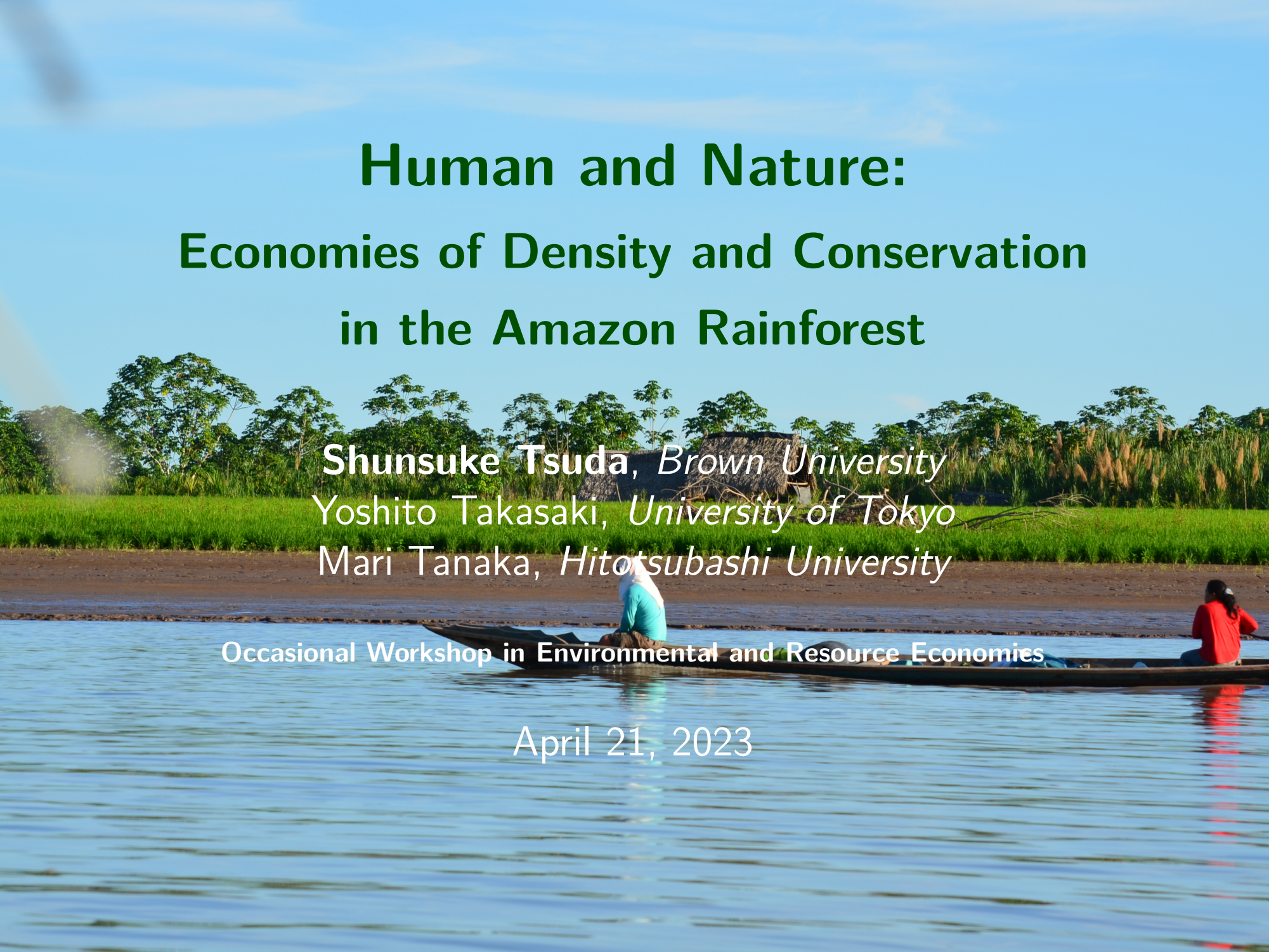

Human and Nature:
Economies of Density and Conservation in the Amazon Rainforest

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Human-Nature Interactions across Space in Rainforests



Tropical forests:

- Home to much of the world's bio-diversity and natural resources
- Indigenous populations

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Spatial reallocation: Protected areas $\Rightarrow$ Resource depletion in other locations $\uparrow$

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Research question

Are there policies that improve both local populations' welfare and ecological conservation?

