usual

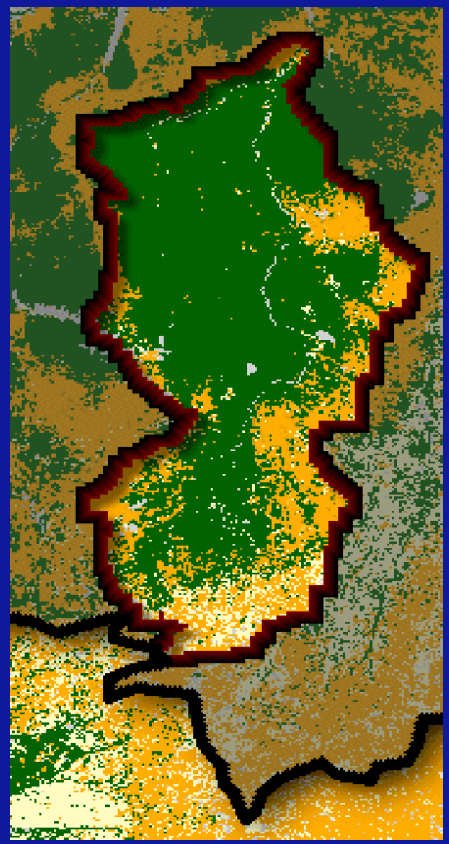


15-25% increase in discharge

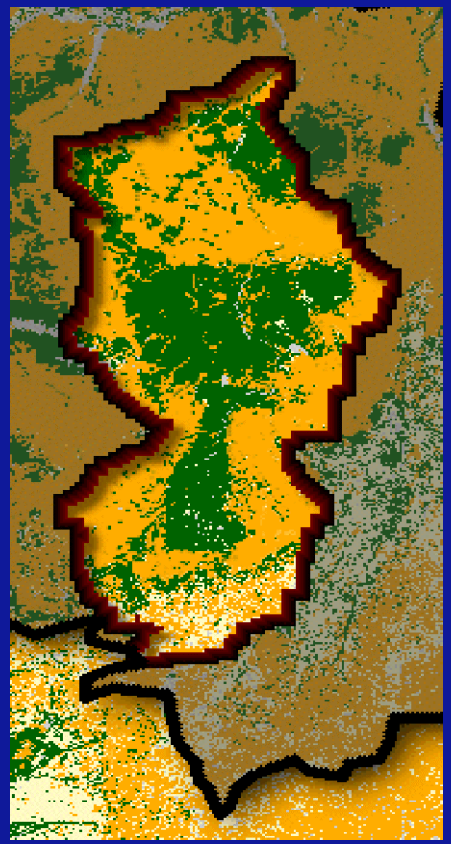
Xingu Basin



2000

