Modeling Carbon Emissions from Land Use Change

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Presentation Overview

- Why model agriculture and land use?
- AgLU model overview
- Land use and demand for food
- Scenarios of land use change
- Model development

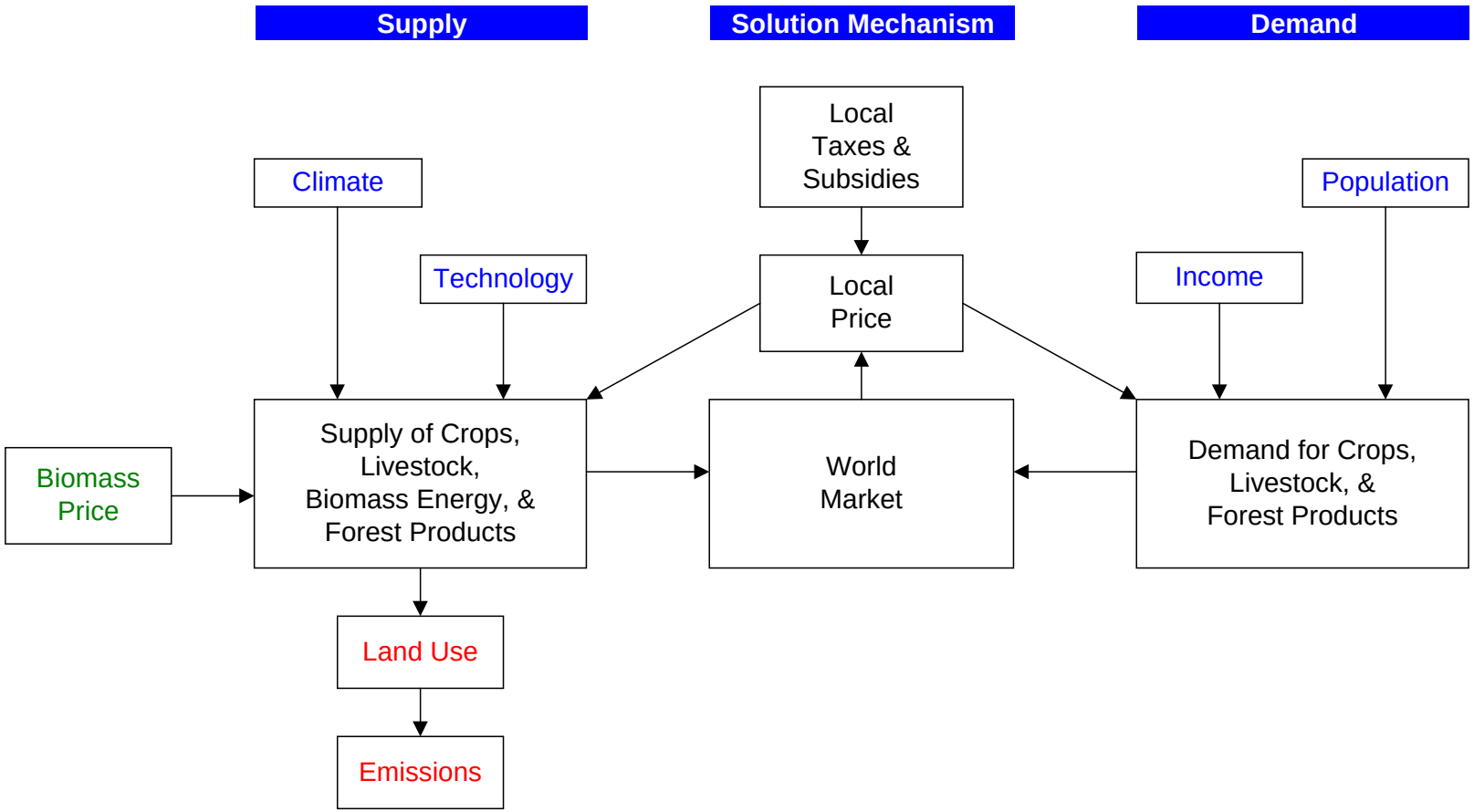
Why Model Agriculture?

- Carbon emissions from energy consumption are not the whole story.
  - Carbon emissions from land-use change
  - Carbon mitigation using biomass fuels
  - CH_4 and N_2O emissions from agriculture
- Impact of climate change on agricultural productivity

AgLU Regions

- Annex I
  - USA and Canada (NAM)
  - Western Europe (WEU)
  - Eastern Europe (EEU)
  - Former Soviet Union (FSU)
  - Japan, Australia, New Zealand (PAO)
- Non-Annex I
  - Latin America (LAM)
  - Middle East (MEA)
  - Africa (AFR)
  - China and Centrally-Planned Asia (CPA)
  - South Asia (SAS)
  - Other Pacific Asia (PAS)

