



AGRICULTURAL LOSSES IN A TELECOUPLED WORLD: MODELING THE CASCADING EFFECTS OF PRODUCTION LOSSES ON GLOBAL LAND USE AND TERRESTRIAL CARBON EMISSIONS

Anthony Janetos and John Patrick Connors



The Frederick S. Pardee Center
for the Study of the Longer-Range Future



MULTIPLE BREADBASKET FAILURE

Breadbasket Failure:

- Productivity losses in major growing regions
- Large enough to have global impacts
- Failures could be catastrophic or episodic
- May be caused by multiple factors, e.g. drought, disease, climate change

Impacts:

- Food price fluctuations
- Decreased food supply
- Deforestation
- Emissions

Top Production Areas For Key Crops

Corn	Wheat	Rice
1. USA	1. China	1. China
2. China	2. Western Europe	2. Southeast Asia
3. Latin America	3. India	3. India

RECENT FAILURES

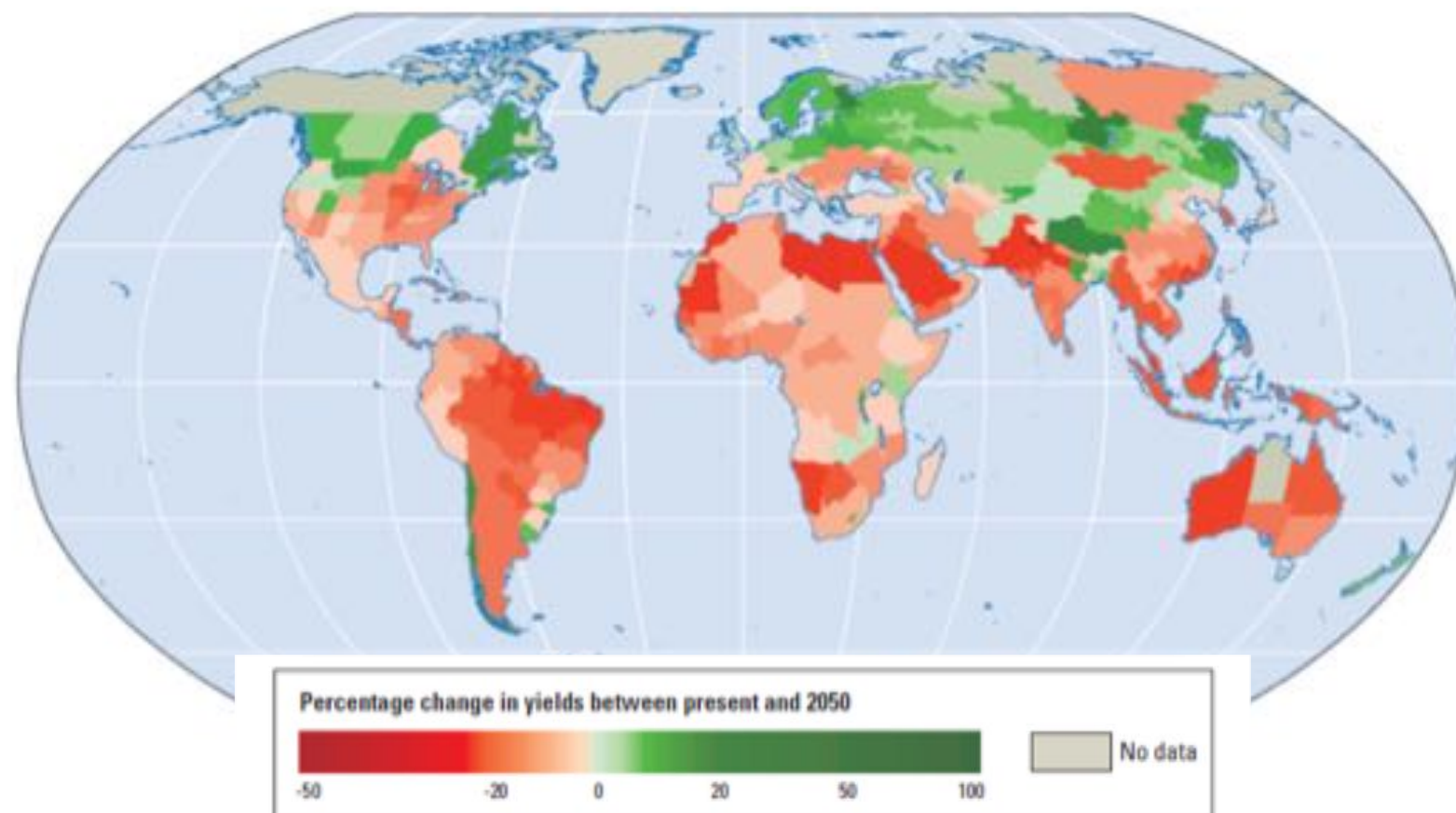
- Major breadbasket failures have occurred in the past, affecting global food supplies and food prices.

Recent Global Crop Losses

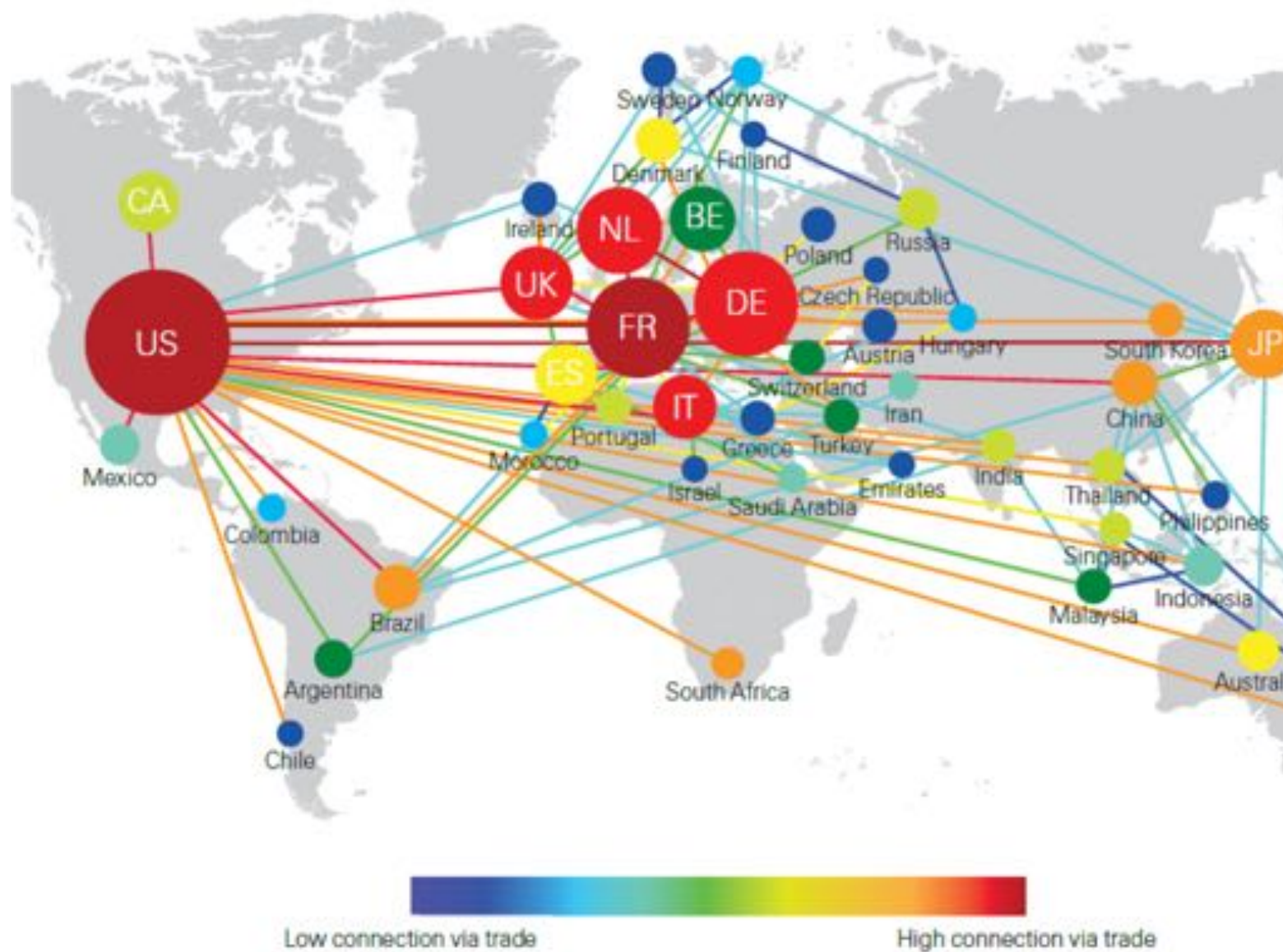
Crop	Year	% Global Production Decrease	Absolute Production Loss (Million Tonnes)
Maize	1988	12%	55.9
Soybean	1988/89	8.5%	8.9
Wheat	2003	6%	36.6
Rice	2002/03	4%	21.7

