NASA LCLUC Science Team Meeting – April 2013

Land and resource use on the Amazon floodplain under evolving management systems and environmental change: Fish, forests, cattle, and settlements

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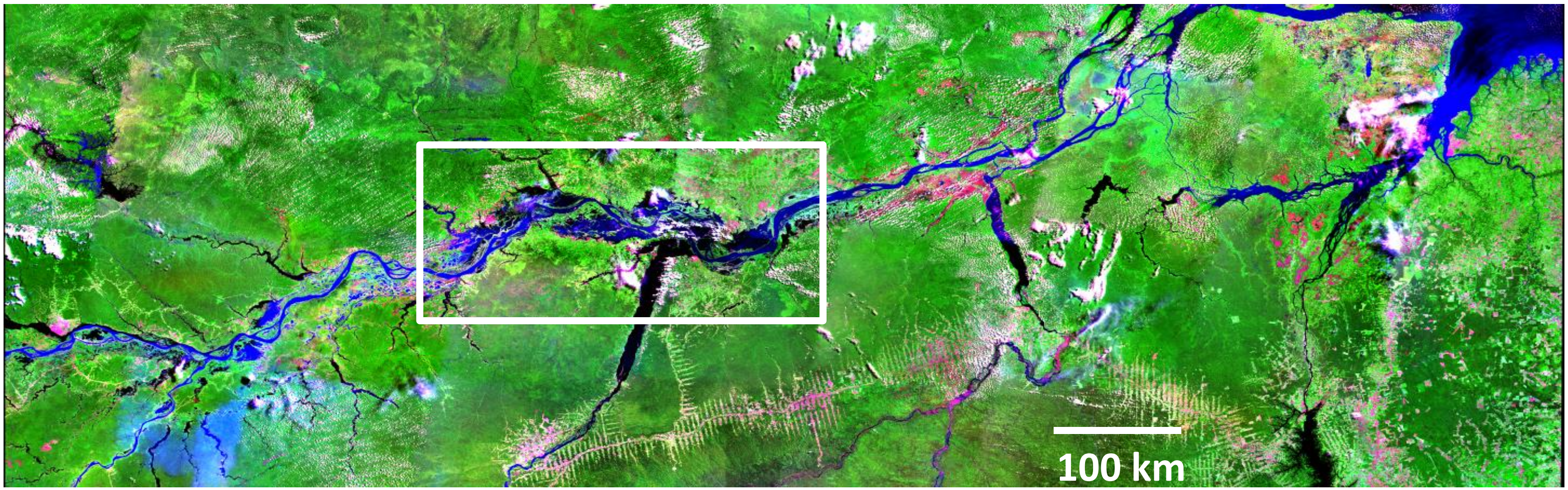
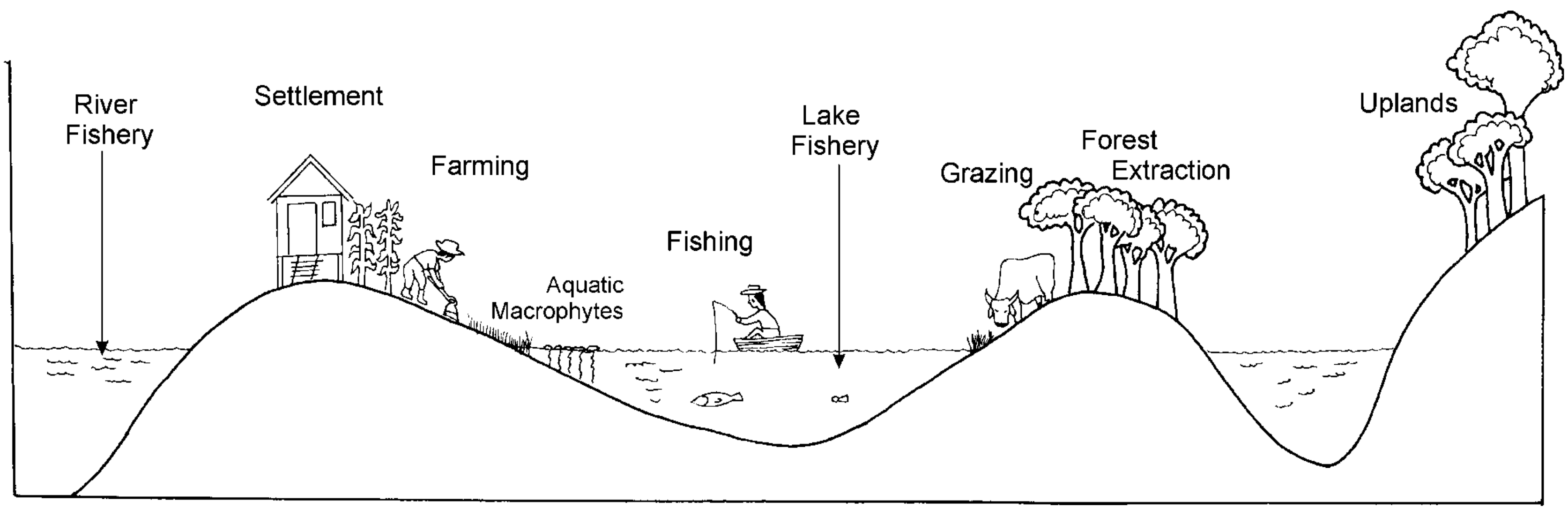
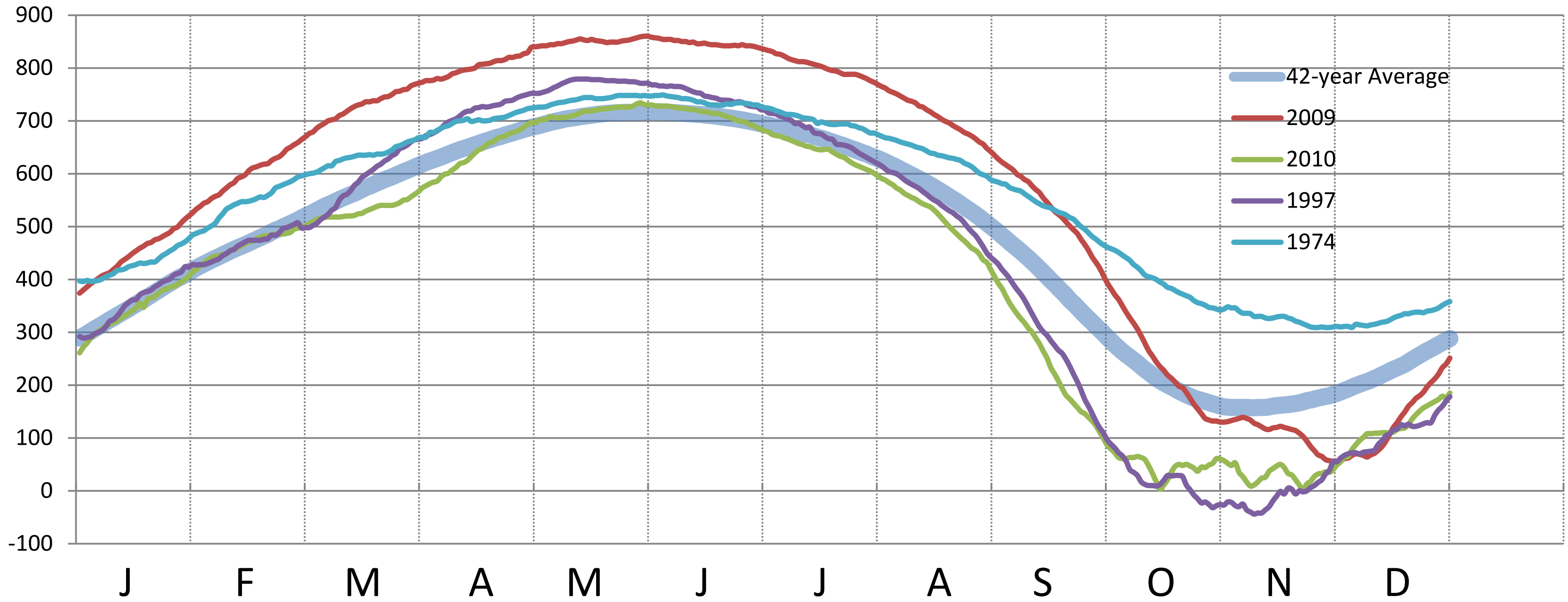
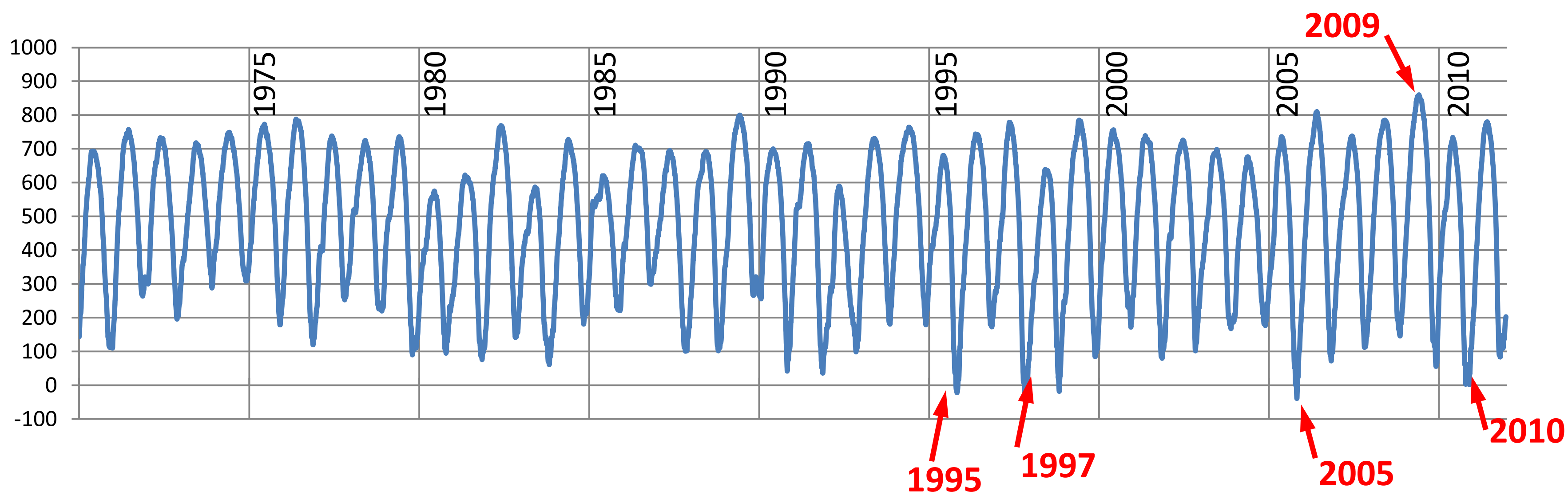
The Amazon Várzea