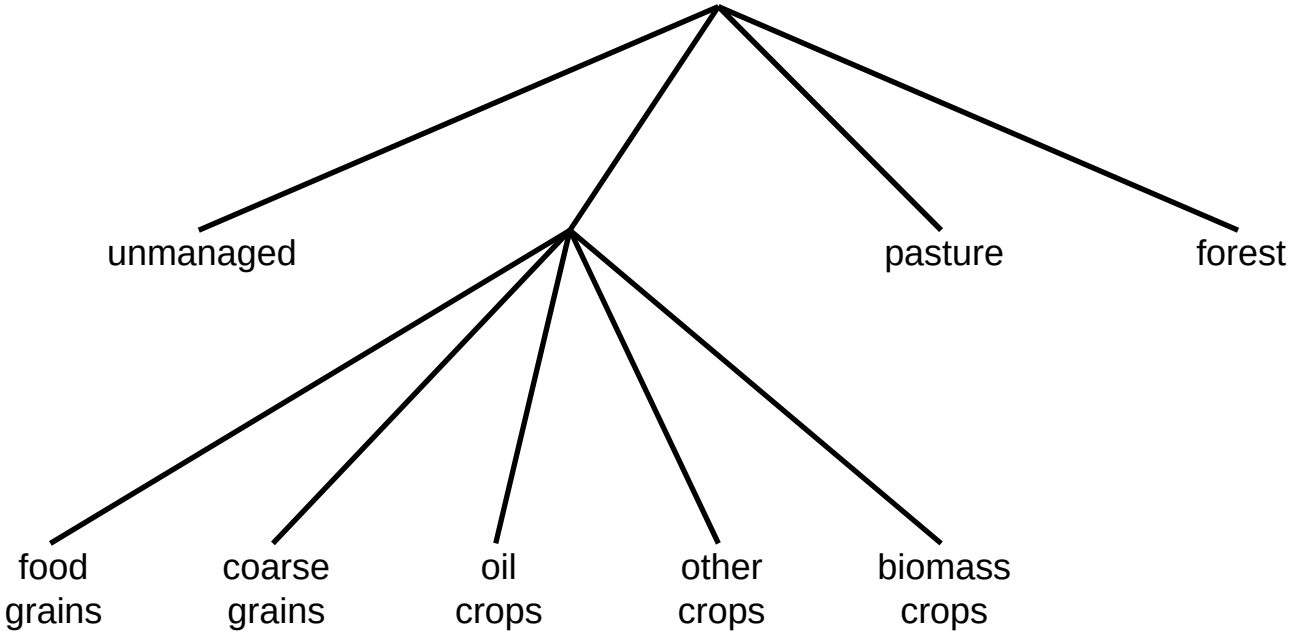
AgLU Model Structure



Methodology Highlights

- Forest Dynamics
  - Trees in AgLU grow for 45 years
  - Two forest markets (current and future) needed for model stability
- Land Allocation
  - Land owners compare economic returns across crops, biomass, pasture, and future trees
  - Underlying probability distribution of yields per hectare

