Land Use in the iPETS Integrated Assessment Model: Progress Report

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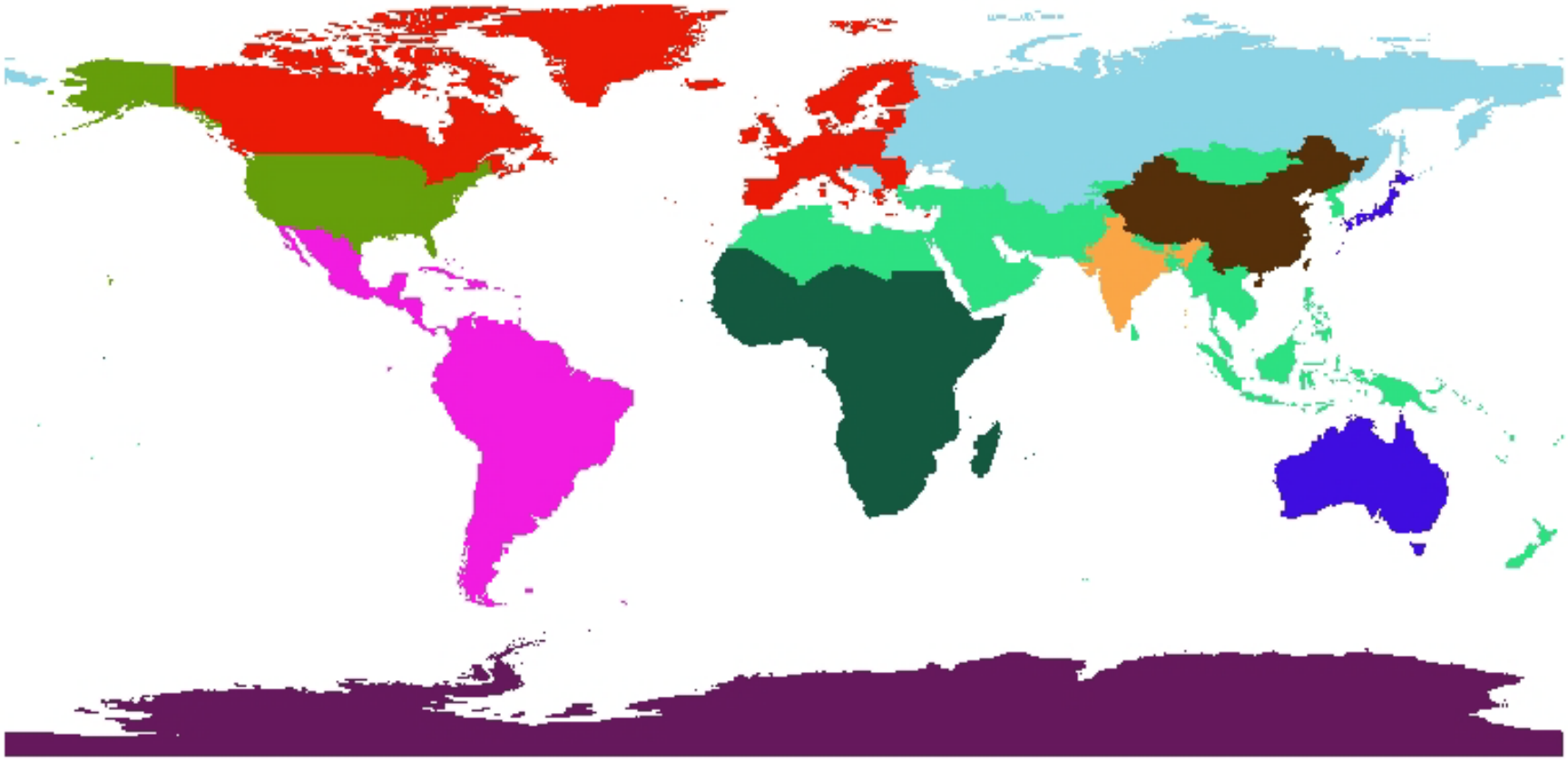
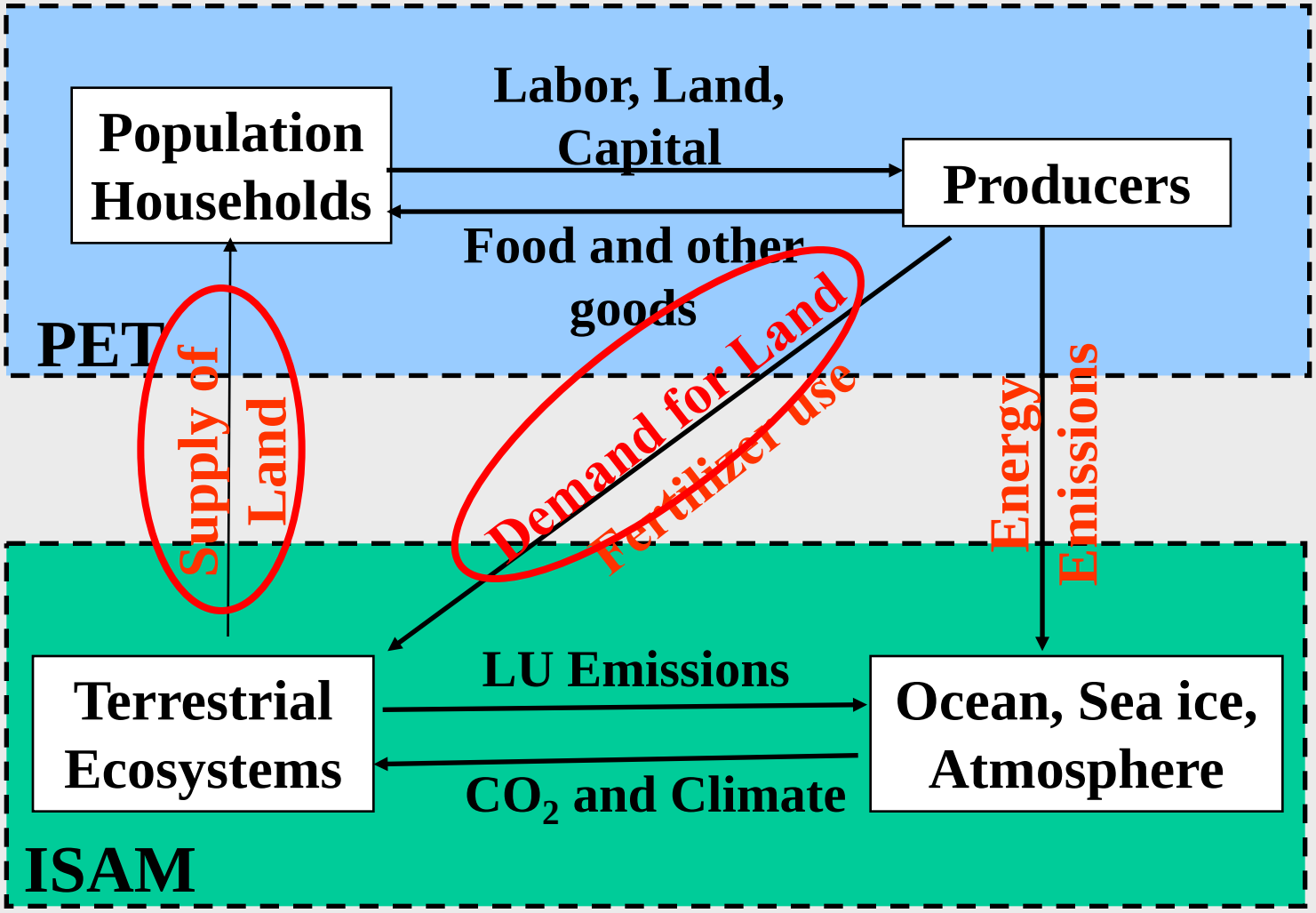
iPETS: 9-Region CGE Model, with Trade



