

Estimating the potential effectiveness of REDD style programs

Kate Calvin, Jae Edmonds, and Marshall Wise

International Energy Workshop 2011
Stanford, California

July 6, 2011



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Overview of the Presentation

- ▶ Brief overview of GCAM 3.0
- ▶ How effective are REDD type programs...
 - ...when there is no climate policy?
 - ...when there is a global price on fossil fuel & industrial carbon emissions?
- ▶ Sensitivities that will affect the results
 - Population size
 - Agricultural Productivity
 - Fragmented Policy

THE GLOBAL CHANGE ASSESSMENT MODEL (GCAM)

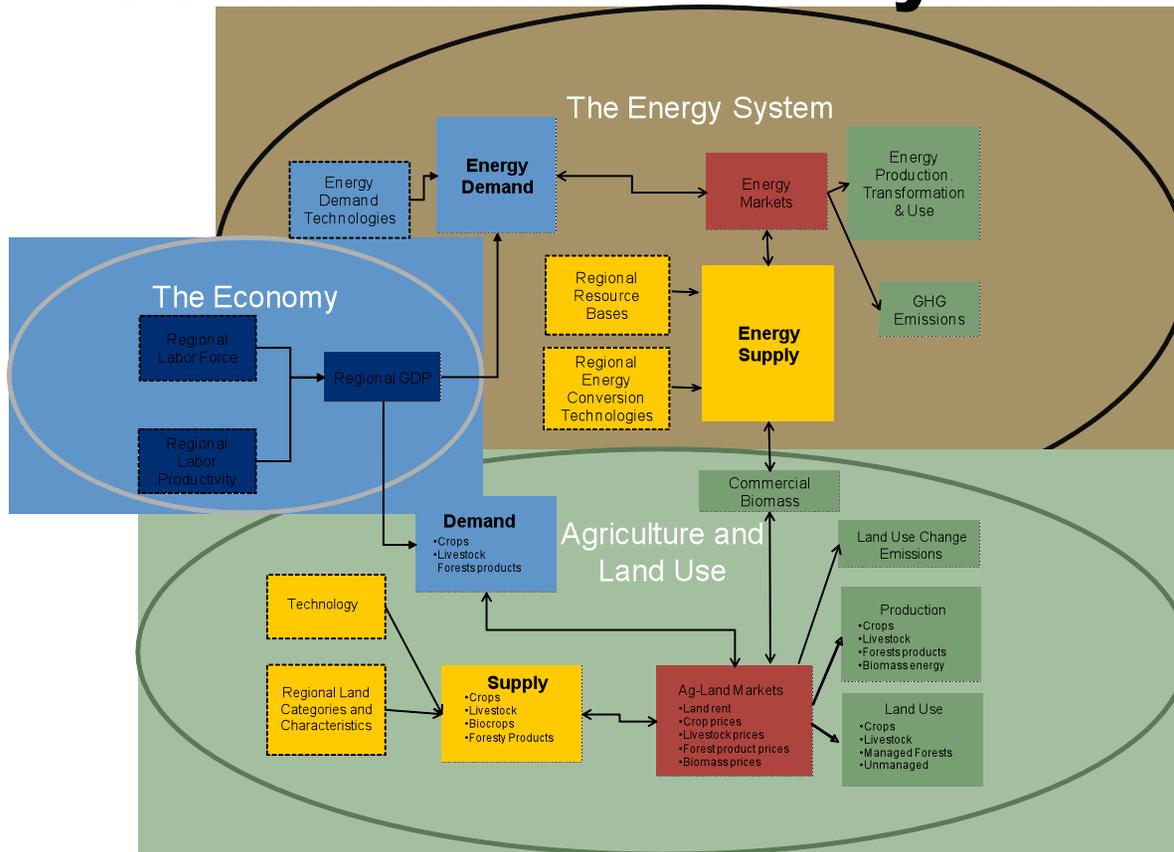


Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

GCAM is an integrated assessment model

GCAM human Earth systems



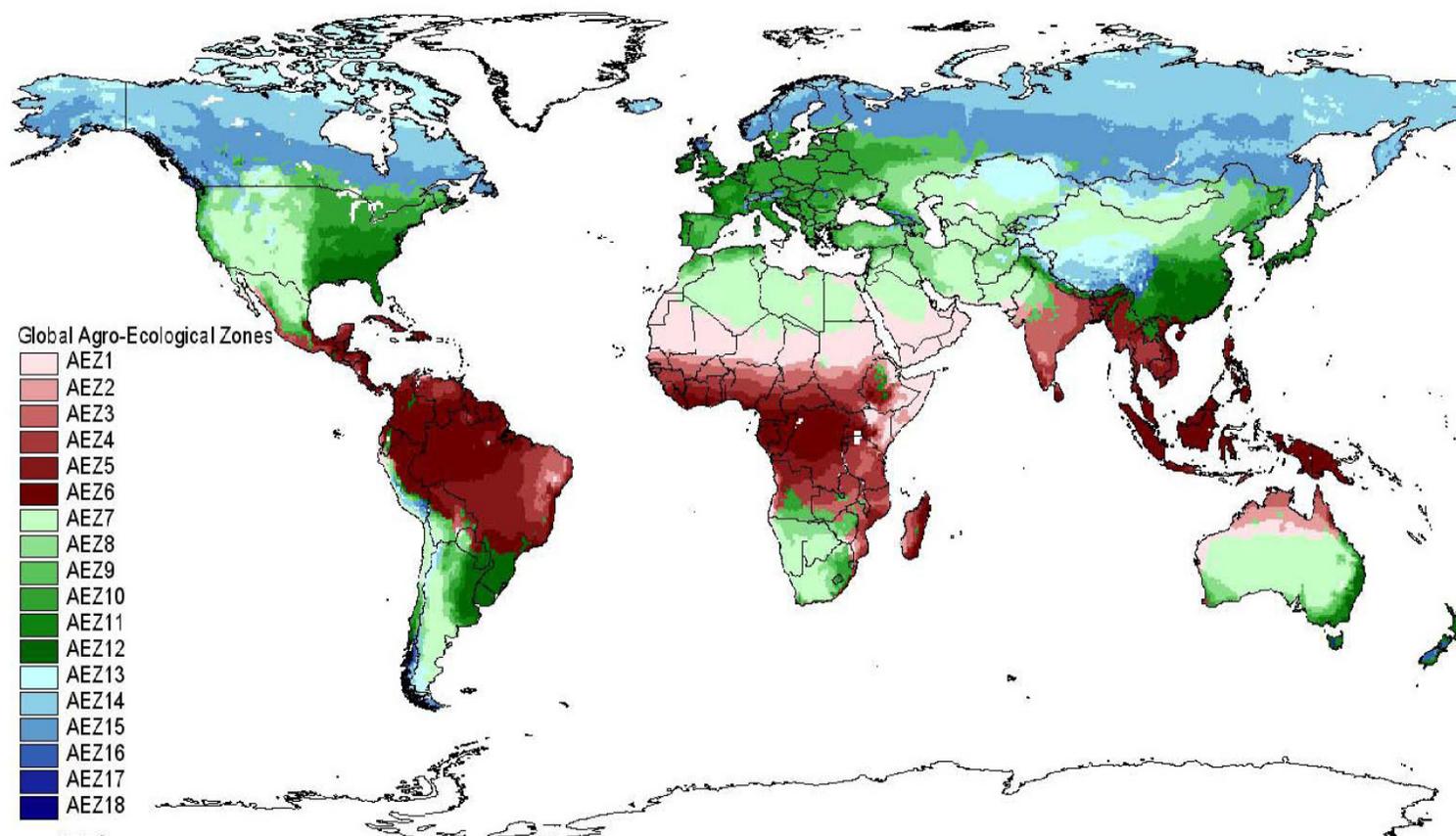
GCAM has 14 Regions



- ▶ Open source model.
- ▶ Research model.
- ▶ Dynamic-recursive model.
- ▶ **The GCAM human Earth systems model has Economic, Energy and Land-use systems.**
- ▶ Technological detail.
- ▶ Emissions of 16 greenhouse gases and short-lived species: CO₂, CH₄, N₂O, halocarbons, carbonaceous aerosols, reactive gases, sulfur dioxide.
- ▶ **Runs through 2095 in 5-year time-steps (time step is variable).**

GCAM Agriculture & Land Use Model

- ▶ The world is divided into **151** regions based on agro-ecosystem zones (AEZs)



GCAM Agriculture & Land Use Model

- ▶ Farmers allocate land across a variety of uses in each geospatial region, in order to maximize expected profit.
- ▶ There is a distribution of profits for each land type across each of the **151** regions.
- ▶ The actual share of land allocated to a particular use is the probability that that land type has the highest profit.
- ▶ Farmers and land-owners are connected to consumers via markets, which determine prices and determine international trade.

Reducing Emissions from Deforestation and Forest Degradation

REDD



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

REDD in a reference scenario

ASSUMPTIONS

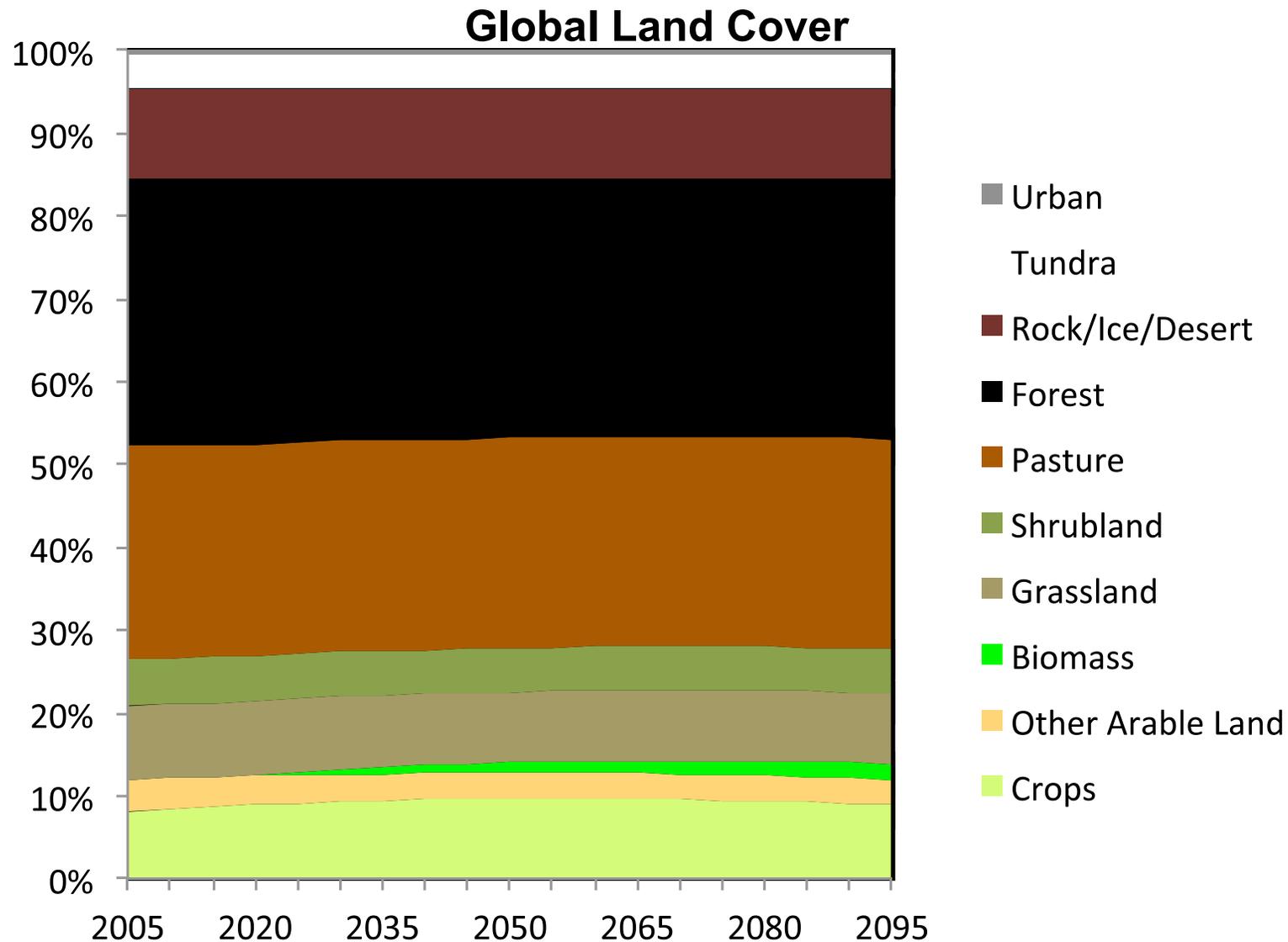
- ▶ There is no price on carbon anywhere.
- ▶ We assume that some fraction of forests are set aside in **carbon parks**.
- ▶ Carbon parks cannot be converted to managed ecosystems.
- ▶ Most other land (e.g., grassland, shrubland, pasture) can be converted to managed ecosystems.
 - ▶ Exception is tundra, rock, ice, desert, urban land



