Assessing the impacts of agriculture on deforestation in Mato Grosso

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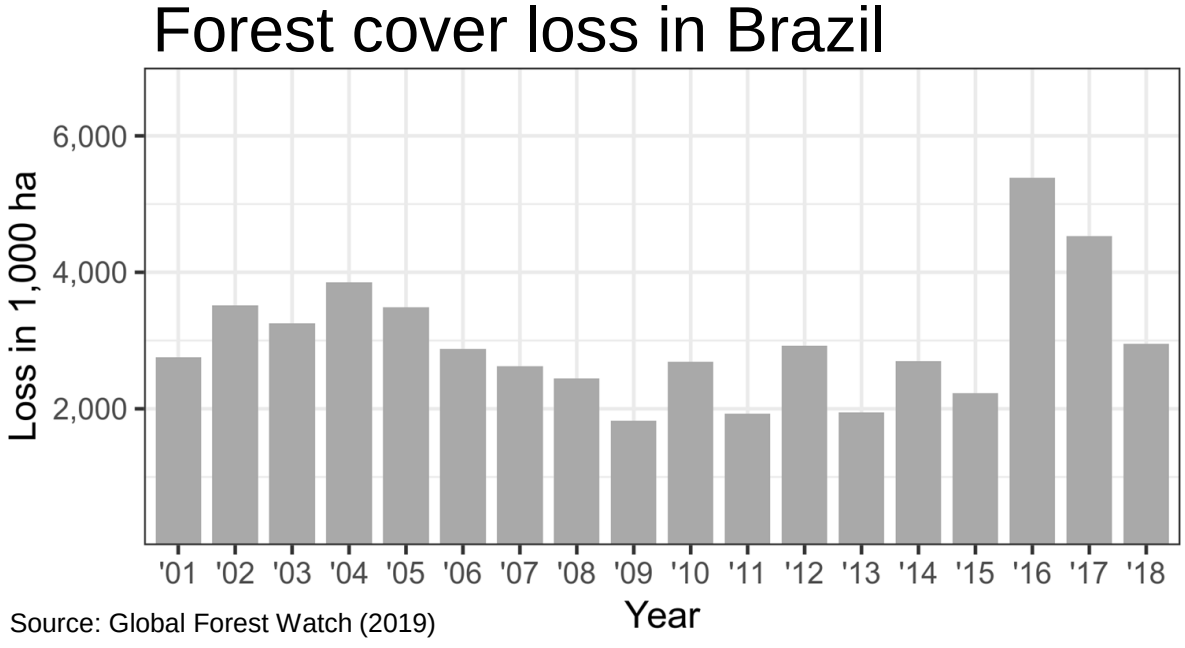
Brazilian Amazon