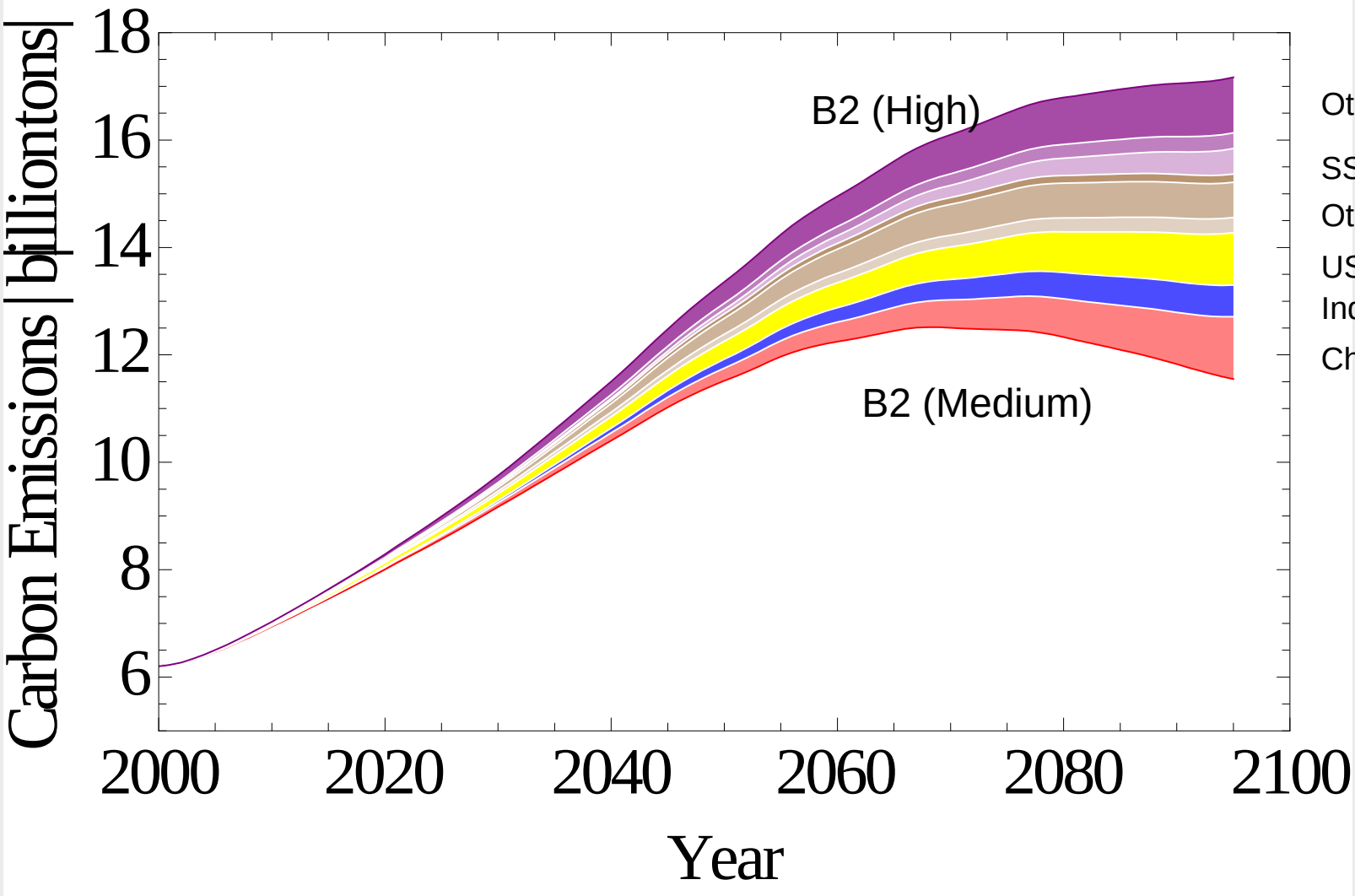
iPETS: Global, regionally disaggregated IA Model