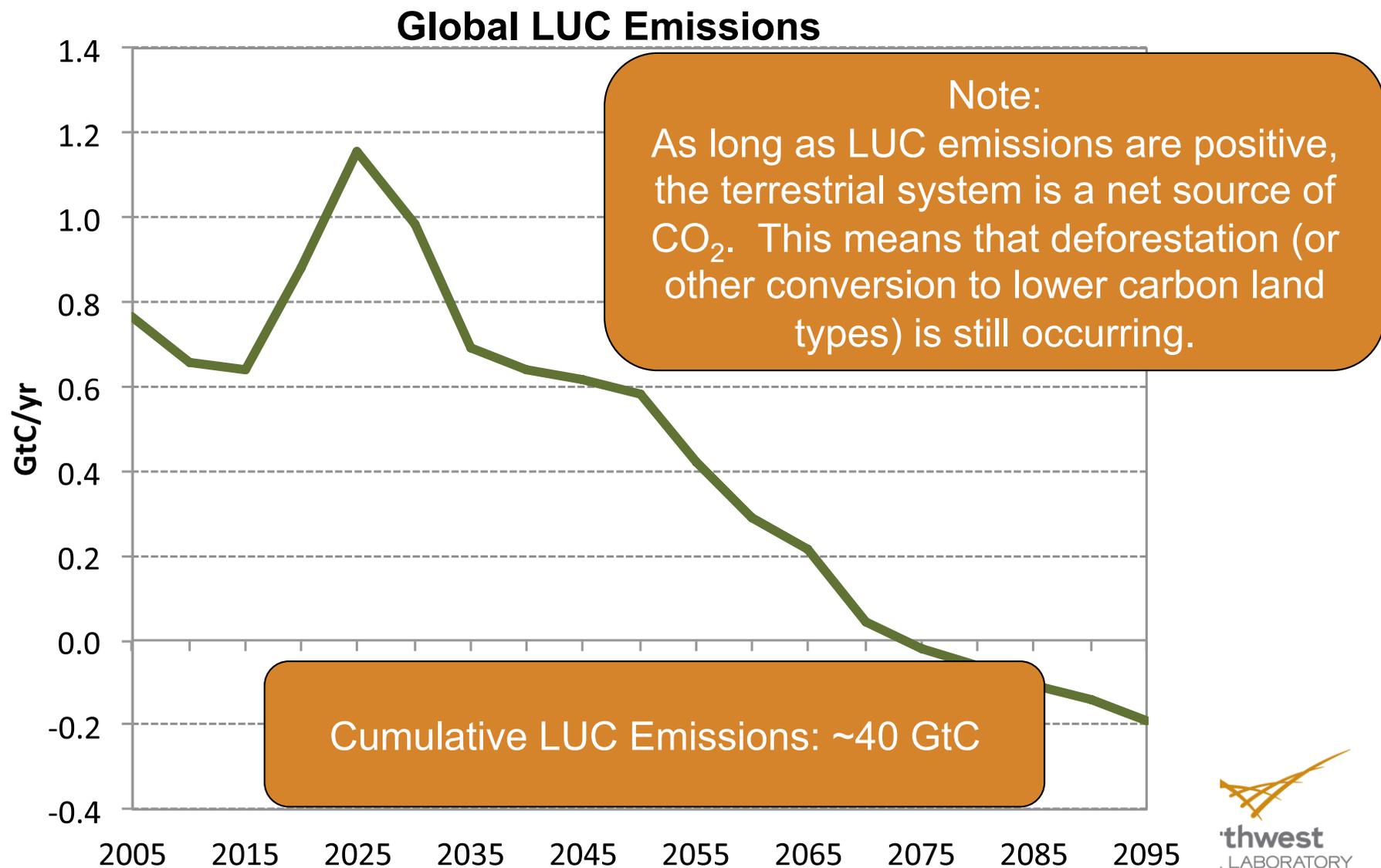
Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

In the reference scenario, cropland expands to feed a growing, increasingly wealthy population

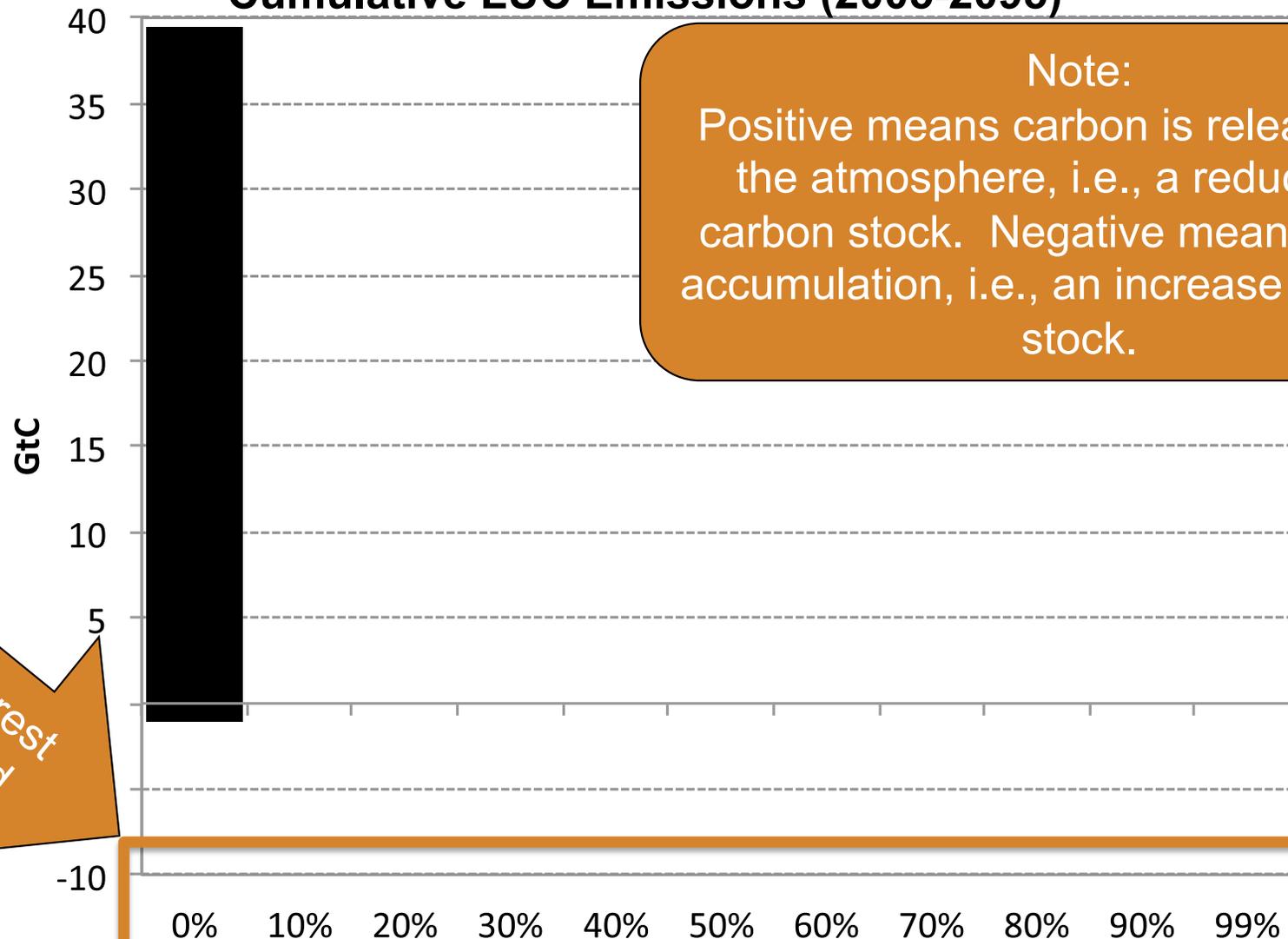


Global LUC Emissions increase as cropland expands, and then decline later in the century



What happens to cumulative emissions as we protect more and more of the world's forests?

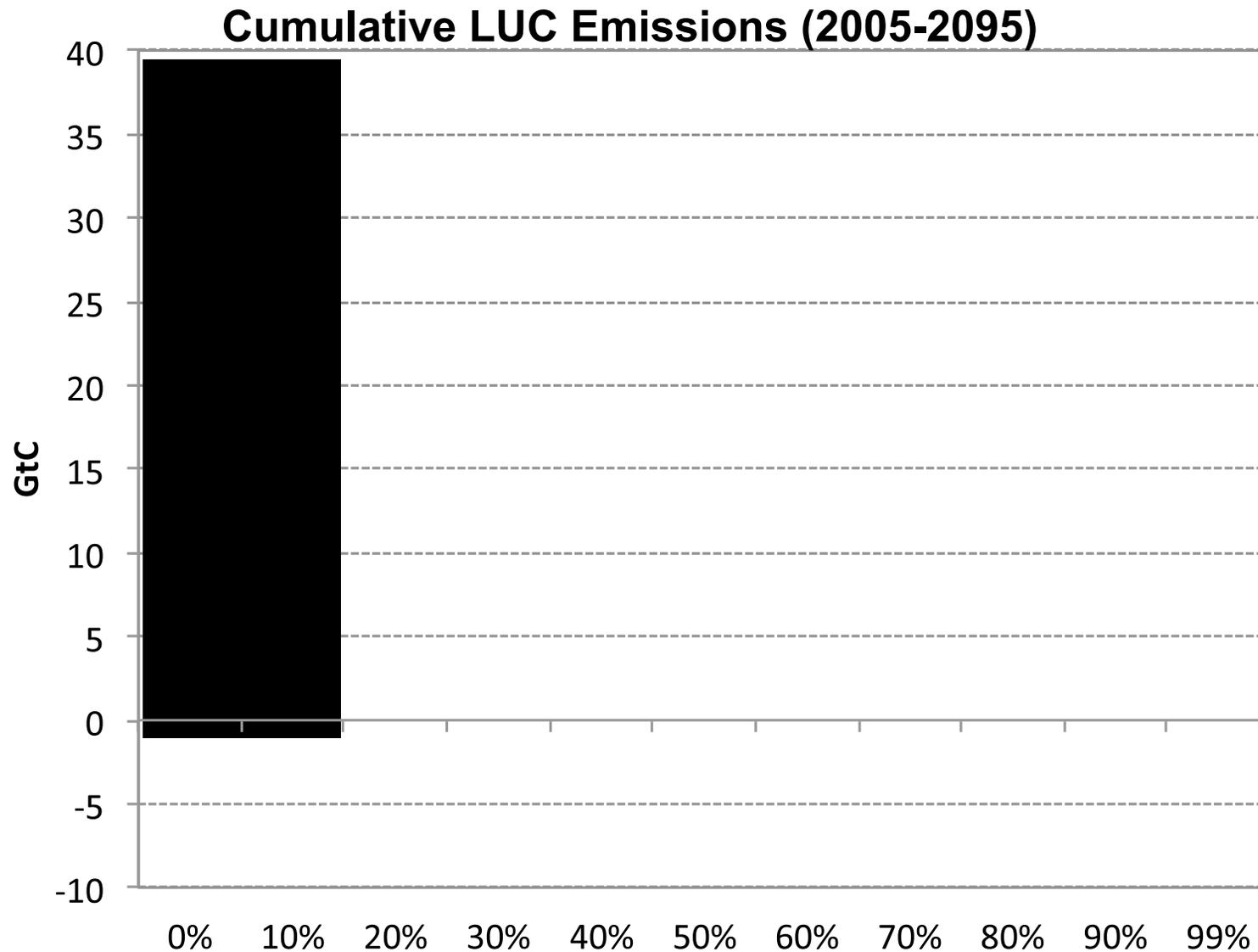
Cumulative LUC Emissions (2005-2095)