- World‘s largest rainforest
- Deforestation tied to various issues



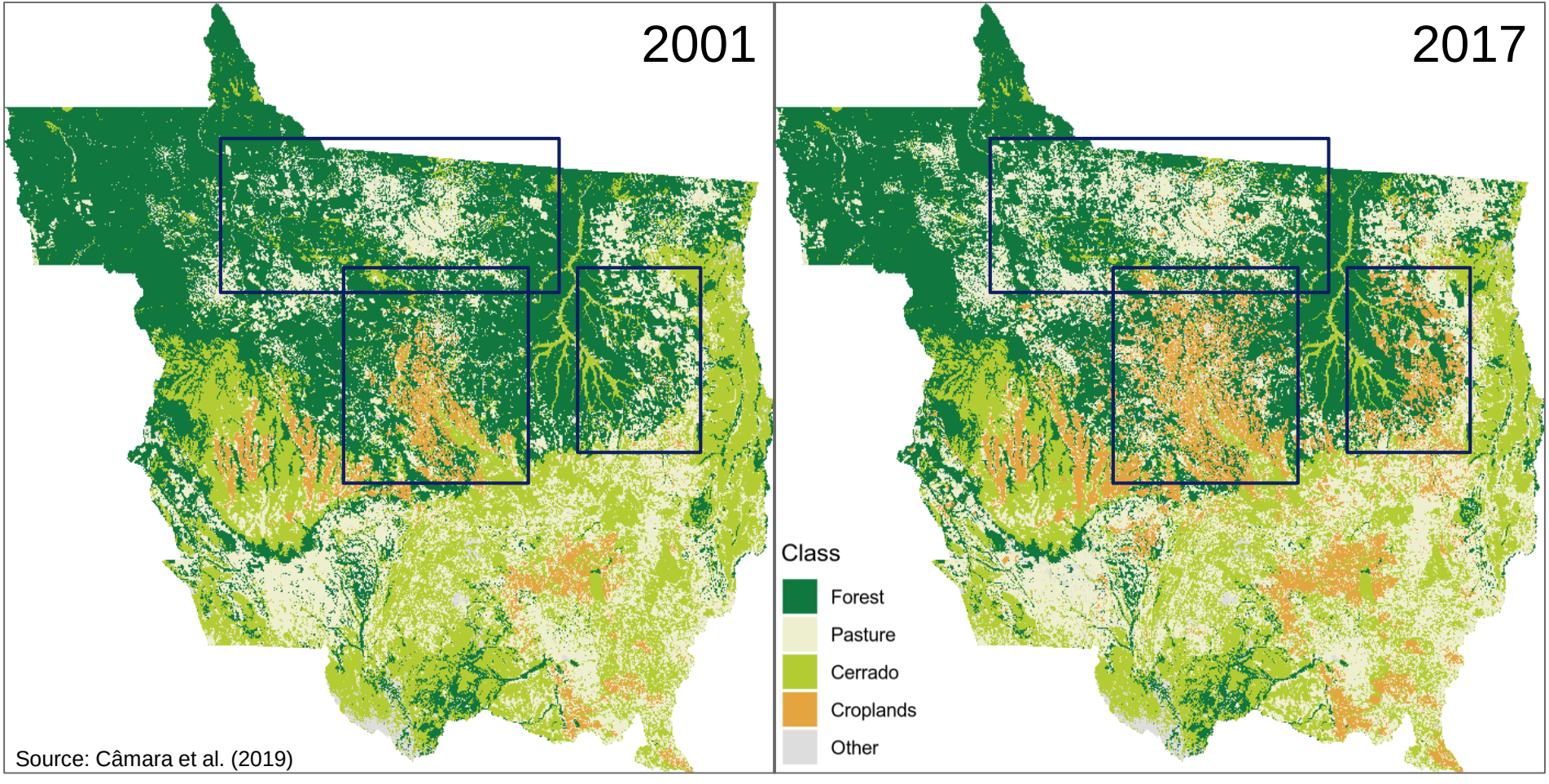
Source: Global Forest Watch (2019)

Mato Grosso

- 3,441,998 inhabitants
- 903,357 km²
- 30,479,887 tons of soy
- ~50% forest cover

Source: Wikimedia Commons (CC BY-SA 3.0)

Mato Grosso



Source: Câmara et al. (2019)

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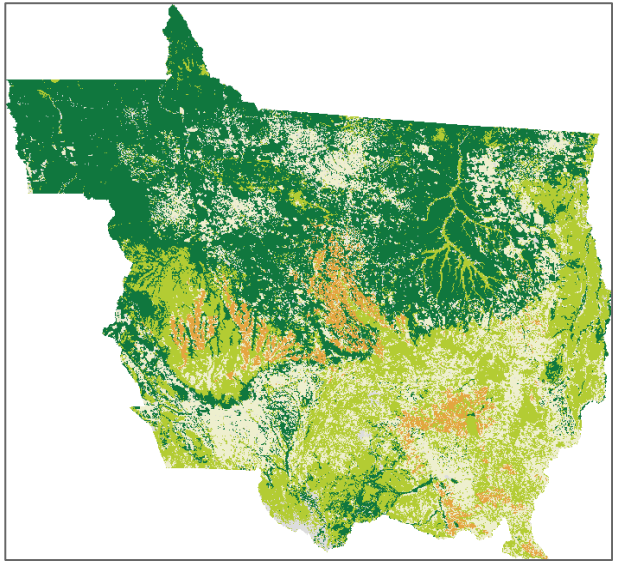
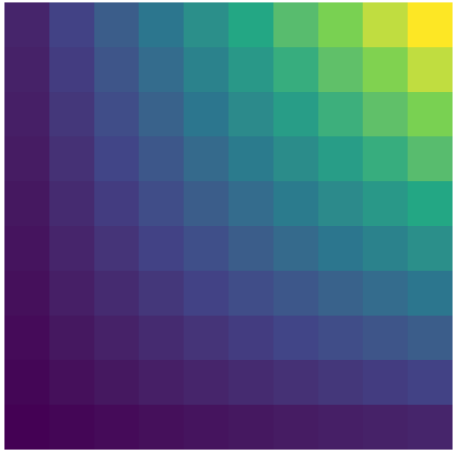
- Move analyses of impacts, material flows and footprints to a spatially explicit level
- Spatial level comes naturally to deforestation
  - New possibilities through remote sensing
  - Dynamics of croplands, pasture, infrastructure, poverty, mineral extraction, etc.