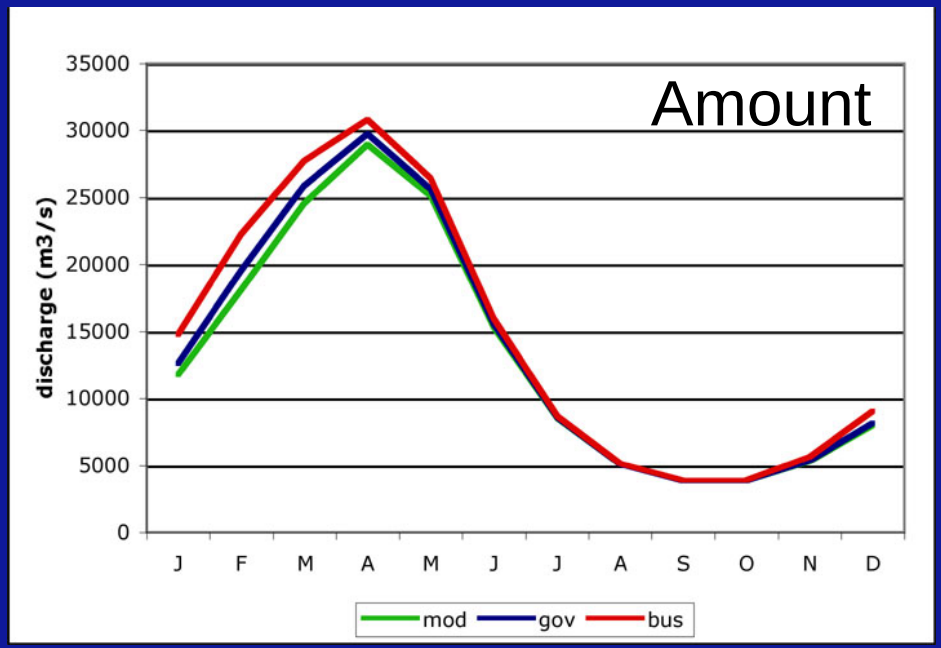


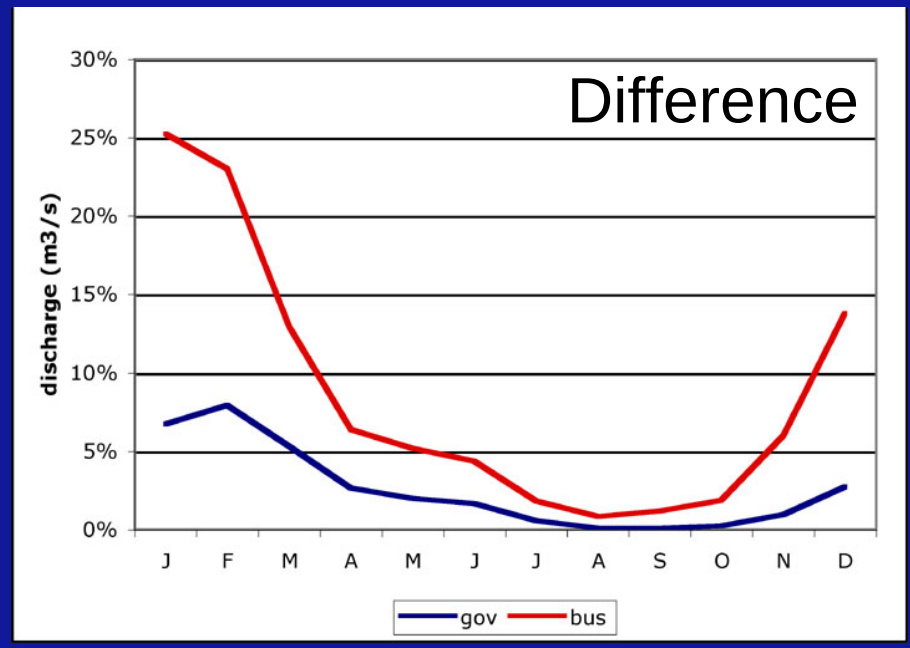
2050 GOV



2050 BAU

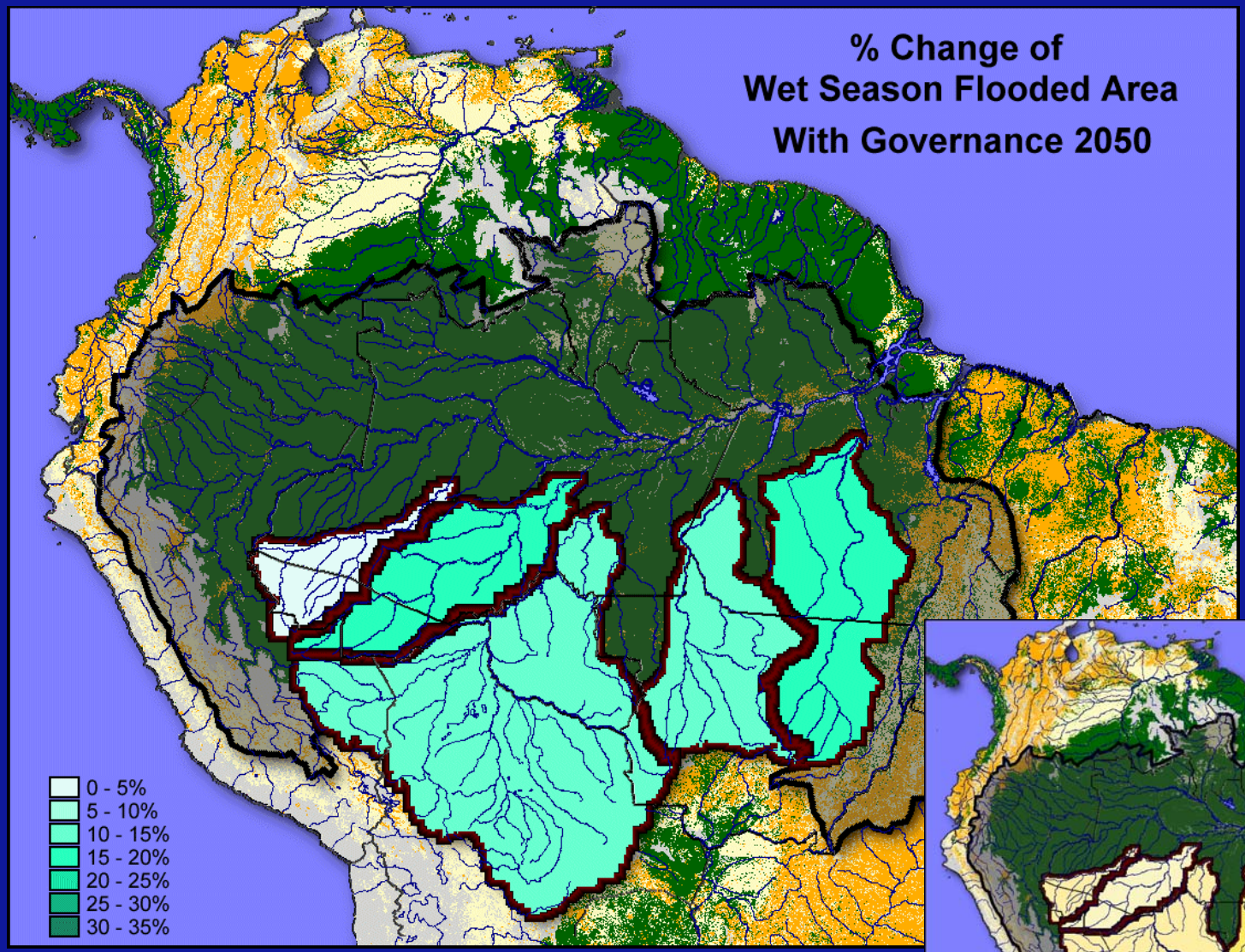
