

# **ENERGY, LAND USE, AND CLIMATE STABILIZATION: *Results From GCAM***

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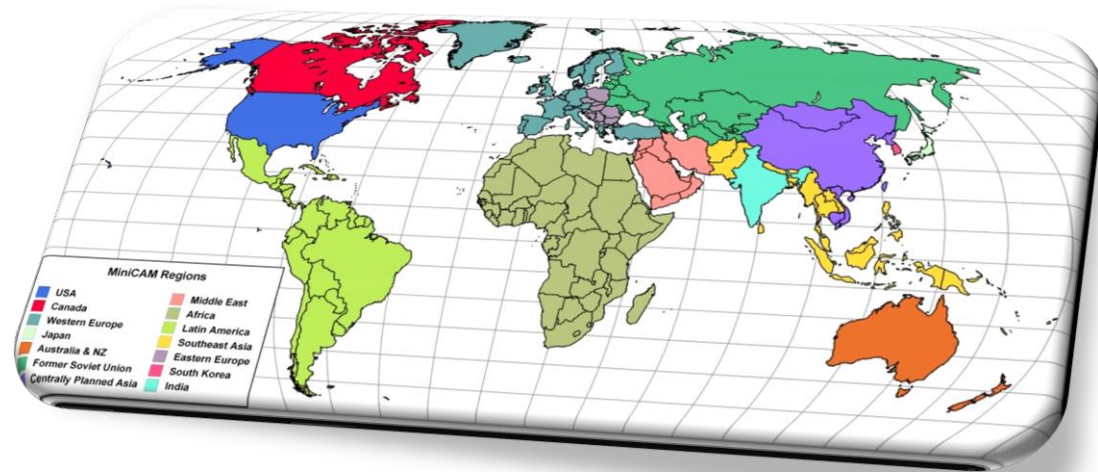
# OVERVIEW

*This presentation explores, in three parts, some of the interactions between energy, the economy, agriculture, and land use, in the context of stabilizing the concentration of atmospheric CO<sub>2</sub> :*

- ▶ The PNNL integrated assessment model, Global Change Assessment Model (GCAM).
- ▶ An example, energy, land-use, and stabilizing CO<sub>2</sub> with idealized emissions mitigation (Wise, et al. ***Science***, **324**:1183-1186)
- ▶ Extending the analysis to a less-than perfect world (Calvin et al. ***Energy Economics***, **31**:S107-S120)