Amazon River stage at Óbidos (cm)

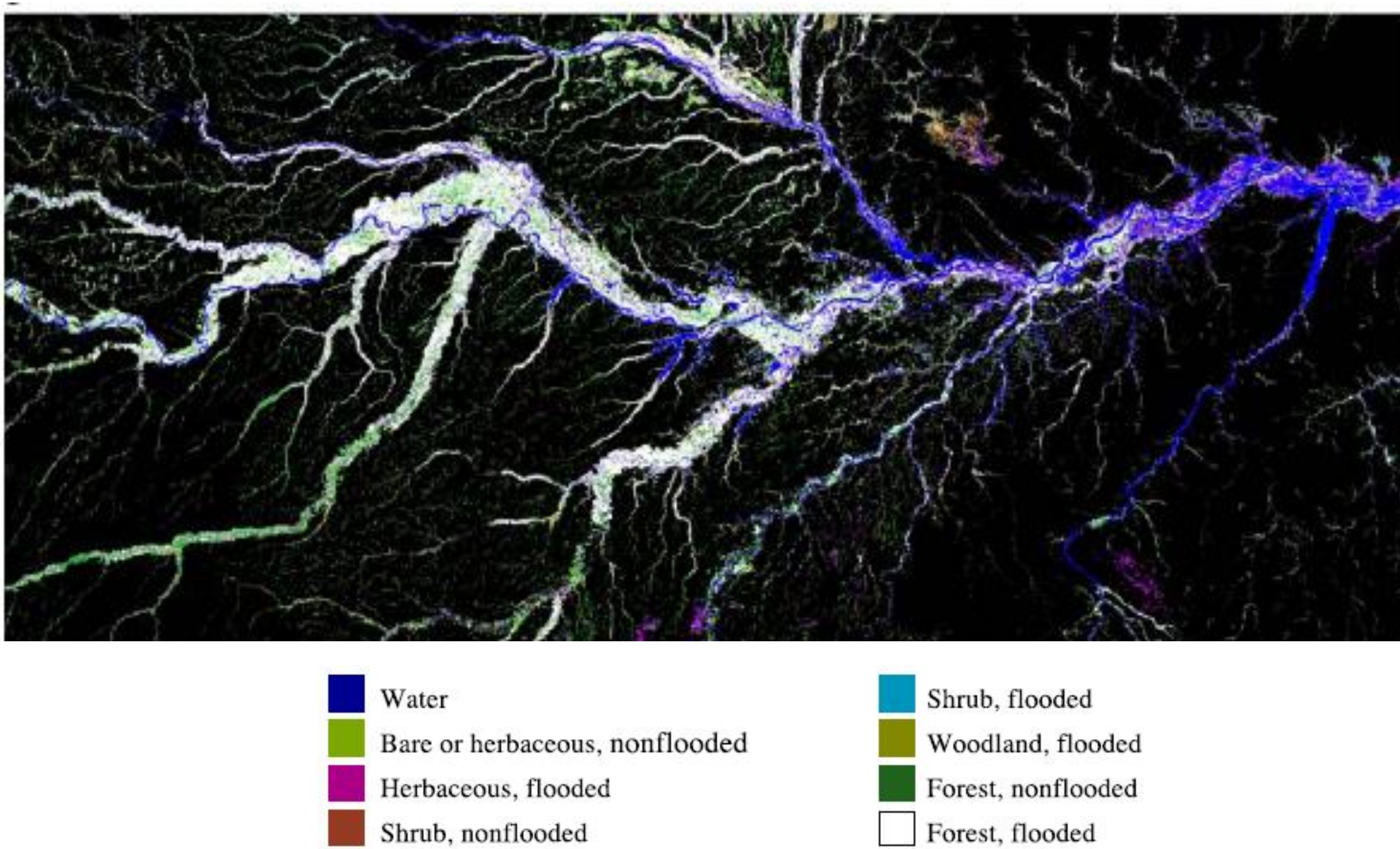




Low water stage
(October 2010)

High water stage
(June 2009)

JERS-1-based land cover mapping, May-June 1996 (Hess et al. 2003)



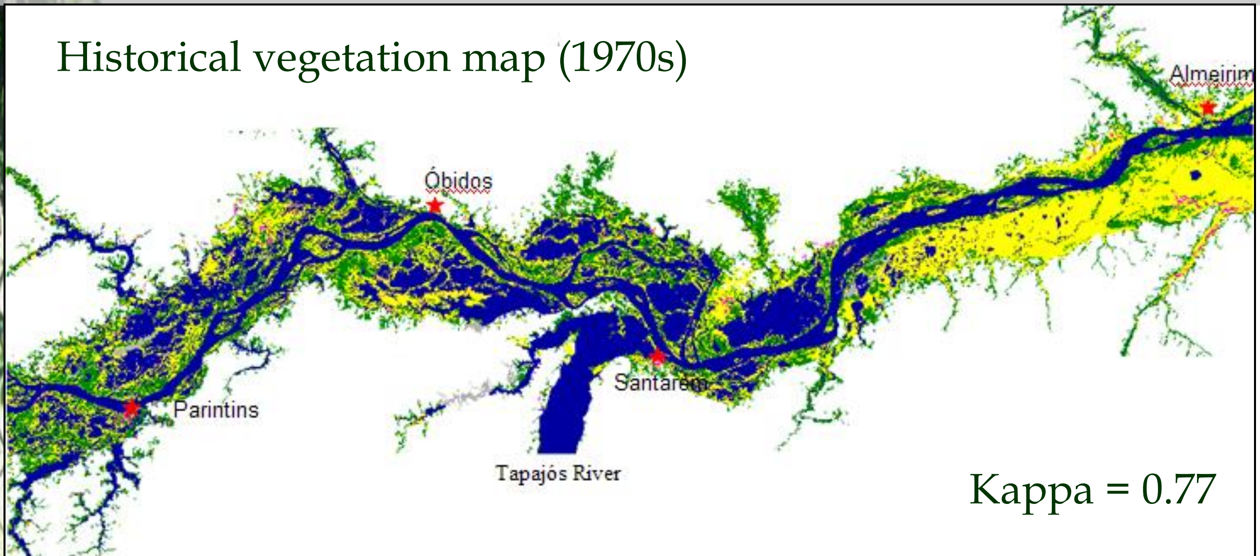
Land cover differences between the upper and lower Amazon: how much is anthropogenic?

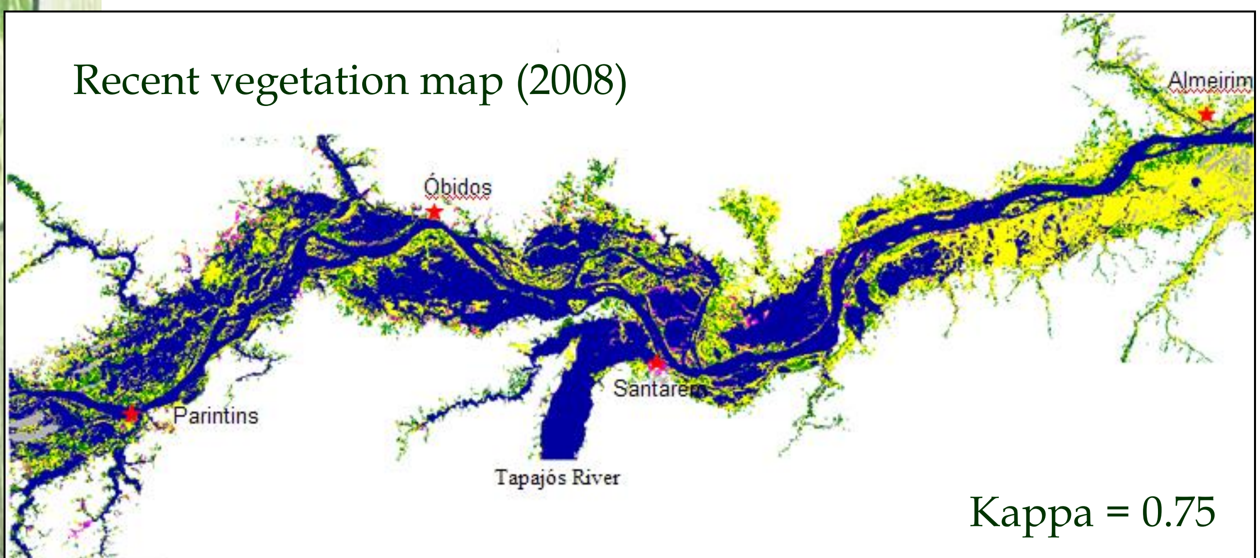
Deforestation Evolution in the Amazon Floodplain