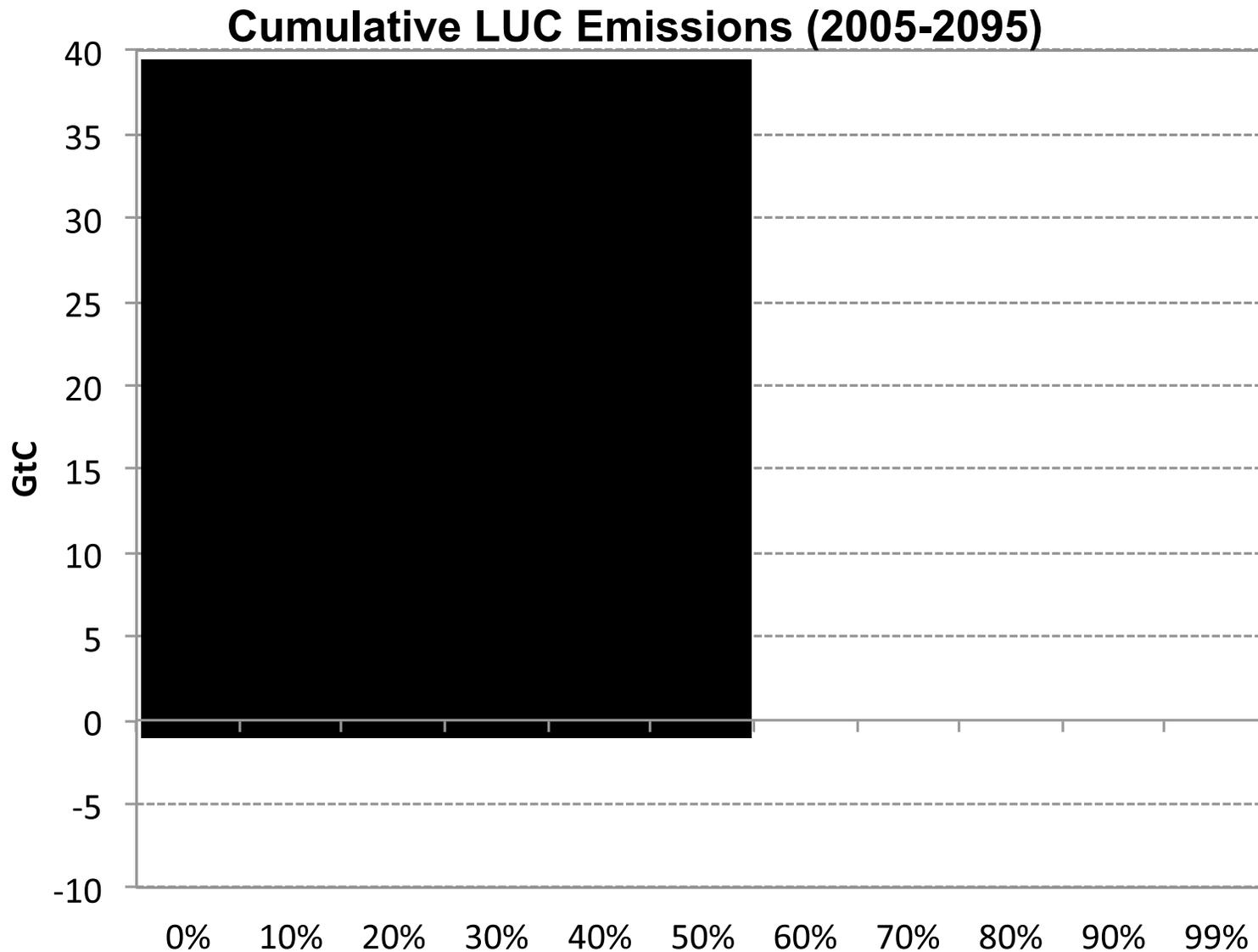
Note:
Positive means carbon is released into the atmosphere, i.e., a reduction in carbon stock. Negative means carbon accumulation, i.e., an increase in carbon stock.

% of forest protected

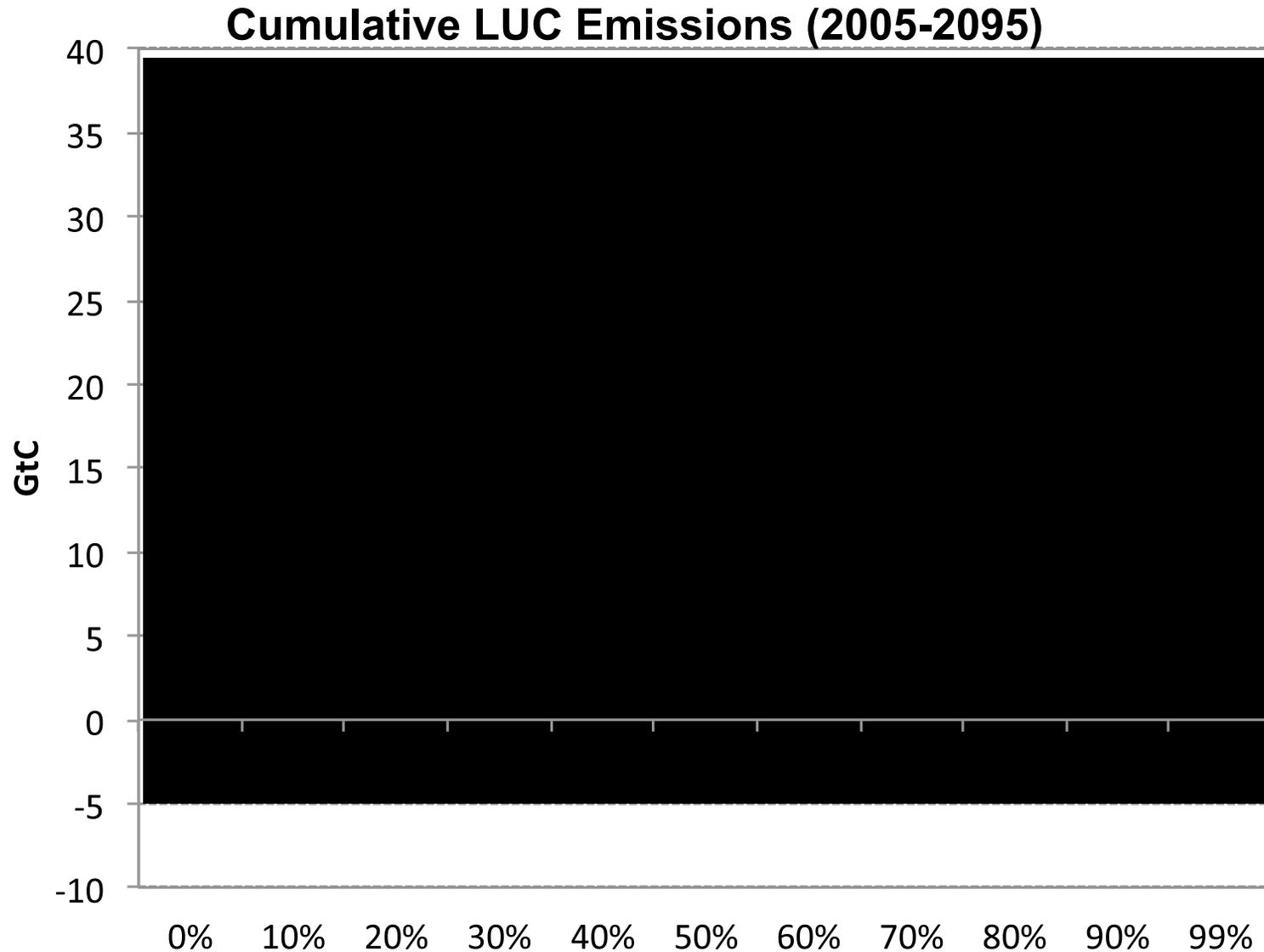
What happens to cumulative emissions as we protect more and more of the world's forests?



What happens to cumulative emissions as we protect more and more of the world's forests?