# GCAM—Model Characteristics

- ▶ Integrates energy, economy, agriculture, land use, & natural Earth Systems



- ▶ **Regional Details:**

- *Regional Scope:* Global
- *Number of Sub-Regions:* 14

- ▶ **Time Step:** 15 years

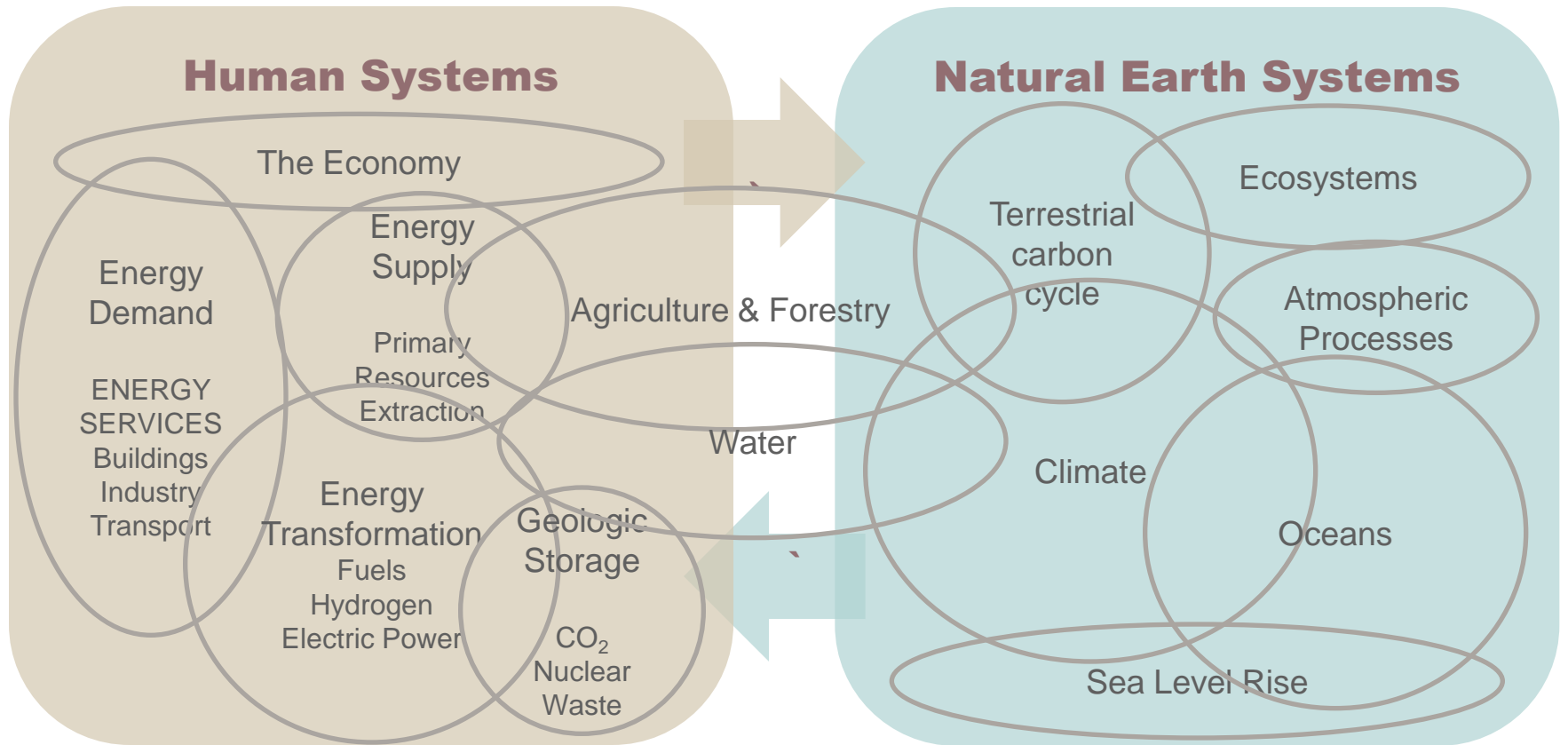
- ▶ **Time Frame:** 1990 to 2095

- ▶ **Model Type:** Dynamic Recursive

- ▶ **Equilibrium Type:** Market Equilibrium

**Computing Framework:** C++  
**Availability:** Open (exe, data, & source code)

# GCAM integrates human Earth systems—energy, economy, agriculture, land use—and natural Earth Systems

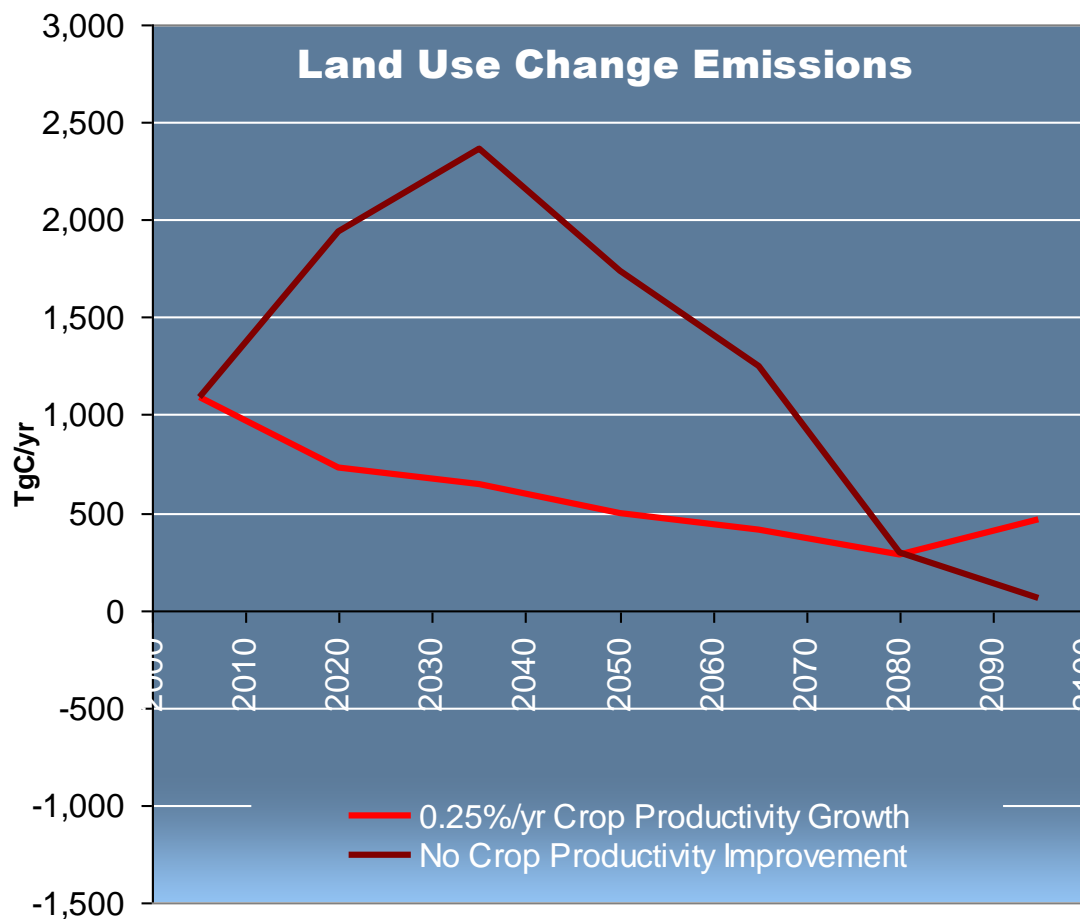


# **Crop Yield Improvements as a Carbon Emissions Mitigation Technology**

# Land Use Change Emissions and Crop Productivity

## ► Cumulative Emissions 2005 to 2095

- 0.25%/yr crop productivity growth:
  - **50 PgC**
- No crop productivity growth:
  - **122 PgC**
- Difference
  - **72 PgC**



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# **Valuing Terrestrial Carbon Storage Services—OR NOT—in an Idealized World**