Land Allocation



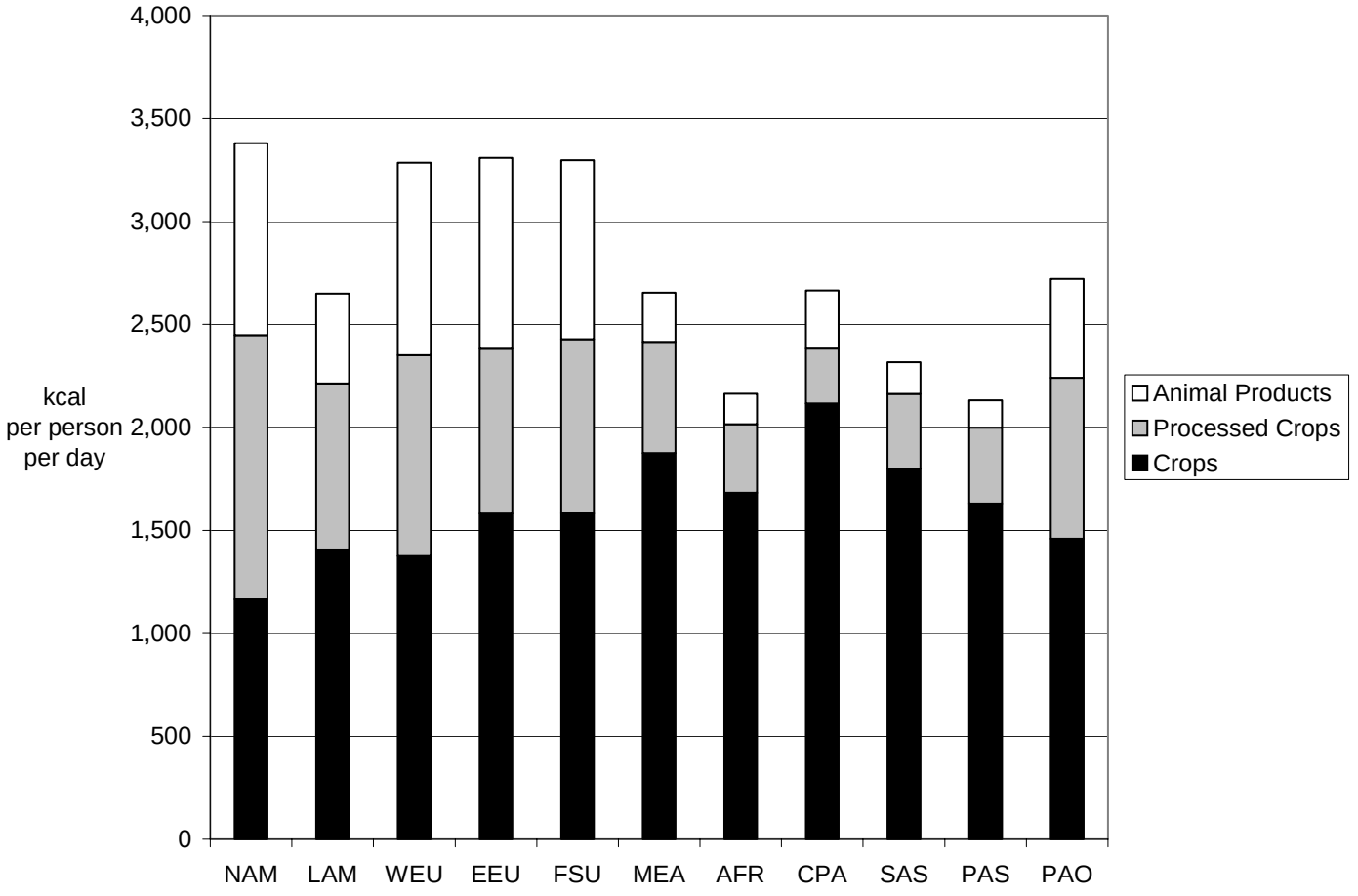
Demand for Food

- Crops
  - Rice, Wheat, Coarse Grains
  - Starchy Roots, Fruits, Vegetables, Pulses
- Processed Crops
  - Vegetable Oils
  - Sweeteners
  - Alcoholic Beverages
- Animal Products
  - Beef, Pork, Poultry
  - Milk, Butter, Eggs

Global Food Balance (kcal per person per day)

	Activity			Final Demand			
	Crops	Processed Crops	Animal Products	Food	Other Uses	Stock Change	Total Production
Crops	344	748	1,041	1,726	51	49	3,959
Processed Crops	0	0	2	532	80	-4	609
Animal Products	0	0	37	382	38	0	457

