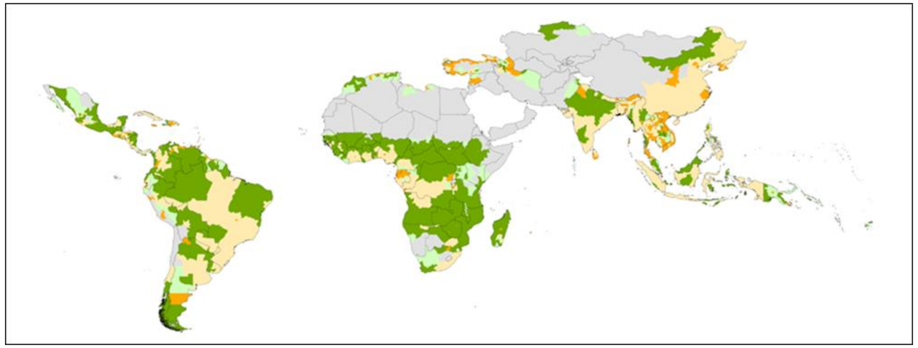
Using Spatial Datasets to Improve Modeling of AR Costs, Carbon Accumulation, and Net Tree-Cover Gain in the Global South



Jeffrey R. Vincent

Nicholas School of the Environment, Duke University

11th Forestry and Agriculture GHG Modeling Forum

North Carolina State University, Raleigh NC

March 6, 2024

United States
Department of
Agriculture

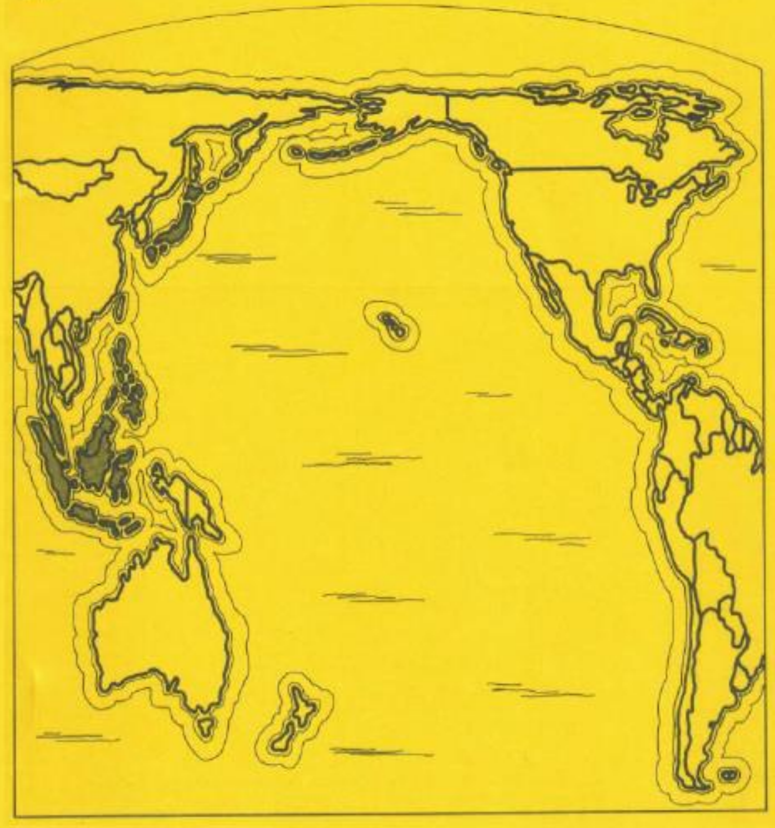
Forest Service

Pacific Northwest
Research Station

General Technical
Report
PNW-GTR-210

Modeling Japan – South Seas Trade in Forest Products

Jeffery R. Vincent



C I N T R A F O R

Working Paper

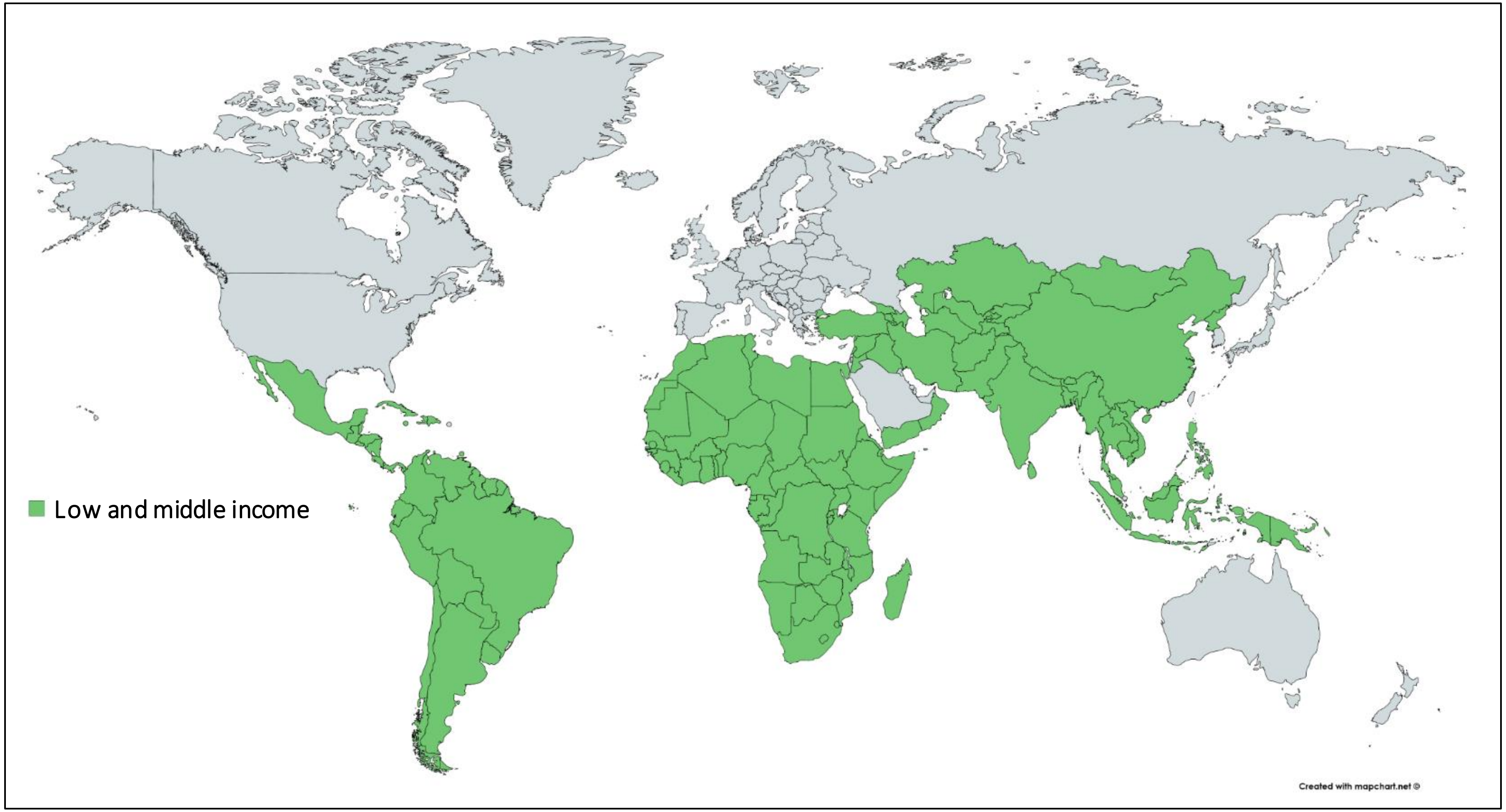
18

An Economic Analysis of Short-Run Timber Supply Around the Globe

1988

P. A. Cardellichio, Y. C. Youn, C. S. Binkley,
J. R. Vincent, D. M. Adams

CENTER FOR INTERNATIONAL TRADE IN FOREST PRODUCTS
UNIVERSITY OF WASHINGTON
COLLEGE OF FOREST RESOURCES AR-10
SEATTLE, WASHINGTON 98195


Low and middle income
Created with mapchart.net ©

Economists are dismal scientists

- 2011–2023 search: *afforestation* OR *reforestation* OR *forest restoration*
  - Web of Science: 14,984 documents
  - EconLit: 186 documents
- 2011–2023 search: *deforestation*
  - EconLit: 906 documents

Despite: > ½ of LMICs having

net tree-cover gain during 2005 – 2020

ANNUAL REVIEWS

Annual Review of Environment and Resources

Forest Restoration in Low- and Middle-Income Countries

Jeffrey R. Vincent,[1] Sara R. Curran,[2] and Mark S. Ashton[3]

[1]Nicholas School of the Environment, Duke University, Durham, North Carolina 27708, USA; email: jeff.vincent@duke.edu

[2]Henry M. Jackson School of International Studies, University of Washington, Seattle, Washington 98195, USA; email: scurran@uw.edu

[3]The Forest School at the Yale School of the Environment, Yale University, New Haven, Connecticut 06511, USA; email: mark.ashton@yale.edu

Research program 1 (micro): impact evaluations of AR programs

PAKISTAN (2): Billion Tree Afforestation Program (enclosures, plantations)