Vivian Fróes Renó

National Institute for Space Research (INPE), Brazil

Results



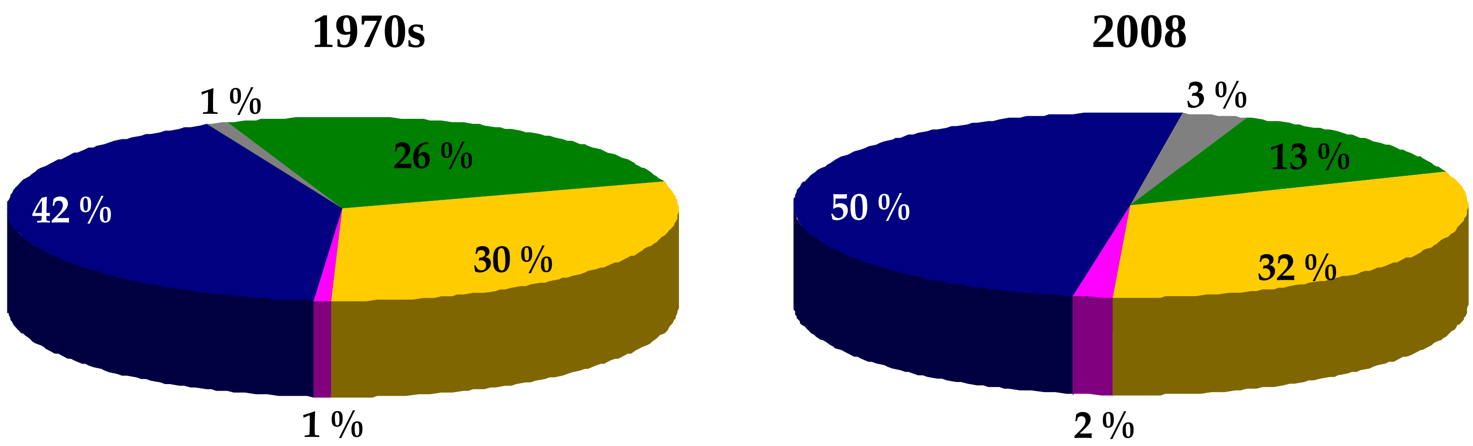


LEGEND

- Floodplain forest
- Non-forest vegetation
- Bare soil
- Water surface
- Cloud
- Mainland mask

Renó, V. F., Novo, E. M., Suemitsu, C., Renno, C. D., & Silva, T. S. (2011). Assessment of deforestation in the Lower Amazon floodplain using historical Landsat MSS/TM imagery. *Remote Sensing of Environment*, *115*(12), 3446-3456.

Results



	Classes	Area (km^2) 1970s	Area (km^2) 2008
(green)	Floodplain forest	7795	4073
(yellow)	Non-forest vegetation	9096	9548
(pink)	Bare soil	248	600
(blue)	Water surface	12691	15032
(beige)	Cloud	309	887
	Total area	30140	

Renó, V. F., Novo, E. M., Suemitsu, C., Renno, C. D., & Silva, T. S. (2011). Assessment of deforestation in the Lower Amazon floodplain using historical Landsat MSS/TM imagery. *Remote Sensing of Environment*, *115*(12), 3446-3456.

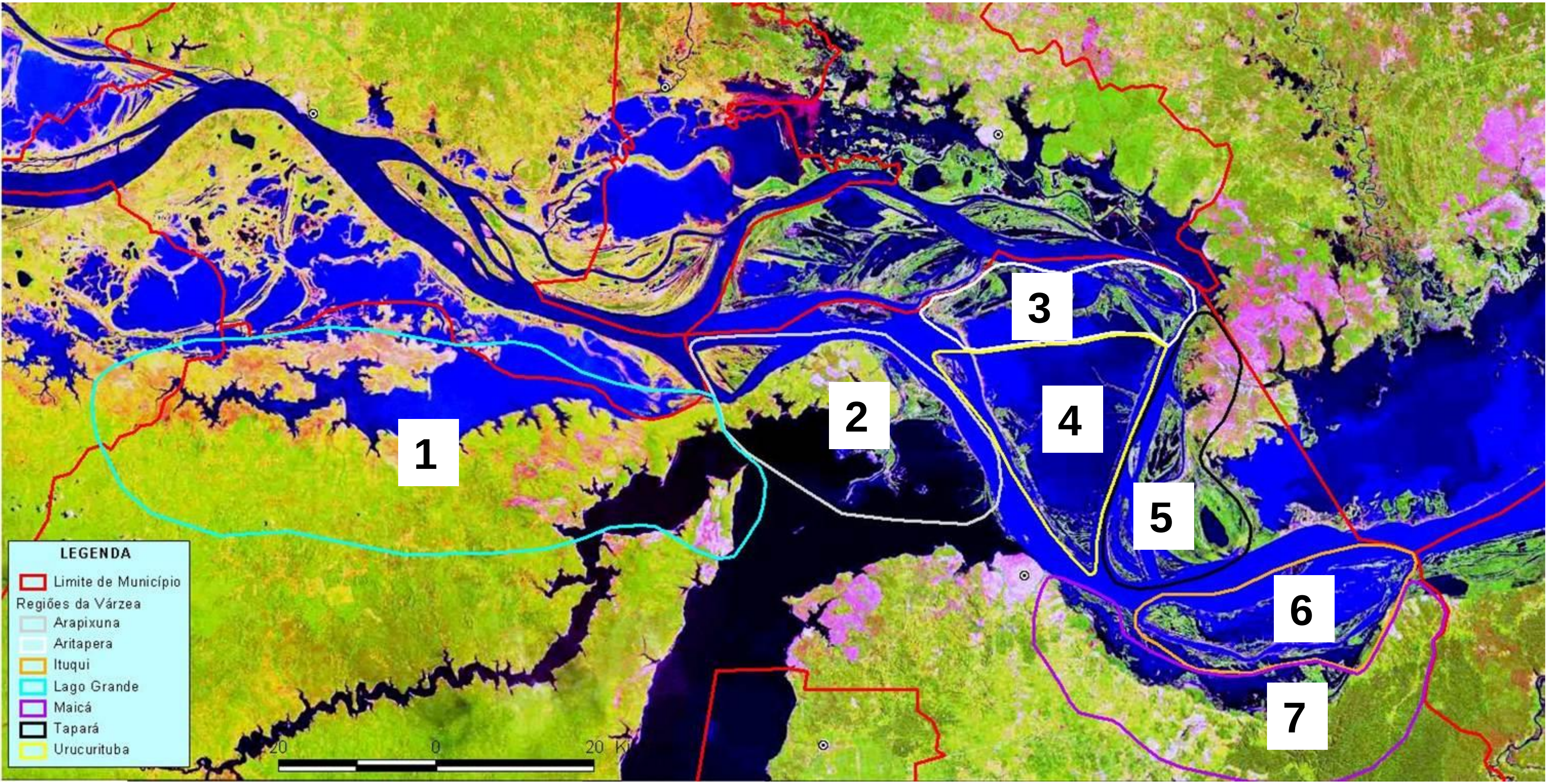
Increasing Pressure on Floodplain Resources

Forest degradation for farming, ranching and forest extraction

Increasing numbers of cattle & water buffalo on natural grasslands

Decreased yields from lake fisheries

Sistema Municipal de Co-Manejo da Pesca: 1997-2005



7 Conselhos Regionais de Pesca, 180 comunidades, pop. 35,000

Evolution of the várzea comanagement system in the lower Amazon

Comanagement: A collaborative arrangement in which the community of local resource users, local and senior governments, other stakeholders, and external actors share responsibility and authority for management of the natural resource in question.

(1) IBAMA developed and implemented a fisheries comanagement policy in the Santarém region

(2) Individual *várzea communities and the Public Ministry negotiated* agreements, Termos de Ajuste de Conduta (TACS), with local cattle owners to regulate cattle grazing on community grasslands

(3) These comanagement agreements were integrated into a more comprehensive land tenure and settlement policy based on the **Projetos de Assentamento Agroextractivista (PAEs)**

Thus far 41 várzea PAEs have been created, including some 13,000 families and covering a total area of 740,000 ha in eight Lower Amazonian municipalities

McGrath, D. G., De Castro, F., Futemma, C., de Amaral, B. D., & Calabria, J. (1993). Fisheries and the evolution of resource management on the lower Amazon floodplain. *Human Ecology*, 21(2), 167-195.