# Carbon Pricing

## Two alternative carbon pricing regimes

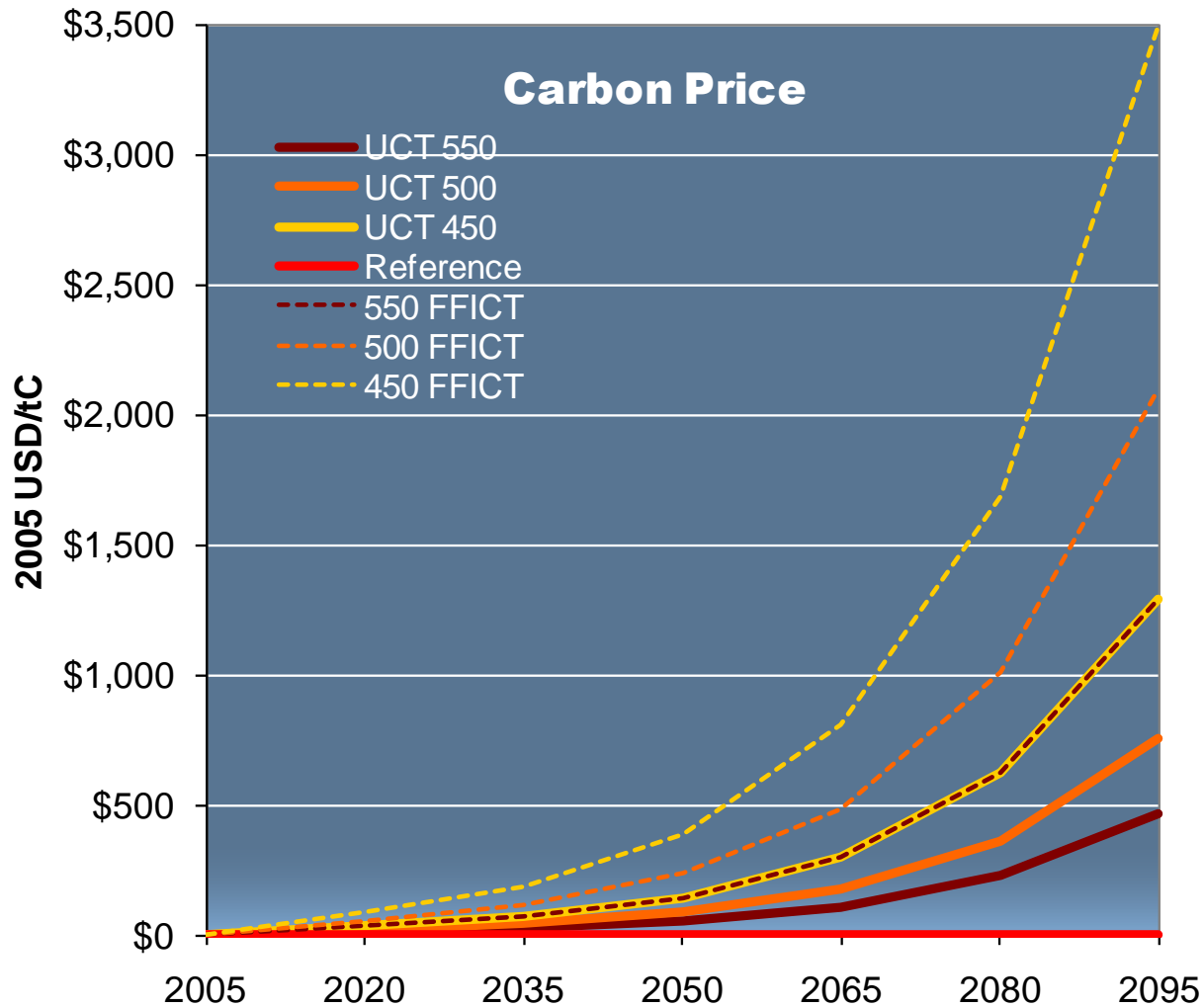
- 1. Fossil fuel and industrial carbon tax (FFICT)**—in this regime only fossil fuel and industrial carbon emissions are valued. Bioenergy is treated as having no net carbon. **Terrestrial carbon emissions are valued at zero.**
- 2. Universal carbon tax (UCT)**—in this regime all carbon emissions are valued equally regardless of either their origins or the activity that introduces it to (or removes it from) the atmosphere.



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# Carbon Prices: FFICT and UCT

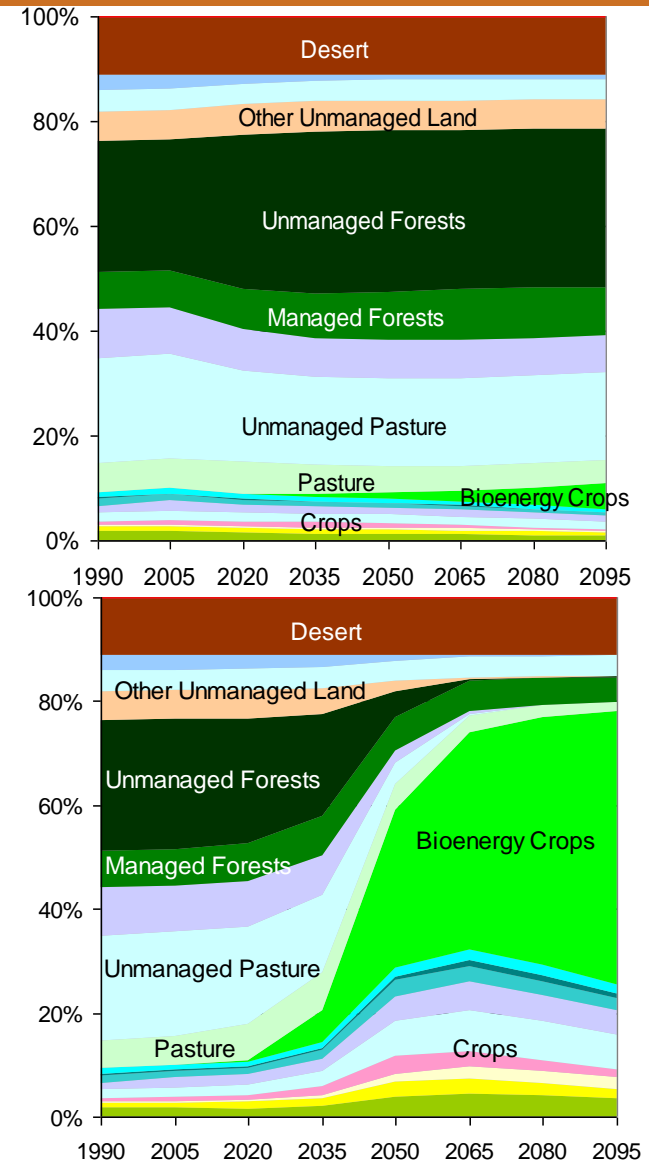
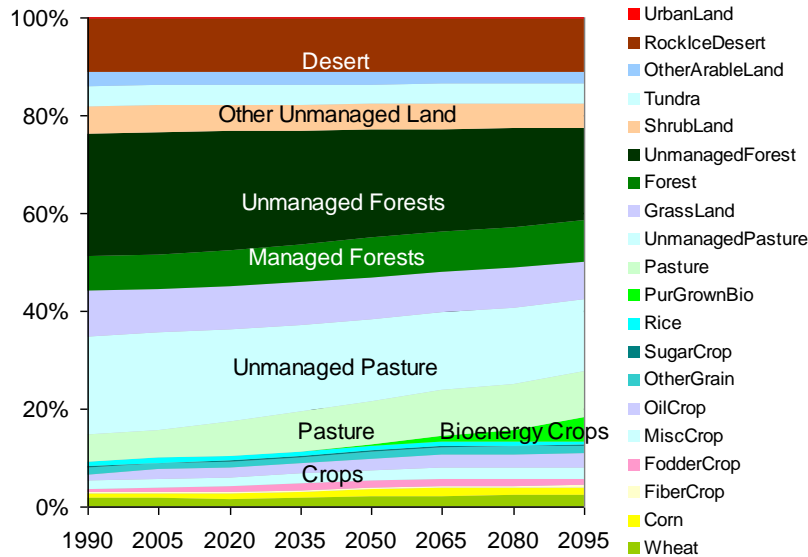