NEPAL: Plantation Registration Programme

CHINA (2): 3-North Shelter Forest Program; Yunnan Pilot Carbon Credit Program

BANGLADESH: Social Forestry Program

UGANDA: Sawlog Production Grant Scheme

INDIA: National Agroforestry Policy

SRI LANKA: National Agroforestry Programme

Research program 2 (macro):
LMIC-wide AR patterns and processes

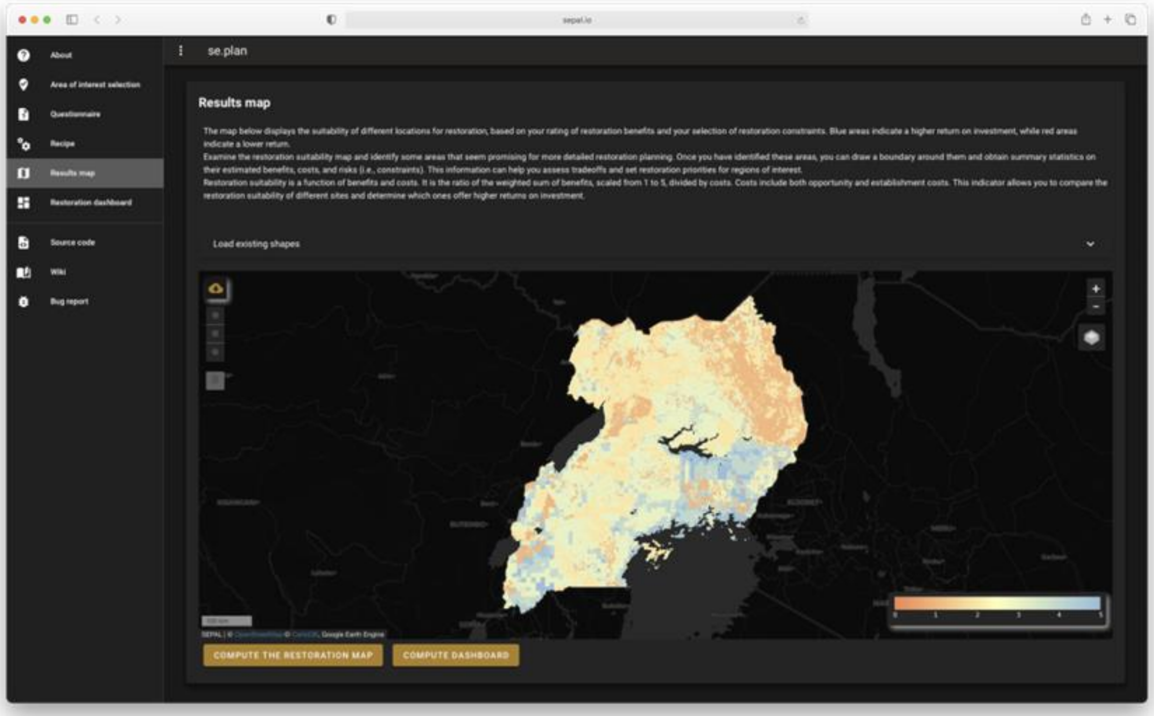
- se.plan: spatially explicit forest restoration planning tool
  - FAO Open Foris SEPAL (https://docs.sepal.io/en/latest/modules/dwn/seplan.html)
  - Google Earth Engine-based
- Ongoing development since mid-2020