GLOBAL FOOD SECURITY AND ENVIRONMENTAL CHANGE

- Population growth and shifting diets may require increases of 50-100% of production.
- Increased homogenization of food production systems has increased risk of wide-scale crop losses to disease and pests.
- Climate change is expected to cause losses in production in many of the world's most productive regions.



Global food trade network



Based on Ercsey-Ravasz et. al 2012 doi:10.1371/journal.pone.0037810

Figure 1

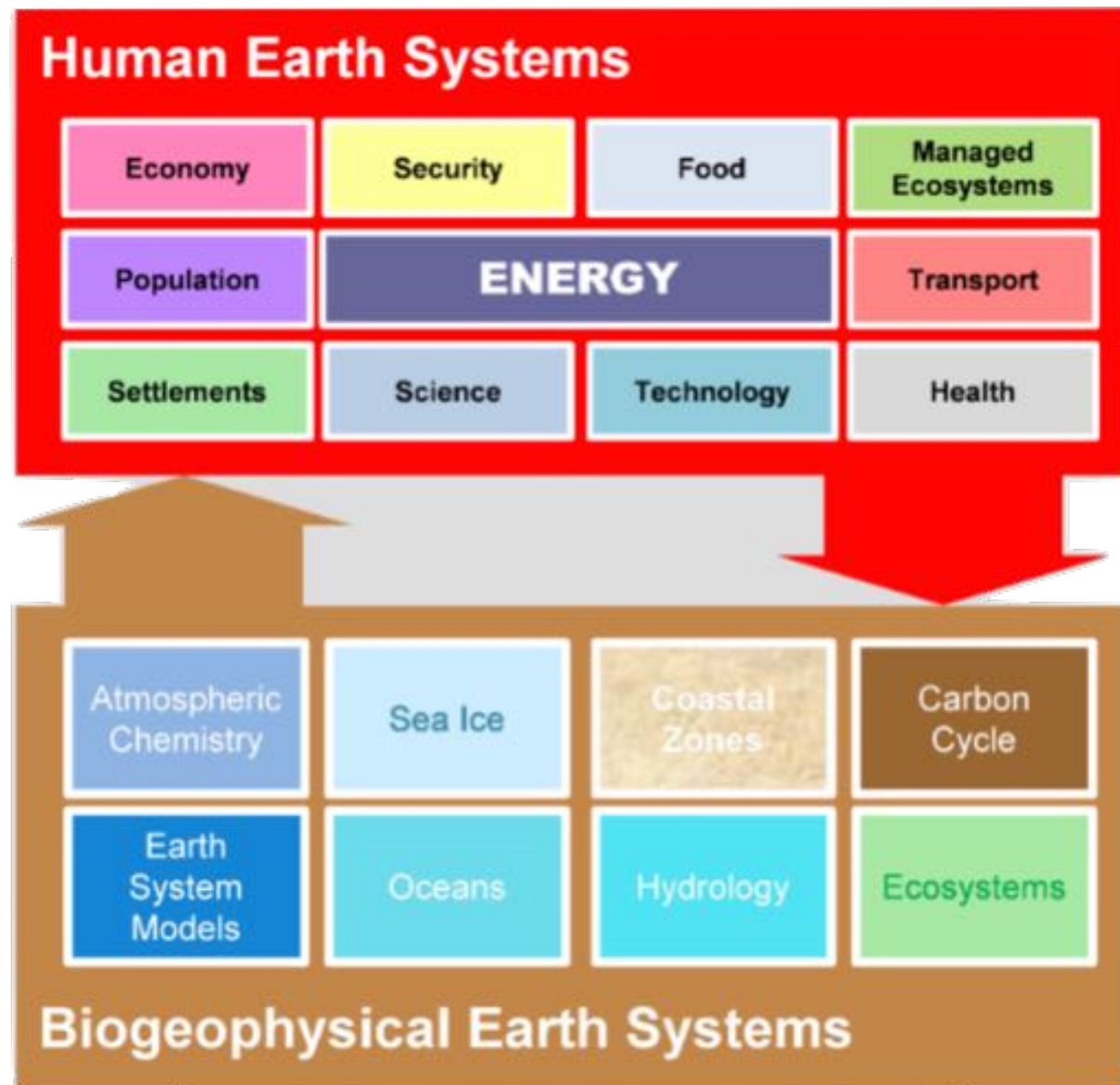


Global food trade networks increasingly link land and food systems.