1990 Food Consumption



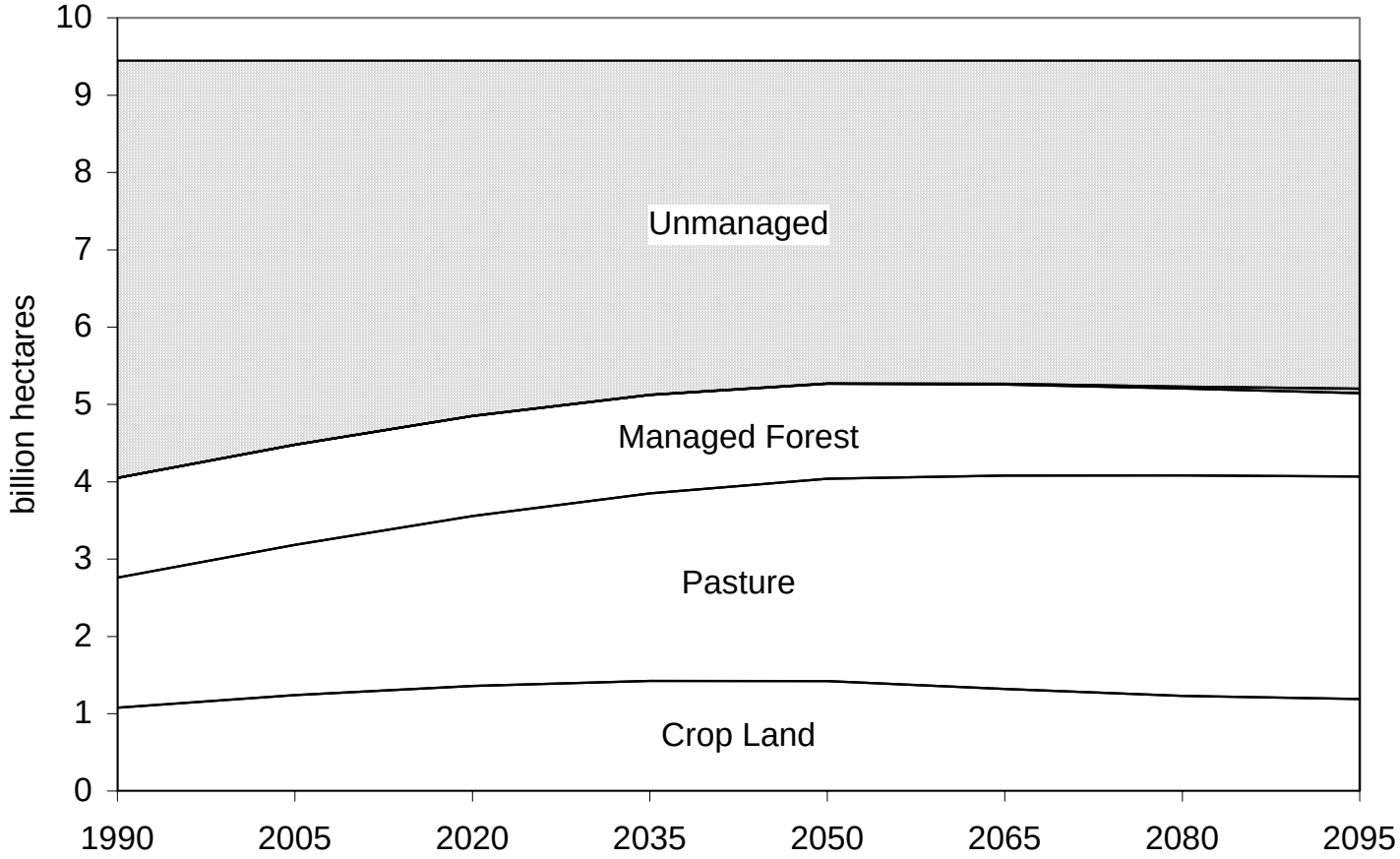
Demand for Food

$$X_{ijt} = A_{ij} P_{ijt}^{\alpha_{ij}} Y_{ijt}^{\beta_{ij}} N_{jt} C_{ijt}$$

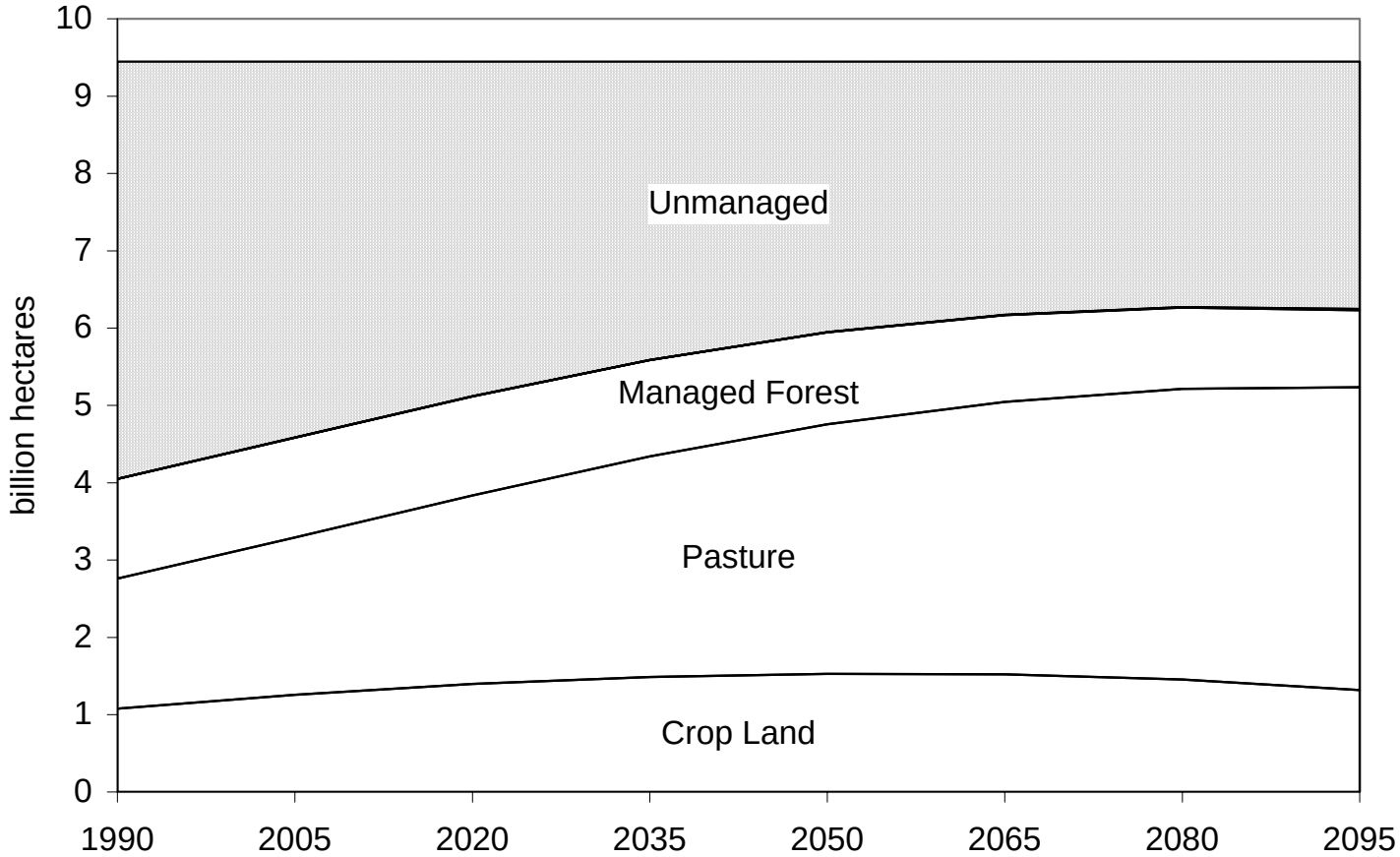
i = crops, processed crops, animal products
j is a region index
t is time

X is quantity demanded
A is a constant to calibrate the price and income feedback terms
P is price
Y is per-capita income
N is total population by region
C is calories consumed per person per day in base year