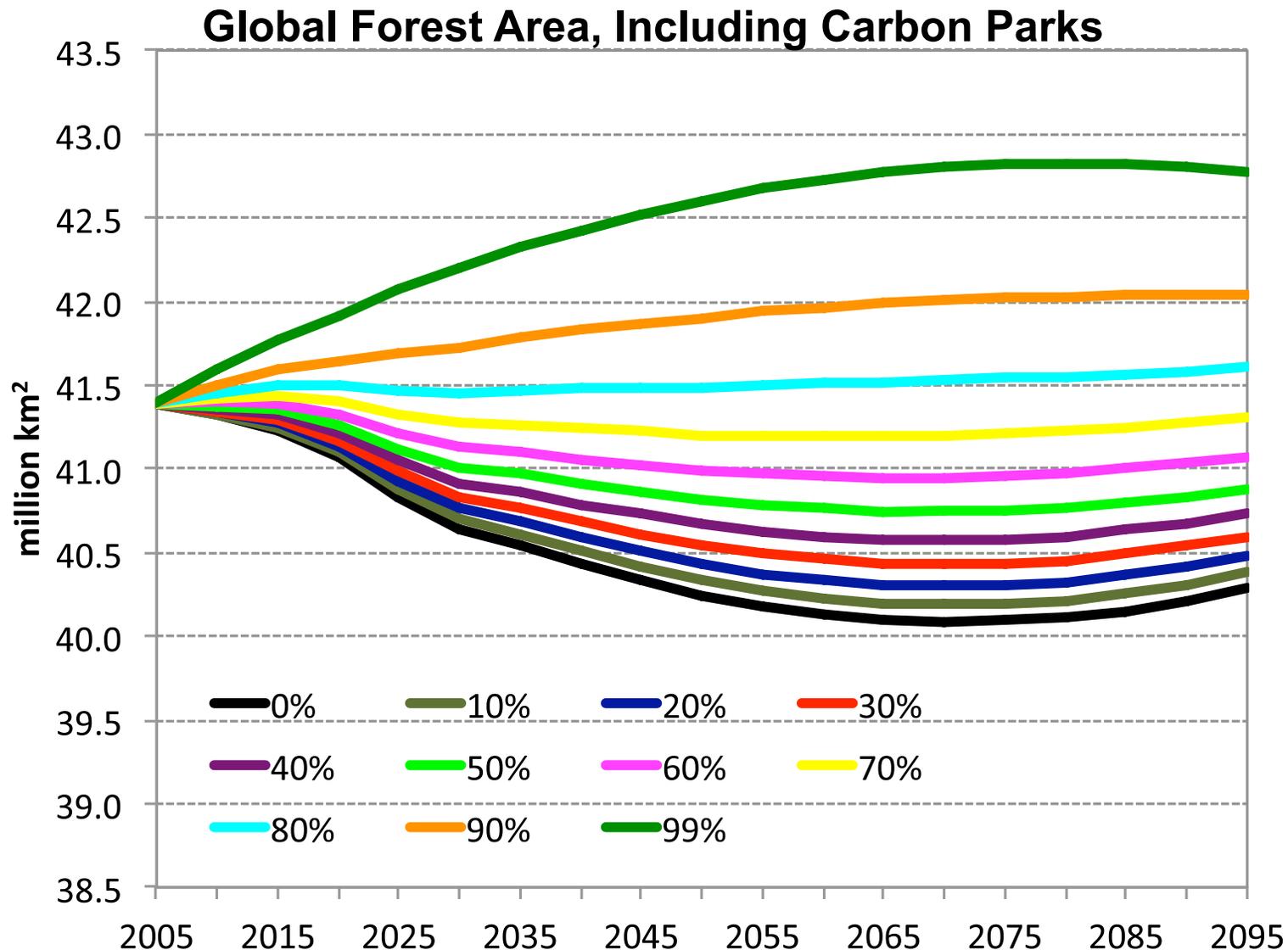


What happens to cumulative emissions as we protect more and more of the world's forests?



Proudly Operated by Battelle Since 1965

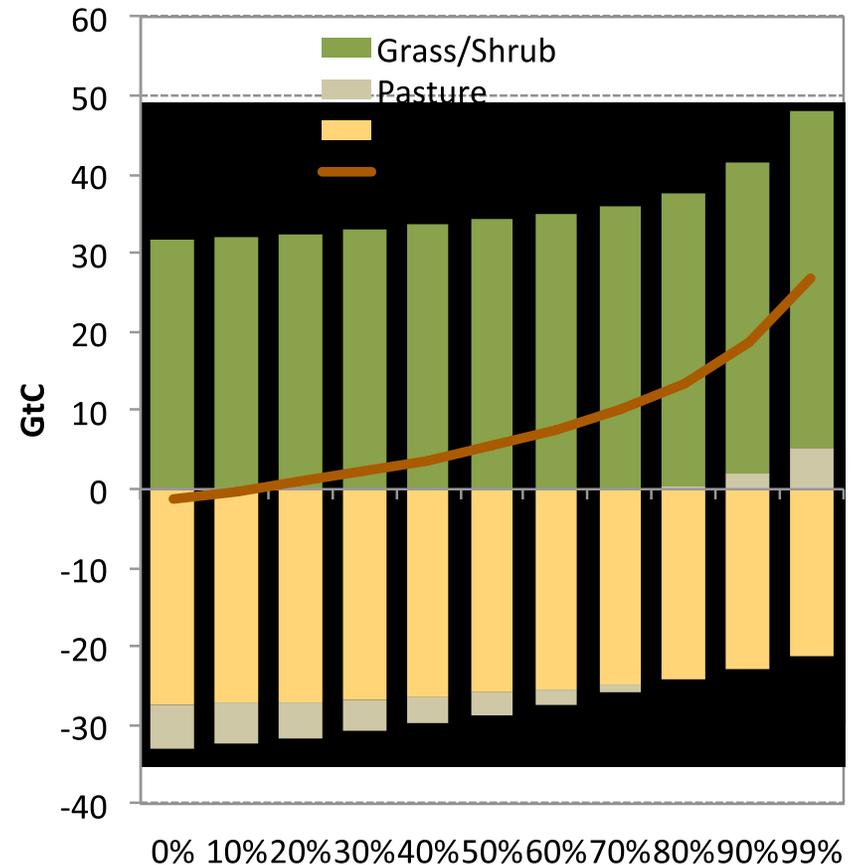
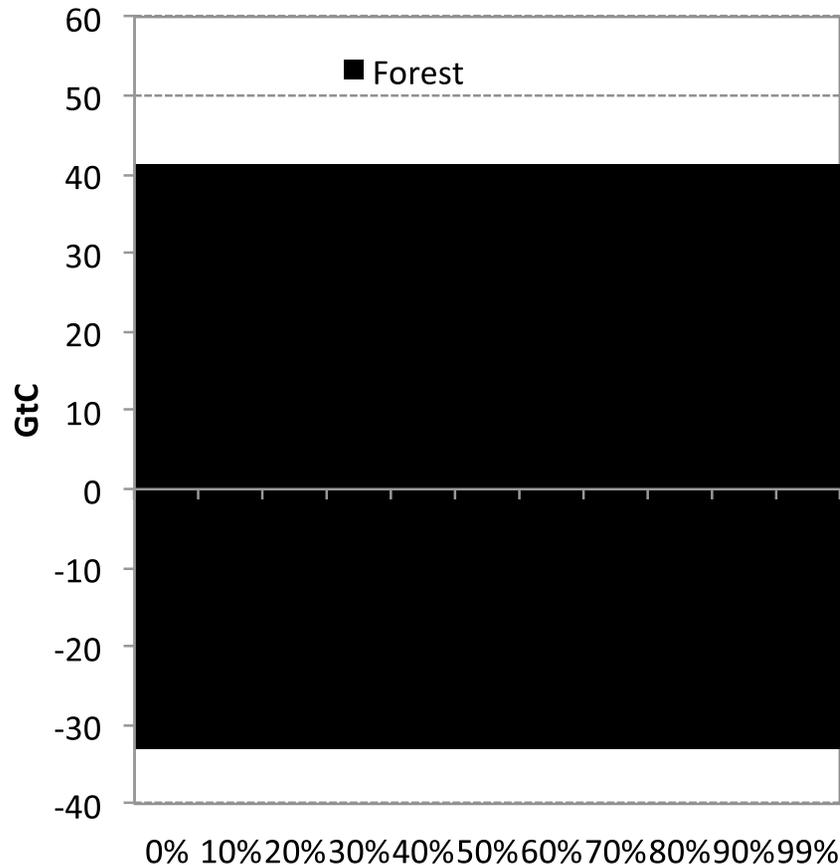
Unless we protect more than 80% of forests, total forest area declines from 2005 levels.



Proudly Operated by Battelle Since 1965

When most forests are protected, managed ecosystems expand at the expense of other land types.

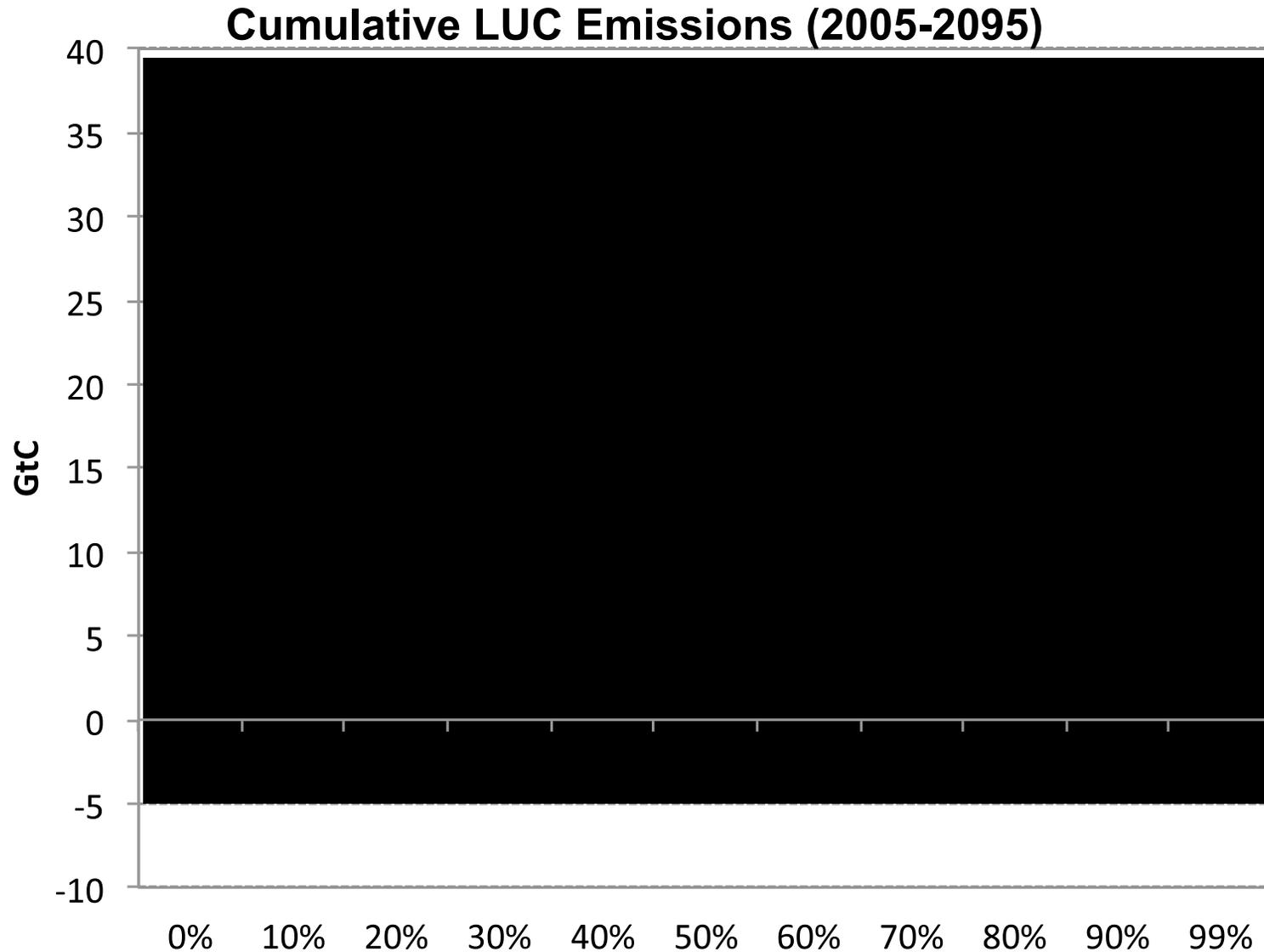
Change in Carbon Stock by Ecosystem(2005-2095)