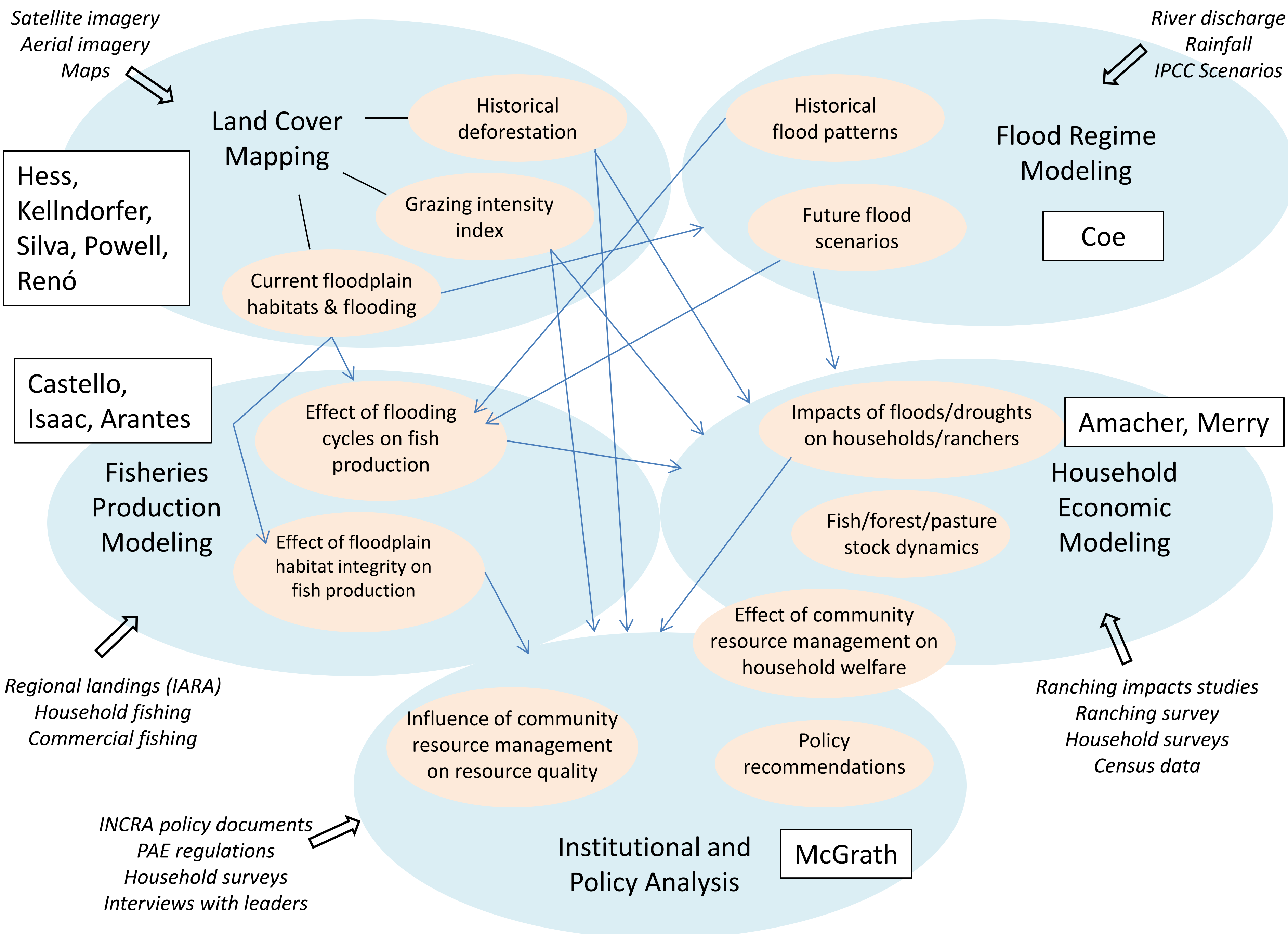
LCLUC Study Hypotheses

1. Observed reduction in forest area and degradation of grasslands is due to an increase in cattle densities on the floodplain and associated cattle management practices.

2. Reduction of forests and degradation of remaining forests and aquatic macrophyte communities, combined with an increased frequency of extreme flood events, could lead to reduction in the productivity of floodplain fisheries.

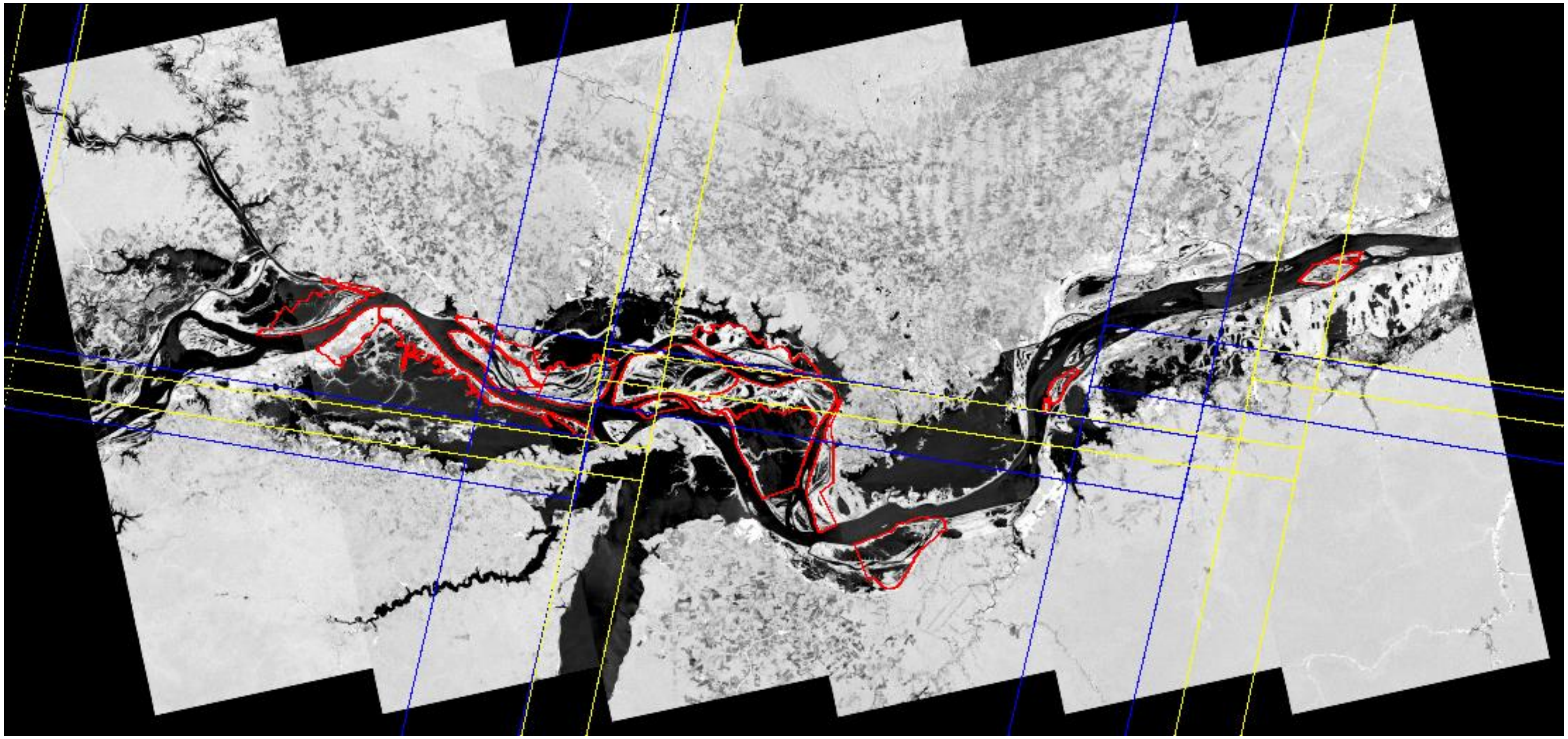
3. Household and rancher economic strategies and associated cattle management practices are the primary drivers of deforestation and habitat degradation on the Lower Amazon floodplain.

4. Effective co-management policies can influence household and rancher economic strategies to reduce pressure on forest and grassland habitat and floodplain fisheries and increase resilience to impacts of climate change.

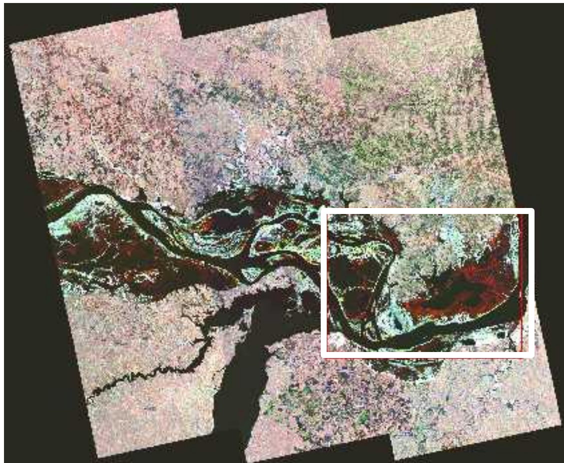

Satellite imagery
Aerial imagery
Maps
Land Cover Mapping
Historical deforestation
Grazing intensity index
Current floodplain habitats & flooding
Hess, Kellndorfer, Silva, Powell, Renó
River discharge
Rainfall
IPCC Scenarios
Historical flood patterns
Future flood scenarios
Flood Regime Modeling
Coe
Castello, Isaac, Arantes
Effect of flooding cycles on fish production
Effect of floodplain habitat integrity on fish production
Fisheries Production Modeling
Regional landings (IARA)
Household fishing
Commercial fishing
Impacts of floods/droughts on households/ranchers
Amacher, Merry
Household Economic Modeling
Fish/forest/pasture stock dynamics
Effect of community resource management on household welfare
Ranching impacts studies
Ranching survey
Household surveys
Census data
Influence of community resource management on resource quality
Policy recommendations
INCRA policy documents
PAE regulations
Household surveys
Interviews with leaders
Institutional and Policy Analysis
McGrath