Food and Agriculture Organization of the United Nations

SilvaCarbon

Spatial Informatics Group

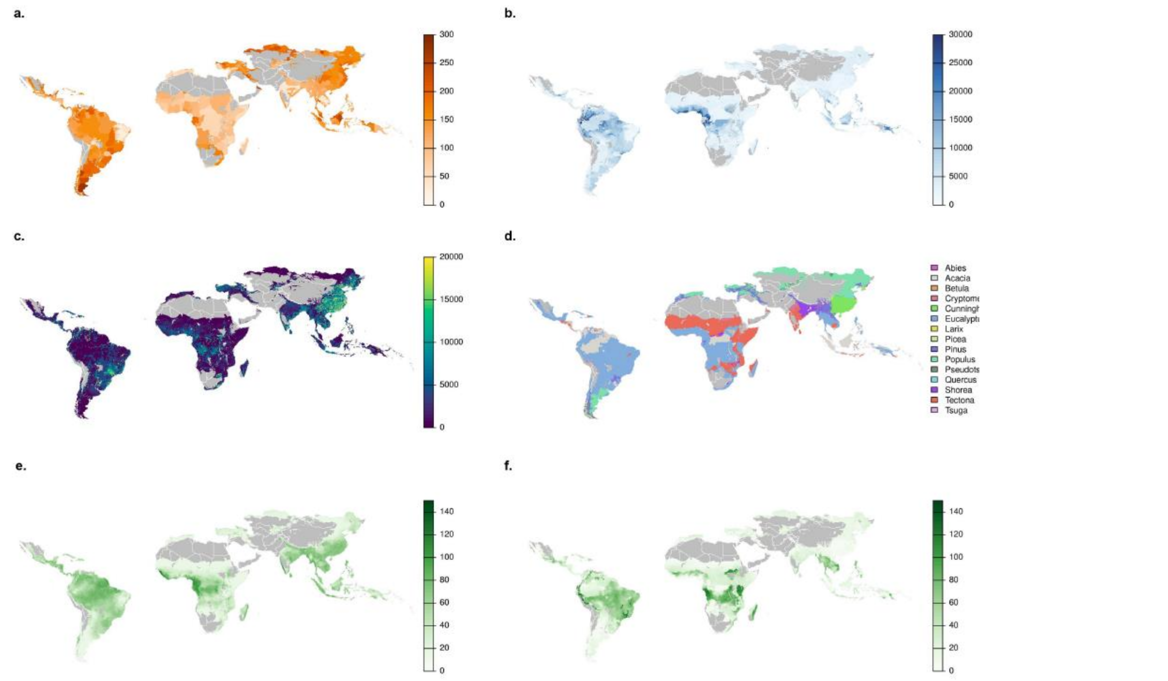
Duke UNIVERSITY



Gridded datasets on AR costs, genera choice, and C accumulation rates

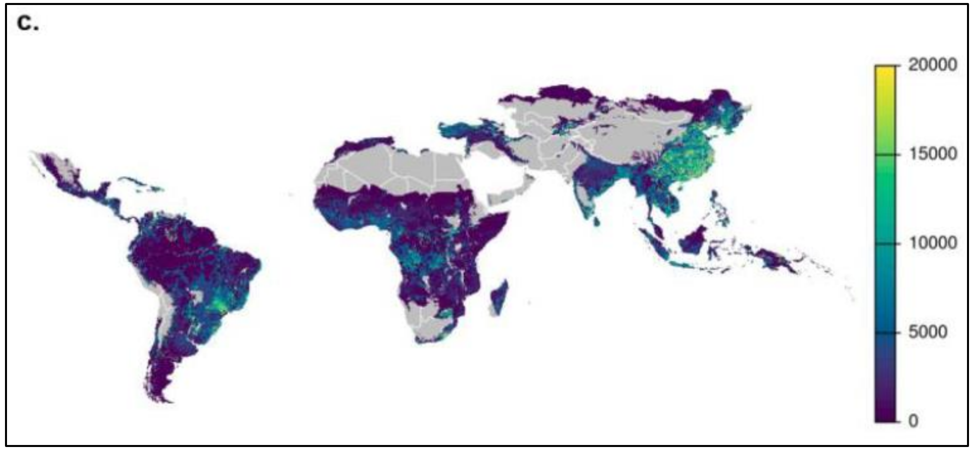
J. Busch, J.J. Bukoski, S.C. Cook-Patton, B. Griscom, D.J. Kaczan, M.D. Potts, Y.Y. Yi, and J.R. Vincent (in review), "Tree planting vs. natural forest regeneration: relative cost-effectiveness at mitigating climate change"

Figure 1. Costs, likely plantation genus, and carbon accumulation from reforestation. a) implementation cost of natural forest regeneration ($/ha); b) implementation cost of plantation, including replanting ($/ha); c) opportunity cost ($/ha); d) most likely plantation genus; e) carbon accumulation for natural forest regeneration (tC/ha); f) carbon accumulation for plantations (tC/ha). 138 low- and middle-income countries; 30 years; time-discounted at 5%; 2020 USD.

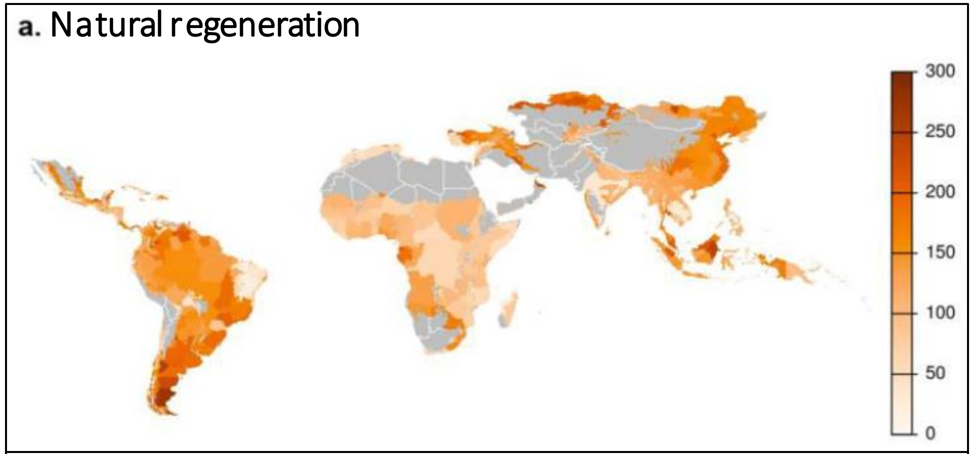


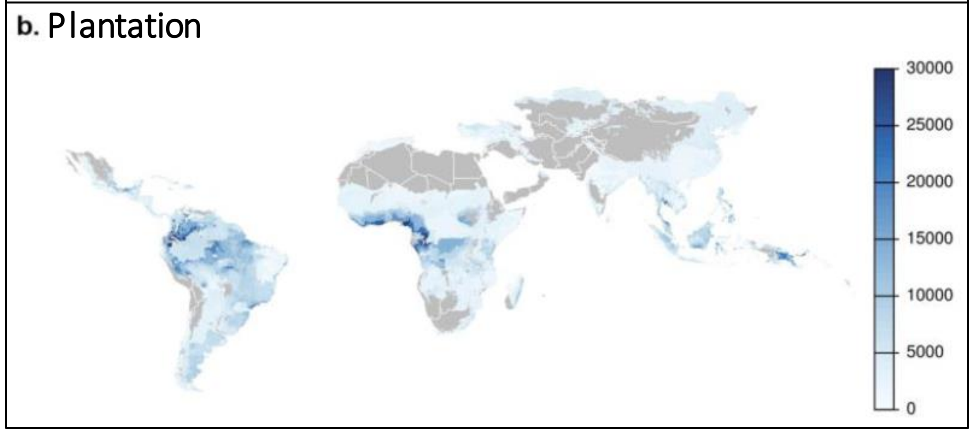
AR costs

Opportunity cost: agricultural land rent (PV, 5%)
[~10 km]