Discharge --Xingu





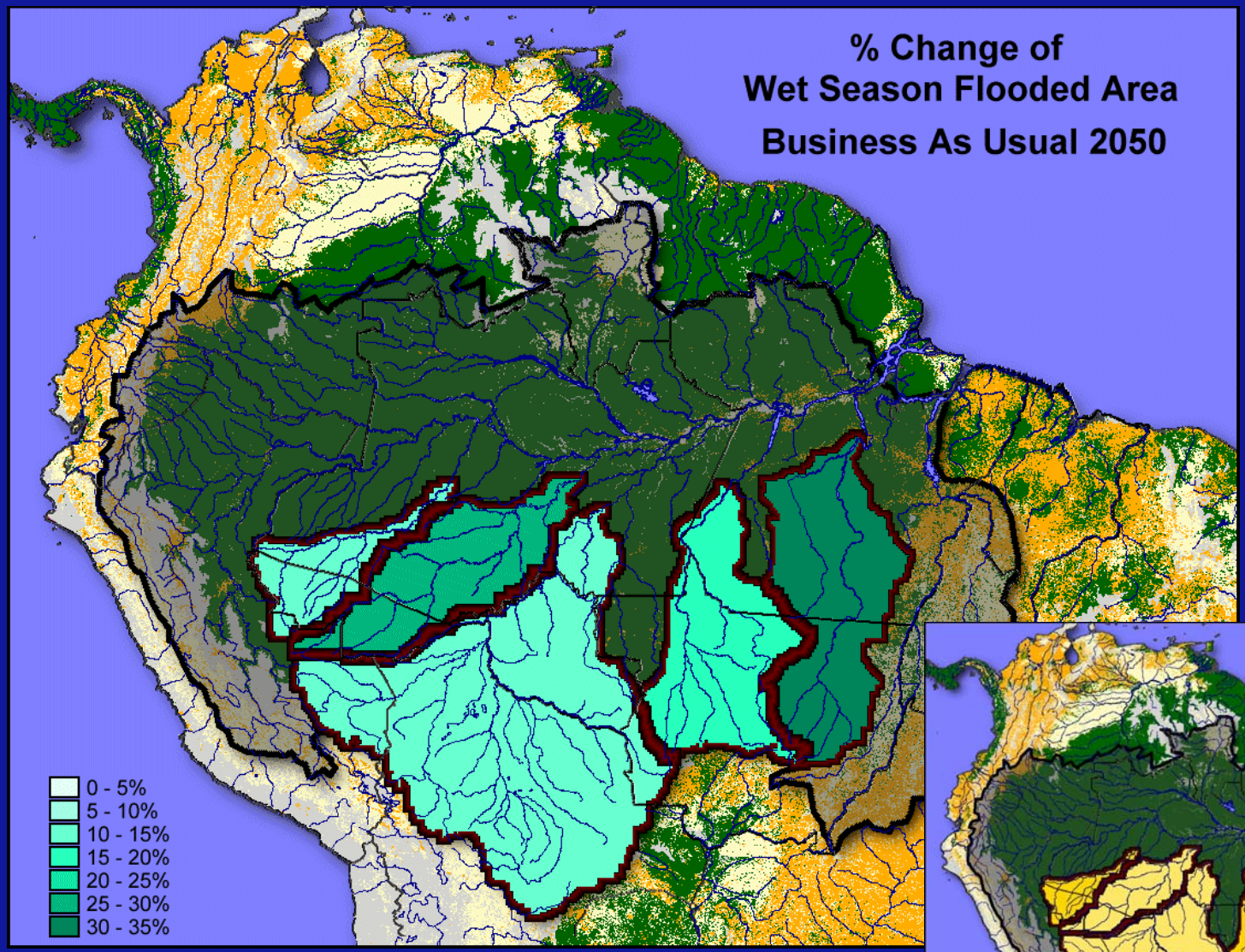
Xingu	2000	2050-gov	2050-bus
Area deforested	15%	20%	55%
Wet season change		+8%	+25%