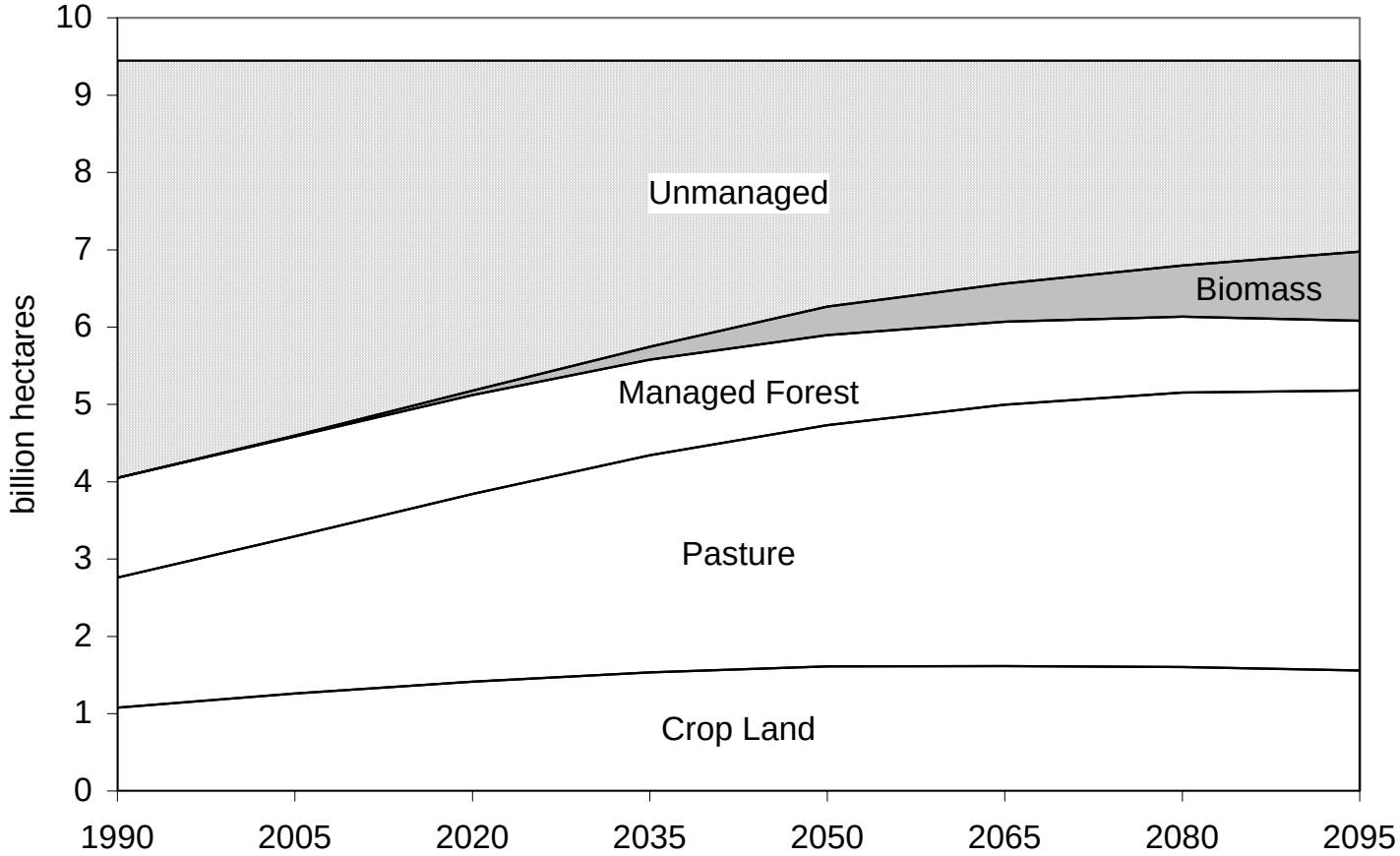
Land Use (reference case)



Land Use (increased animal products)



Land Use (+ animal products, C policy)