Implementation costs (= estab. + 3-5 yrs. maint.)
[Level 1 subdivision]





Workflow for opportunity cost: cropland

1. Obtain 2010* gridded data on crop production value

MAPSPAM

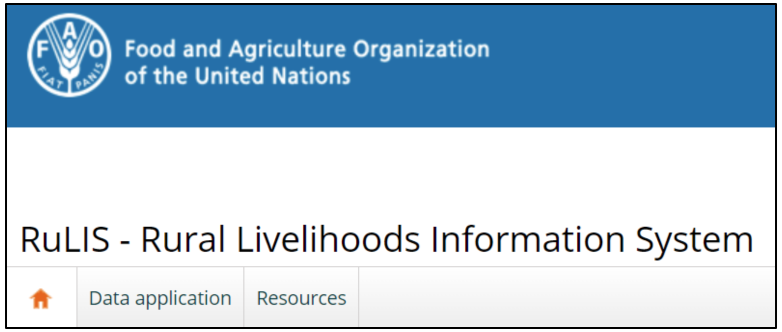
https://www.mapspam.info/

*2020 data now available

2. Update to 2019 using national data

http://www.fao.org/faostat/en/#data/QV/metadata

3. Determine land-rent share using LSMS household survey data



http://www.fao.org/in-action/rural-livelihoods-dataset-rulis/en/

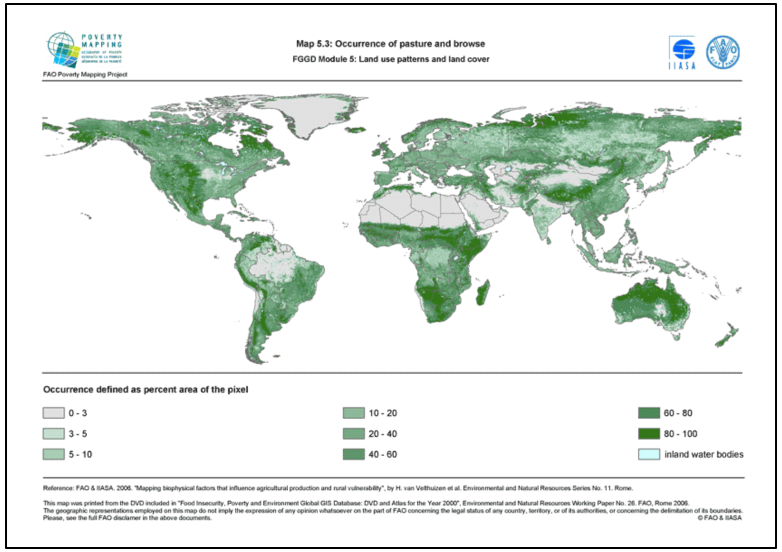
4. Capitalize annual land rent using 5% real discount rate

https://databank.worldbank.org/home

Workflow for opportunity cost: pastureland

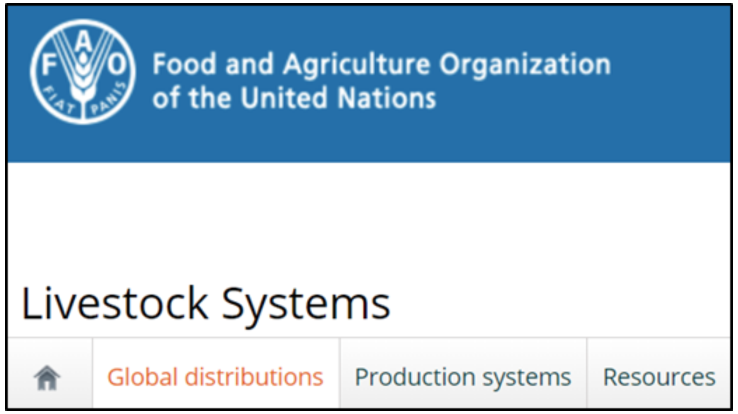
Similar to cropland value, but use different datasets, including:

1. 2000 FAO pasture map, updated to 2015 using spatial statistical methods



https://data.apps.fao.org/map/catalog/srv/eng/catalog.search#/metadata/913e79a0-7591-11db-b9b2-000d939bc5d8