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# 450 ppm Stabilization Scenario When ALL Carbon is Valued (UCT)

## Reference Scenario

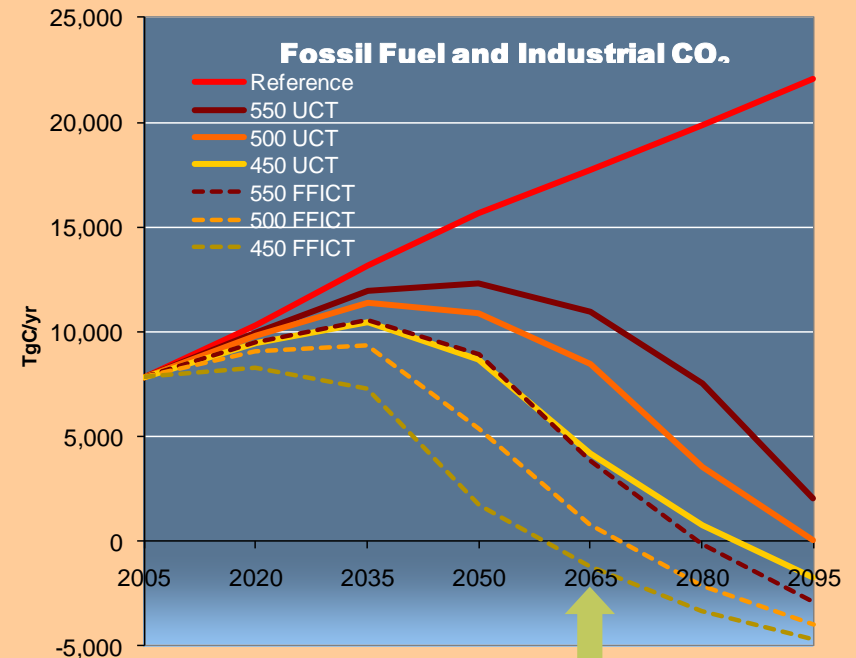
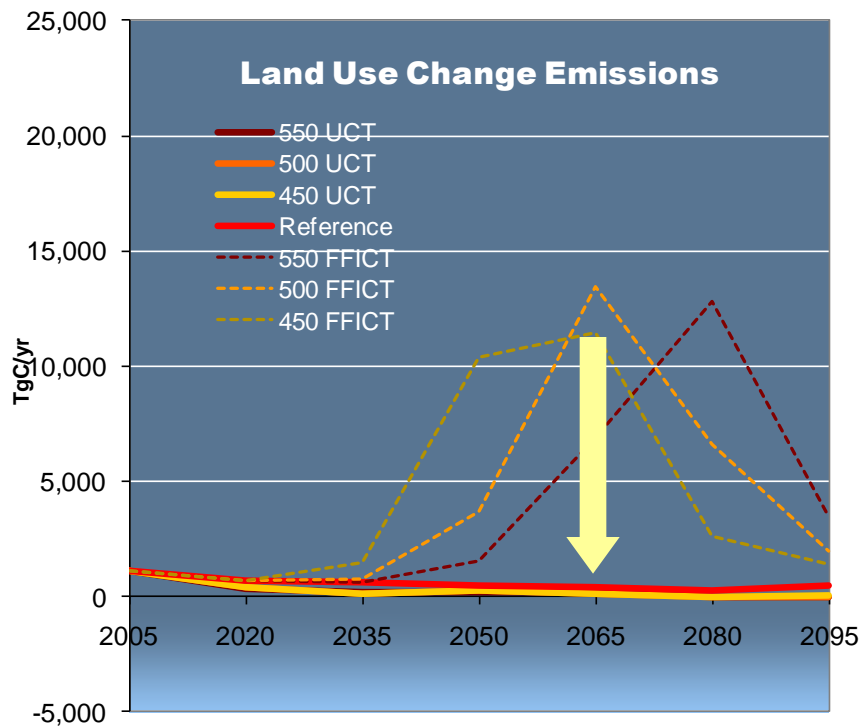


# 450 ppm Stabilization Scenario When Terrestrial Carbon is NOT Valued (FFICT)

# Net Land Use Change Emissions & Fossil Fuel and Industrial CO<sub>2</sub> Emissions

For a given CO<sub>2</sub> concentration limit

- In the UTC regime ILUC disappears as an issue.
- In the FFICT regime high carbon prices drive bioenergy demands and ILUC

