

# Tropical Deforestation

Robin Burgess      Allan Hsiao

December 8, 2022

# Why we care

## ① Climate change

- Direct carbon emissions
- Loss of carbon sinks

## ② Measurement revolution

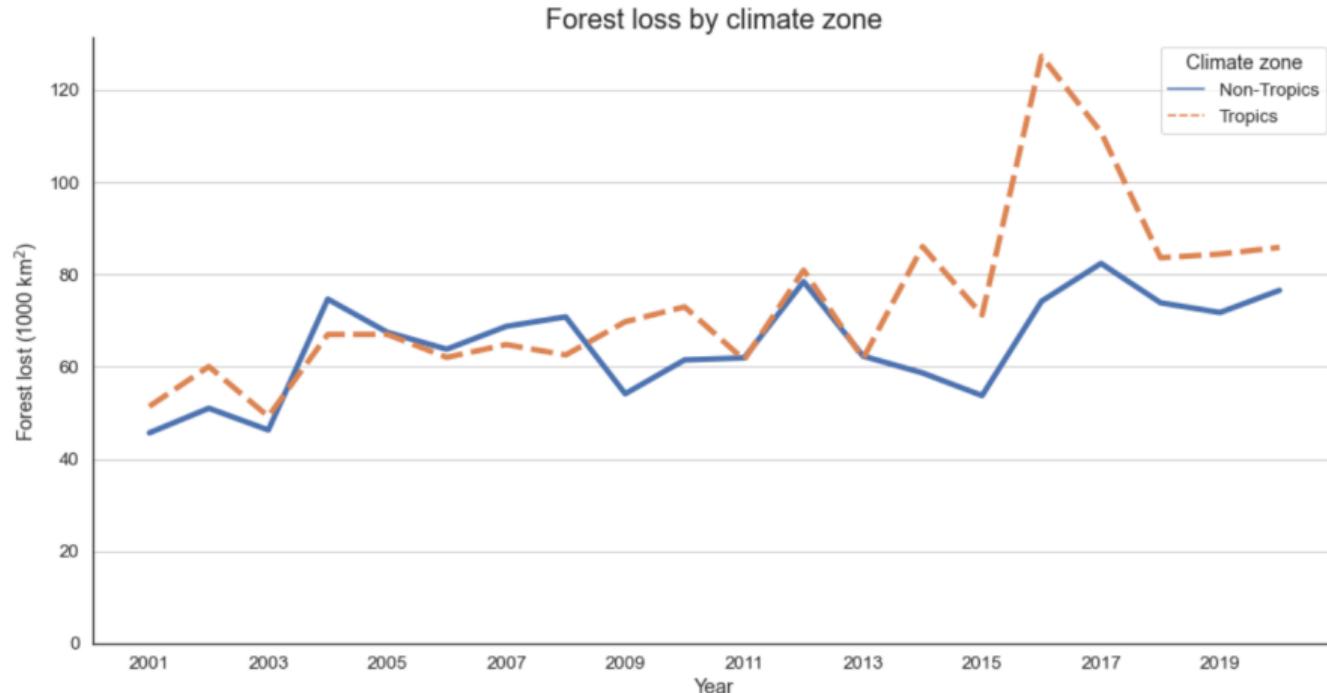
- Satellite imagery (Donaldson & Storeygard 2016)
- Empirics (Deschenes & Meng 2018)

## Global emissions, 1990-2019 (Gt/yr CO<sub>2</sub>)

Country	<b>Total</b>	Forest	Country	Total	<b>Forest</b>
China	7.07	-0.44	Brazil	1.71	0.85
USA	5.92	-0.38	Indonesia	1.44	0.73
EU	3.69	-0.33	DRC	0.50	0.46