2. 2010 gridded livestock data, updated to 2019 using national data

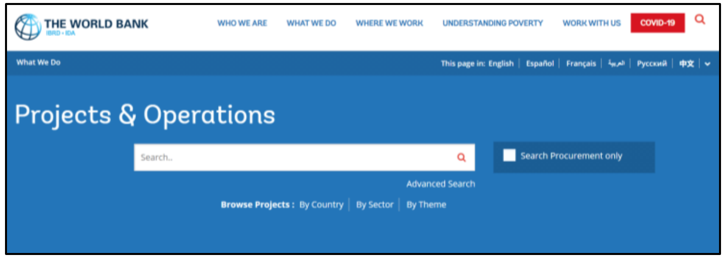


http://www.fao.org/livestock-systems/global-distributions/en/

More confident in cropland OC estimates than pastureland OC estimates

Workflow for implementation costs

1. Extract 355 cost estimates from 99 documents (World Bank, other)



https://projects.worldbank.org/en/projects-operations/projects-home

2. Obtain spatial data on variables hypothesized to affect costs

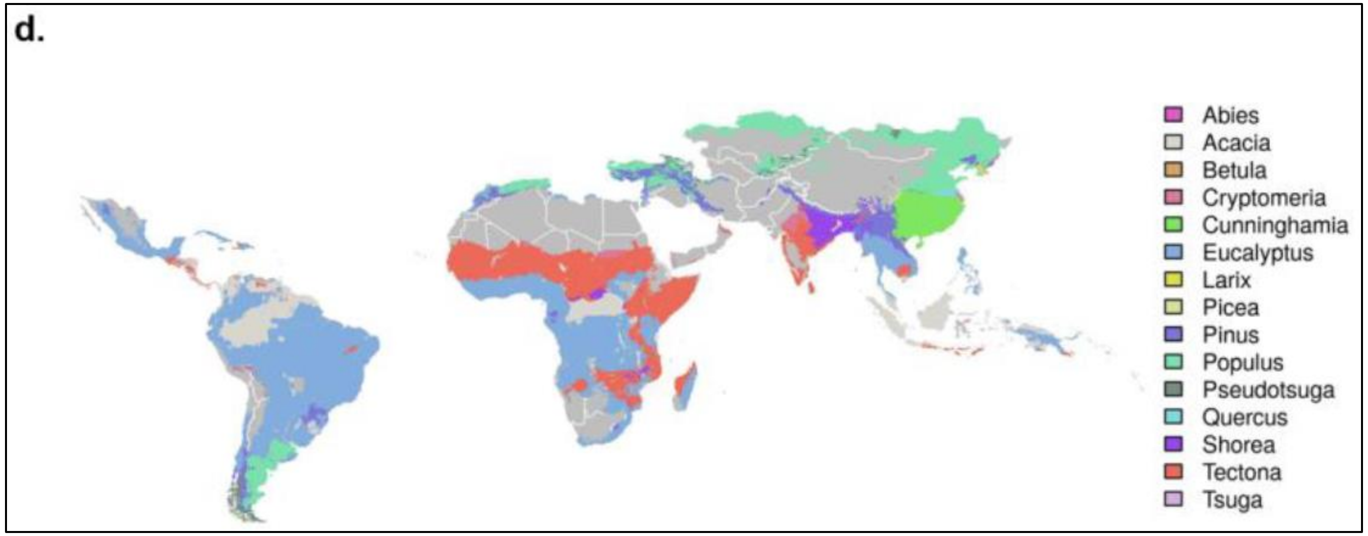
https://datadryad.org/stash/dataset/doi:10.5061/dryad.dk1j0

3. Use ML (lasso) to statistically relate cost estimates to spatial variables

Variable	Coefficient
Dummy: regeneration method = planting	1.35
Dummy: regeneration method = passive natural	-0.916
Dummy: regeneration included native species	-0.356
ln(GDP per capita)	0.329
Dummy: cost estimate spans multiple years	0.206
Dummy: cost estimate not disaggregated by inputs or activities	-0.154
Area share: biome = tropical & subtropical dry broadleaved forest	-1.27
Area share: biome = Mediterranean forests and woodlands	0.725
Area share: biome = deserts and xeric shrublands	-1.04
Year of implementation	0.0123
Constant	-21.9

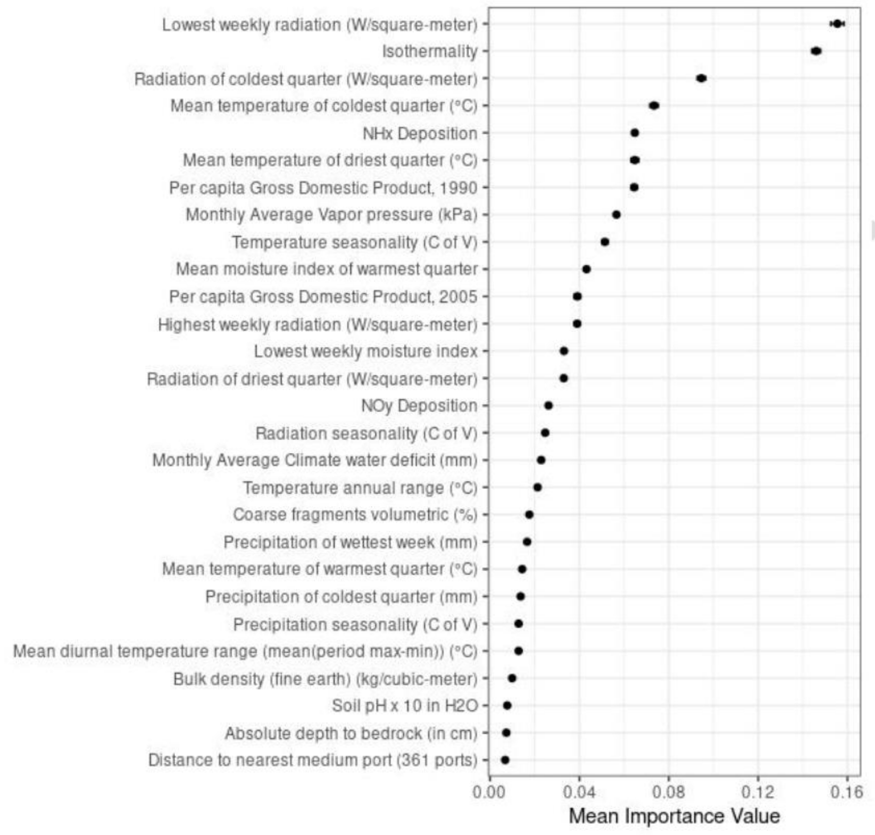
4. Predict costs for Level 1 subdivisions using statistical model