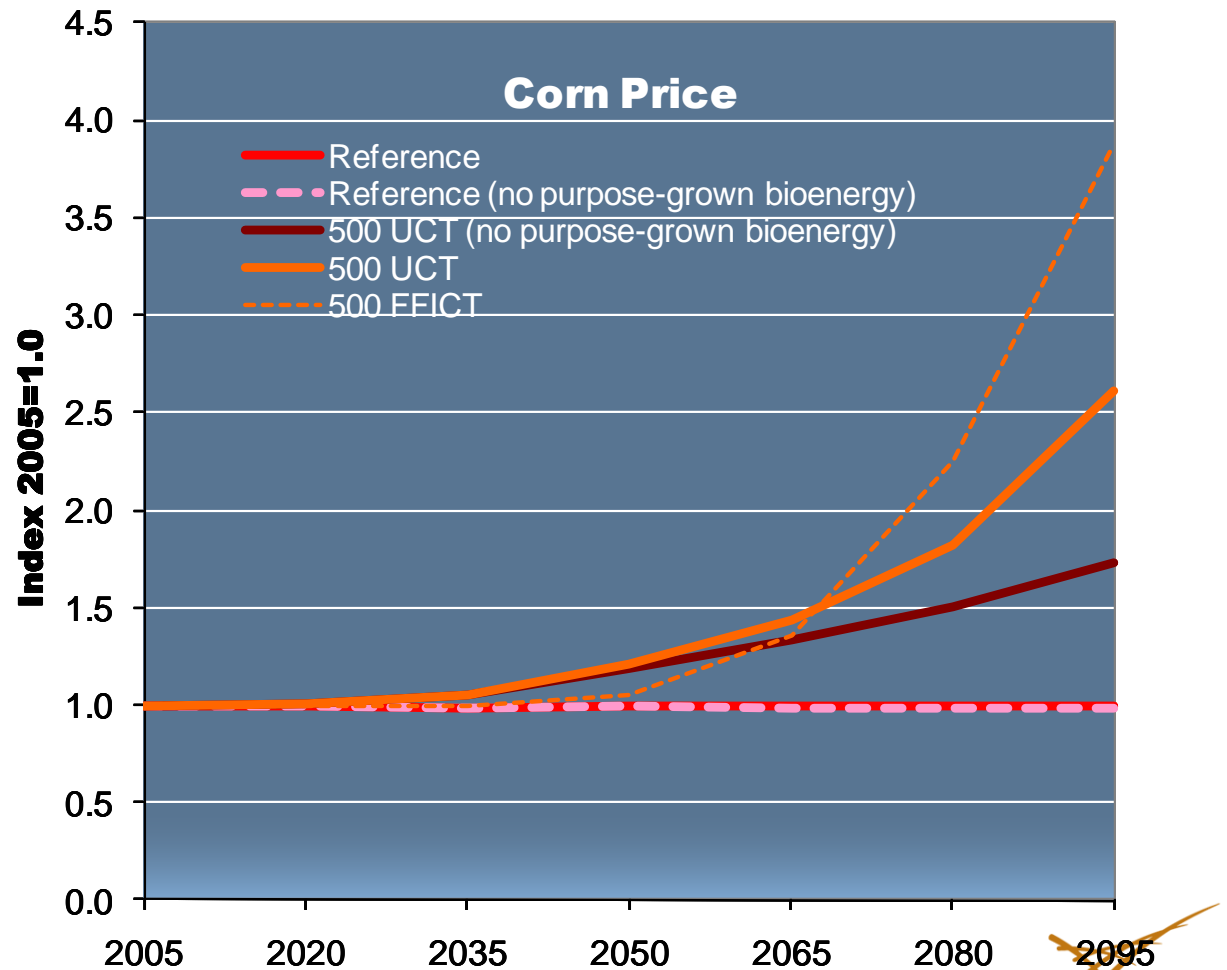


Lower FF emissions are needed in FFICT regime to offset land use change emissions

# Corn Price When Carbon Is Valued But No Bioenergy Is Produced

- ▶ Significant crop price escalation occurs if carbon is valued, **even in the absence of purpose grown bioenergy production.**

- Prior to 2040 the influence of bioenergy is negligible.
- Prior to 2040 crop price escalation, relative to the reference scenario, is predominantly driven by the value of carbon.



# Extension to an Imperfect World

## EMF 22

- ▶ Examined a world in which regions of the world began explicit emissions mitigation policies at different times in the future.
- ▶ We look at one of the scenarios that modelers were asked to explore, namely a regime that stabilizes radiative forcing at  $3.7 \text{ W/m}^2$  (550 ppm  $\text{CO}_2$ -equivalent, but  $\sim 450$  ppm atmospheric  $\text{CO}_2$ )
- ▶ Today I want to **contrast** the implications for land use in an **idealized world** in which all nations begin emissions mitigation immediately with one in which **some regions begin later than others**.