Spatial Interaction

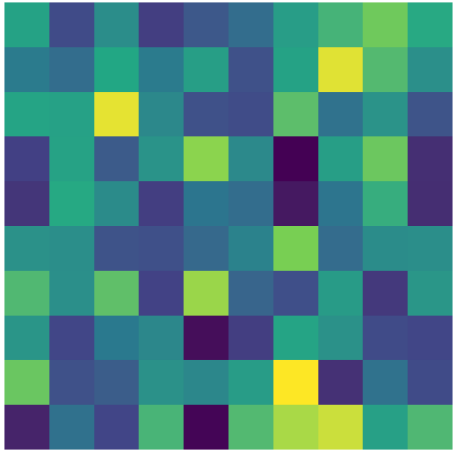
- Spatial dependence
  - Autocorrelation
  - Heterogeneity



Land cover, Mato Grosso



Positive spatial autocorrelation



No spatial autocorrelation

Research Questions

- What are the drivers of deforestation in Mato Grosso?
- Are there significant spillover effects?
- Have there been structural breaks?

Model

$$y = \rho W y + X\beta + WX\theta + \epsilon$$

- y … dependent variable (i.e. deforestation)
- X … explanatory variables
- W … weights to impose a spatial structure
- Spatial spillovers affect interpretation

Data

- Câmara et al. (2019)
  - Land cover change maps
- Brazilian Institute of Geography and Statistics (IBGE)
  - Agricultural (crops & livestock)
  - Socioeconomics (population & GDP)
- Vicente-Serrano at al. (2010)
  - SPEI (drought index)

Results

- Moran‘s I significantly positive
- Improved fit over classic linear models
- $R^2 \sim 0.6$
- $\rho \sim 0.75$
- Drivers generally match the literature

Results

Forest cover change per km² ~

- Forest density (-)
- Pasture density (-)
- Milk production per cow & cattle per pasture
- Cropland density (-)
- Maximal crop yield (+)
- Extreme dryness & extreme wetness (-)
- Population density & GDP per capita

Outlook

- Regional subsets (Pantanal, Cerrado)
- Encoding of SPEI & agricultural yields
- Out-of-sample forecasts
- Structural breaks
- Data on mineral extraction

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Appendix

- Câmara, Gilberto; Picoli, Michelle; Maciel, Adeline; Simoes, Rolf; Santos, Lorena; Andrade, Pedro R; Ferreira, Karine; Begotti, Rodrigo; Sanches, Ieda; Carvalho, Alexandre X Y; Coutinho, Alexandre; Esquerdo, Julio; Antunes, Joao; Arvor, Damien (2019): Land cover change maps for Mato Grosso State in Brazil: 2001-2017 (version 3). PANGAEA, https://doi.org/10.1594/PANGAEA.899706.
- Global Forest Watch (2019): Forest change. Retrieved on 2019-05-06 from https://www.globalforestwatch.org/.
- Vicente-Serrano S.M.; Santiago Beguería; Juan I. López-Moreno, (2010): A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index - SPEI. Journal of Climate 23: 1696-1718.
- Wikimedia Commons (2011): Mato Grosso in Brazil. Retrieved on 2019-05-08 from https://commons.wikimedia.org/wiki/File:Mato_Grosso_in_Brazil.svg.

Appendix

Dependent variable: Forest cover change per km²

Variable	Direct Effect	Indirect Effect
Constant	-0.012	-0.022
Forest density	-0.246***	-0.057
Pasture density	-0.159***	-0.027
Cropland density (lag)	-0.045**	-0.722***
Population density	0.108	0.365
GDP per capita	-0.001**	-0.002
Milk production per cow	0.013	0.007
Cattle per pasture	0.132	0.001
Maximal crop yield (lag)	-0.001	0.008*
Extreme wetness	-0.018	-0.060
Extreme dryness	-0.008	0.014

R^2 = 0.591; ρ = 0.675; ***, ** & * indicate significance at the 1, 5 & 10 percent level