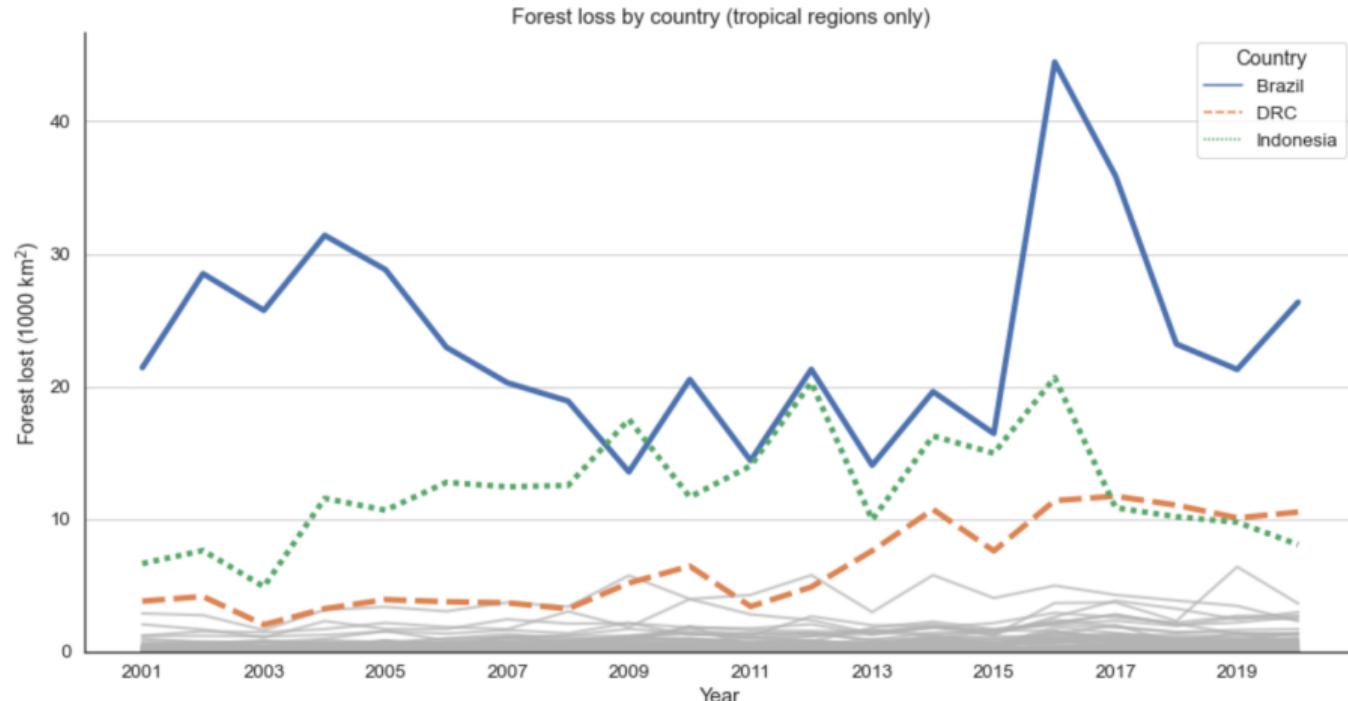
Data: Climate Watch

# Tropical deforestation, 2001-2020



Data: Hansen Global Forest Change

# Tropical deforesters, 2001-2020



Data: Hansen Global Forest Change

## Emissions vs. production, 1990-2019 (\$1T)

Country	Deforestation emissions	Agricultural value
Brazil	2.55	1.68
Indonesia	2.19	2.54
DRC	1.39	0.16

Data: Climate Watch, World Bank  
(\$100/t SCC, agriculture/forestry/fishing value added)

## Large, global externalities

- Land use change is **14%** of CO<sub>2</sub> emissions (Global Carbon Budget 2019)
  - Land use change is  $1.5 \pm 0.7$  Gt/yr (2009-2018)
  - Fossil fuels are  $9.5 \pm 0.5$  Gt/yr
- Carbon targets relative to 2010 levels (IPCC 2018)
  - 2°C: 25% decline by 2030, net zero by 2070
  - 1.5°C: 45% decline by 2030, net zero by 2050