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

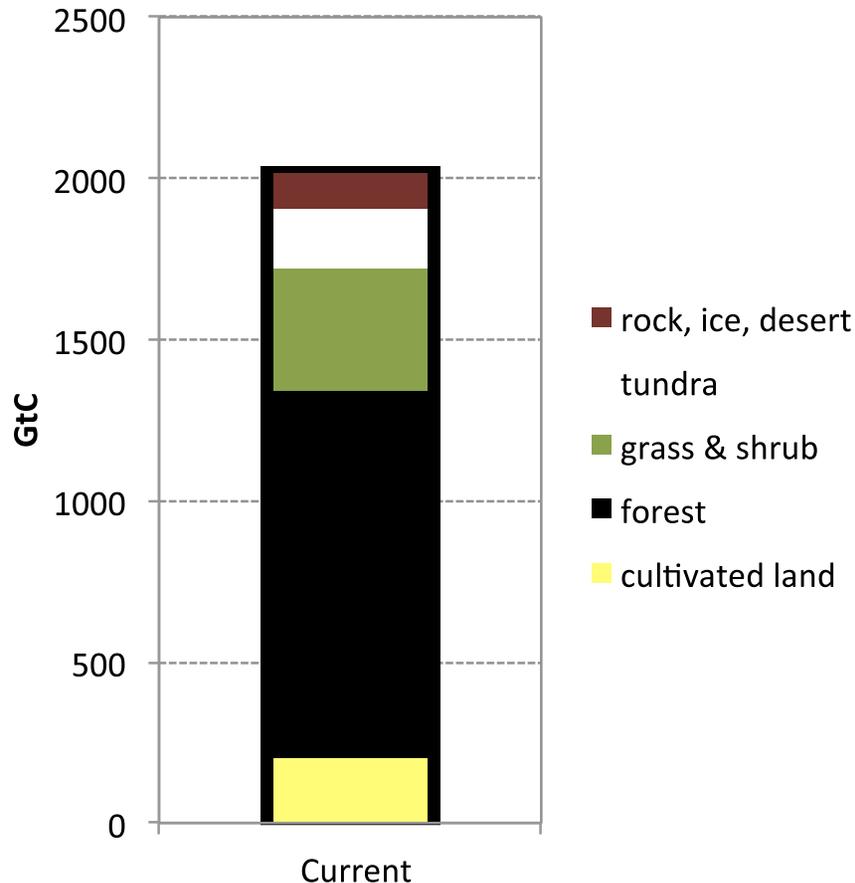
The net effect of forest carbon sequestration & carbon release from other ecosystems is still negative...if we protect 99% of forests



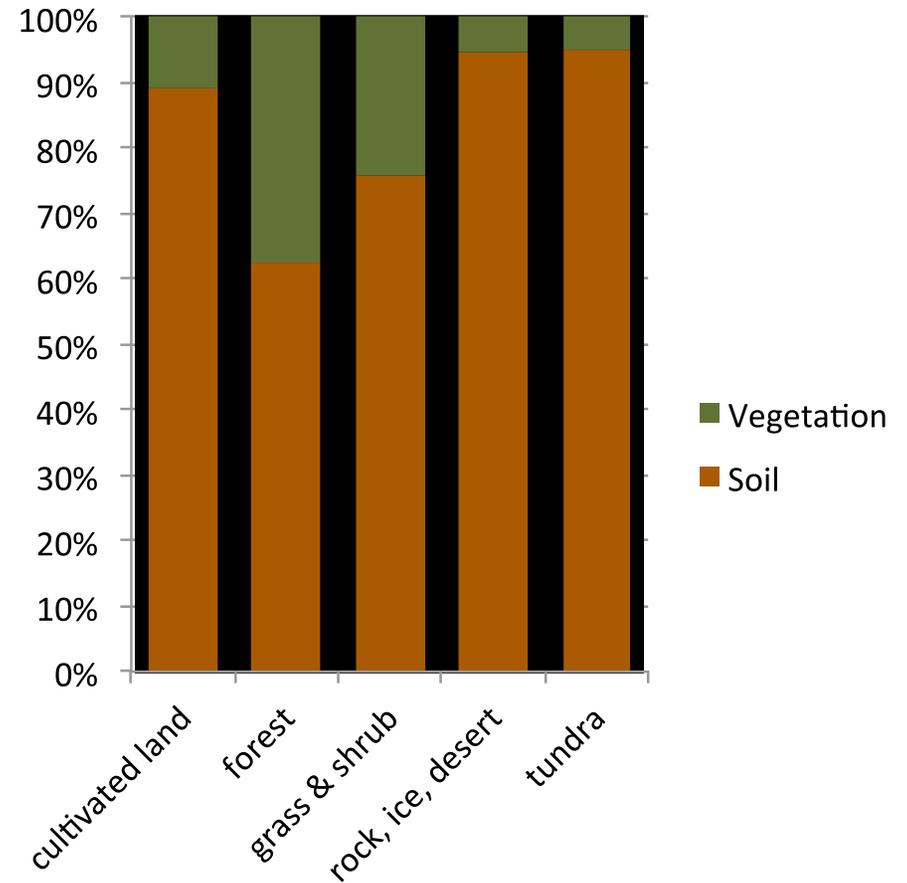
Proudly Operated by Battelle Since 1965

There is a lot of carbon in the terrestrial system, and not all of it is in forests.

Carbon Stock Today



Distribution Across Pools



Source: Schlesinger, W. (1997). Biogeochemistry: An analysis of global change. Elsevier Science. San Diego, California

SUMMING UP



Pacific Northwest
NATIONAL LABORATORY

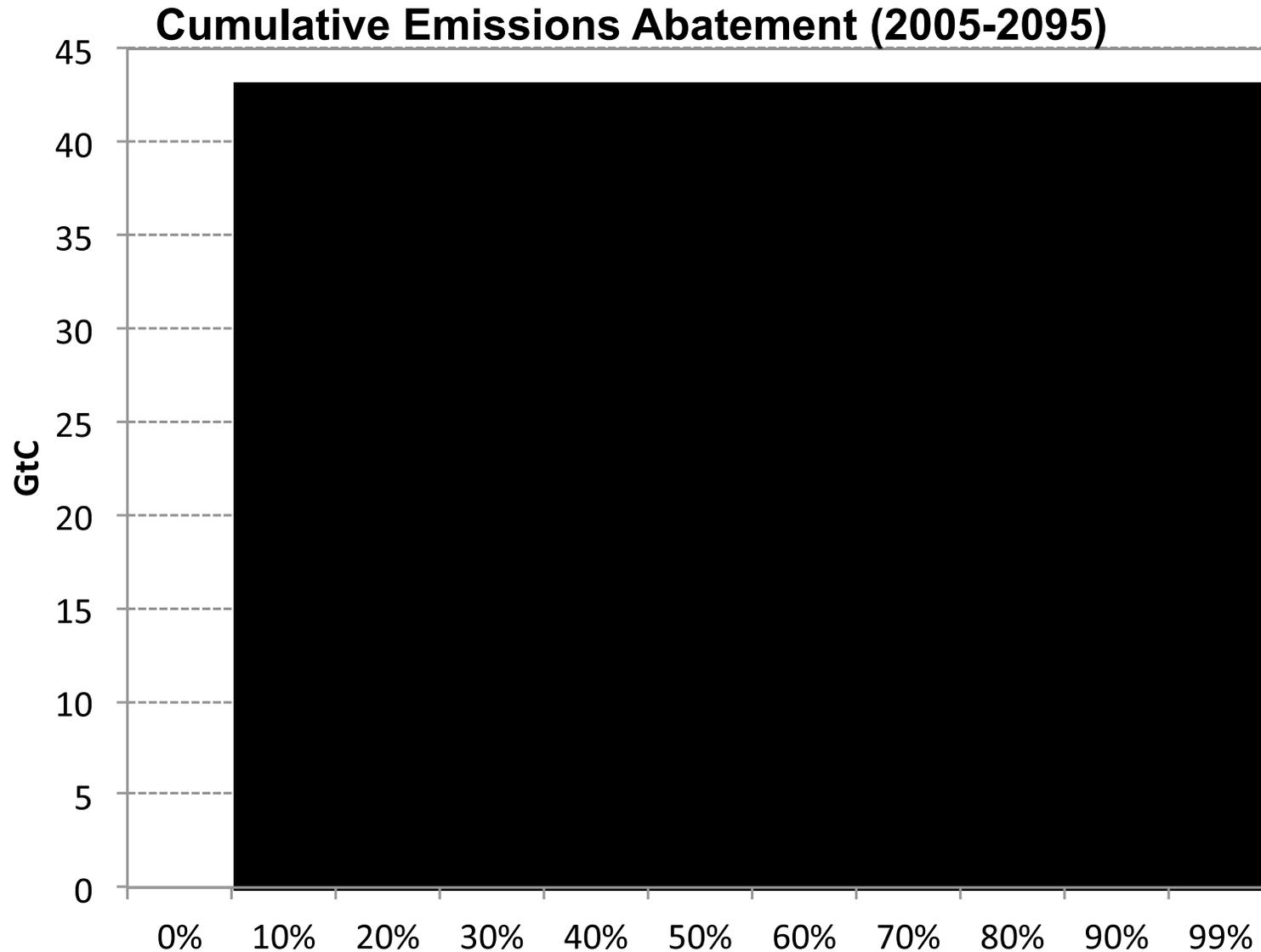
Proudly Operated by Battelle Since 1965

Key Points

- ▶ Without a climate policy, REDD programs can be effective...
 - ...but, a significant fraction of forests must be protected.
- ▶ With a climate policy, REDD programs can reduce emissions...
 - ...but 50% of forests must be protected just to limit emissions to the no climate policy, no carbon park levels
- ▶ Higher population and/or lower crop yields result in higher land-use change emissions. REDD programs can reduce those emissions, but not eliminate them.