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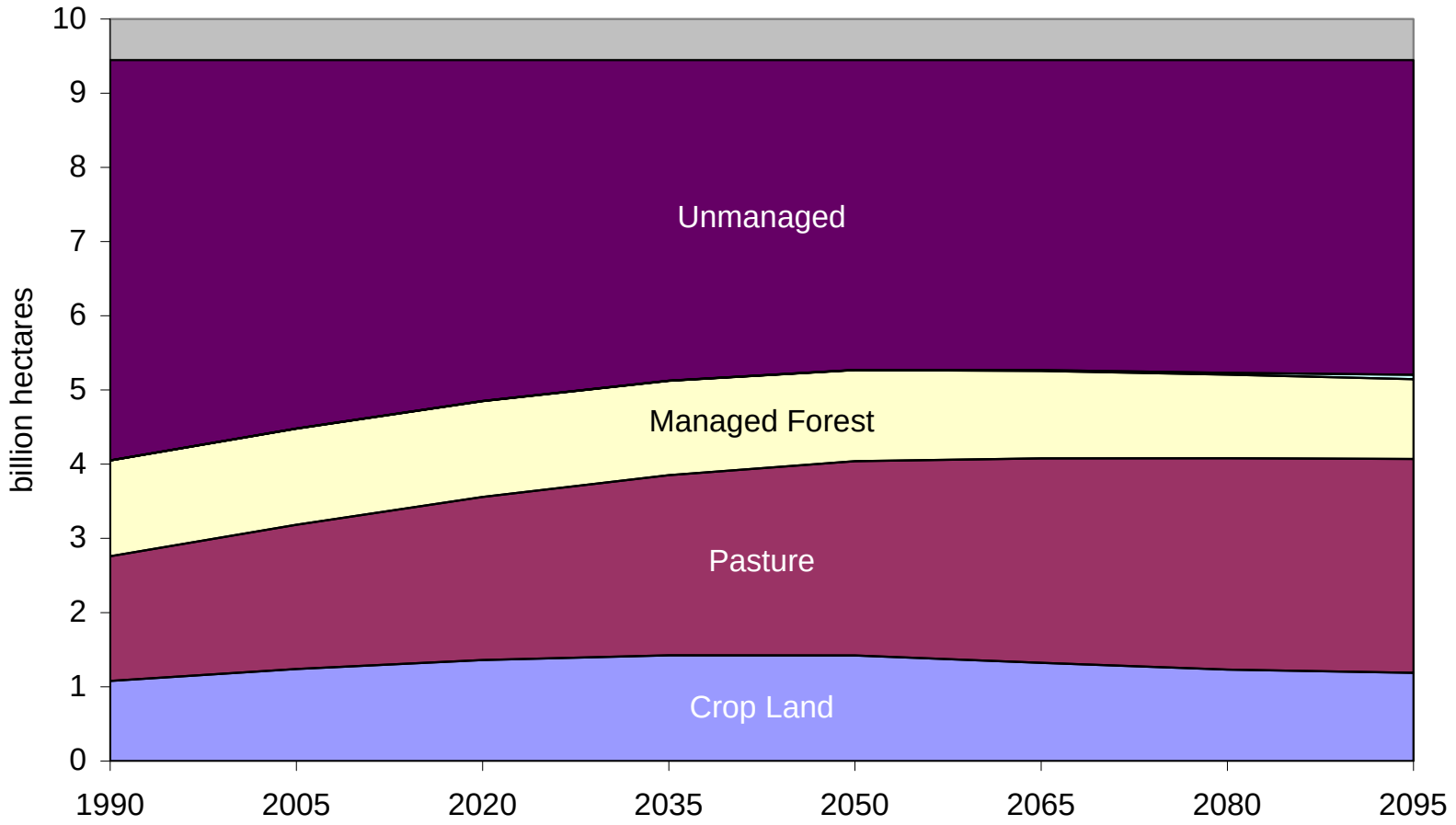

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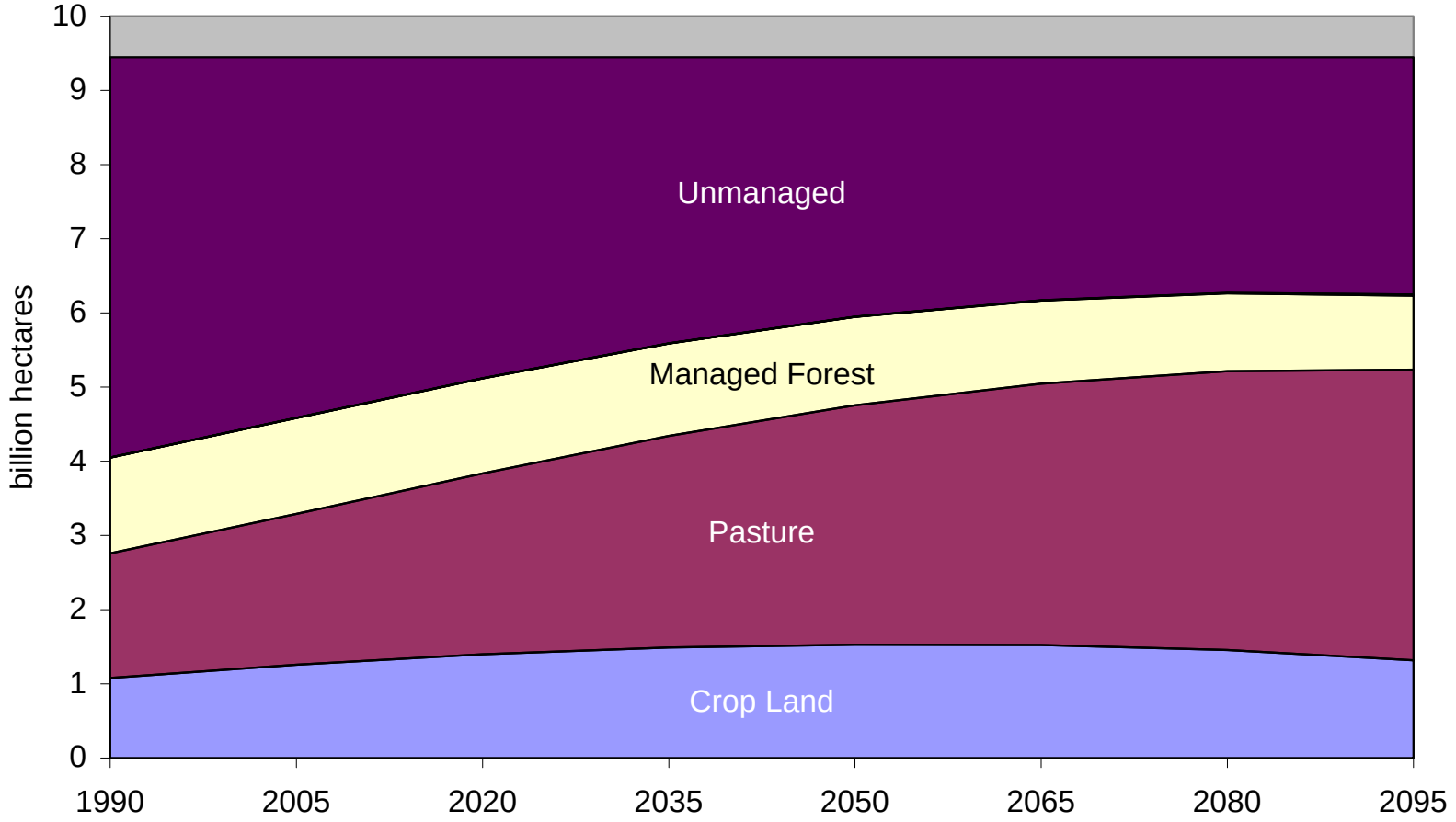