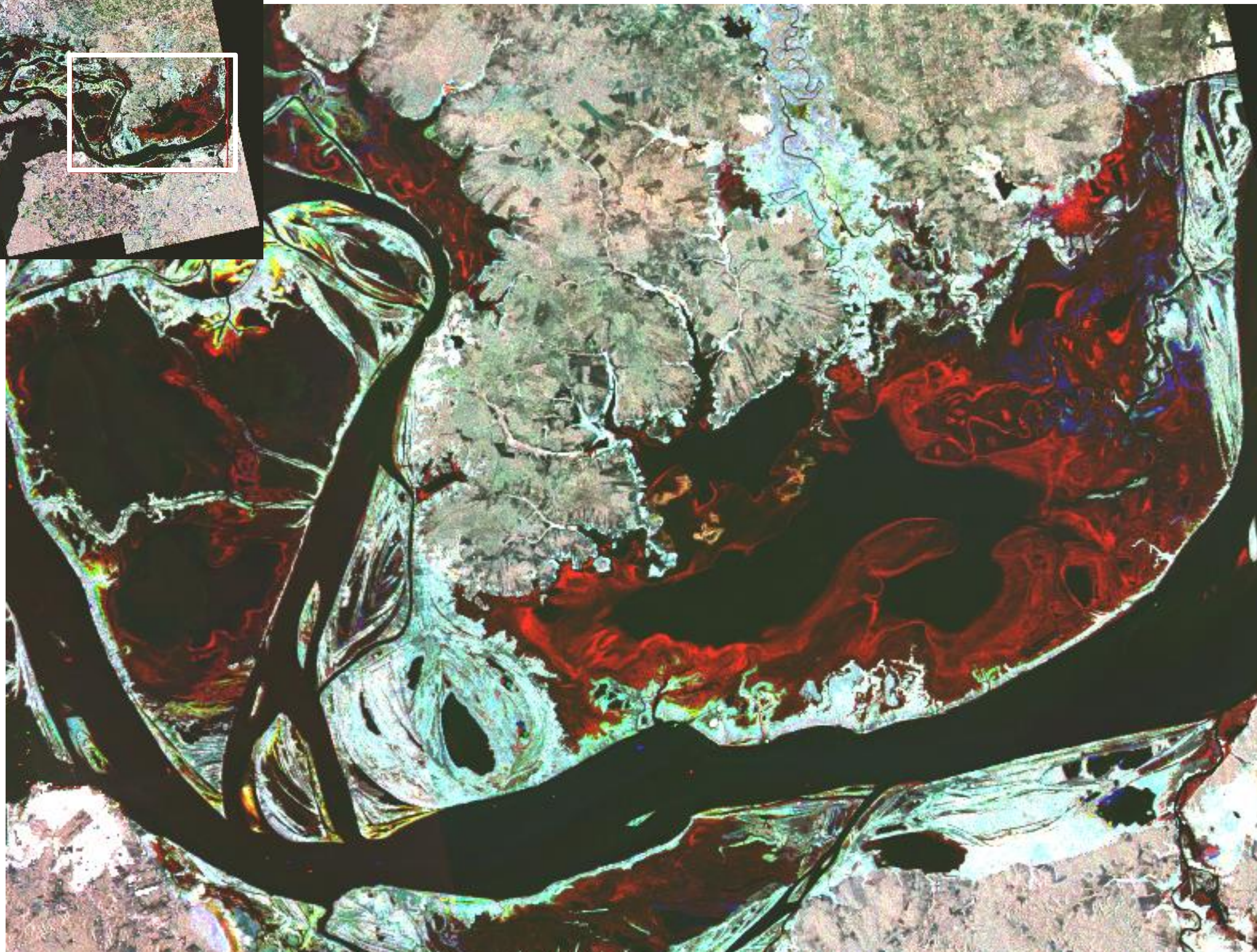
Land Cover Mapping Inputs

- ALOS PALSAR, Fine-Beam Dual and Single Pol modes, 2006-2011 (12.5 m)
- Landsat TM: 1982-1990, 1991-1995, 1996-2000, 2001-2005, and 2006-2010
- Landsat MSS: 1975-1981
- Aerial photography (1940s; 1:40,000)
- MODIS Surface Reflectance



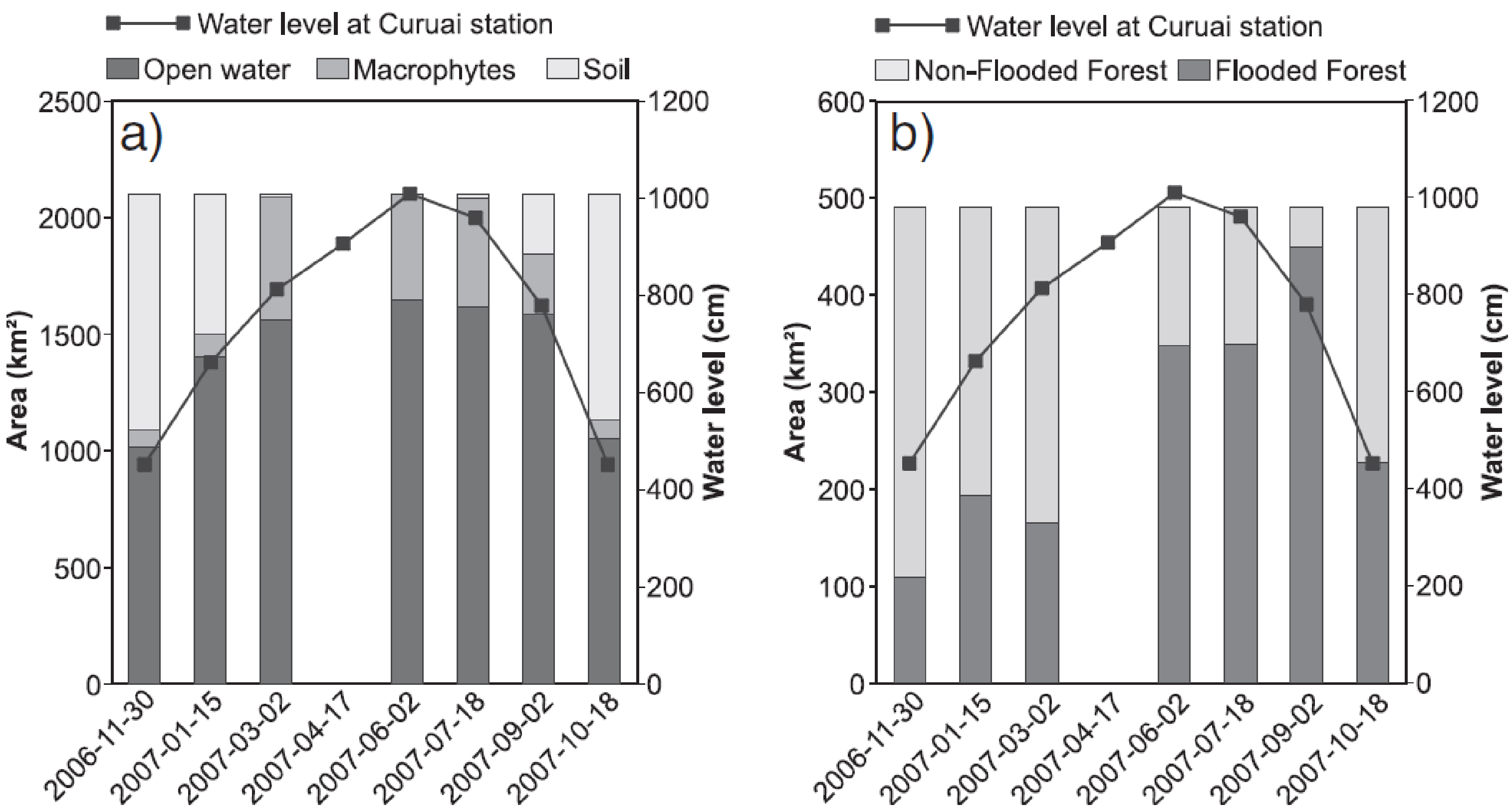
PALSAR HH Mosaic, RGB = Low-, Mid-, High-water Stages
(NovDec 2010, JulAug 2010, MayJun2010)





PALSAR + Optical Classification (30 m): Contemporary Land Cover

-eCognition multi-resolution segmentation using low-water optical then PALSAR
- segment on 8-bit stretched input; classify on original values
- hierarchical classification gives cover (non-veg, herbaceous, shrub, woodland, forest) and flooding state on each date
- anomalous multi-temporal patterns identify areas of erosion and deposition
- cover areas stratified by PAE and lake system are inputs to fisheries and household economic models



Arnesen, A. S., Silva, T. S., Hess, L. L., Novo, E. M., Rudorff, C. M., Chapman, B. D., & McDonald, K. C. (2013). Monitoring flood extent in the lower Amazon River floodplain using ALOS/PALSAR ScanSAR images. *Rem. Sens. Environment*, *130*, 51-61

Hydrologic Modeling

- Spatially continuous estimates of historical flood height, duration, and area at 1km^2 resolution will be calculated with the THMB terrestrial hydrology model (Coe et al., 2007).