(Integrated Population-Economy-Technology-Science Model)



Collaborators: O'Neill (NCAR); Dalton (NOAA); Jain (U. Illinois); Jiang (PAI); Fuchs/Gmeiner/Pachauri/Zigova (IIASA)

Global CO2 Emissions Scenarios (Energy Only)



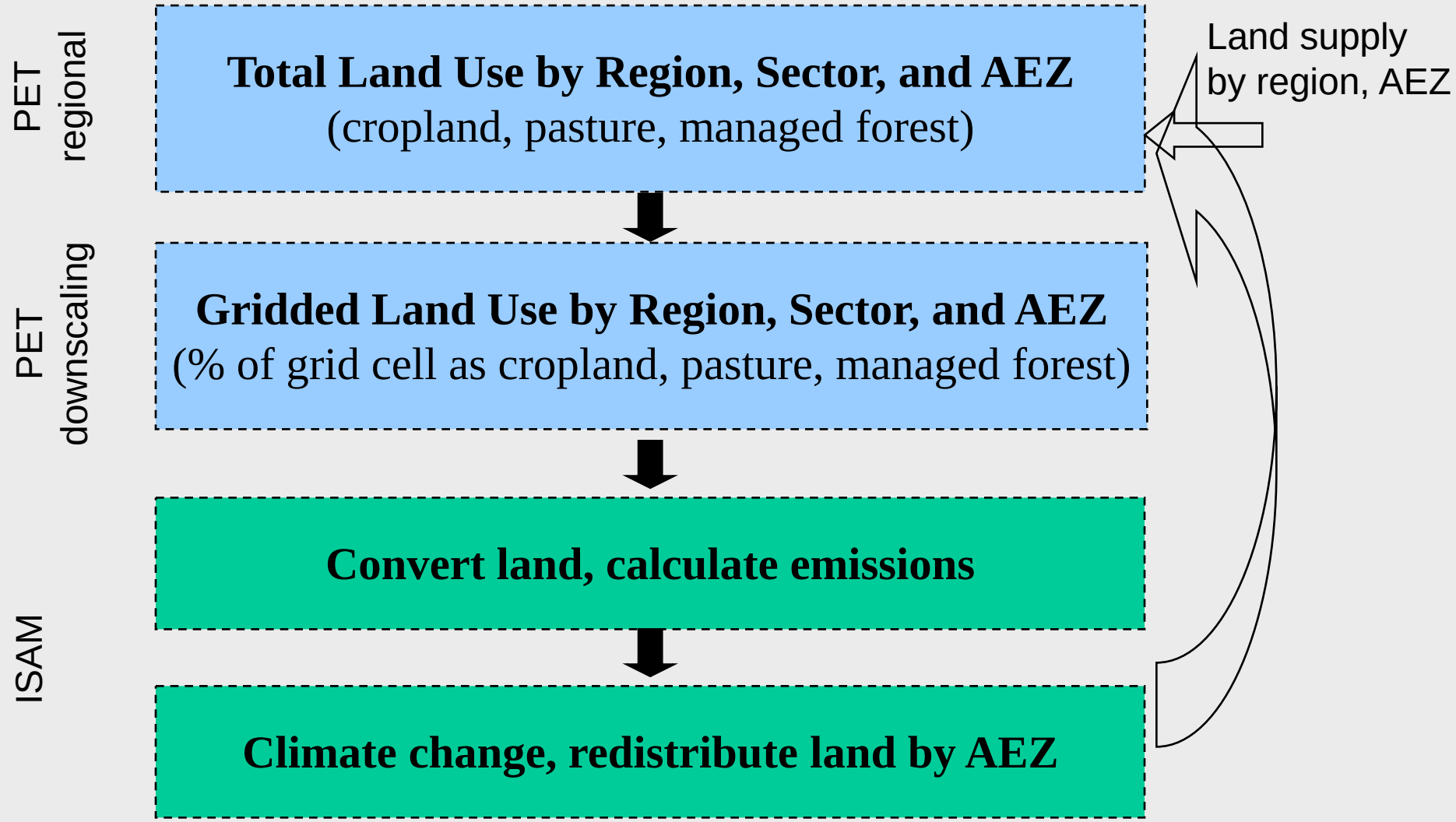
Sector Disaggregation in iPETS

Agriculture	**Crops**	→	**Cropland**
	Animal products	→	**Pasture**
	Forestry	→	**Mngd. Forest**
Energy	**Coal**		
	Oil		
	Gas		
	Electricity		
	Petroleum products		
Other	**Manufacturing**		
	Services		