# Measurement revolution

- Rich satellite data capturing deforestation
  - Over time and space
  - Including vegetation type and density
- For researchers
  - Within-country studies (not just cross-country)
  - Better measurement of externalities
- For regulators
  - Real-time monitoring technology
  - Including for global agencies

Indonesia

[Hsiao 2022, Hansen et al. 2013]



Aerial photograph showing a river (Sungai Trus) flowing through a landscape of green fields. The river is a prominent brownish-gold line winding through the terrain. The surrounding land is divided into rectangular agricultural plots, likely for rice cultivation, with distinct patterns of green and brown. A small town or cluster of buildings is visible at the bottom left. The image is taken from a high vantage point, providing a clear view of the waterway and its surroundings.

Sungai Trus

Sungai Trus



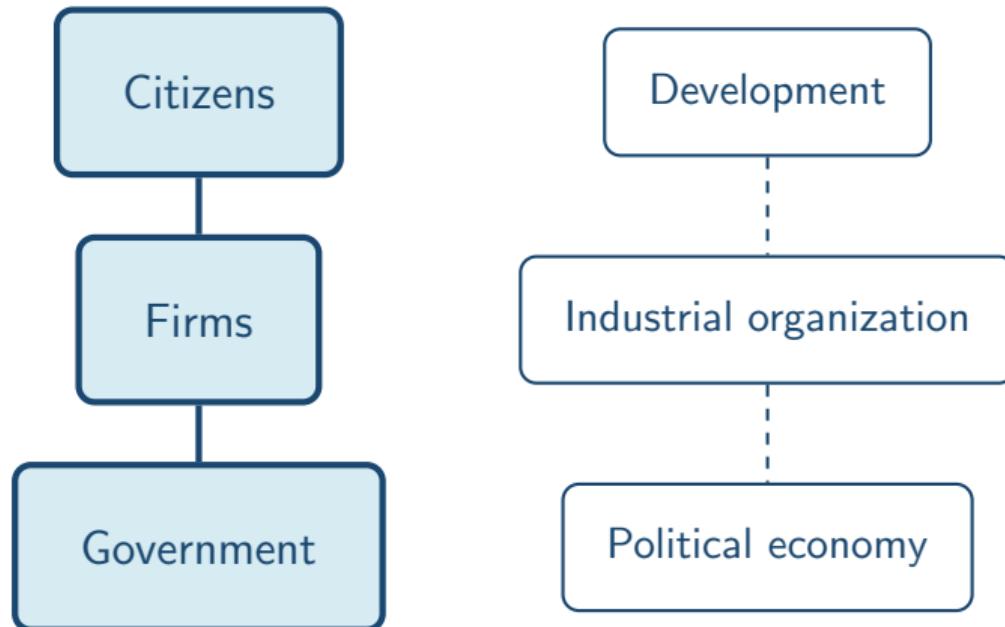


# Outline

- ① What we know
- ② What is missing
- ③ What to do

## What we know

# An extraction equilibrium



# Economic development drives deforestation

- Land use change for agriculture
  - Rather than for extracting resources like timber and minerals
  - Recurring revenue from exporting to world markets

[Roberts & Schlenker 2013, Scott 2013, Costinot et al. 2016, Sotelo 2020]

- Importance of poverty reduction
  - Industrial policy targeting agricultural production
  - Assets for individuals during lean times

[Jack & Jayachandran 2017, Jayachandran et al. 2017, Edwards 2019, Edwards et al. 2020, Jack et al. 2022]

# Industrial organization and firm incentives affect regulation

- Industrial agricultural by large firms
  - Rather than small-scale production by individuals
  - Market structure determines profits of farmers vs. processors

[Bergquist & Dinerstein 2020, Chatterjee 2022, Dhingra & Tenreyro 2022, Domínguez-lino 2022, Méndez & Van Patten 2022, Rubens 2022, Zavala 2022]

- Firm behavior matters for the impacts of regulation
  - Want detailed firm-level modeling and microdata
  - Discrete choice over deforestation activities
  - Estimated elasticities differ with static vs. dynamic estimation