REDD programs do result in abatement, but only if we protect a lot of land



DISCUSSION



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

EXTRA SLIDES

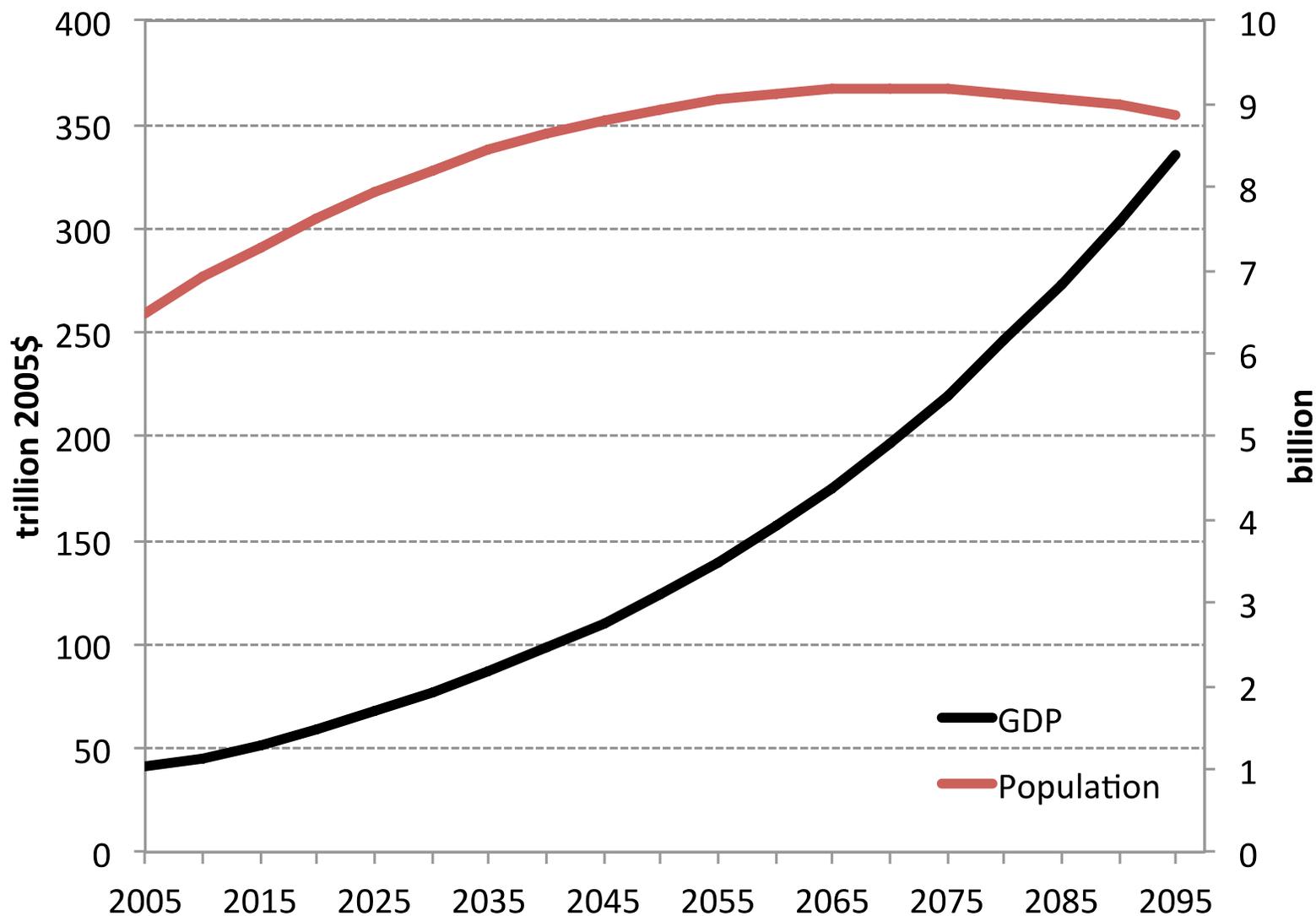


Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

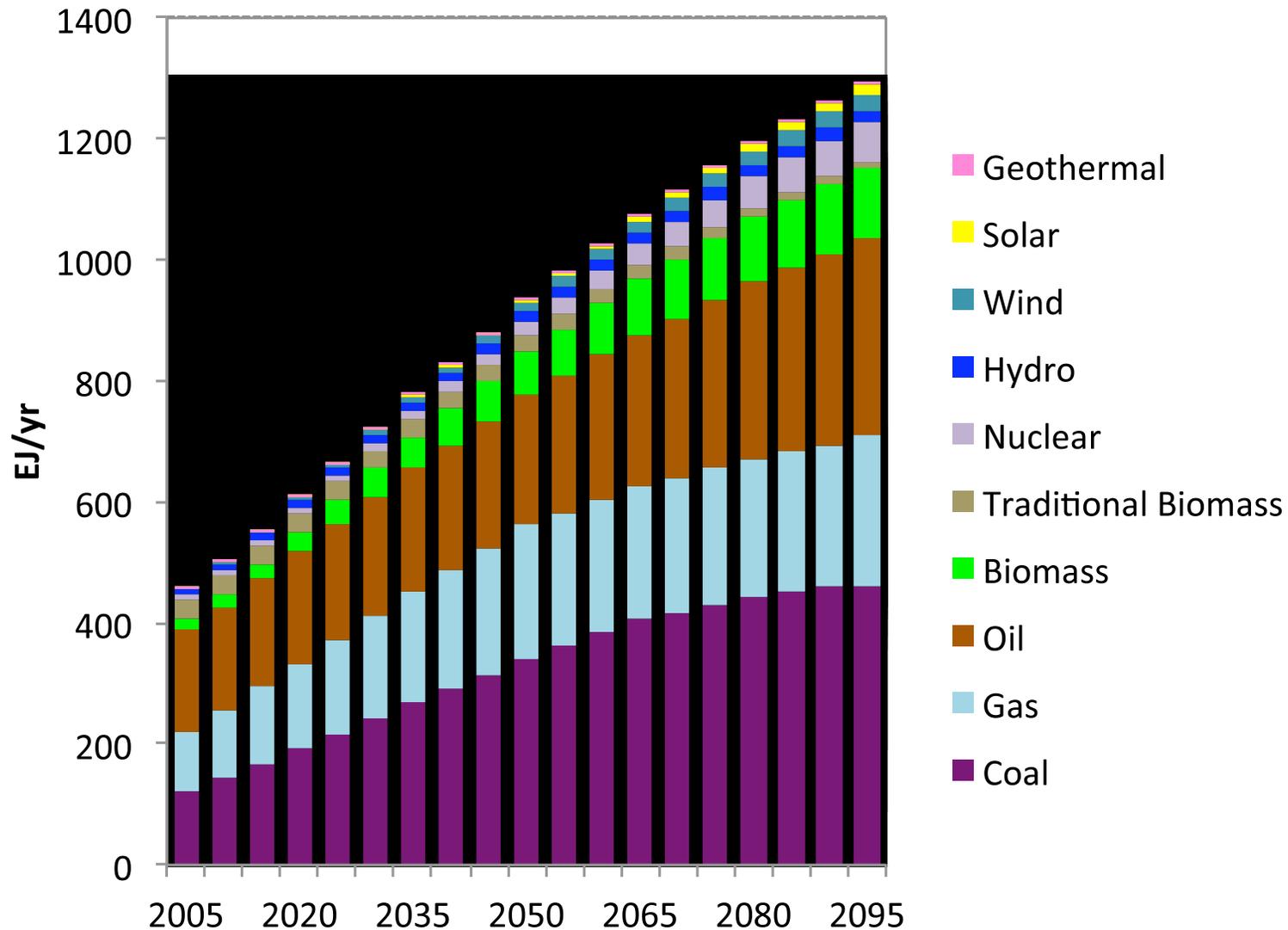
The GCAM Reference Scenario

Global GDP and Population



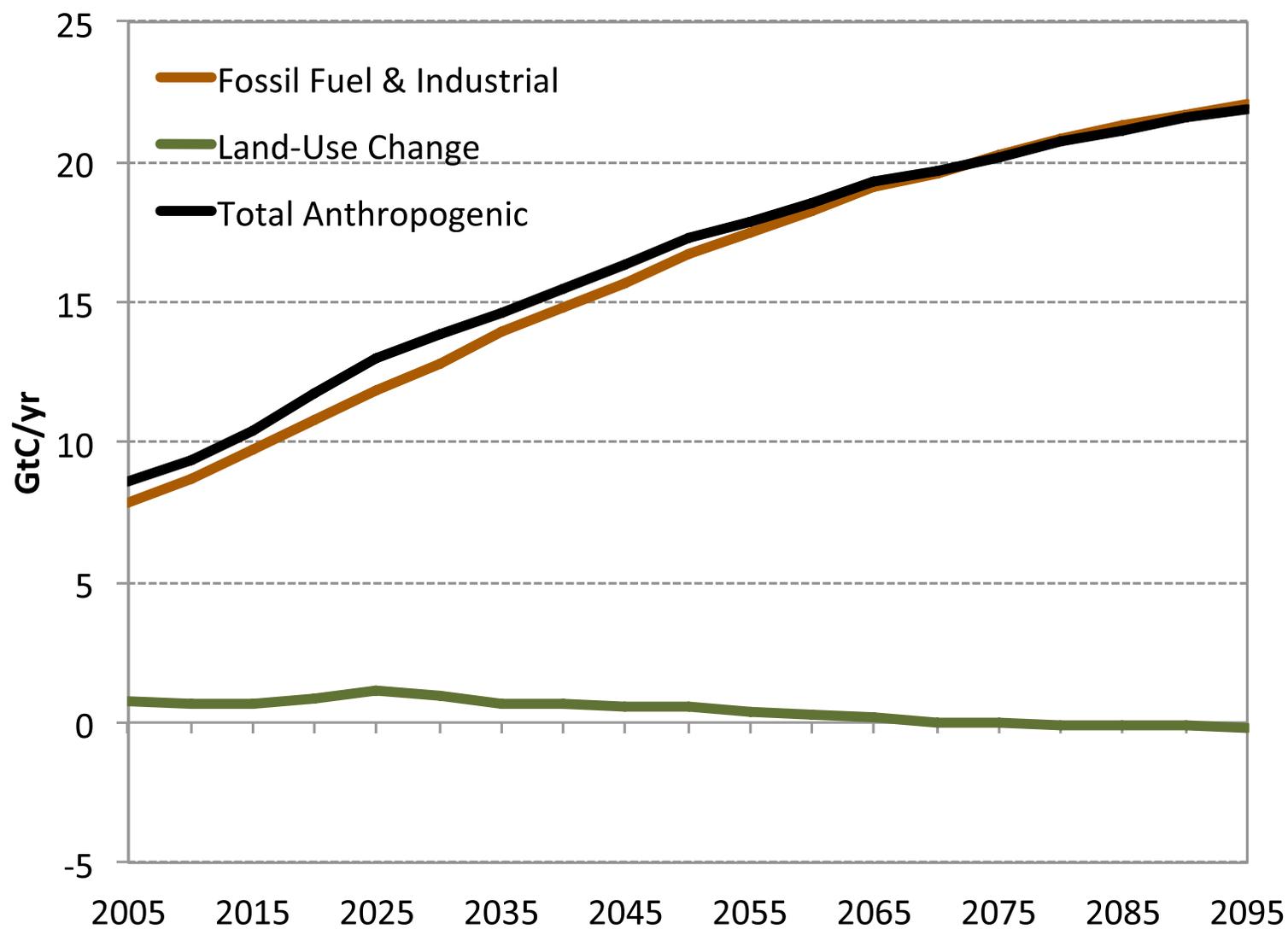
The GCAM Reference Scenario

Global Primary Energy Consumption



The GCAM Reference Scenario

Global Carbon Emissions

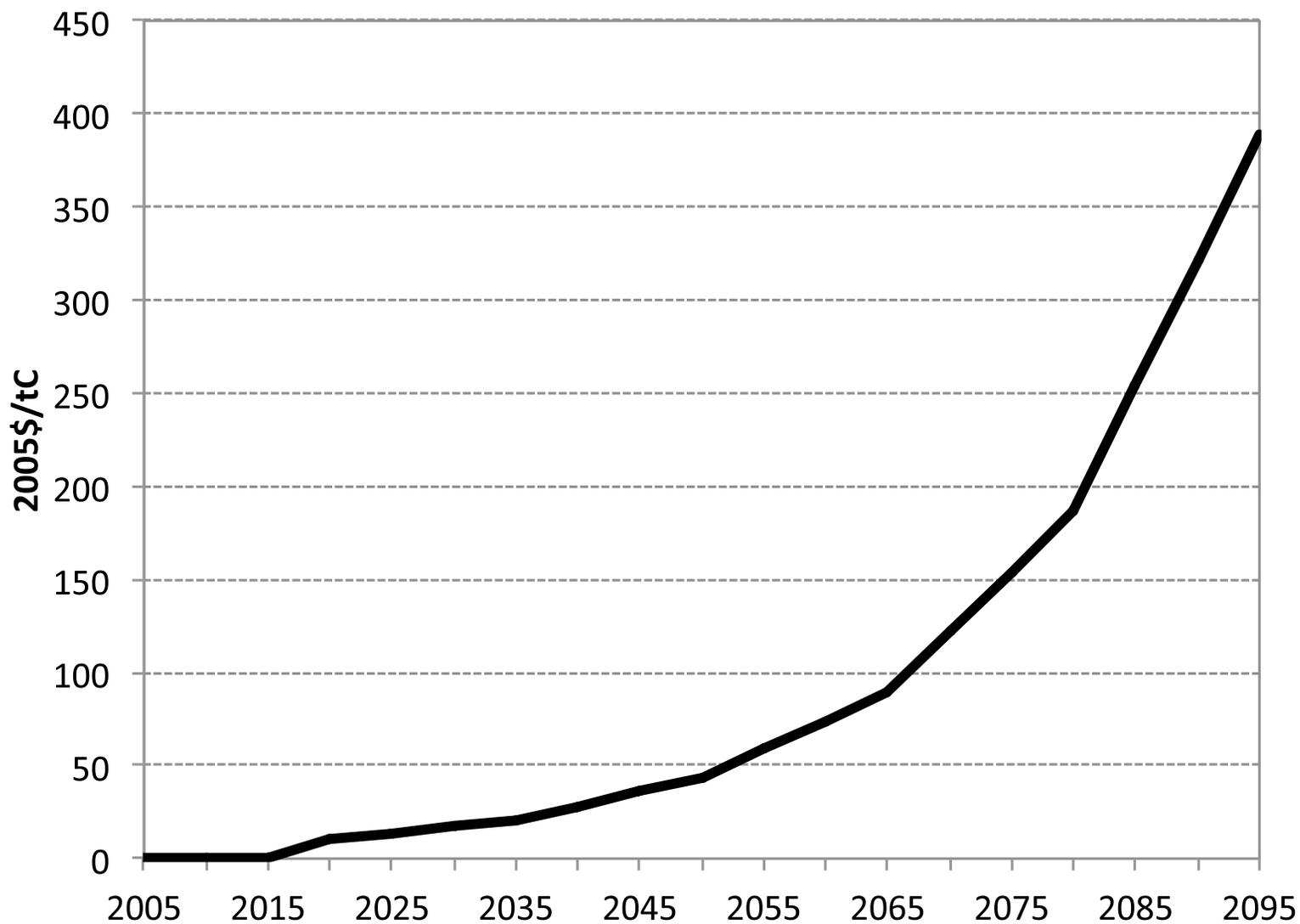


REDD in a climate policy scenario