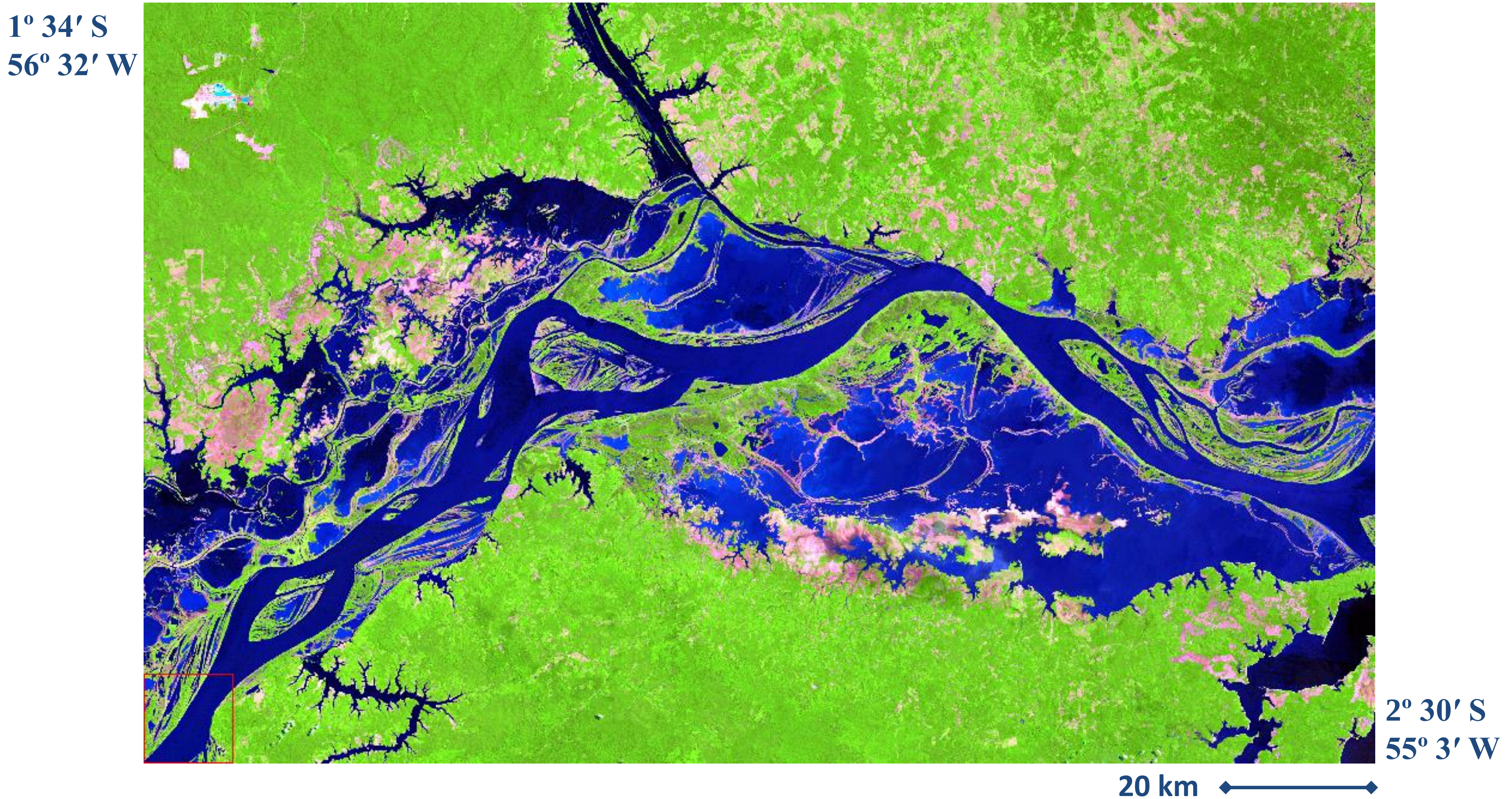
- THMB will be forced with daily discharge data from the Agência Nacional das Águas (ANA, www.ana.gov.br) at the upstream domain boundary and climate data (precipitation and evaporation) within the domain to calculate the time-varying daily flood height for the period 1980-2010.

- The results will be calibrated and validated against the PALSAR-derived estimates of flooded area and water height

Optical Imagery Analysis

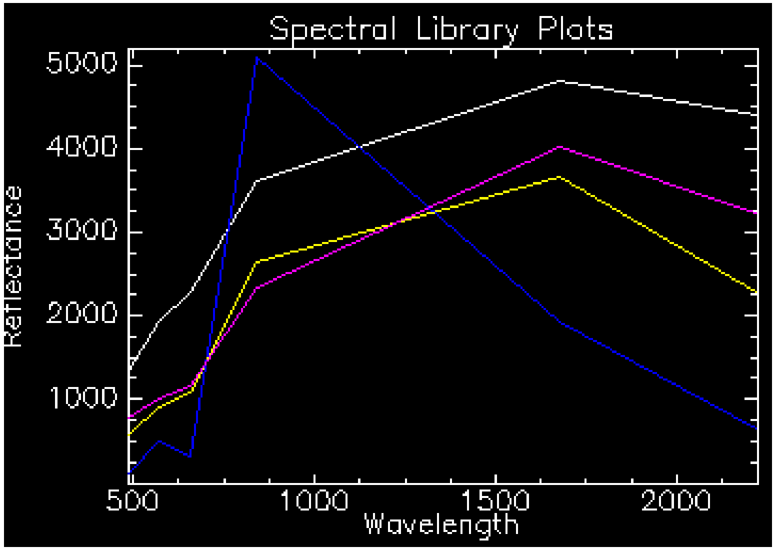
Rebecca Powell – Wake Forest University & University of Denver
Jason Isherwood – University of Denver

- Landsat TM – P228/R61-62 (August 25, 2005)
- Reflectance retrieval – ENVI FLAASH Atmospheric Correction Model



Dominant spectral components of the várzea

- Spectral library iteratively selected
  - Initial endmember candidates selected from dominant land-cover components
  - Subset of optimal candidates identified as those that successfully unmix other spectra within their own class
  - Constrained 3-endmember SMA models applied to identify pixels not sufficiently represented; new candidate endmembers identified



- Green Vegetation – *blue*
- Sand – *white*
- Mud – *magenta*
- Non-photosynthetic vegetation – *yellow*
- Shade – *zero reflectance*

NPV example: Senescent macrophyte

Multiple endmember spectral mixture analysis (MESMA)

Roberts et al. (1998)

- Each pixel modeled as all possible 2-, 3- and 4-endmember model combinations

Two-endmember
Sand + Shade
Mud + Shade
NPV + Shade
GV+ Shade

Three-endmember
Sand + GV + Shade
Mud + GV + Shade
NPV + GV + Shade
Sand + Mud + Shade
Sand + NPV + Shade
Mud + NPV + Shade

Four-endmember
Sand + Mud + GV + Shade
Sand + NPV + GV + Shade
Mud + NPV + GV + Shade
Sand + Mud + NPV + Shade

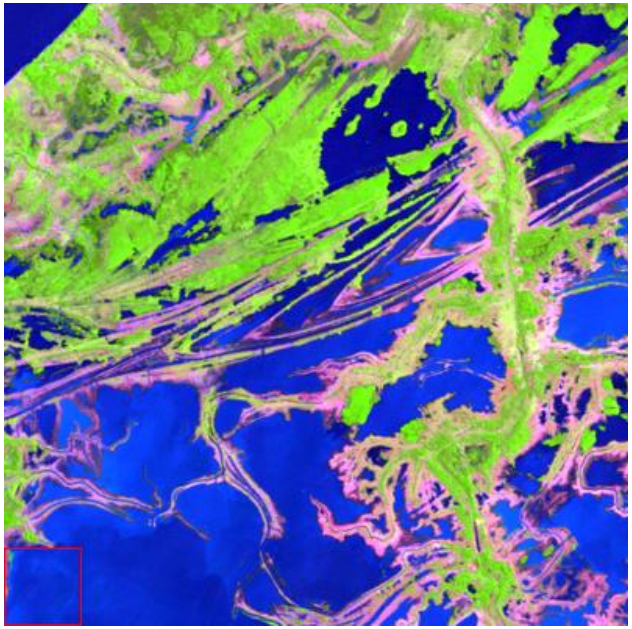
Single constraint:
Sum of all fractions = 1

Endmember selection for MESMA using endmember average RMSE (Dennison & Roberts 2003)

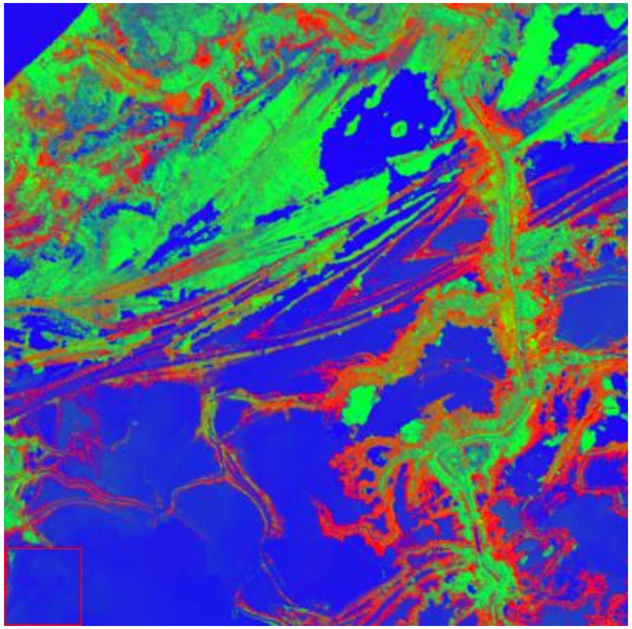
- "Winning" model for each pixel selected based on the following rules:
  - Fractions for all bright endmembers ≥ +0.05*
  - Shade fraction ≥ -0.05**
  - Minimum root mean square error (RMSE)***
- Models tested in order of highest to lowest complexity
  - If 4-endmember model meets constraints, then keep
  - Else, consider 3-endmember model, etc.