[Scott 2013, Souza-Rodrigues 2019, Assunção et al. 2021, Araujo et al. 2022, Hsiao 2022]

# Political economy constrains regulation

- Winners vs. losers + implications for regulation
  - Local benefits, but global costs
  - Local voters, firms, and governments are aligned
  - Need transfers to address distributional effects

[Harstad 2012/2016, Harstad & Mideksa 2017, Harstad 2022]

- Infeasibility of first-best regulation
  - Corruption, electoral incentives, administrative constraints
  - Ill-defined property rights complicate Coasian bargaining

[Burgess et al. 2012, Balboni et al. 2021, Morjaria 2021, Dahis & Bragança 2022]

# Trade policy can implement regulation

- Environmental regulation by trade policy
  - Direct regulation faces issues of sovereignty
  - Indirect regulation sidesteps local government

[Copeland & Taylor 1994, Antweiler et al. 2001, Kortum & Weisbach 2017, Shapiro 2021, Harstad 2022, Hsiao 2022]

- International coordination for international problem
  - Climate clubs to incentivize participation

[Nordhaus 2015, Böhringer et al. 2016, Farrokhi & Lashkaripour 2021]

Brazil

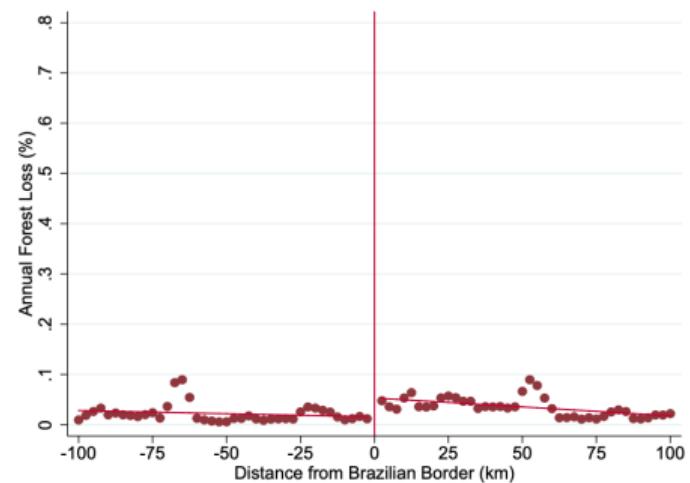


[Burgess et al. 2019, Hansen et al. 2013]