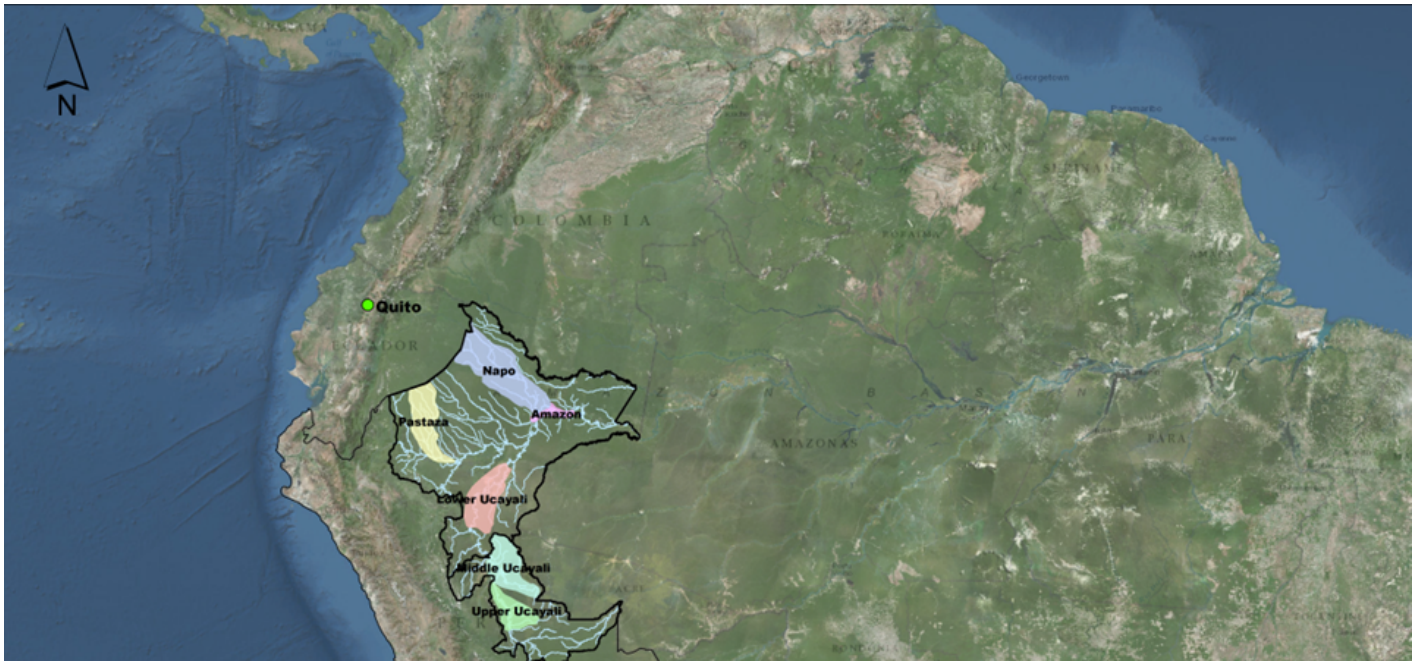
The Peruvian Amazon

- Data: remote sensing, original census and survey, national censuses
- Primary activities: agriculture (shifting cultivation), fishing, hunting
- Traditional ways of life in remote areas without modern technology and large-scale external investments (in contrast to the Brazilian Amazon)

$\Rightarrow$ Attribute resource extractions to small-scale farmers and hunter-gatherers & focus on externalities that they cause

- River networks almost solely constitute the transportation routes

$\Rightarrow$ Identify key structural parameters by exploiting exogenous river shapes



Spatial Model of Rainforest Communities

General equilibrium in a river basin with:

- Trade across multiple locations
- Mobile population within the river basin
- 3 sectors: Agriculture (rural), Natural resource (rural), Urban

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The balance between concentration and dispersion forces determines the spatial distribution of economic activities in equilibrium:

- Concentration forces:
  - **Agglomeration in agricultural production**
  - Higher market access
  - Proximity to an urban center
- Dispersion forces:
  - **Congestion in land access by clearing forests**
  - **Congestion in natural resource extraction**