Data for base year: GTAP 6.0

$ of input/output by industry
Hectares of land by industry

Land Use Modeling Framework

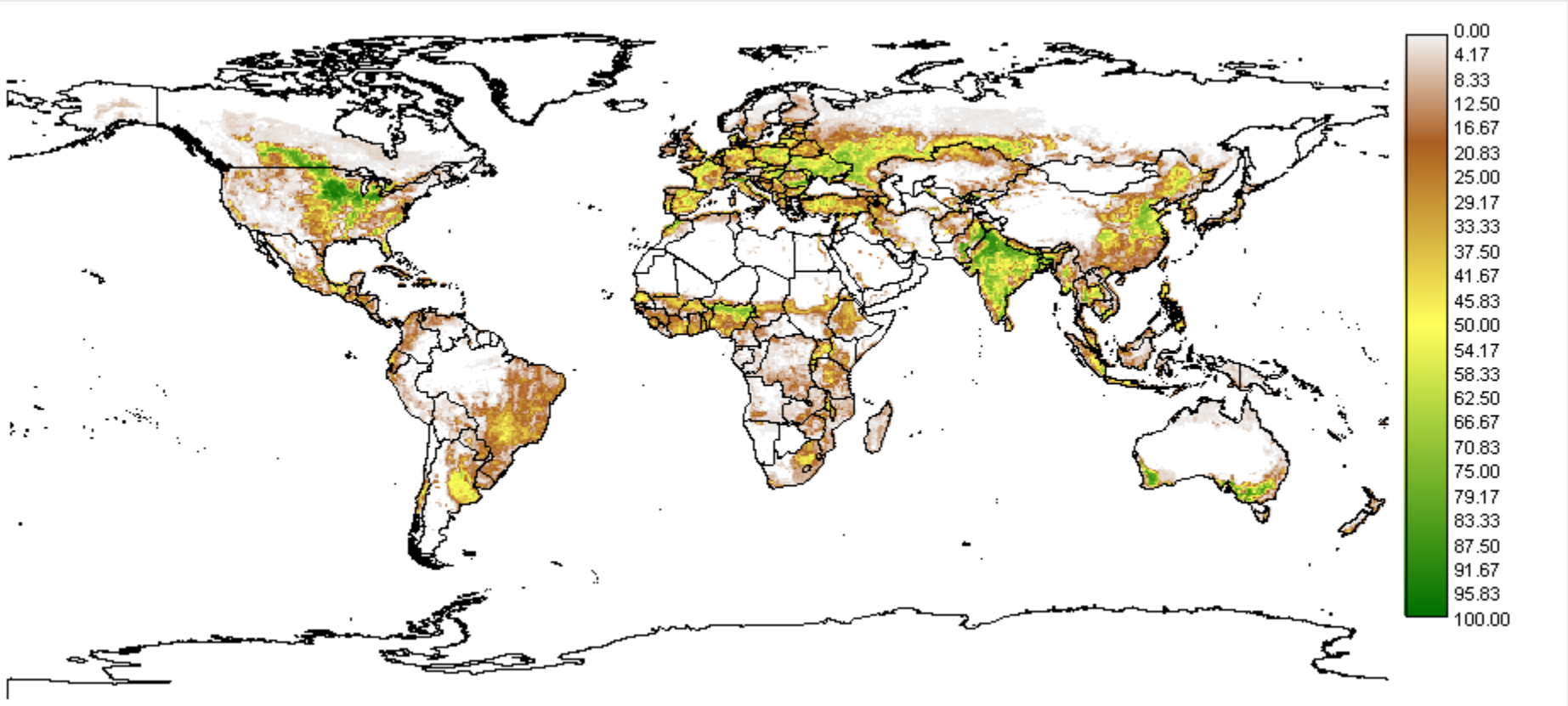


Agro-Ecological Zones (AEZ)

- **AEZ defined primarily by Length of Growing Period (LGP)**
- **LGP = number of days annually with temperatures above 5°C when moisture conditions are considered adequate**
- **LGP a function of**
  - Climate conditions (temperature, precipitation)
  - Soil conditions and properties
  - Ecosystem processes