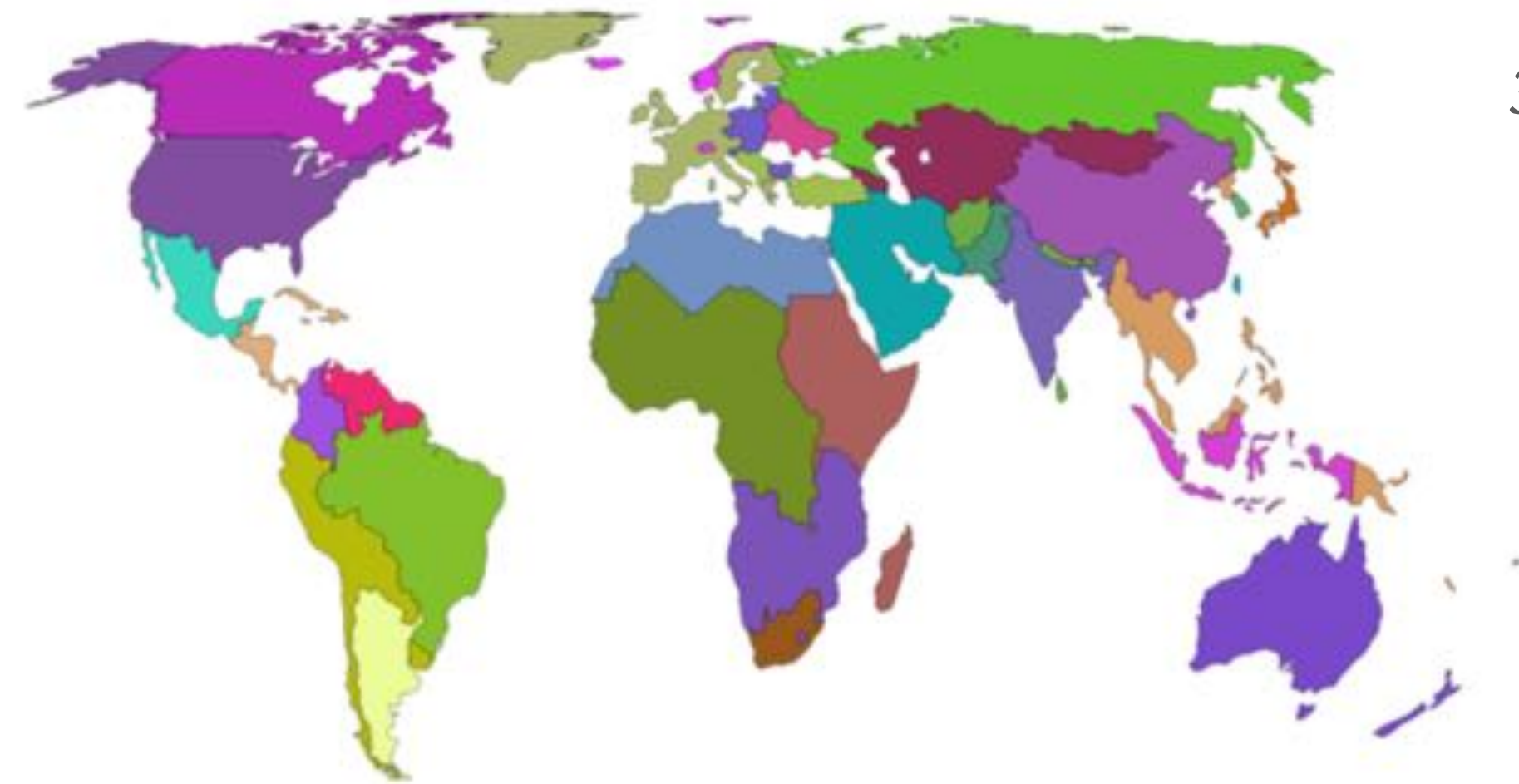
RISKS OF GLOBAL BREADBASKET FAILURE

- ▶ Risk = Magnitude of Impact X Probability of Occurrence
- ▶ Focus on risks that are globally important, recognizing that underlying phenomena may not be global, and global risks can be a consequence of regionally significant phenomena.
- ▶ Objectives:
 - ▶ Assess impacts of breadbasket failures in food and energy systems
 - ▶ Evaluate the likelihood of occurrence of such events
 - ▶ Quantify risks associated with failure of multiple breadbaskets

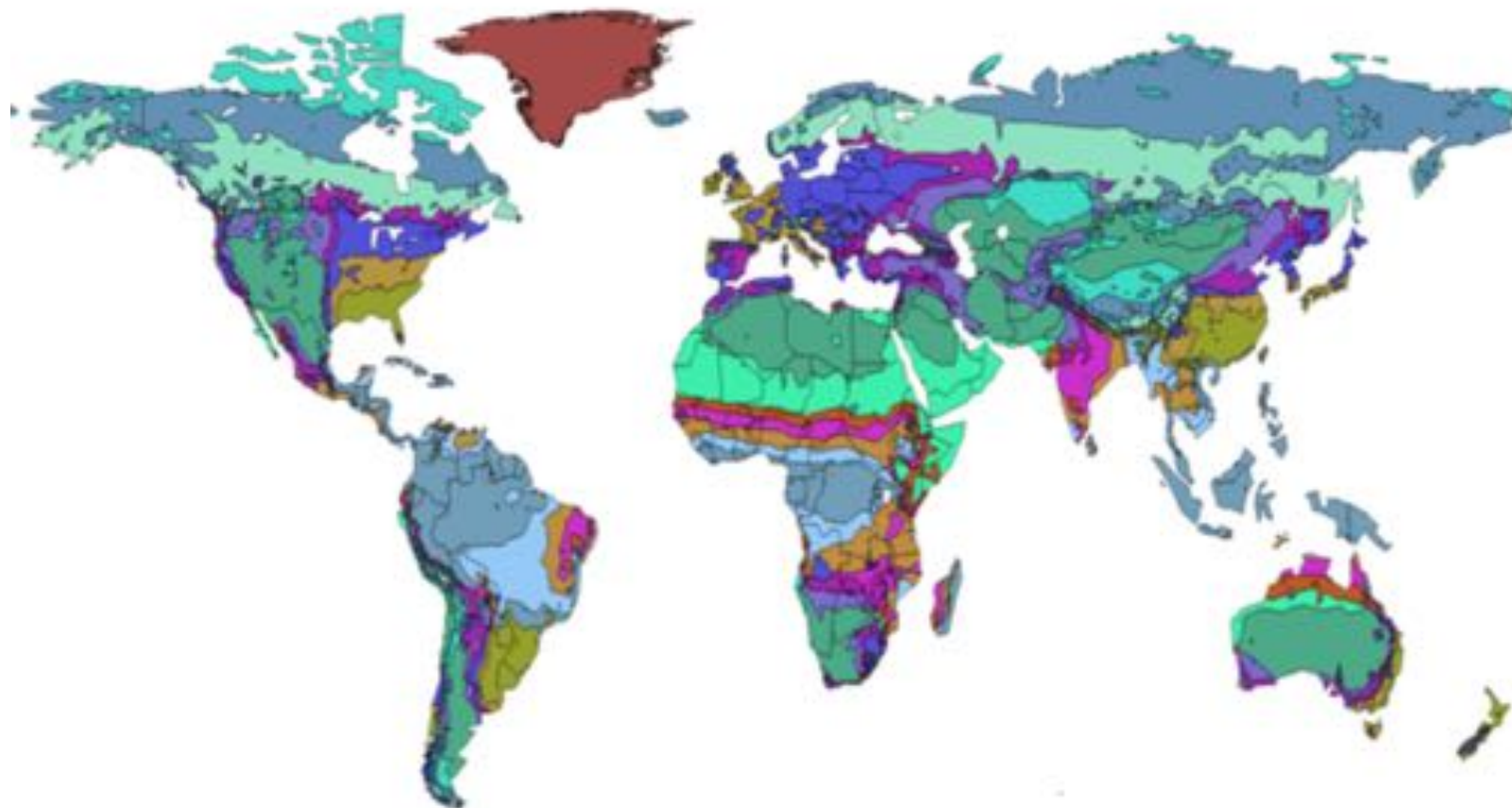
GLOBAL CHANGE ASSESSMENT MODEL



- GCAM is an integrated assessment model that integrates economic, energy, land use, water, and physical Earth systems models.
- Freely available community model developed and maintained by PNNL's Joint Global Change Research Institute
- We use GCAM to model changes in agricultural production, prices, land use, and emissions from 1990-2100.