# Carbon Pricing

**When a region mitigates its carbon emissions, it values ALL carbon equally.**

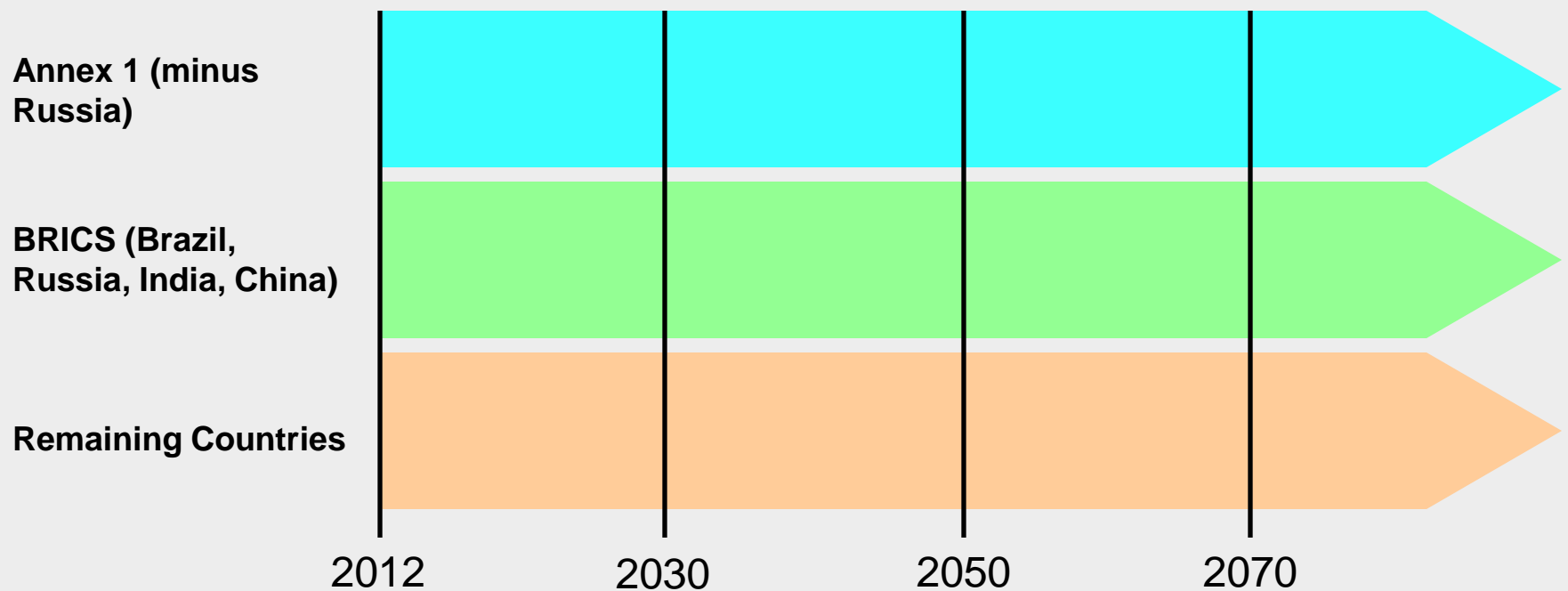
**Universal carbon tax (UCT)**—in this regime all carbon emissions are valued equally regardless of either their origins or the activity that introduces it to (or removes it from) the atmosphere.



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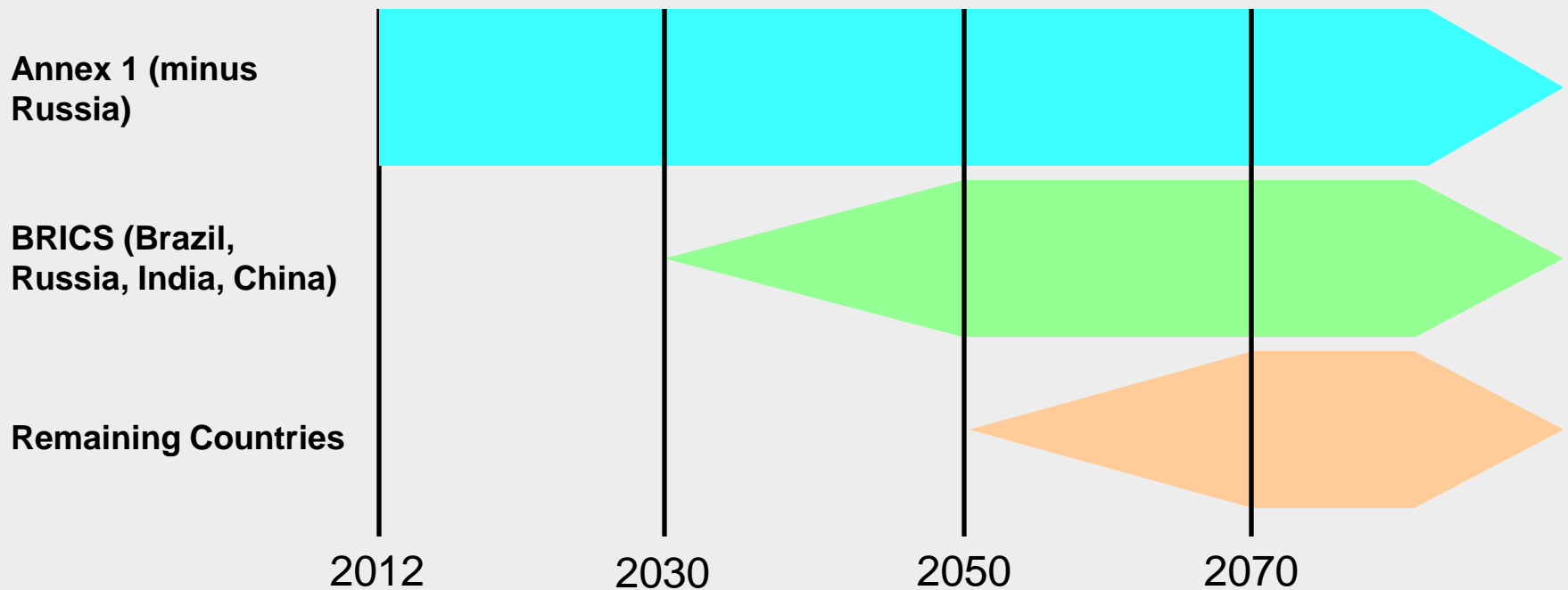
# Full Participation: All Begin Reductions Immediately: S1