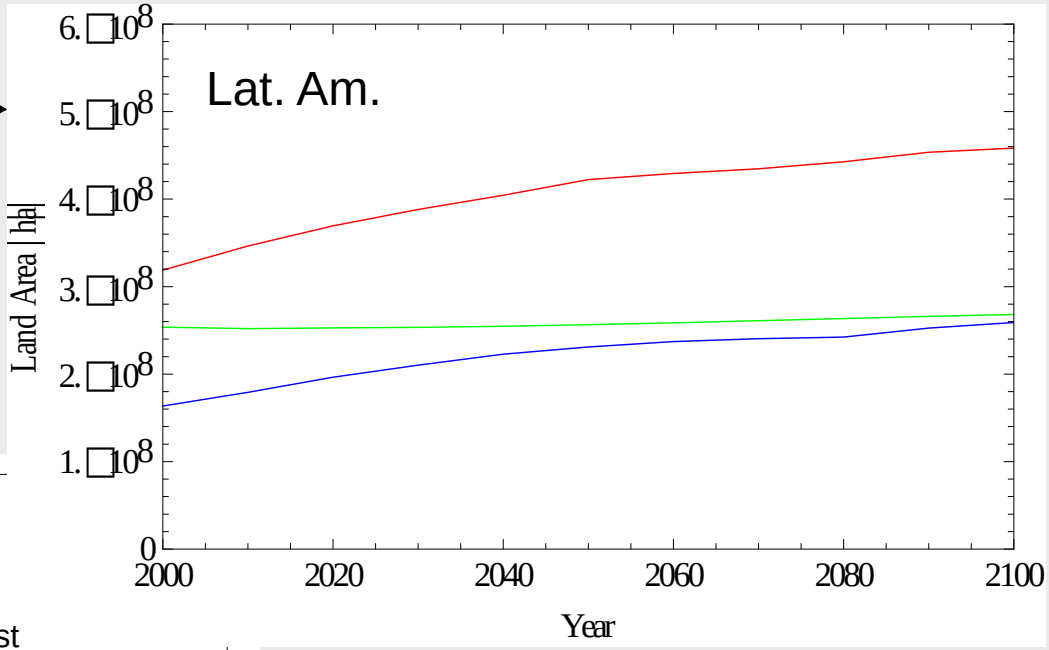
Land Use Modeling

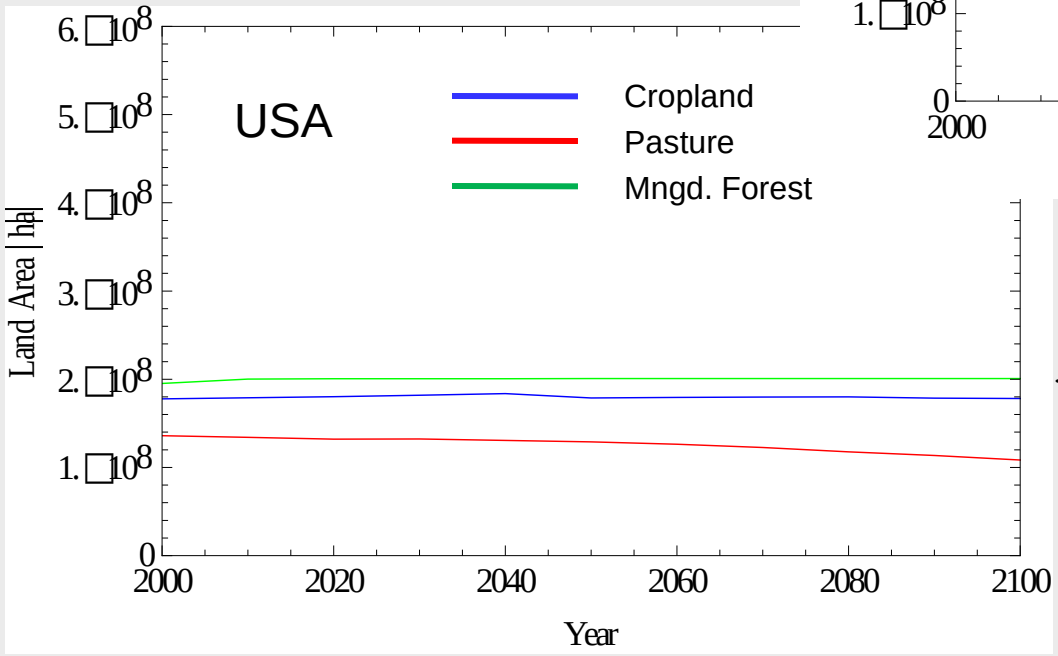
Percent of grid cell in crop production, A2r scenario
IIASA model



Total Land Use by Region, Sector (IIASA A2r, RCP8.5)

Only Latin America & Sub-Saharan Africa experience significant aggregate change





Most regions experience relatively little aggregate change

iPETS downscaling model: Three principles

1. Satisfy demand at regional level
2. Maximize revenues at the grid cell level
3. Economic tradeoffs between different uses of land within each grid cell are efficient, and are informed by current land use data

Grid cell-level land use decisions

Within each grid cell (k) in a given region:

$$\underset{S_i}{Max}\, R_k = \sum_{i=1}^{I} P_i^S S_{ik} \quad \text{s.t.} \quad H(S_{1k},...,S_{Ik}) = 0$$

maximize revenues by choosing land (S) for three different sectors (i)

stay on the Production Possibility Frontier (PPF)

Across all grid cells in a given region:

$$\sum_{k \in AEZ(j)} S_{ik}^{*}(P_i^{*S}) = s_{ij}(P_i^y, P_j^S, y_i) \quad \forall\, i, AEZ(j)$$