Estimating density externalities in rural sectors by exploiting the structure of river networks

Parameter	Point estimate	Standard error	Description
(A) Agriculture			
$\tilde{\mu}_{Ag}$	0.064	0.010	$= \mu_{Ag} - (1-\gamma)\mu_L$
	J test p-value $= 0.648$		
μ_L	0.522	0.094	Congestion in forest clearing
μ_{Ag}	0.273		Agglomeration in agricultural production
(B) Natural resource extraction			
μ_{Nr}	0.335	0.042	Congestion in natural resource extraction
ν	0.593	0.075	Spatial decay of congestion externality
	J test p-value $= 0.821$		

Notes: Estimates of density externalities in agriculture (panel A) are based on the linear specification using $\ln RNA_o$ and the initial community existence in 1940 as instruments. Estimates of parameters governing congestion externality in natural resource extraction (panel B) are based on the non-linear GMM using $\ln RNA_o$ and $\{\ln \sum_{d|D_{o,d}\leq x} RNA_d\}$ for $x \in \mathcal{X} = \{2, 5, 10, 25, 50, 75, 100\}$ as instruments.

(A) Agglomeration in agriculture > Congestion in access to land

- Population ↑ ⇒ Productivity ↑ & Deforestation *per farmer* ↓
- Without the agglomeration ⇒ welfare ↓ 10% & Deforestation ↑ 30%

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(B) Congestion with spatial spillovers from surrounding populations in natural resource extraction

$$Q_o^{Nr}(j) = \underbrace{z_{o,Nr}(j)\Big[\sum_{d\in\mathcal{R}} D_{od}^{-\nu} N_{d,Nr}\Big]^{-\mu_{Nr}}}_{\text{productivity}} \cdot N_{o,Nr}(j)$$

Counterfactual Policy Simulations: Overview

The aim is to design a "win-win" policy that simultaneously achieves:

- Local populations' welfare $\uparrow$
- Deforestation $\downarrow$
- Natural resource depletion $\downarrow$

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Implications:

- *Well-targeted* place-based protection policies and transport infrastructure are complementary to improving human & ecological well-being

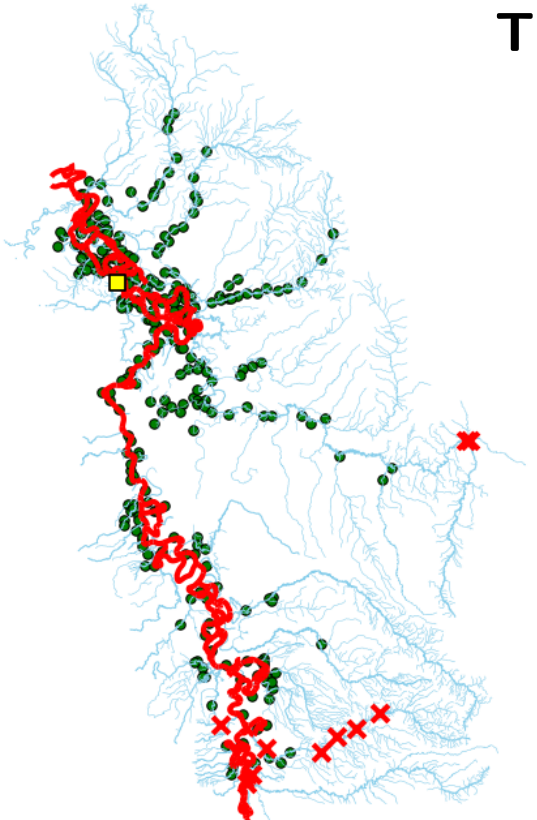
e.g. *Direction* of deforestation impacts depends on where transport infrastructure is improved

Counterfactuals	**Welfare**	**Deforestation**	**Natural resource depletion**
(A) Protection policies			
i. Protecting the rural frontier	−	−	−
ii. Targeting the smallest communities	−	−	+
(B) River Transport infrastructure			
i. Connecting hinterlands to the center	+	−	?
ii. Concentrating in the center	+	+	?
(A) i. + (B) i.	**+**	**−**	**−**

(A) Protecting the rural frontier &
(B) Transport infrastructure that connects hinterlands to the center

Basin	Welfare	Deforestation	Natural resource depletion
Napo	+1.6%	-6.7%	-0.6%
Pastaza	+1.0%	-4.7%	-0.3%
LowerUcayali	+2.1%	-1.0%	-2.4%
UpperUcayali	+1.0%	-3.1%	-0.5%

The trade-offs are relaxed!