ASSUMPTIONS

- ▶ There is a carbon price on all fossil fuel & industrial emissions in the world.
 - ▶ The price starts at ~\$7/tC in 2020 and rises at 5%/yr
- ▶ We assume that some fraction of forests are set aside in **carbon parks**.
- ▶ Carbon parks cannot be converted to managed ecosystems.
- ▶ Most other land (e.g., grassland, shrubland, pasture) is fungible.
 - ▶ Exception is tundra, rock, ice, desert, urban land

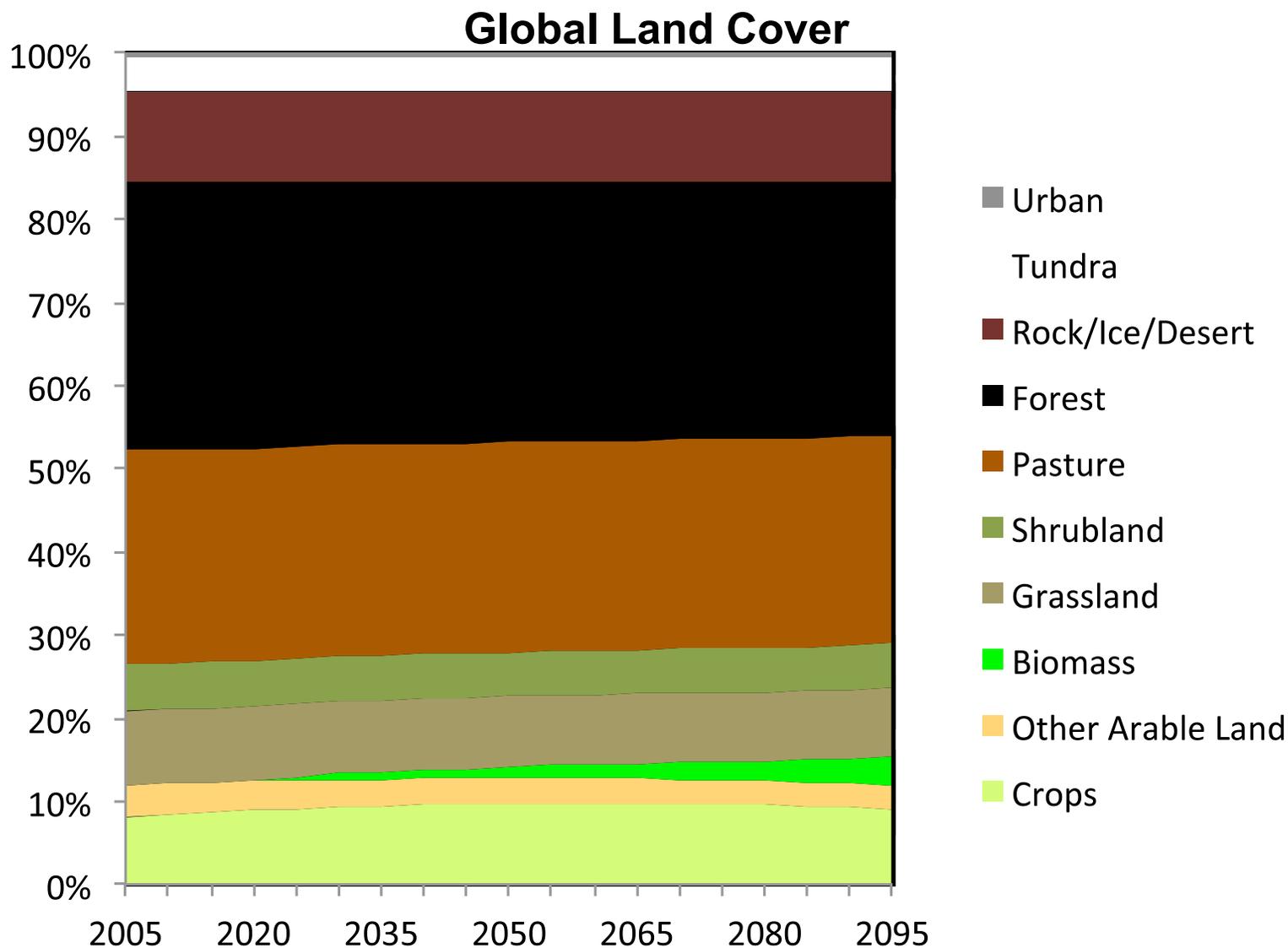
Carbon Price



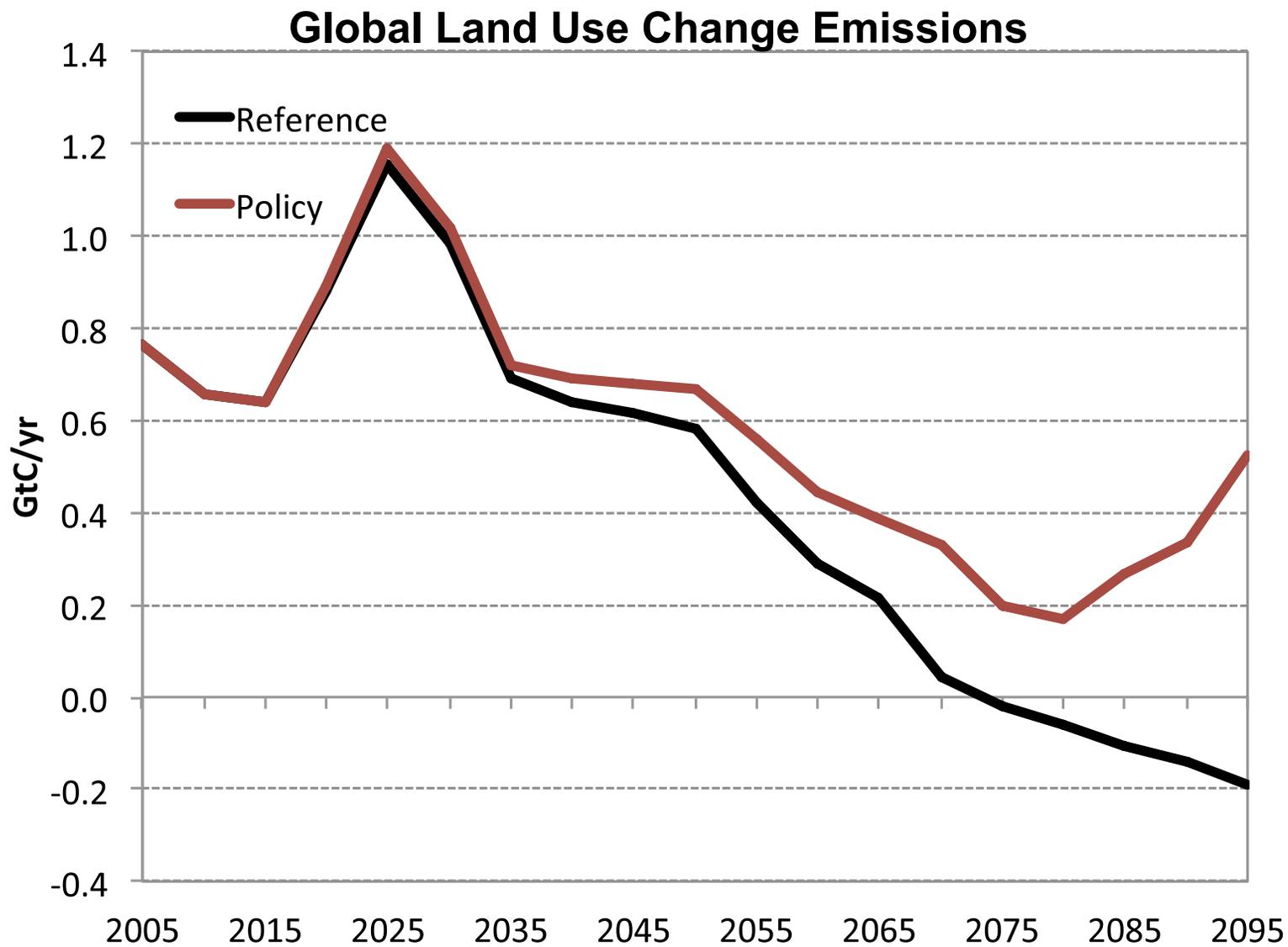
Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