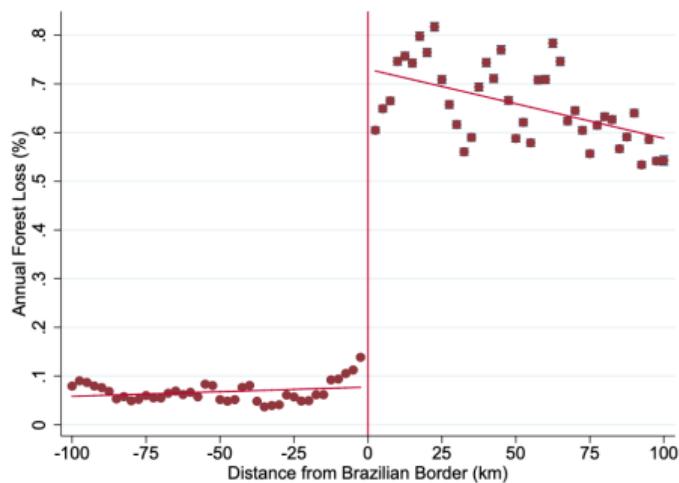
# Brazilian forest loss

2001-2005

Protected areas



Non-protected areas

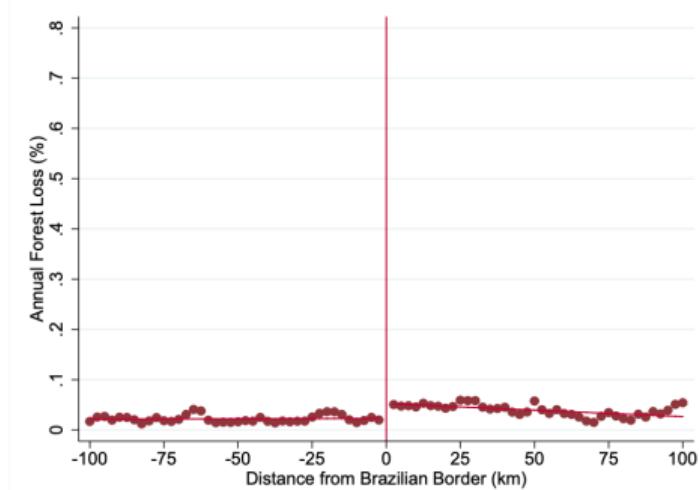


[Burgess et al. 2019]

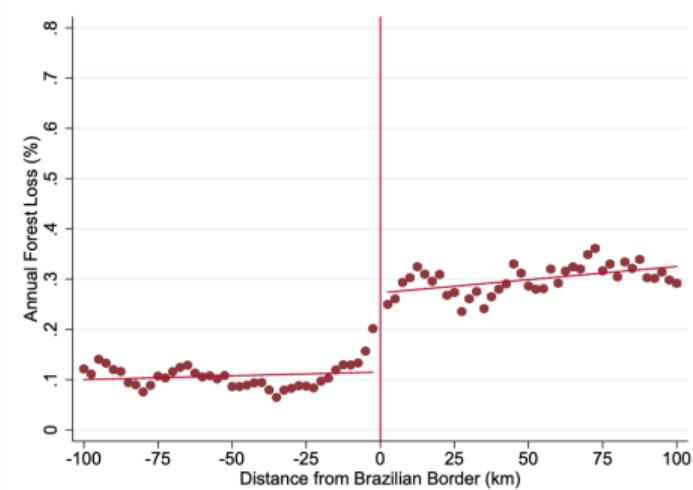
# Brazilian forest loss

2006-2013

Protected areas



Non-protected areas

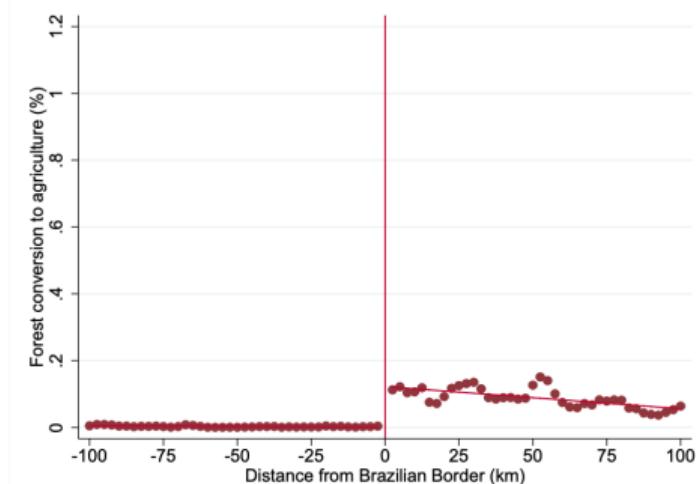


[Burgess et al. 2019]