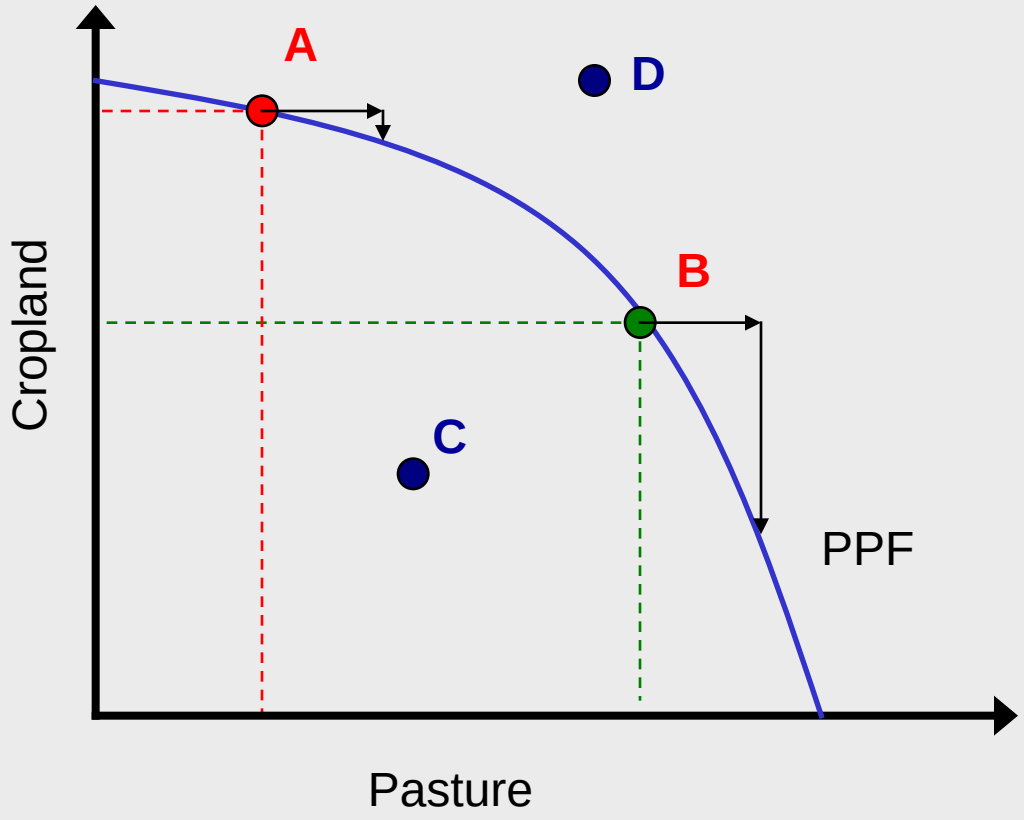
sum of land used in each sector across all cells

=

total land used in each sector at regional level

Production Possibility Frontiers (PPFs)

Economically efficient combinations of production of animal products (using pasture) and crops (using cropland).