32 geopolitical regions



232 Agroecological Zones



SCENARIO STRUCTURE

- ▶ We ran 60 scenarios of shocks to agricultural production given both RCP 4.5 policy targets and no climate policy targets (120 scenarios total).
- ▶ One Region, One Crop
- ▶ One Region, All Crops
- ▶ Two Regions, One Crop
- ▶ Two Regions, Two Crops
- ▶ Two Regions, All Crops
- ▶ Three Regions, One Crop
- ▶ Three Regions, All Crops

1 REGION & 1 CROP

Region	Crop	Productivity Decreases
China	Corn	10%/50%
China	Rice	10%/50%
China	Wheat	10%/50%
USA	Corn	10%/50%
Latin America	Corn	10%/50%
Southeast Asia	Rice	10%/50%
India	Rice	10%/50%
India	Wheat	10%/50%
Western Europe	Wheat	10%/50%

3 REGIONS & 1 CROP

Regions	Crop	Productivity Decreases
USA China Latin America	Corn	10%/50%
India China Southeast Asia	Rice	10%/50%
India China Western Europe	Wheat	10%/50%

2 REGIONS & 1 CROP

Regions	Crop	Productivity Decreases
China Southeast Asia	Rice	10%/50%
China India	Rice	10%/50%
Southeast Asia India	Rice	10%/50%
China Western Europe	Wheat	10%/50%
India Western Europe	Wheat	10%/50%
China Latin America	Corn	10%/50%
China USA	Corn	10%/50%
Latin America		

TOP 3 REGIONS FOR TWO CROPS

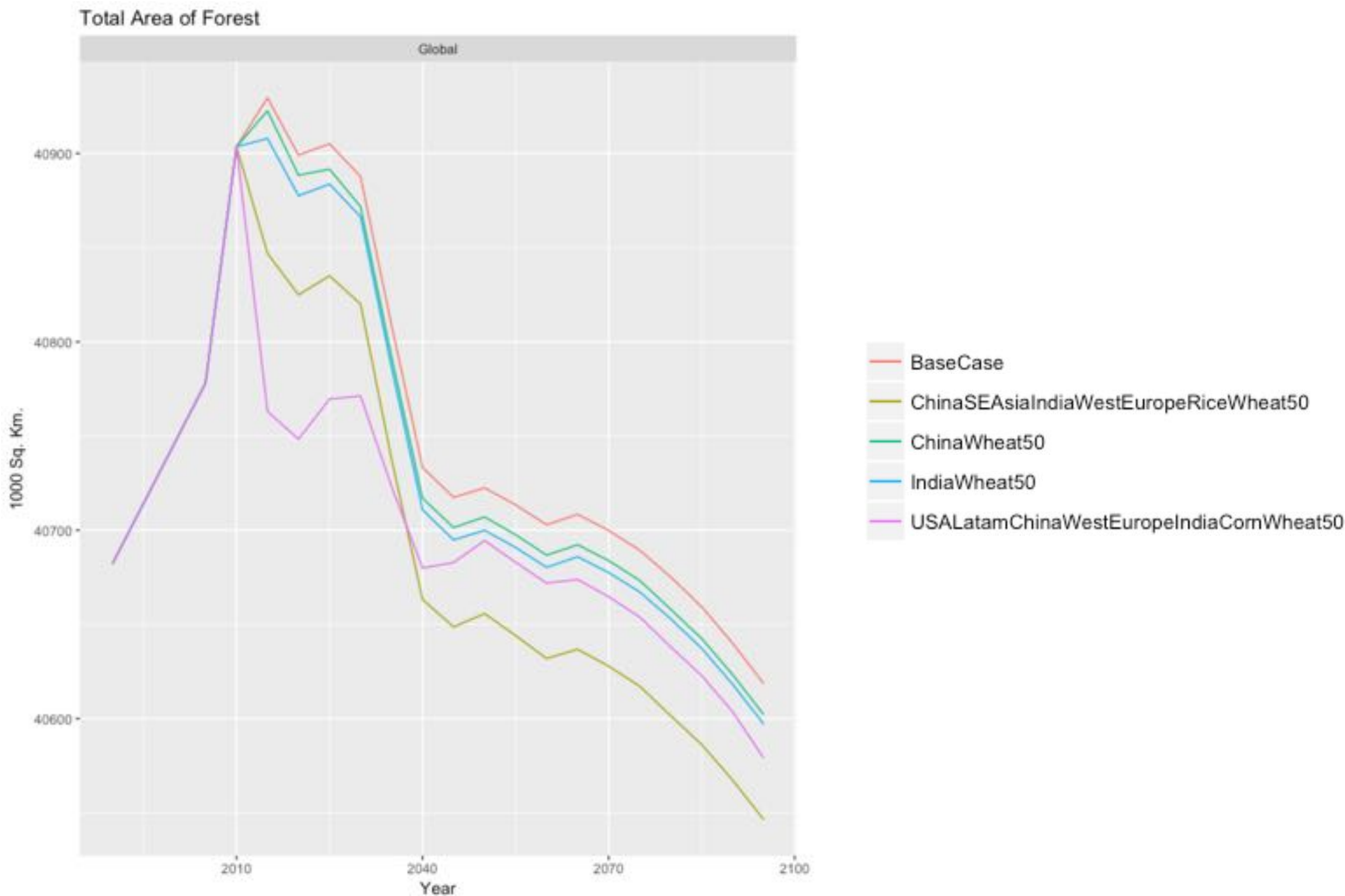
Regions	Crop 1	Crop 2	Productivity Decreases
USA China Latin America India Southeast Asia	Corn	Rice	10%/50%
USA China Latin America Western Europe India	Corn	Wheat	10%/50%
India China Western Europe Southeast Asia	Wheat	Rice	10%/50%

TELECOUPLED SYSTEMS UNDER DIFFERENT SCENARIOS

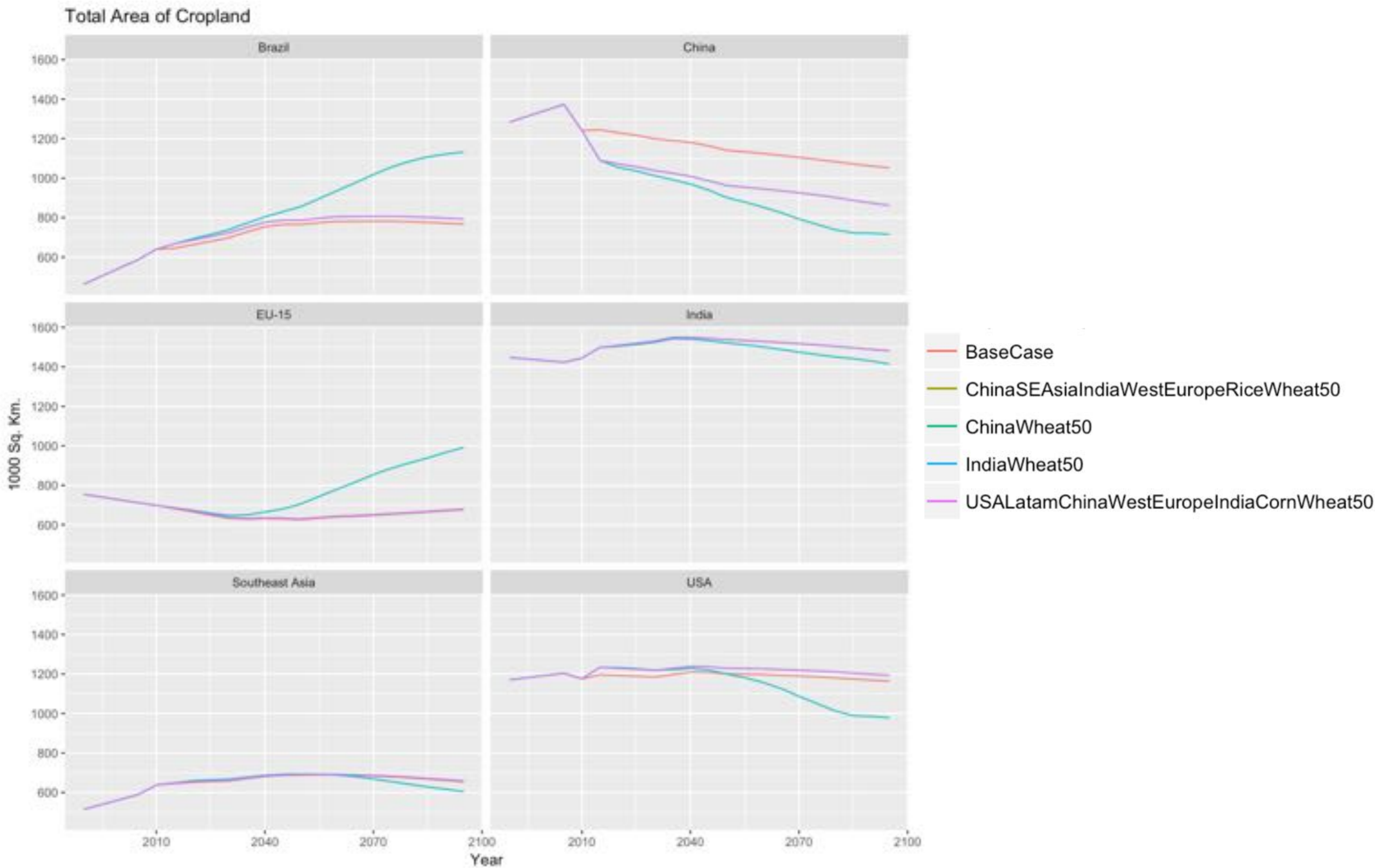
- Reference Case
- RCP 4.5
- Cases with Very Large Shocks
- Cases with Milder Shocks