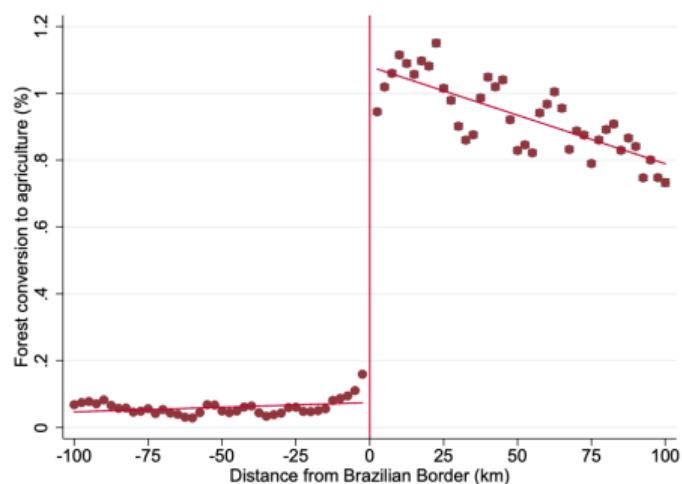
# Brazilian agriculture

2001-2005

Protected areas



Non-protected areas

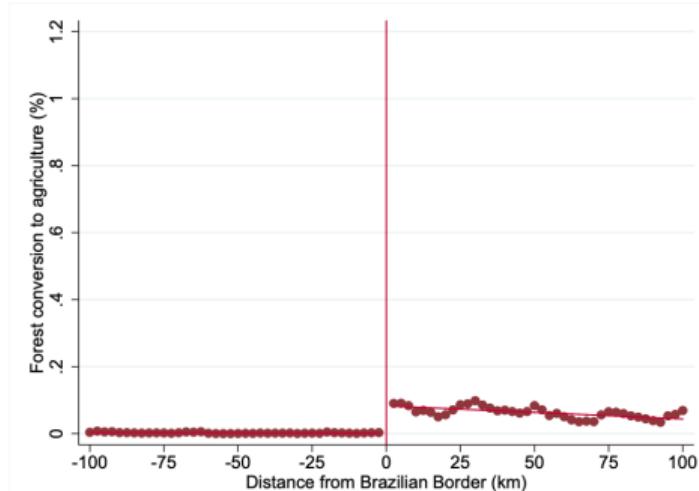


[Burgess et al. 2019]

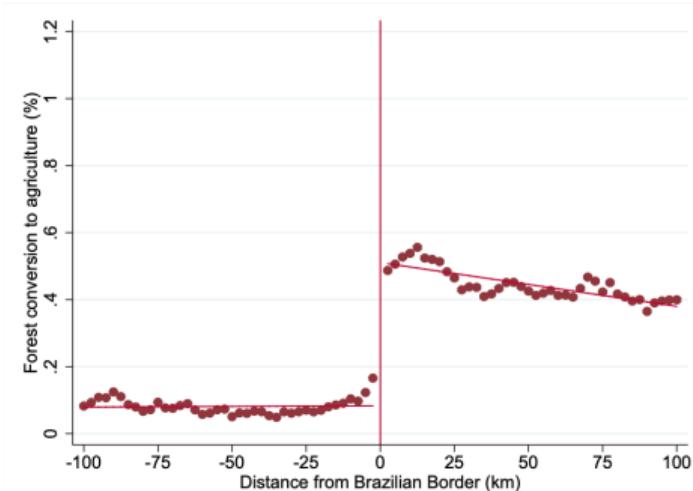
# Brazilian agriculture

2006-2013

Protected areas



Non-protected areas



[Burgess et al. 2019]





What is missing

# Development

- Weak local institutions
  - Property rights, corruption, and administrative capacity
- Agricultural industrial policy
  - Transition to non-resource-based economy, funded by forest
  - Urbanization, migration, and spatial path dependence in GE

- Missing data: Who is cutting?
  - Firm boundaries, customers, legality, revenues, and costs
  - Incentives for firms to monitor supply chains
- Market structure
  - More on intermediaries, but less on global supply chains

# Political economy

- Political incentives
  - Regulatory resistance with votes, lobbying, and bribes
  - Political rotation generates dynamics
- Politically feasible regulation
  - Winners vs. losers, sticks vs. carrots, national vs. local