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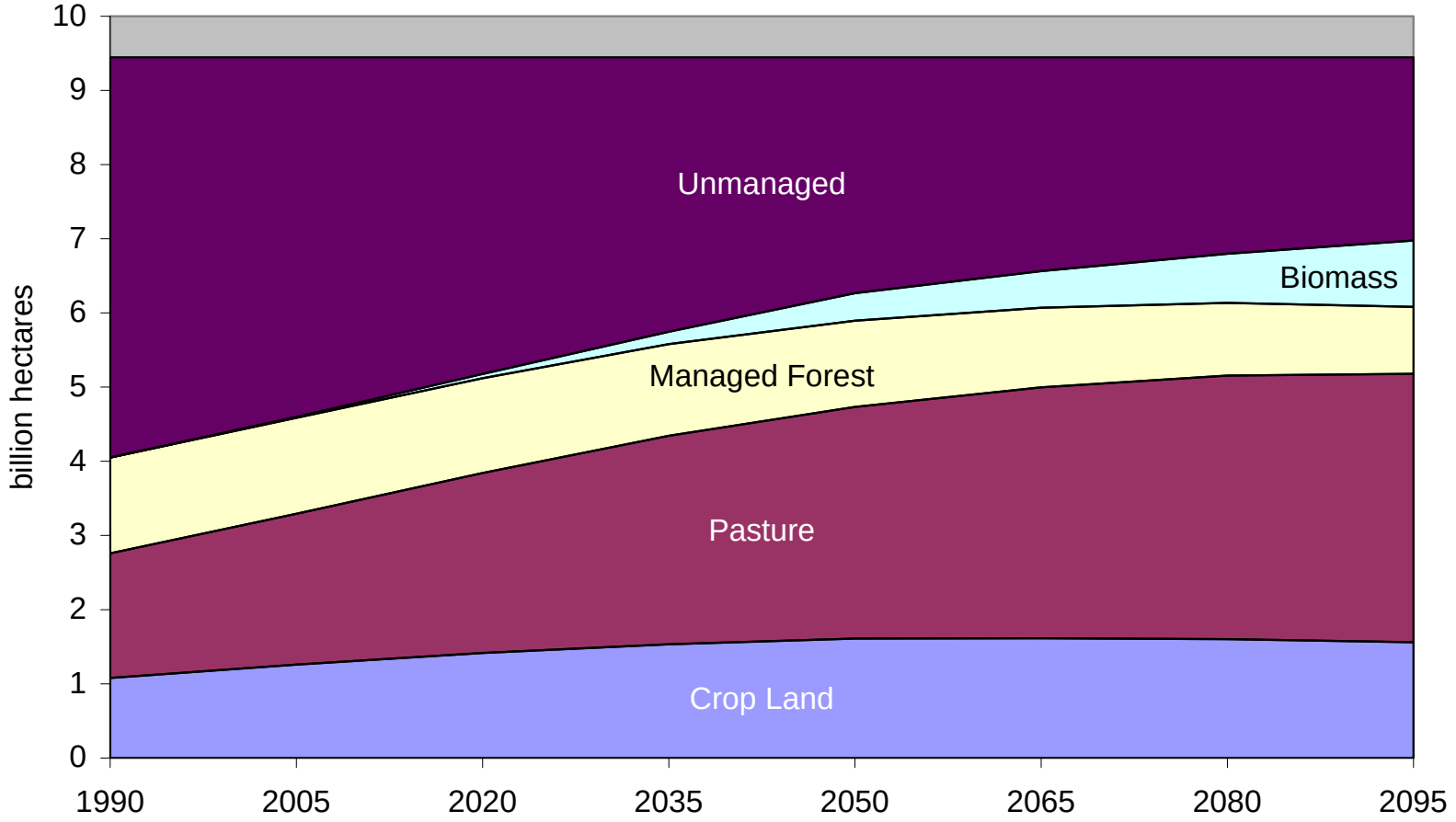
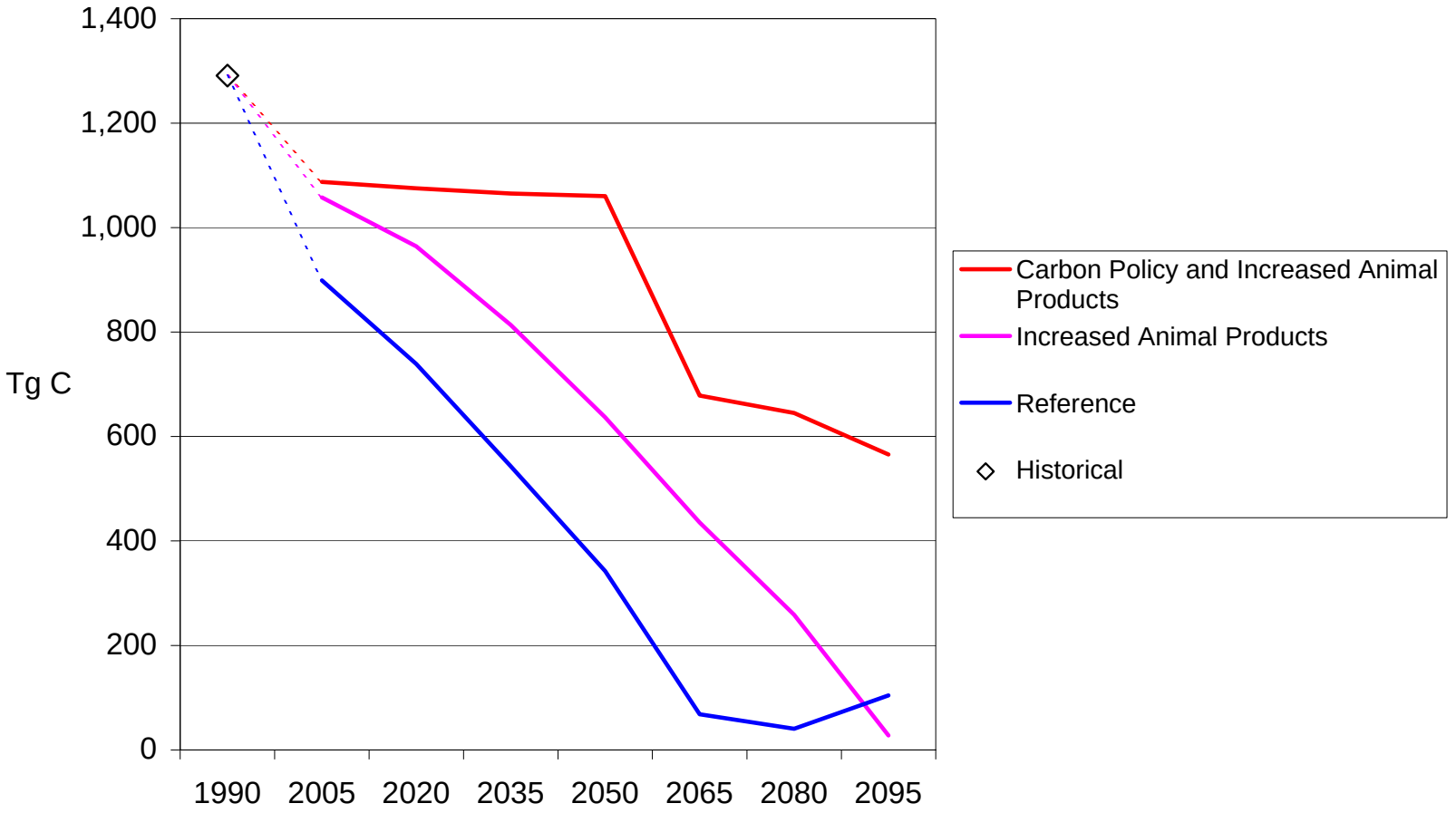