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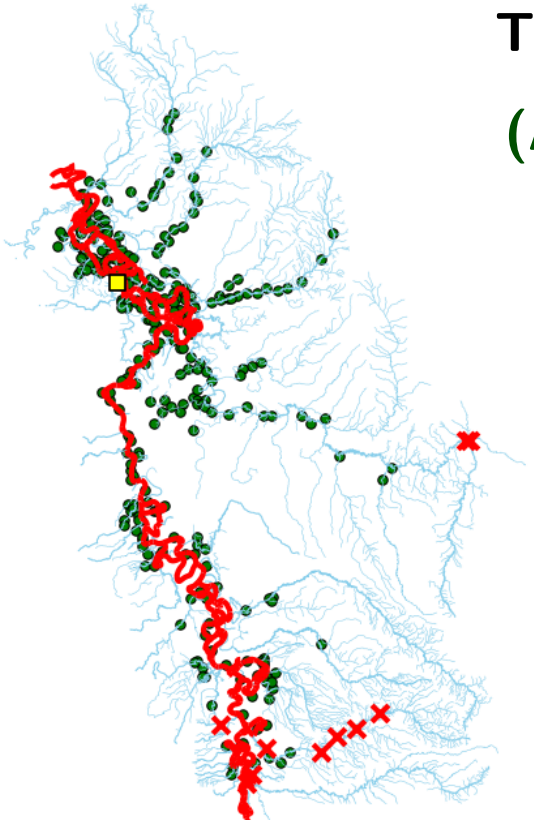

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(A) More compact basin for human settlements

$\Rightarrow$ Congestion $\uparrow$ across populated areas

- Natural resource depletion $\downarrow$

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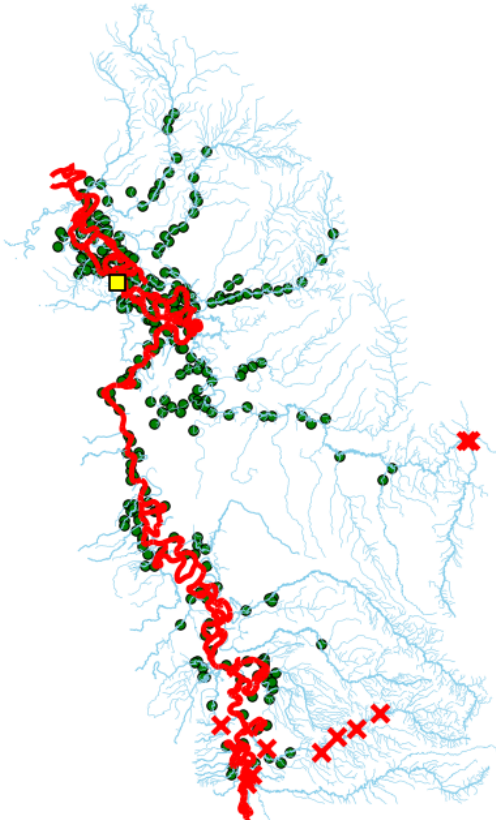

The trade-offs are relaxed!

(A) More compact basin for human settlements

$\Rightarrow$ Congestion $\uparrow$ across populated areas

- Natural resource depletion $\downarrow$

(B) Integrated between the center and hinterlands

$\Rightarrow$ Agglomeration benefits spread more evenly across the basin with more medium-sized settlements

Total deforestation $\downarrow$ given the convex structure of congestion forces in access to land

Conclusions

This paper:

- Applies a multi-sector spatial GE model to rainforest communities
- Estimates density externalities (agglomeration & congestion)

RQ. ***Are there policies that improve both local populations' welfare and ecological conservation?***

* Combination of a protection policy and transport infrastructure investments
* Spatial targeting matters for both
* Even development is better for the environment than uneven development

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Future research:

- Dynamics: community formation, resource depletion, external investments
- Across-sector externalities
- Indigenous populations' values of their traditional ways of life
- Other environmental costs (e.g. desertification)