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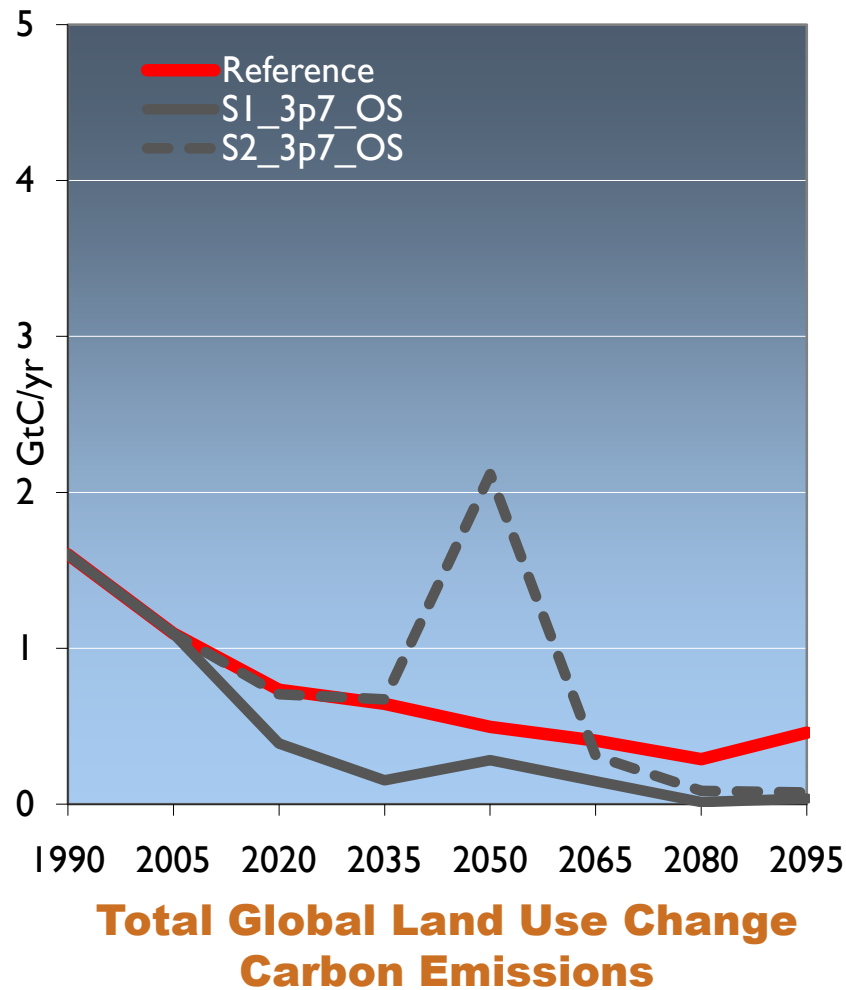
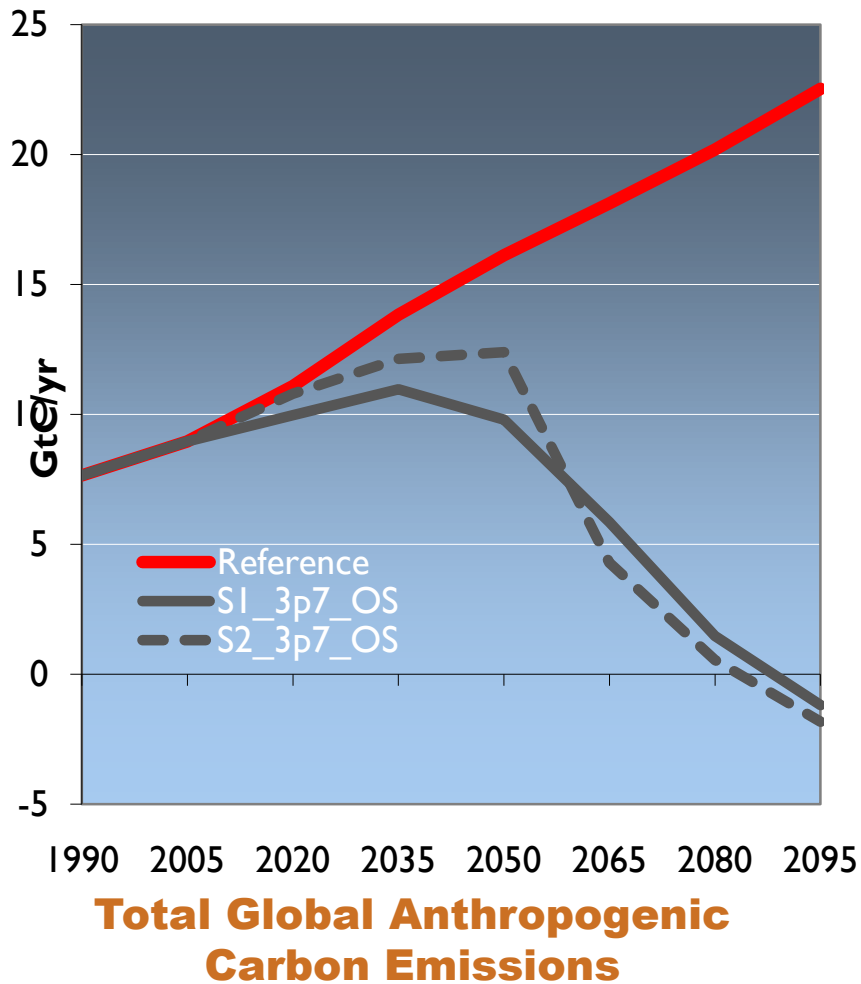
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# Delayed Participation: Regions Enter the Global Coalition over Time: S2



The delayed participation case explores the potential impacts of a one single possibility for delay in non-Annex I participation – it does not represent any real policy proposal. Mechanisms such as offsets may lead to policy structures that lie between the two cases explored in this study.