Carbon Emissions from Land Use Change



Model Development

- Climate impacts
- CH_4 and N_2O emissions from agriculture
- Crop management and carbon sequestered in soils
- Embed in CGE Framework
- Water Supply and Demand

Climate Impacts

- Previous ENSO study for North America
  - El Nino (EN)
  - Strong El Nino (SEN)
  - El Viejo (EV)
- Climate change and crop yields
  - CO_2 at 365 ppmv and 560 ppmv
  - GCMs: UIUC, UIUC+sulfates, BMRC
  - Climate Sensitivity: 1.0 ° C and 2.5 ° C
- EPIC crop growth model

Table III.17. Average Yields across EPIC Representative Farms (Mg ha^{-1})

		Average Yield	Deviation from Average		
Country	Crop	N	EN	SEN	EV
US	Corn	7.05	-0.61	-0.54	-0.12
US	Winter Wheat	1.76	-0.13	0.11	-0.02
Canada	Barley	3.91	-0.15	-0.16	0.10
Canada	Canola	2.68	-0.02	-0.01	-0.01
Canada	Spring Wheat	2.53	-0.07	-0.02	0.16
Mexico	Corn	5.10	-0.33	0.02	0.05
Mexico	Beans	1.16	0.00	0.09	-0.08
Mexico	Wheat	1.75	0.39	0.30	0.17
Mexico	Irrigated Corn	7.18	-0.20	0.13	0.08
Mexico	Irrigated Beans	2.55	0.03	-0.03	0.03
Mexico	Irrigated Wheat	4.53	0.05	0.08	-0.18