Inundation -governance



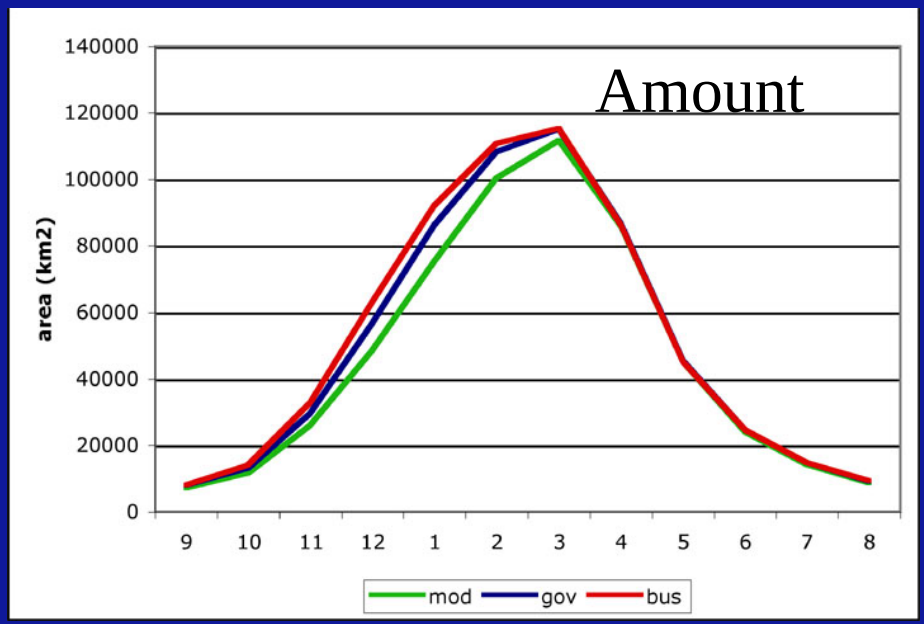
5-15% increase in flooded area

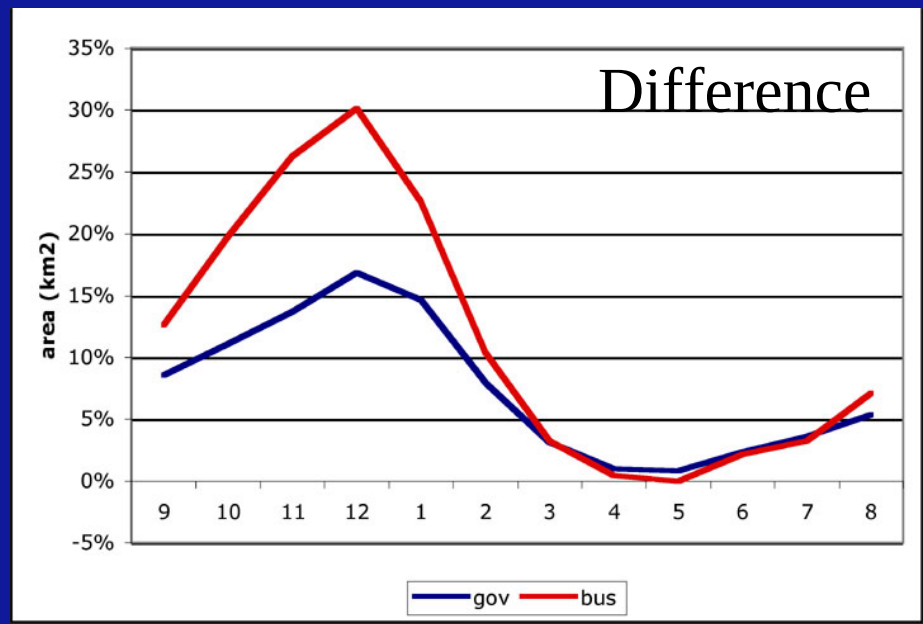
Inundation -business as usual



10-35% increase in flooded area

Flooded area --southern tributaries





All	2000	2030-GOV	2030-BUS
Area deforested	10%	23%	42%
Wet season change		+15%	+30%

Summary

- Humans are likely to affect hydrology of Amazonia through direct and indirect methods
- Observations and models suggest that scale of the effects of land cover change may be important
- Models suggest that differences in outcomes of future land cover scenarios are large
- Future studies will integrate direct and indirect impacts