# 550 ppm CO<sub>2</sub>-equivalent limit in 2100: Total and Land-use Global Anthropogenic Emissions



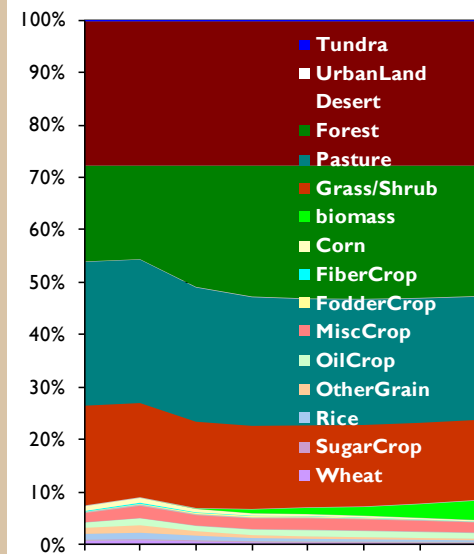
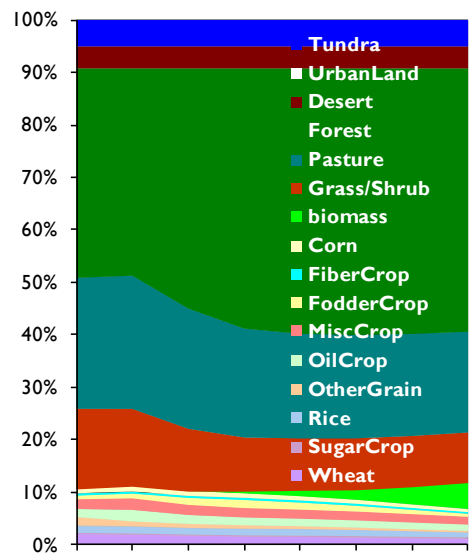
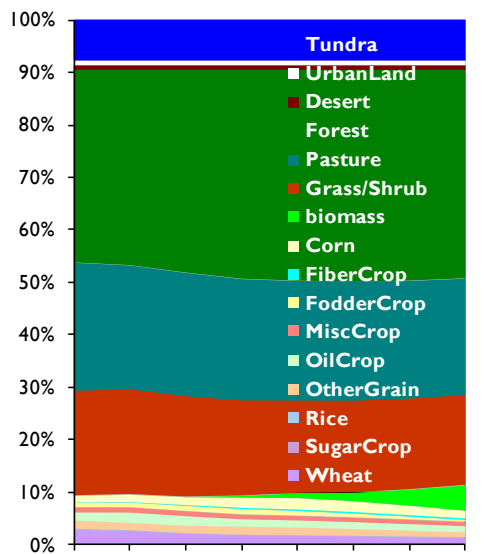
# 3.7 W/m<sup>2</sup> (Overshoot) Land use: Immediate and Delayed Accession

## Annex 1

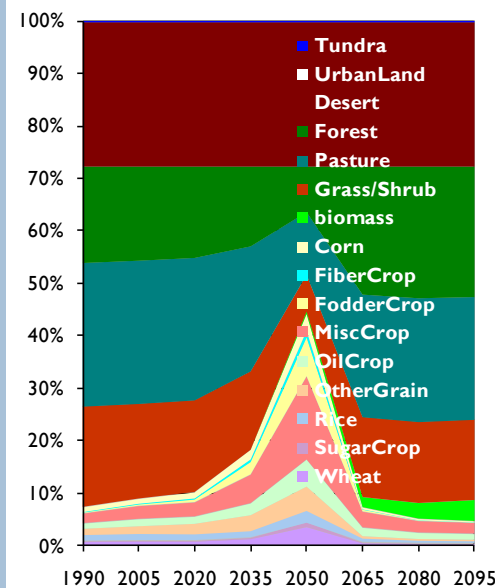
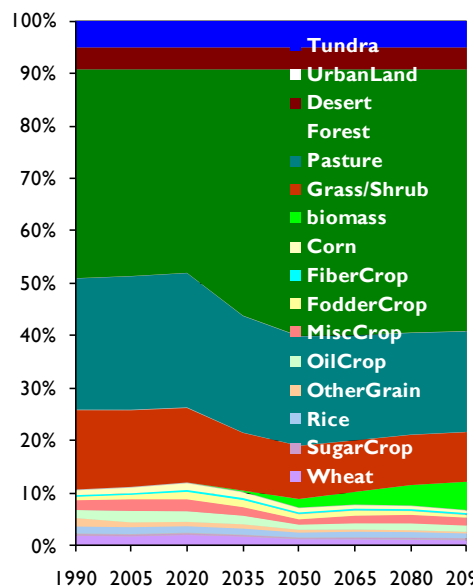
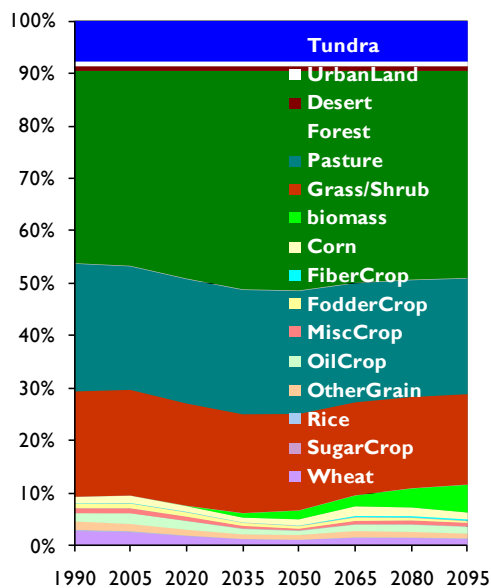
## BRIC

## Rest of World

Immediate Accession



Delayed Accession



# Final thoughts

- ▶ Interactions between energy, the economy, agriculture and land-use systems are complex.
- ▶ The shape of climate policy can have important implications for energy, the economy, and terrestrial systems that go well beyond the direct policy intent.
- ▶ The complex interactions brings difficult issues to the fore.
  - Expanding unmanaged ecosystems implies higher grain prices.
  - Afforestation in one part of the world can drive deforestation in another.

# DISCUSSION



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