LARGE SHOCKS

GLOBAL FOREST COVER GIVEN WHEAT FAILURE

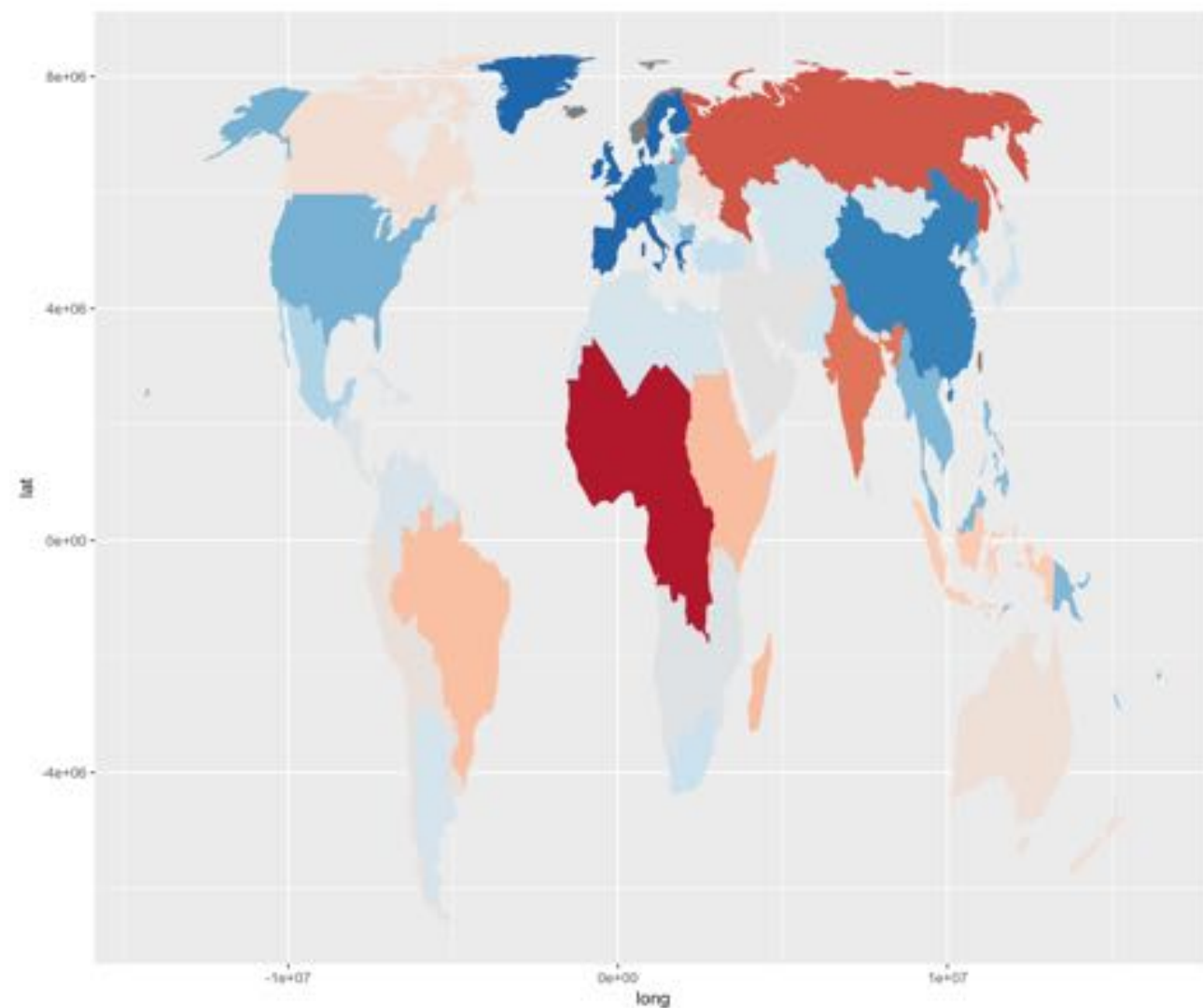


CROP CHANGE BY REGION

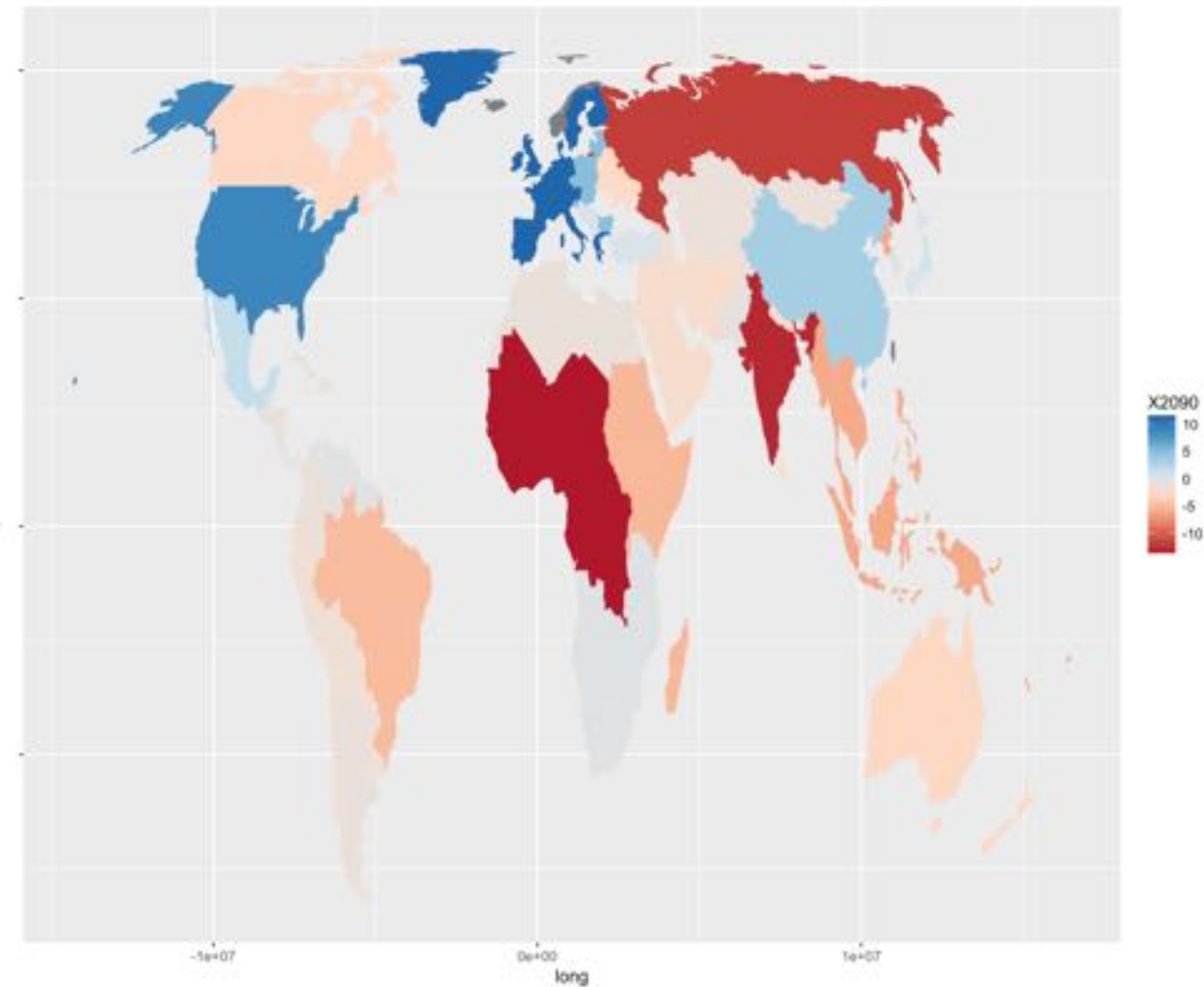


GROSS LAND CHANGE EMISSIONS IN MTC/YR

*China, SE Asia, India, West Europe:
Rice & Wheat*

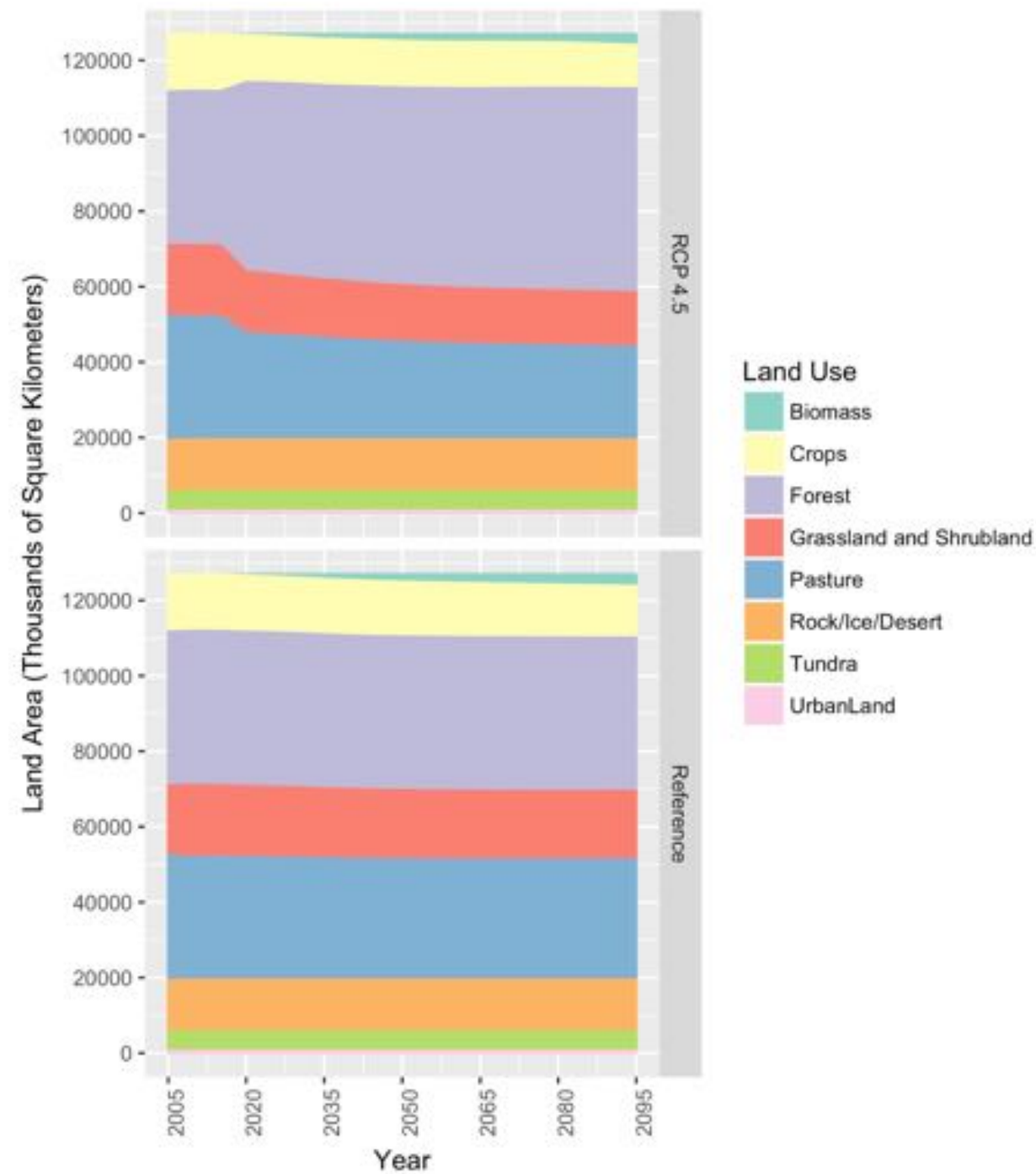


*China, West Europe:
Wheat*

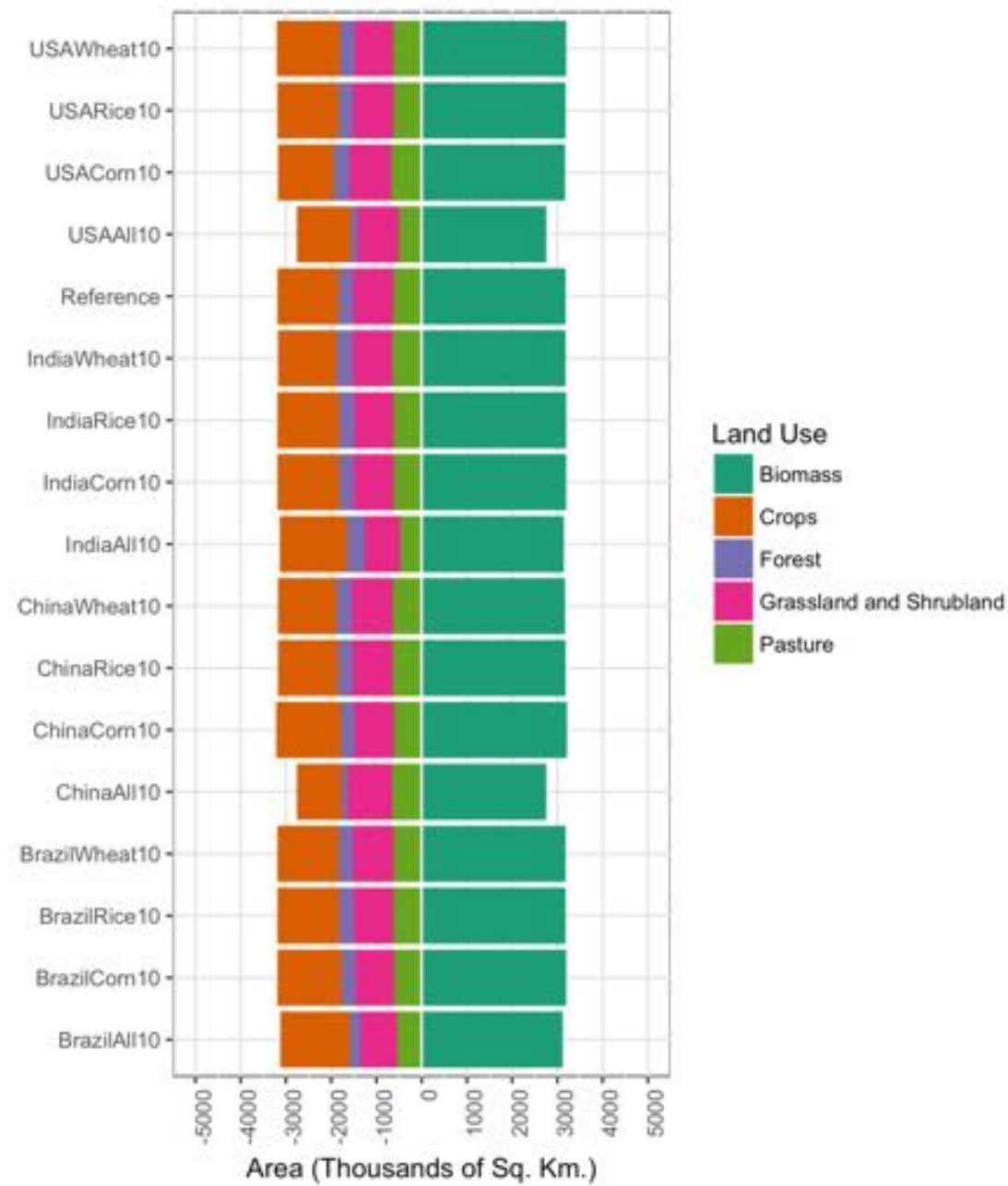


MODEST SHOCKS

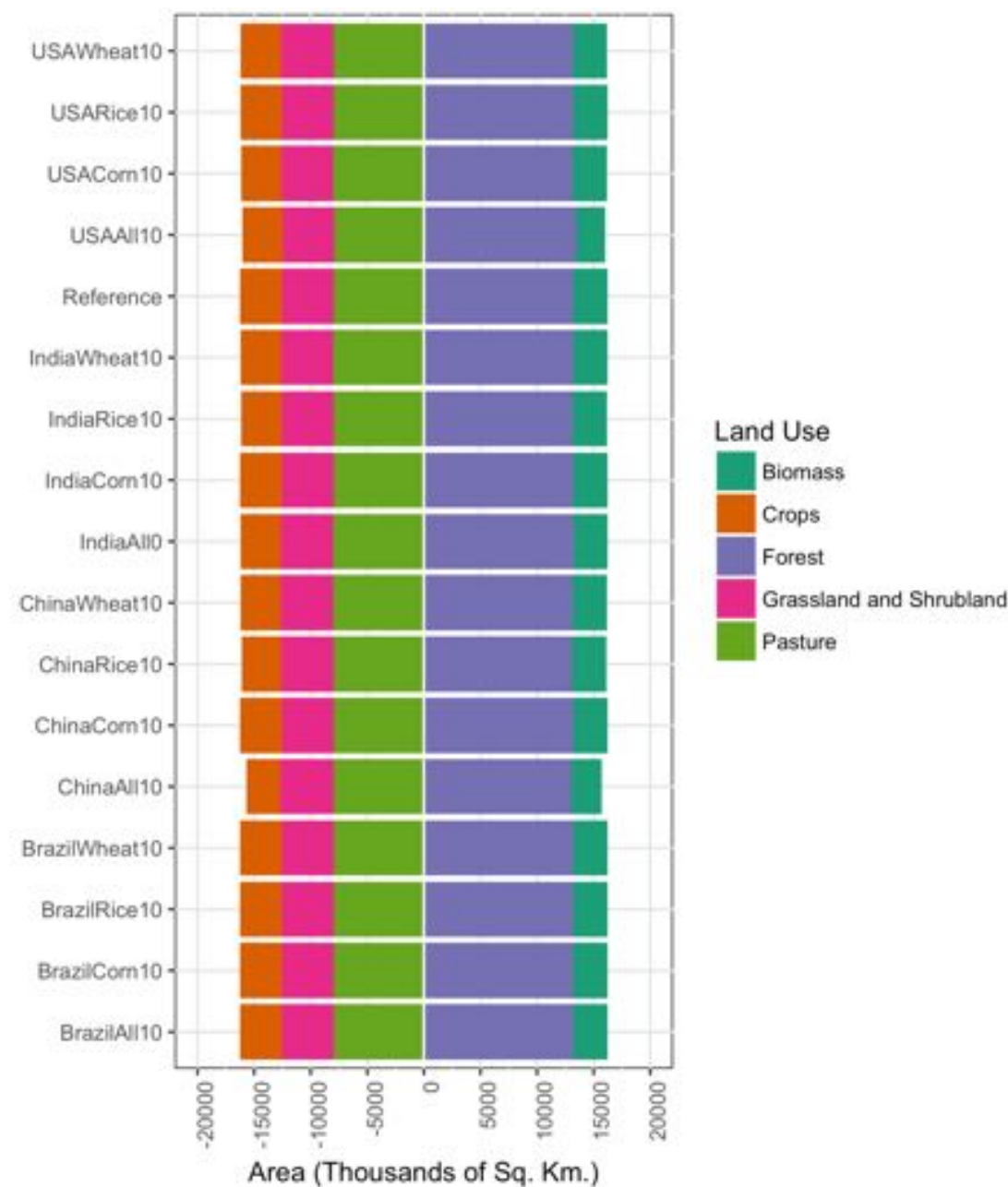
REFERENCE AND RCP 4.5: GLOBAL LAND USE



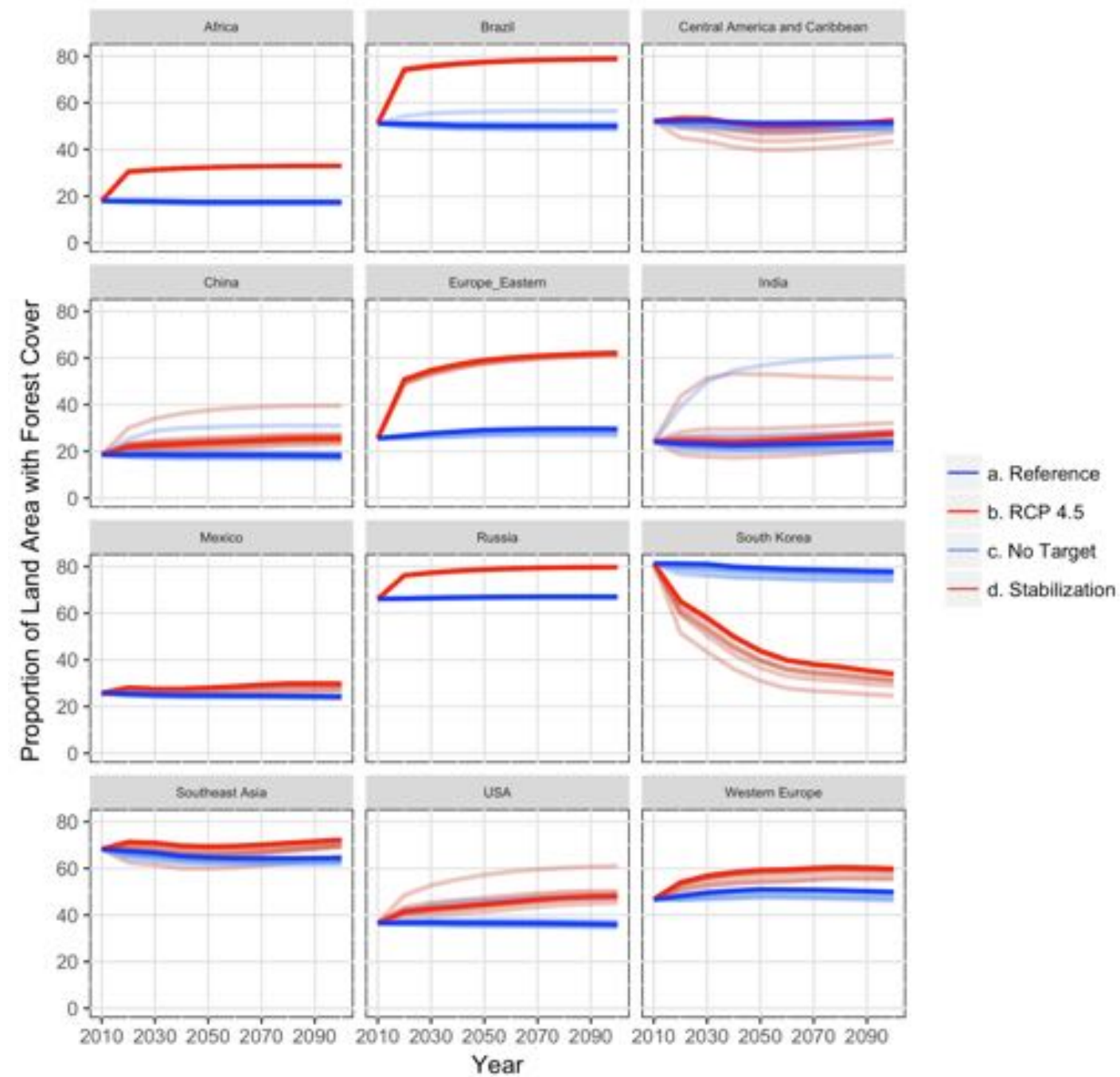
NO-TARGET SCENARIOS: GLOBAL LAND USE