Most likely plantation genus [1 km]

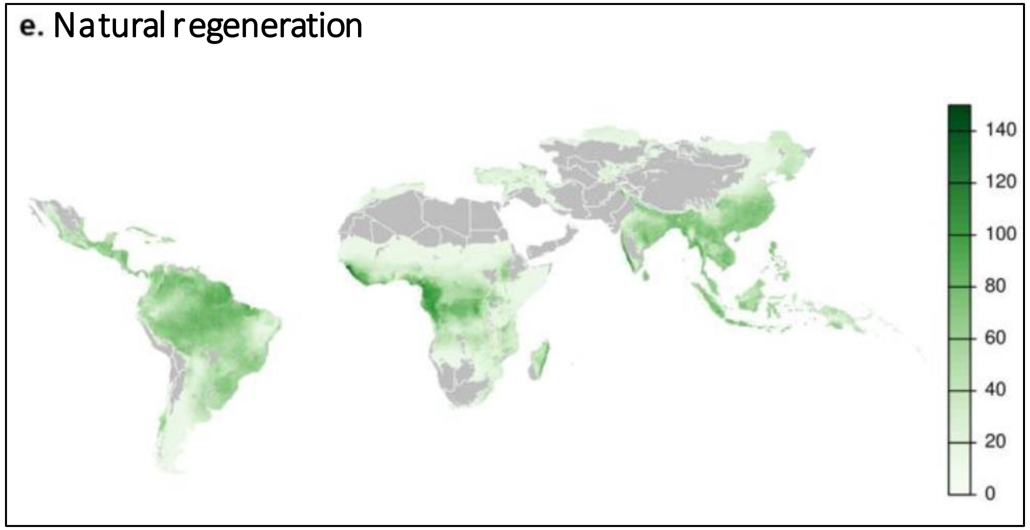


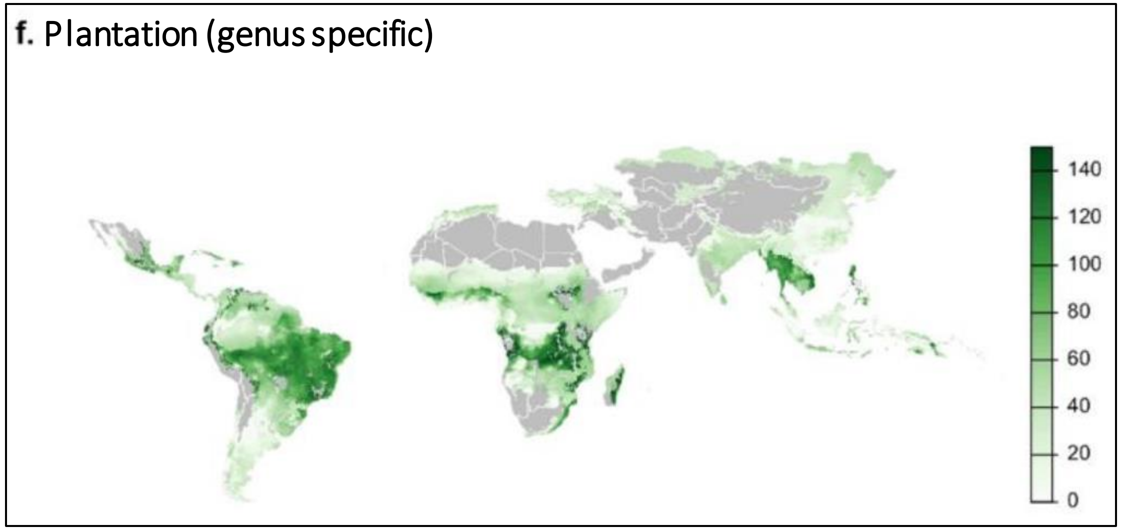
Primary data source: Harris et al., *Spatial Database of Planted Trees, Version 1* (WRI, 2019)

Figure S2. Parsimonious set of predictors for classification of most likely plantation type. Importa scores calculated by the Variable Selection Using Random Forests (VSURF) algorithm.