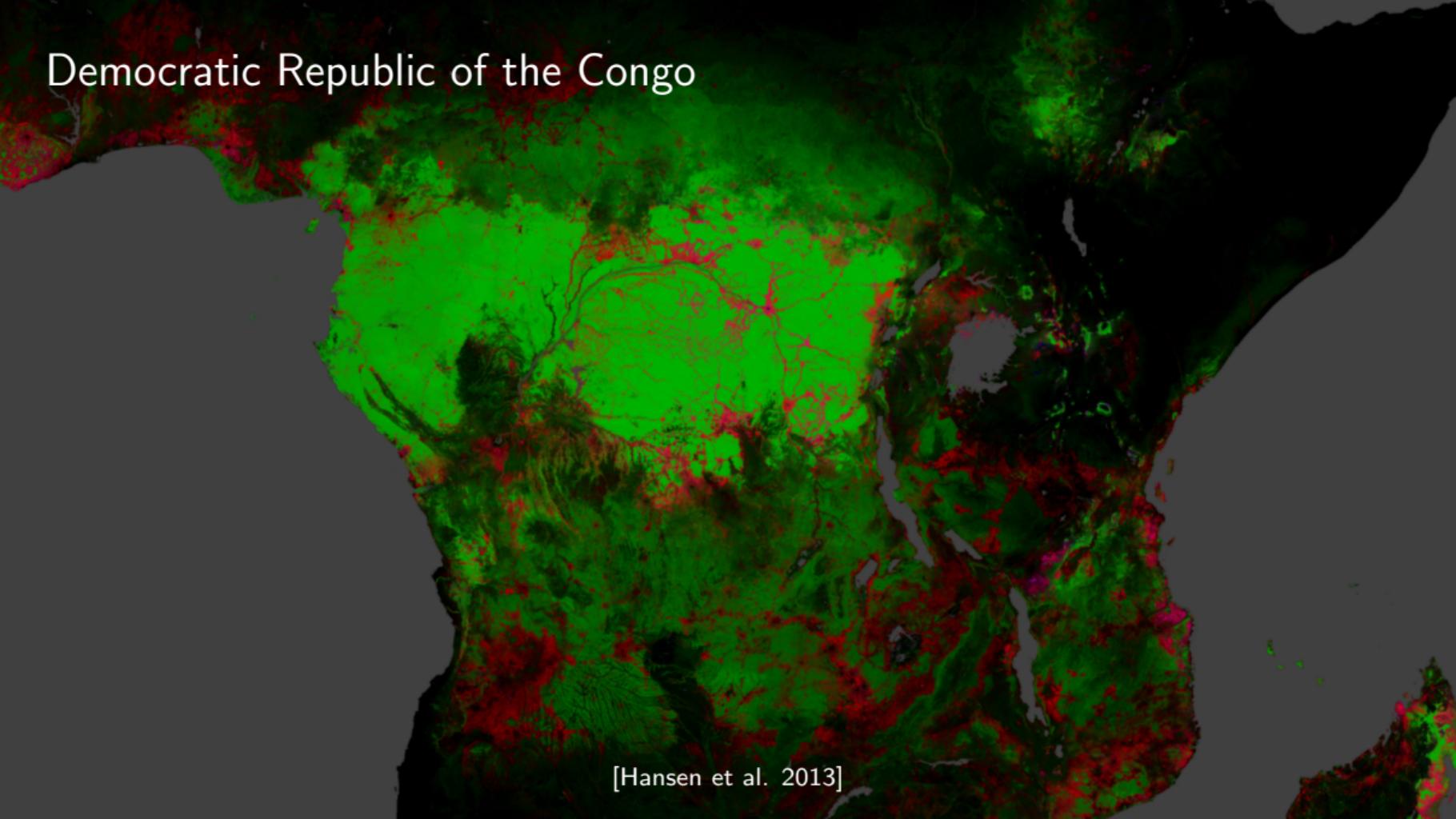
# Trade

- Gains from trade
  - Offset/carbon markets, climate finance, and REDD+
- Regulation via trade
  - Trade policy, climate clubs, and border adjustment taxes

## Other

- New data and models from science
  - Agronomy and land use change
  - Ecology and biodiversity
  - Hydrology and tipping toward desertification
  - Aerodynamics and particulates from burning
- New regions of focus
  - Congo, Papua, central Amazon

# Democratic Republic of the Congo



[Hansen et al. 2013]