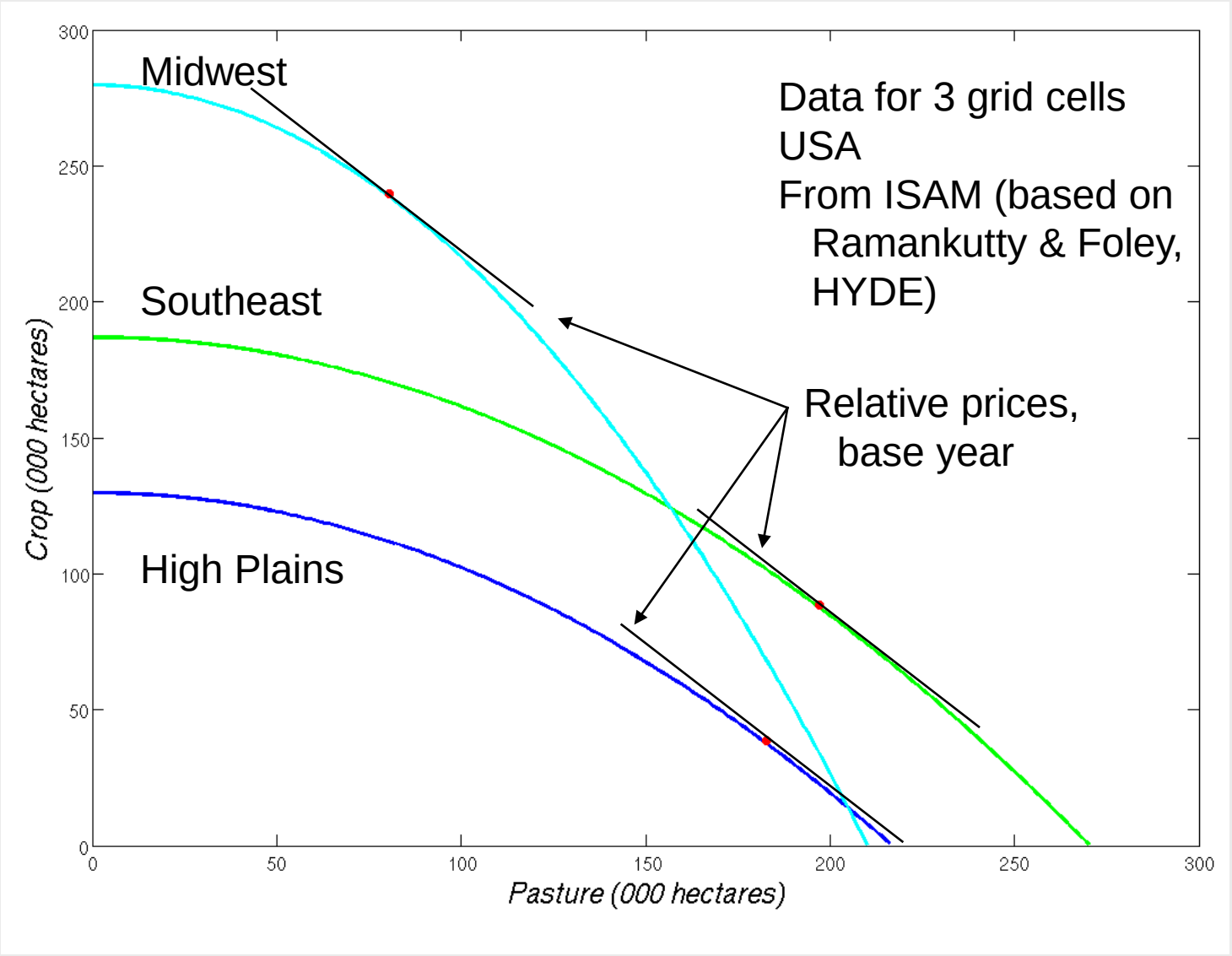


A and B efficient
C inefficient
D not achievable

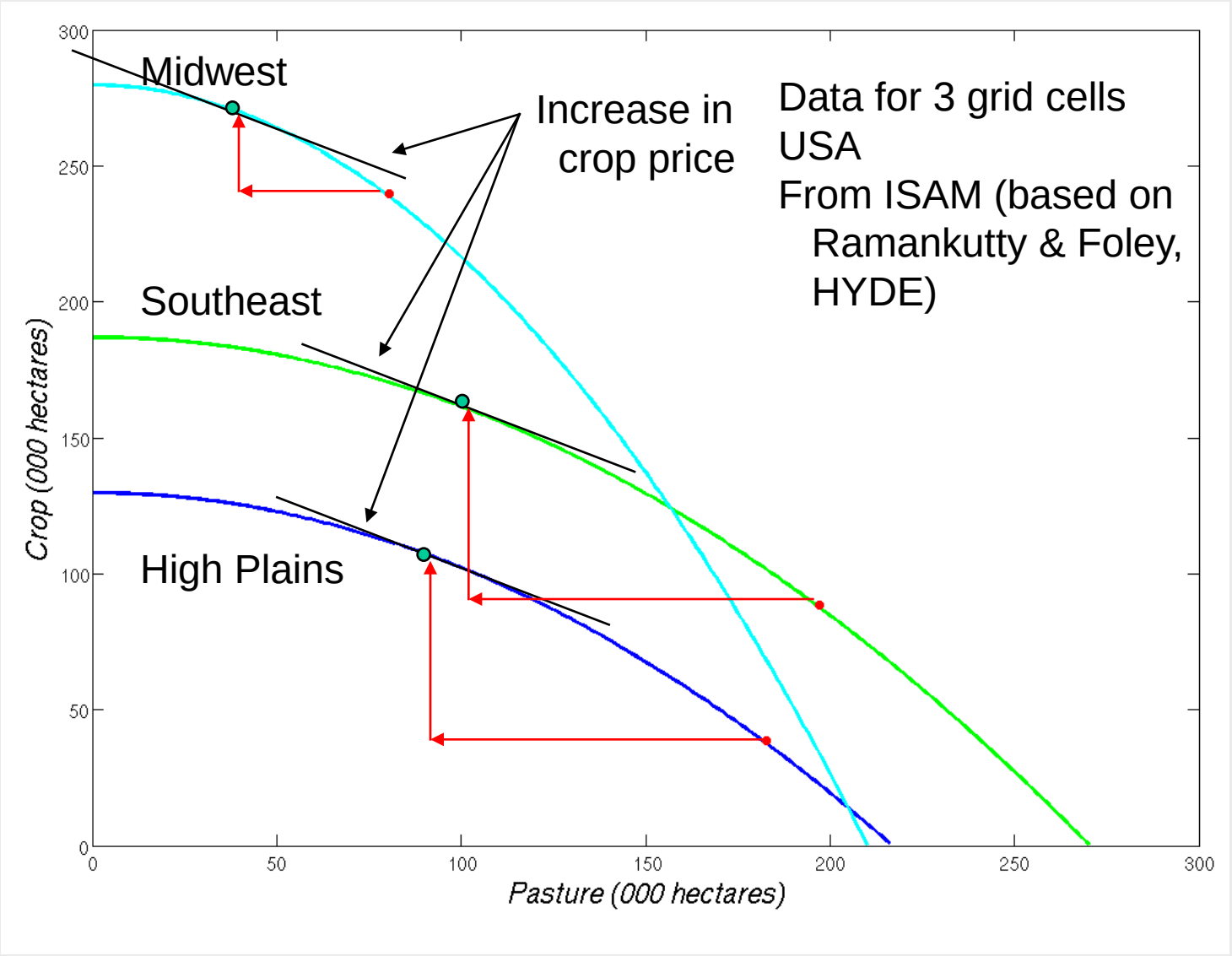
Concavity implies increasing opportunity cost of production