Assumptions: **All materials actually present in pixel*
***Shade fraction constrainted to be physically meaningful (~0 – 100%)*
****Given that fraction constraints met, choose best fitting model*

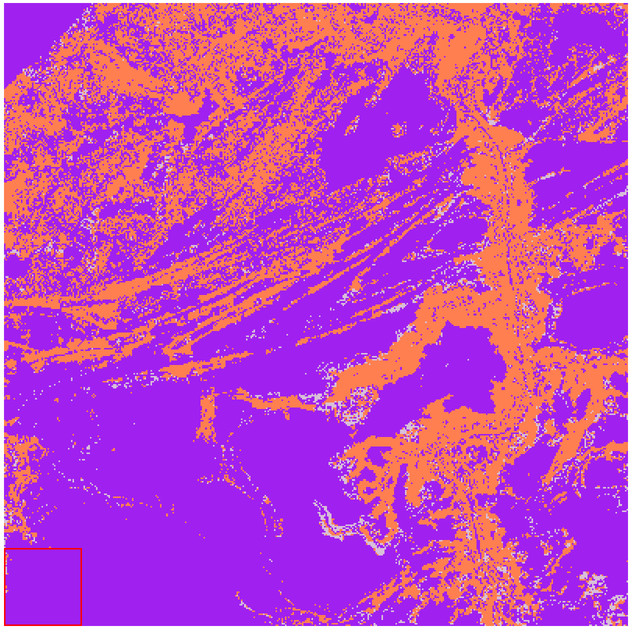
Sample MESMA output
(3-endmember models)



Subset of Landsat 5 scene
RGB = Bands 543



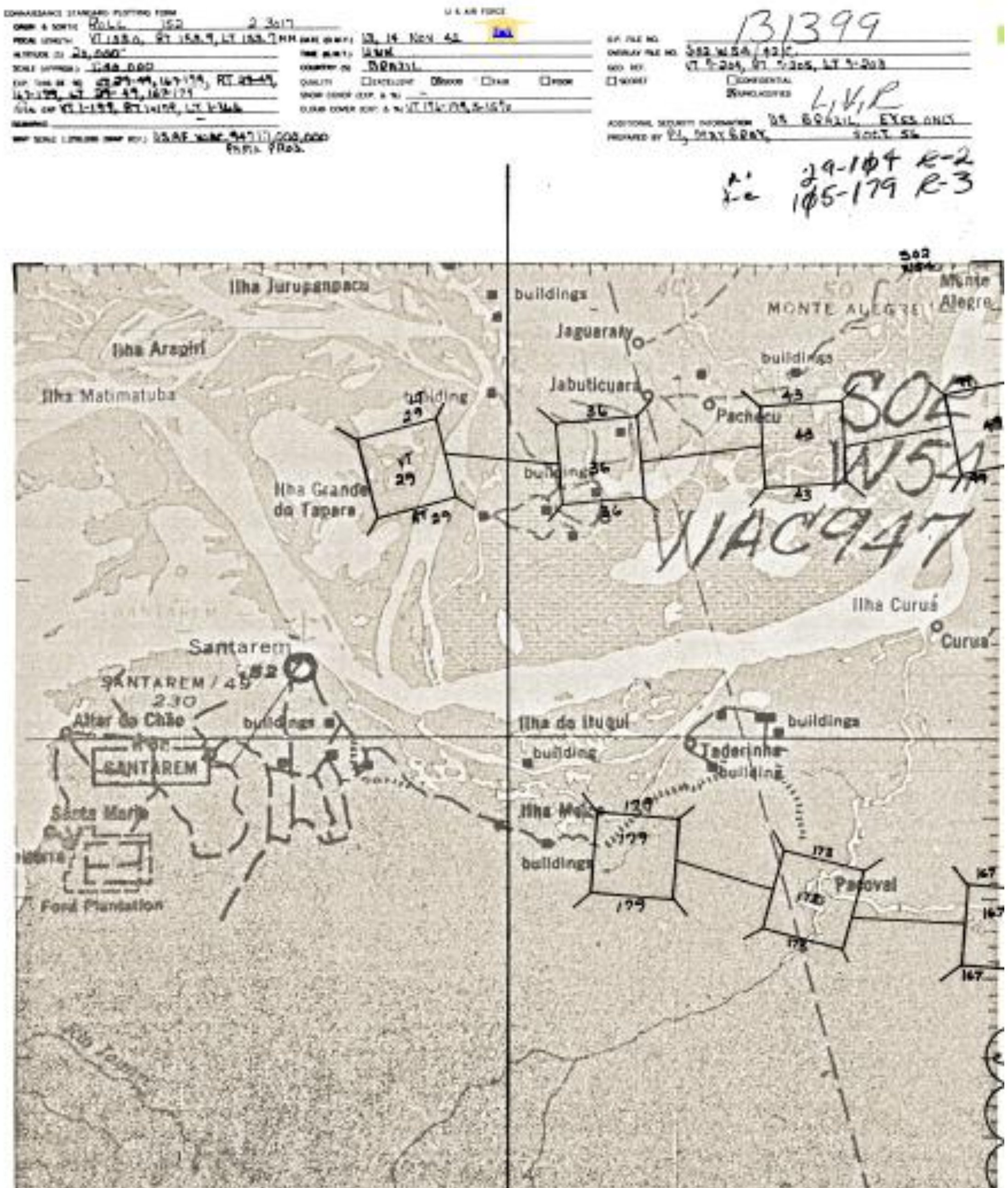
MESMA fractions
R = Sand, NPV, or Soil
G = Green Vegetation
B = Shade



MESMA model
Orange = NPV
Purple = Sand
Gray = Mud

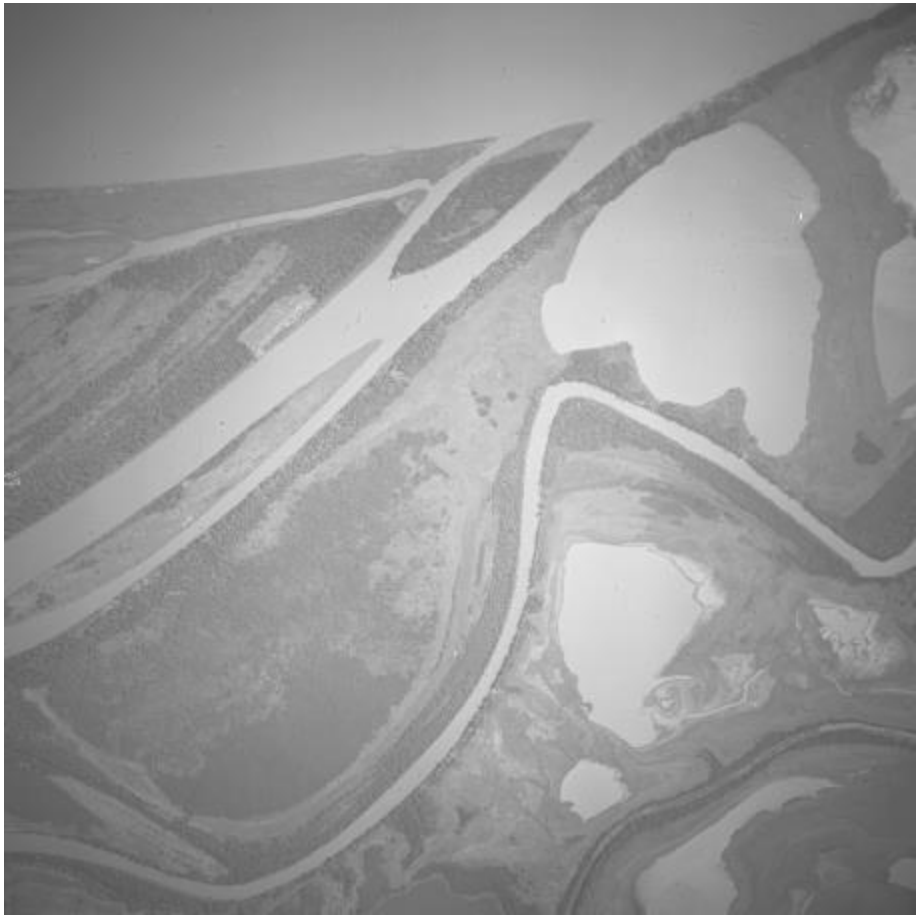
Landsat-derived end members will be used in classifying MODIS time series to calculate seasonal open water / bare ground / macrophyte fractions for lake systems (2000-2012)