Above-ground carbon accumulation functions [1 km]





Primary data source: Cook-Patton et al., "Mapping carbon accumulation potential from global natural forest regrowth" (*Nature*, 2020)

- 2,309 observations from 410 LMIC sites

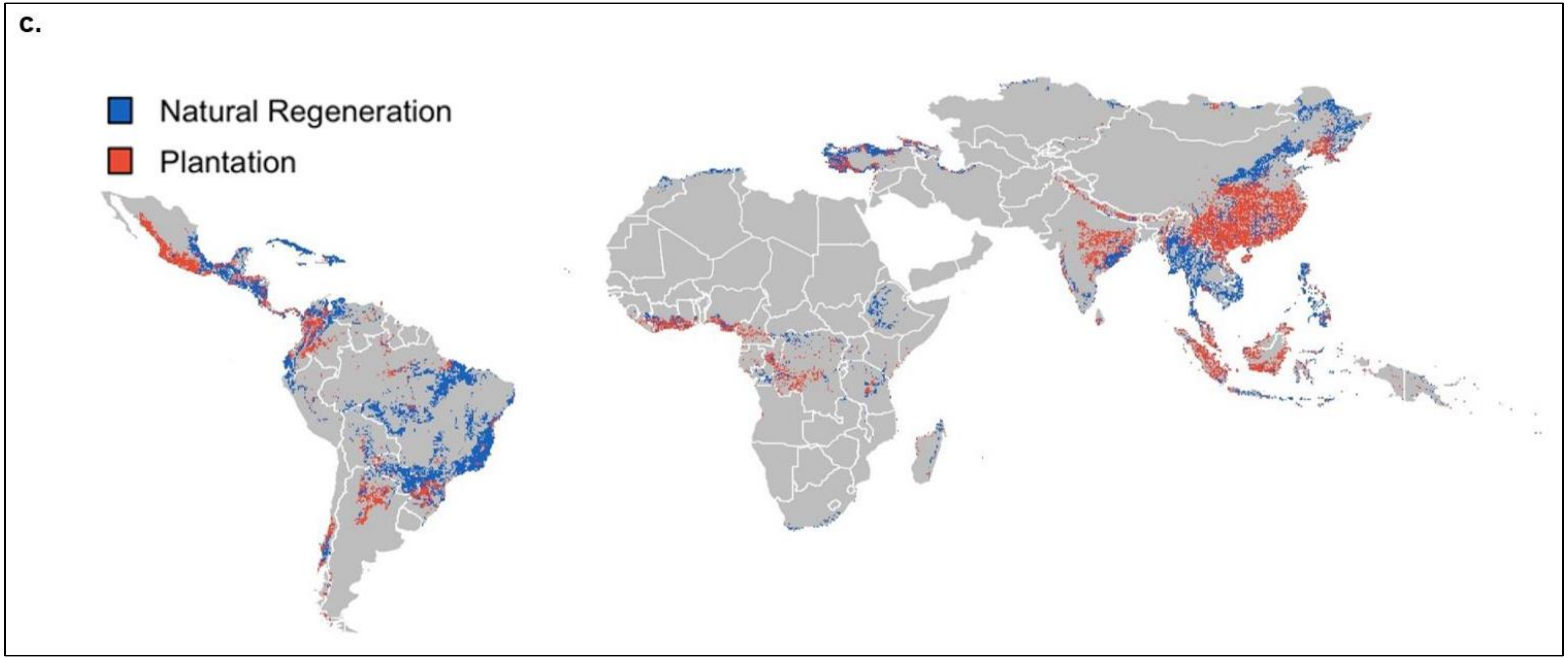
Primary data source: Bukoski et al., "Rates and drivers of aboveground carbon accumulation in global monoculture plantation forests" (*Nature Comm.*, 2022)

- 3,289 observations from 618 LMIC sites

<u>Workflow</u>:

1. Compile spatial data on 64 climatic and soil variables
2. Fit Chapman-Richards growth functions, with spatially varying parameters

Which regeneration method offers lower cost sequestration, and where?
[Plantation: accounts for timber value and C storage in durable wood products]



Natural regeneration (46%) and plantations (54%) have lower sequestration costs in roughly equal areas

AR offers 3-10× more sequestration below \$20 – 50/tCO_2 than estimated by IPCC (2022)

PROPOSAL FOR A SESYNC PURSUIT

Descriptive title: Migration, Marginal Agricultural Land, and Tree-Cover Expansion in Low- and Middle-Income Countries

Short title: Migration and Tree Cover

Name and contact information for PIs

Jeffrey R. Vincent	Sara R. Curran
Nicholas School of the Environment	Henry M. Jackson School of International Studies
Duke University	University of Washington

Demographic drivers of net 5-year tree-cover gain in LMICs

[Level 2 subdivisions; 3 years (2005, 2010, 2015); FE logit models w/ country trends]

Variables	Base model	Add population density	Add net migration rates	Add working-age share	Add youth & elderly shares
Tree cover gap	23.90*** (0)	23.92*** (0)	23.89*** (0)	23.93*** (0)	24.27*** (0)
GDP per capita	-1.95e-05 (0.480)	-1.97e-05 (0.475)	-1.89e-05 (0.491)	-1.89e-05 (0.487)	-1.92e-05 (0.471)

If indicated demographic variable increases by 1 standard deviation, then probability of net tree-cover gain increases by …

Population share: elderly	0.69
Population share: youth	0.54
Population density	−0.22
Net out-migration rate	0.16
Net in-migration rate	−0.001


Thank you,
and please help me find a postdoc with GEE/GIS skills!
(Jeff.Vincent@duke.edu)