Optimal point depends on relative prices

PPFs calibrated to gridded land use data



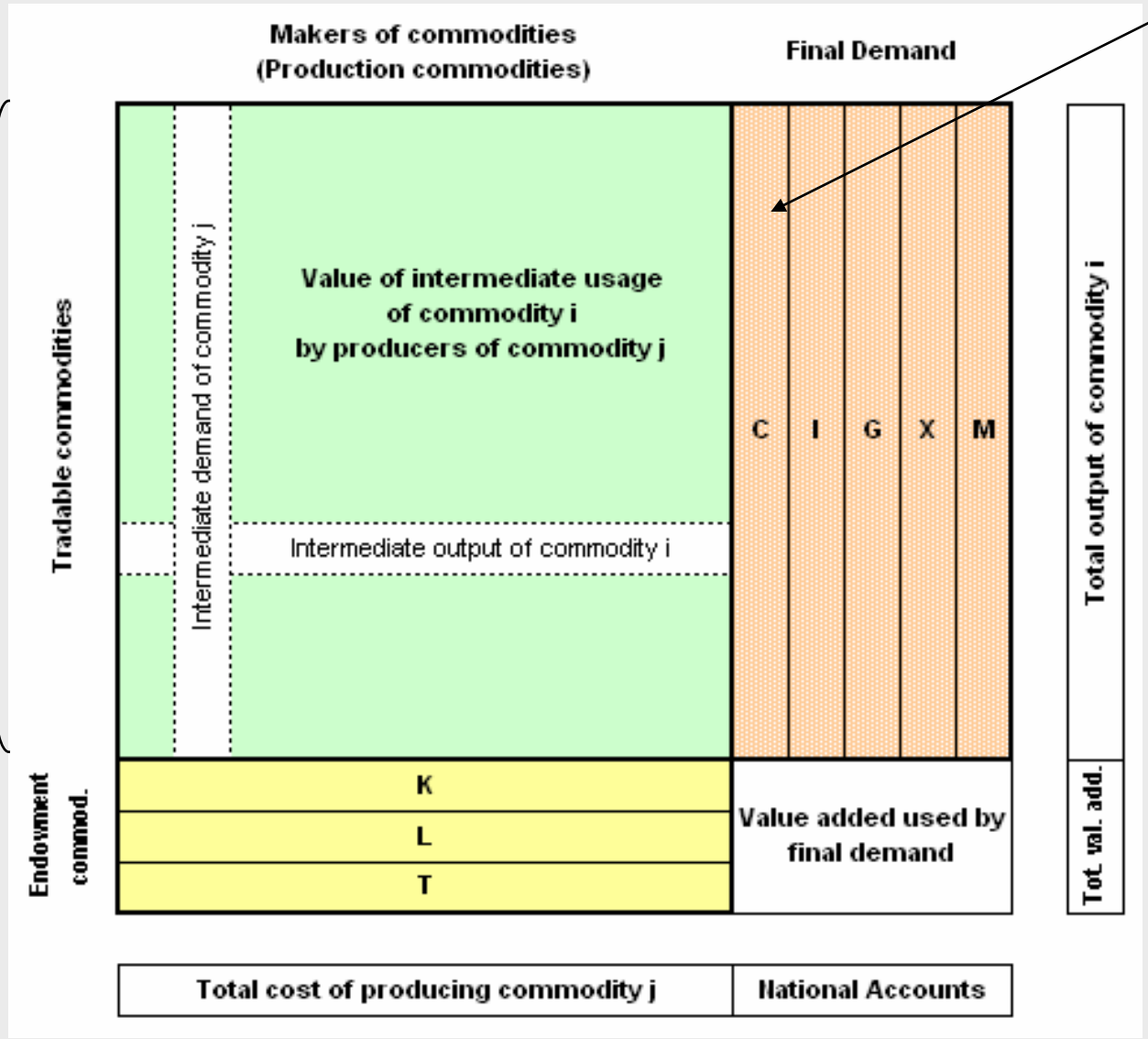
PPFs calibrated to gridded land use data



Next Steps

- Test downscaling model for one region
  - using historical gridded land use data
  - using IIASA regional land use scenario
- Issues:
  - calibrating to cells with zero(s) for current land use
  - representing changing technology (moving PPFs)
- Production of global results
- Link to iPETS
- CLM?

Production data: IO Tables



PET Features: A Few Details

- **Economic growth and technological change**
  - **KLEM production structure can incorporate different patterns of technical change across industries and regions**

$$F\left(a_K(t)\,K, a_L(t)\,L, a_E(t)\,E, a_M(t)\,M\right)$$

- **Solving the model**
  - **Forward looking (perfect foresight)**
  - **Households maximize utility (Stone-Geary)**
  - **Producers maximize profits (nested CES production)**
  - **Market clearing condition**