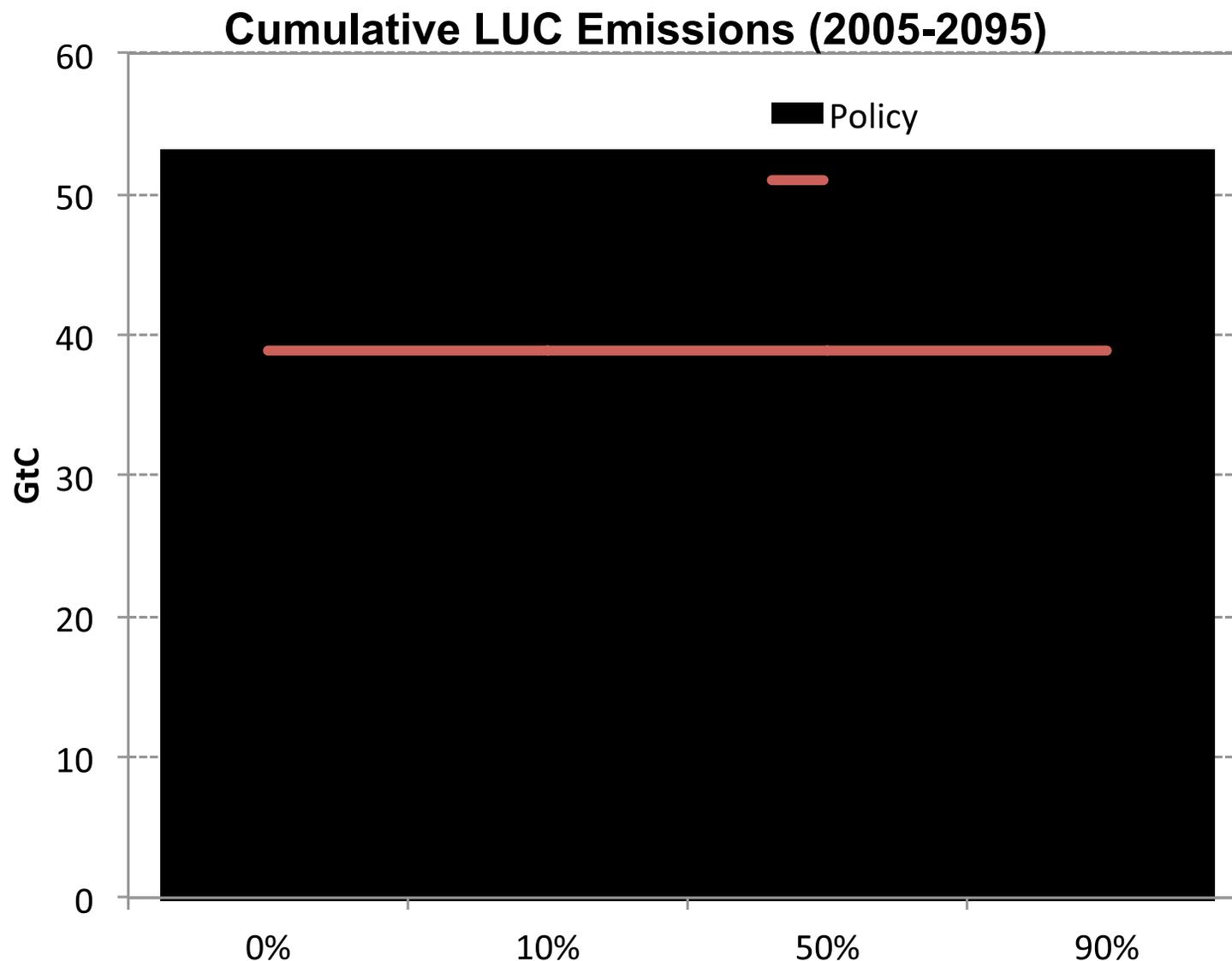
Imposing a Carbon Tax Increases Bioenergy Production at the Expense of Forests



As a result, LUC Emissions Increase

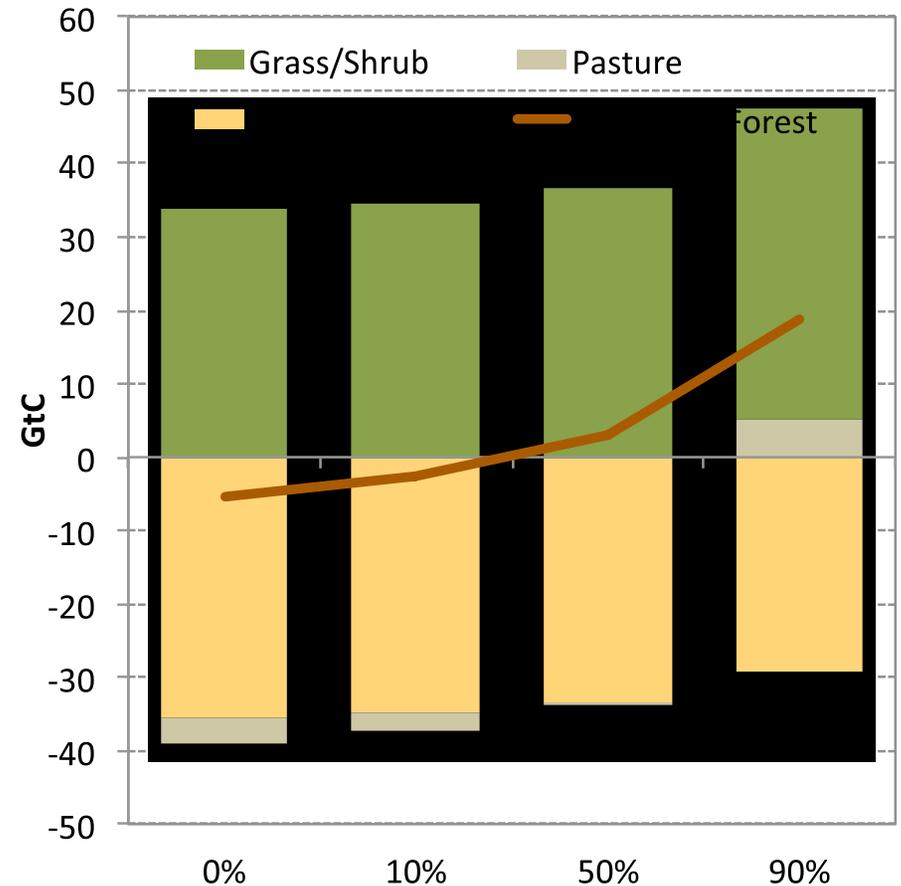
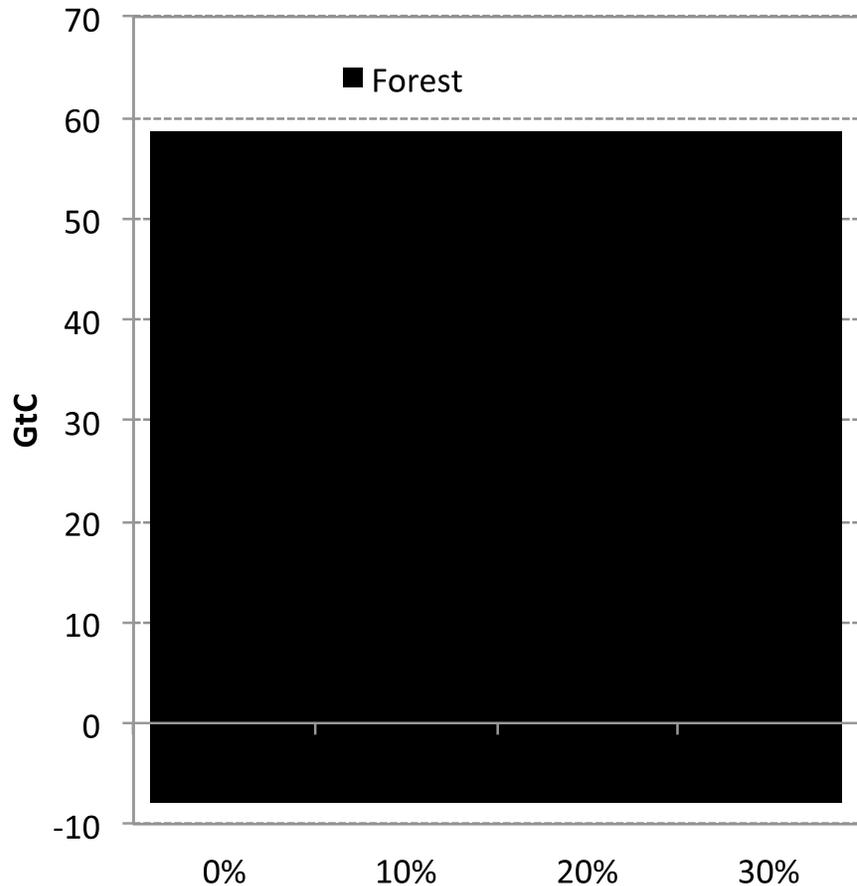


REDD Programs Reduce LUC Emissions, but They Do NOT Eliminate Them



When most forests are protected, managed ecosystems and bioenergy expand at the expense of other land types.

Change in Carbon Stock by Ecosystem(2005-2095)



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

What if...

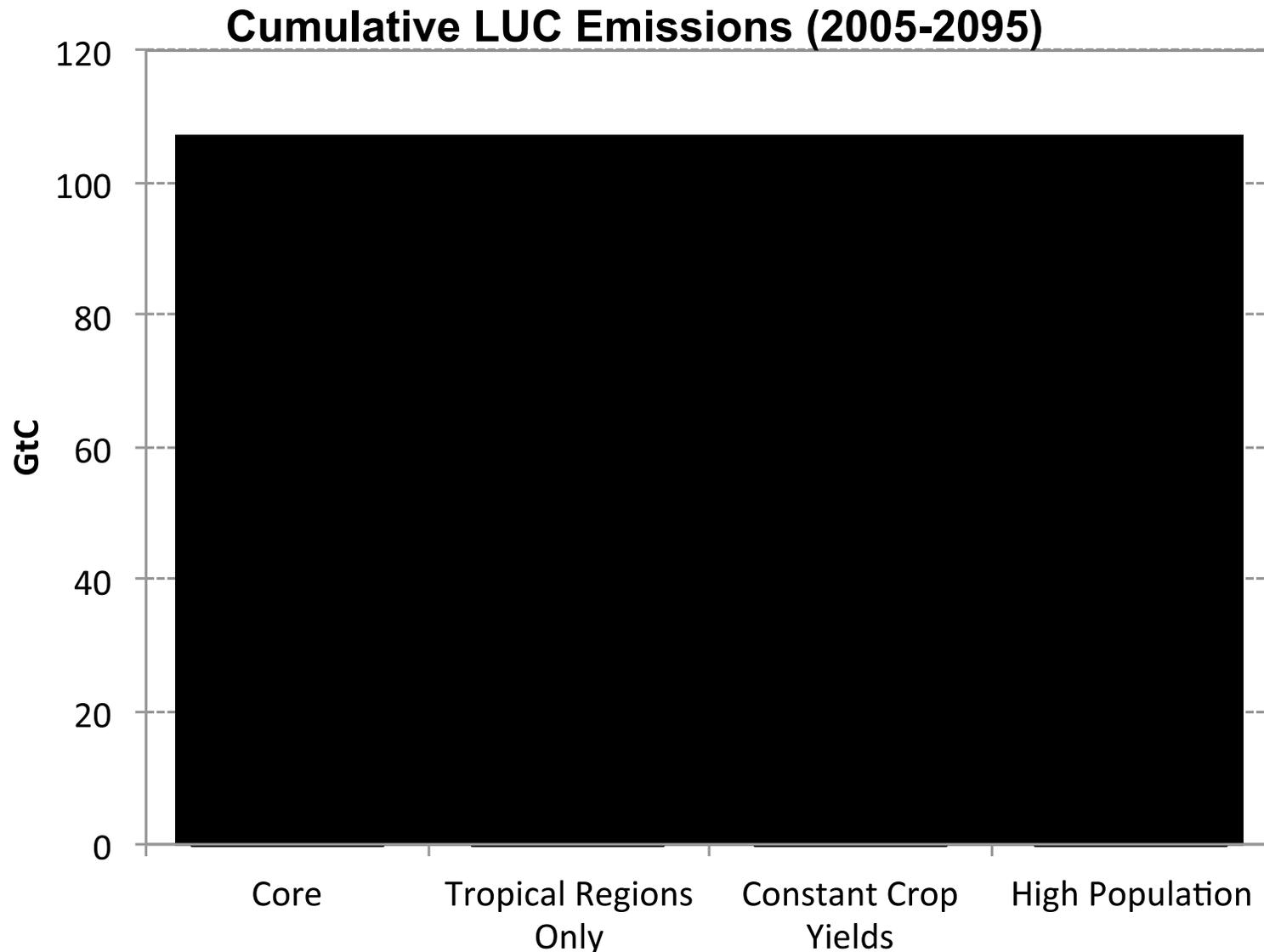
- ▶ We only implemented REDD programs in some regions (e.g., Africa, Latin America, Southeast Asia)
- ▶ Crop yields didn't improve beyond today's levels
- ▶ Global population grew to nearly 14 billion, instead of peaking and declining to 9 billion



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Without any REDD programs, higher population and lower crop yields increase LUC emissions



REDD programs reduce emissions, but not by much.