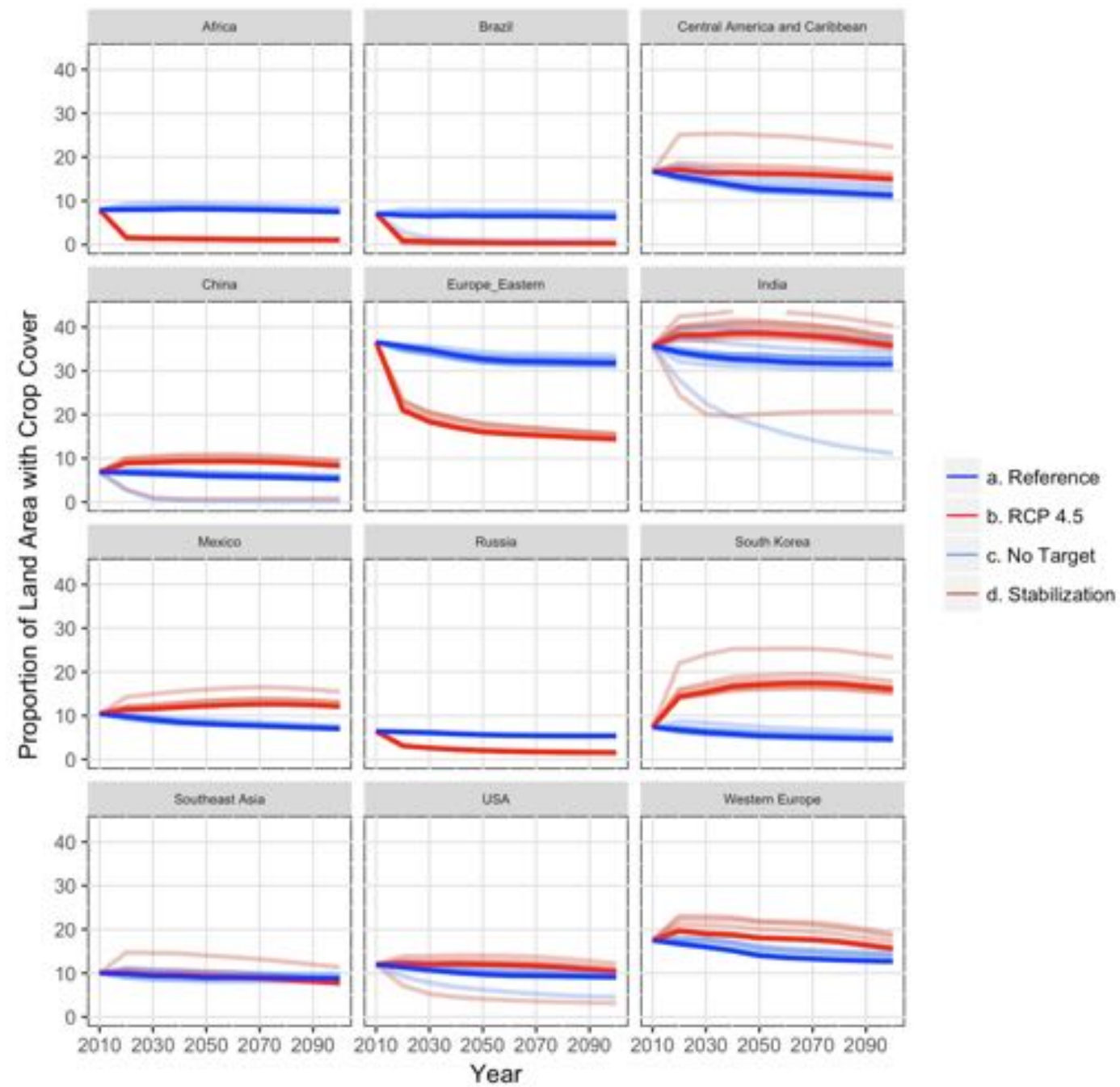
GAINS AND LOSSES IN GLOBAL LAND-USE FOR STABILIZATION SCENARIOS



REGIONAL CHANGES IN FOREST AREA



REGIONAL CHANGES IN CROP AREA





RESULTS

- ▶ Larger shocks have greater impacts on land change and emissions.
- ▶ The response of the shock is dependent upon the the crop, which affects the suitable areas for re-allocation.
- ▶ Emissions are largely a consequence of how much forest has been reallocated to agriculture.
- ▶ Stabilization vs non-stabilization does seem to make a difference, as one might expect, and it grows over time in the simulations.
- ▶ Stabilization effects overwhelm the land use responses due to “minor” shocks to production


DIRECTIONS: NETWORK ANALYSIS AND TELECOUPLING

- ▶ We are drawing from network analysis of global trade
- ▶ Analyzing networks of influence on land use change and carbon emissions
- ▶ Identifying areas where shocks will have greatest effects on global land use
- ▶ Identifying the telecoupled relationships among different systems and under different conditions
- ▶ Reveal asymmetries of “couplings”
- ▶ Characterizing how model structure captures (or fails to capture) telecouplings

DIRECTIONS: EVALUATING RISK

- ▶ Assess the potential impacts of multiple breadbasket failure as they ripple through both food and energy systems.
- ▶ Evaluate the likelihood of occurrence of such events.
- ▶ Quantify the risks associated with the failure of multiple breadbaskets.
- ▶ Explore the scientific foundation of potential interventions and solutions to ameliorate the risk.



 The Frederick S. Pardee Center
for the Study of the Longer-Range Future
@BUPardeeCenter www.bu.edu/pardee



ajanetos@bu.edu
jpcc@tamu.edu