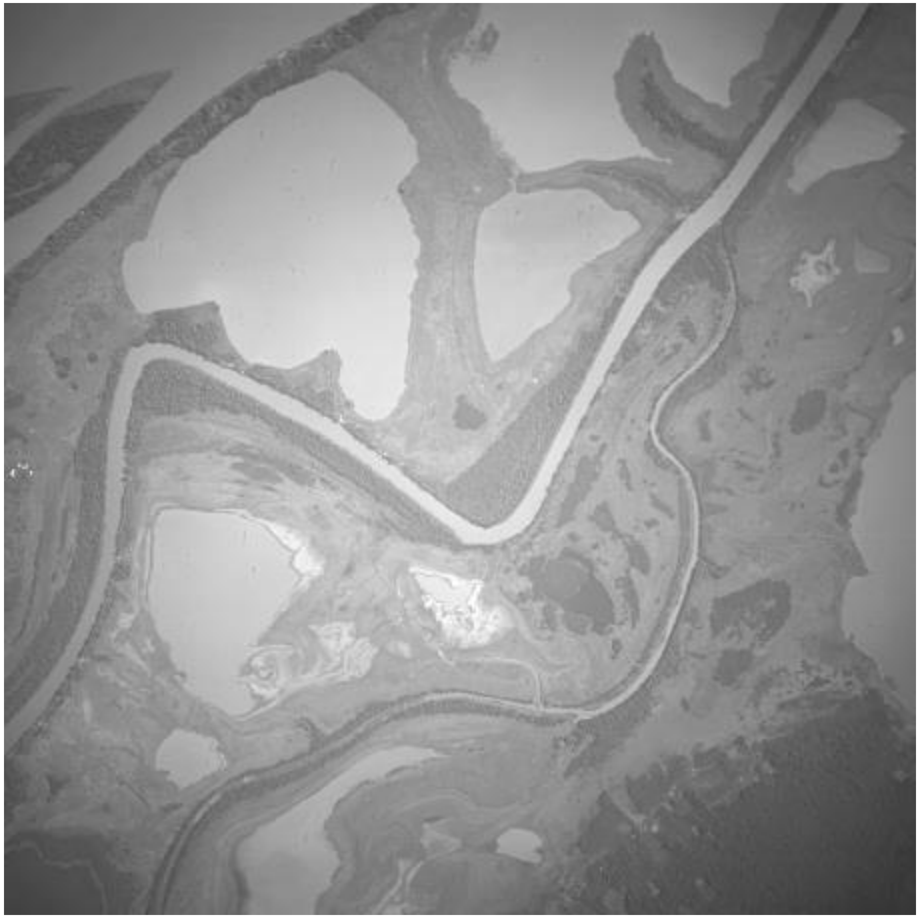
Aerial Photography from U.S. National Archives (1940s; 1:40,000)

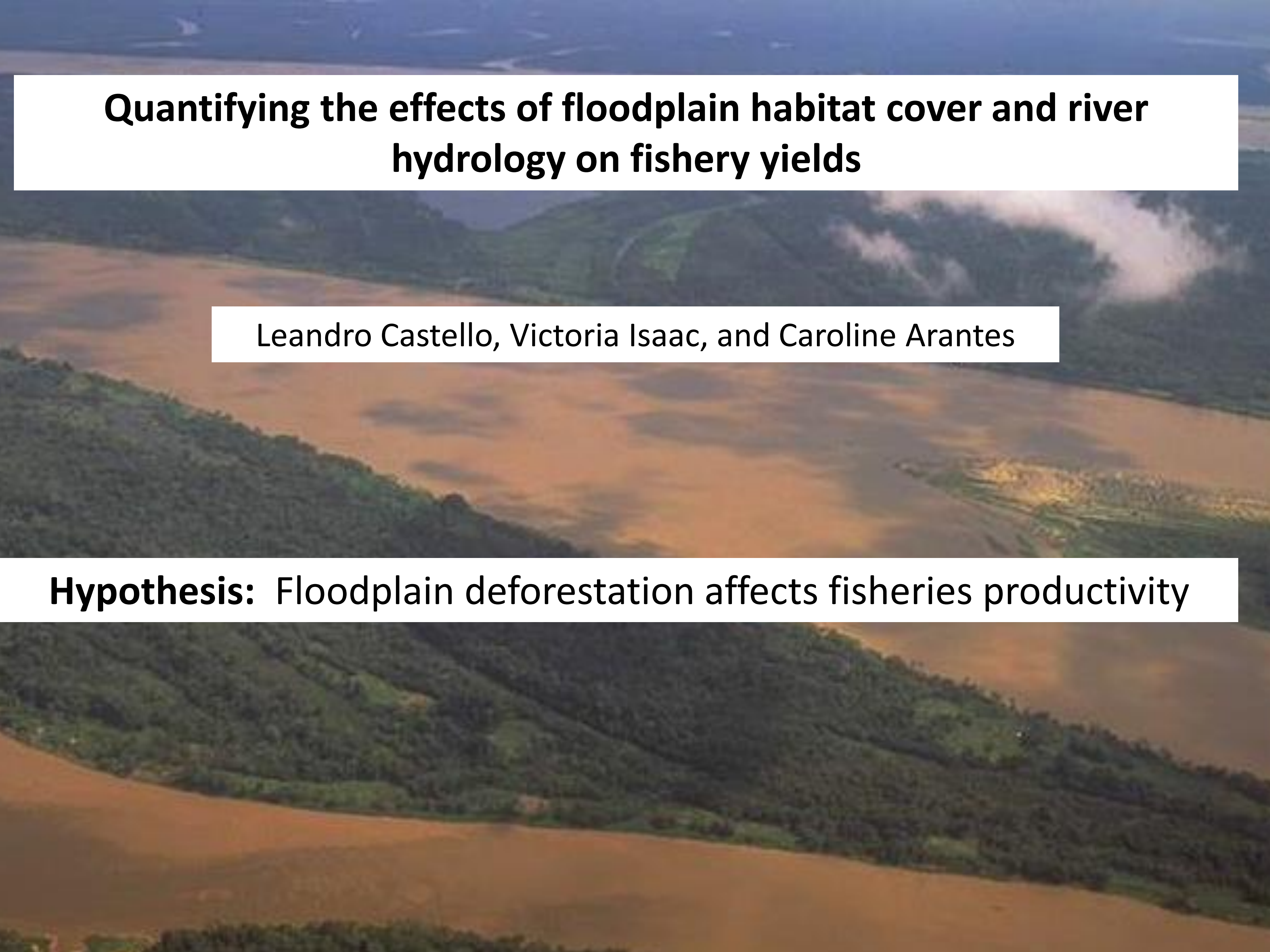


Air Photo Metadata

Aerial Photography from U.S. National Archives
(1940s; 1:40,000)







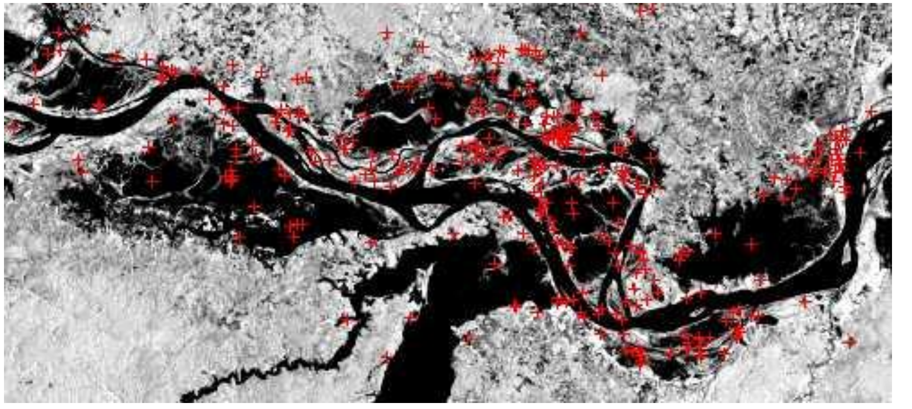
Quantifying the effects of floodplain habitat cover and river hydrology on fishery yields

Leandro Castello, Victoria Isaac, and Caroline Arantes

Hypothesis: Floodplain deforestation affects fisheries productivity

Data variables for general linear models

1. Fisheries catch and effort (kg, fisher*hr)
2. Floodplain habitat structure
3. River flooding
4. Management regime



~ 600 points geolocated so far

1. Regional fisheries data (IARA Project): database for regional landings from 1992 to present for the state of Pará includes date, effort (days fishing, number of fishers, size of vessel), biomass and abundance of catch by species, place of catch (name of lake and lake system), habitat of fishing (lake, channel, river), and gear used (gillnet, hook, castnet).
2. Household fishing activity: Daily interviews, 7 days per month 15% sample of 3-9 communities: 1991-93, 1995-97, 2001-2007. Total of 40,000 interviews.
3. Commercial fishing activity: Interviews with 50 commercial fisherman, 1998
4. New field sampling within the PAEs (Caroline Arantes)

Economic models

Typical household with cattle herd

- Household model based on a utility function

  U=*f*(labor, capital, other factors)

- The model evaluates – among others -- the impact of social organization, lake management, and fisheries management on individual household welfare (utility)

Sampling

Fishermen returning catch to main boat

- Conduct both household quantitative surveys and randomized sampling of fisheries activity
- Will establish household welfare and fisheries quality in lakes
- Sampling to be conducted in ≈6 lakes with varying size and community management

Key questions

- Survey questions include: time fishing; agricultural production; member of community organization; hours spent participating; and so forth, to develop a clear picture of household activities and choices.

- Surveys will follow formats established in our previous work (n=4,000+ surveys in Brazilian Amazon)

Activities for 2013

- Complete contemporary PALSAR and Landsat habitat analyses

- Validation: field survey in Sept-Oct; hi-res satellite imagery

- Hydrologic modeling

- June: begin fisheries analysis (Castello/Isaac)

- Begin historic forest cover analysis (TM, MSS, air photos)

- Household and PAE surveys: Sept-Oct

- Develop new strategy for estimating grazing intensity

- Begin PAE / non-PAE comparison using habitat data