# Congo rainforest

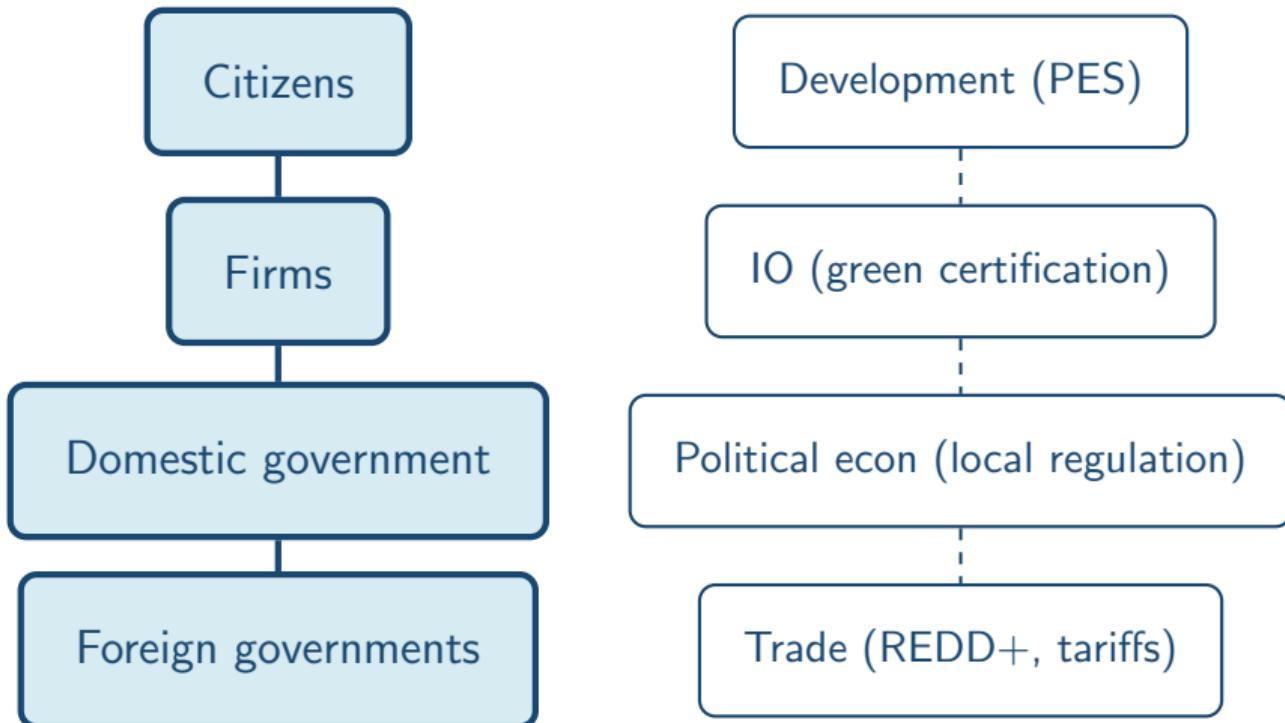
- Second largest in the world
  - Absorbs 4% of global CO<sub>2</sub> emissions annually
- Congo Basin
  - Six countries and 75 million people
  - Deforestation from small-scale, illegal charcoal and mining





# What to do

# Moving toward a conservation equilibrium



# Existing policies

- Local
  - Quantity regulation: protected regions, moratoria, quotas
  - Satellite monitoring
- Global
  - Paying landowners (PES)
  - Paying governments (REDD+)
  - Targeting demand (import tariffs, green certification)
- **Have these policies worked?**
  - What have they taught us?

# New policies

- Scaling up
  - PES works individually, but may not at scale
  - Challenges of attribution, enforcement, and cost
- Price regulation
  - Direct taxation vs. carbon markets
  - Accounting for emissions heterogeneity
- **Can we propose new classes of policies?**
  - And evaluate them empirically?

# We need a big push

- In economics
  - Taking seriously development and political economy concerns
  - Drawing on frontier methods from IO and trade
- In policy
  - Coordinated international action for an international problem
  - Compensation for domestic actors and building enforcement capacity