The impact of land-use change on the vegetation carbon balance

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Introduction

In the last 300 years 42-68 % of the land surface was impacted by land-use activities

Land-use change alters the land surface affecting biogeochemical and biophysical properties.

Alterations to the land surface feeds back to the global climate

Understanding the impacts of land-use change is important in terms of climate mitigation.

Land-use change scenarios

Harmonized global land-use scenarios (1700 -2100)

Historical land-use from HYDE global land-use model (Hurtt et al, 2006)

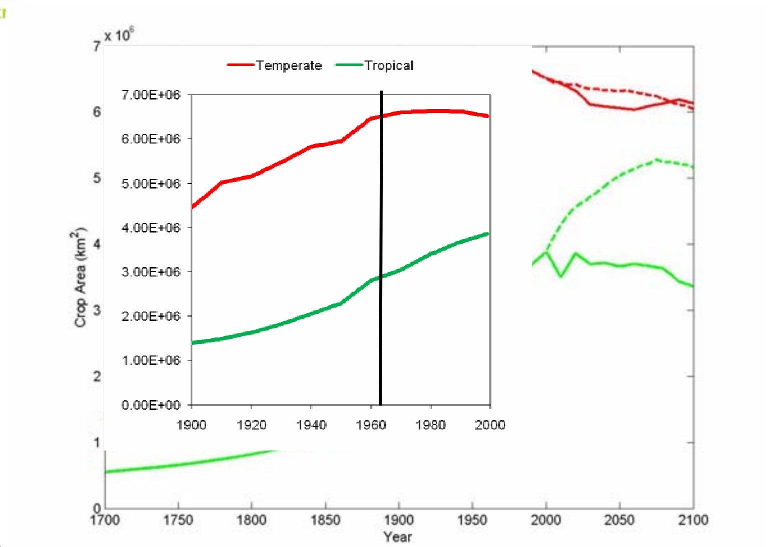
Projections from Integrated Assessment Models

- AIM
- IMAGE

Integrated to minimise differences between historical reconstruction and IAM initial conditions

Hurtt, G.C., S. Frolking, M.G. Fearon, B. Moore III, E. Shevliakova, S. Malyshev, S. Pacala, R.A. Houghton.2006. The underpinnings of land-use history: three centuries of global gridded land-use transitions, wood harvest activity, and resulting secondary lands. Global Change Biology ,12,1-22.

Land-use change scenarios



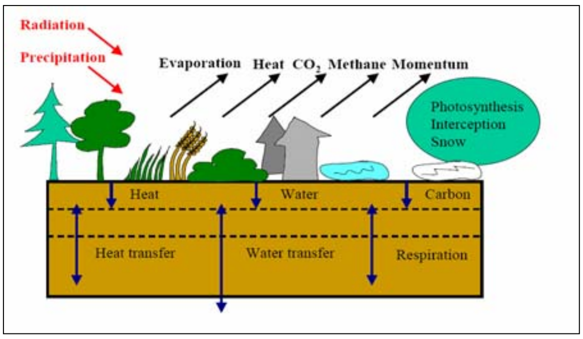
Aims and objectives

To investigate the impact of historic and future land-use change on the vegetation carbon balance

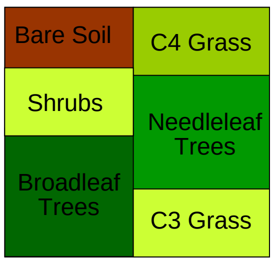
Use reconstructions/projections of cropland to force the JULES land surface model under a climate change scenario.

JULES – Land Surface Model

- Simulates surface exchange of heat, water, momentum and carbon
- Includes TRIFFID Dynamic Vegetation Model that represents the response of vegetation to climate change
- Same model used in Hadley Centre Climate Models

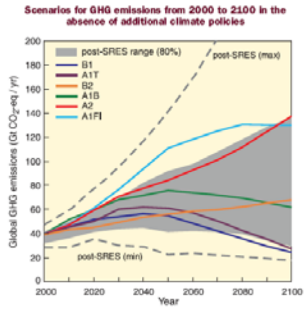


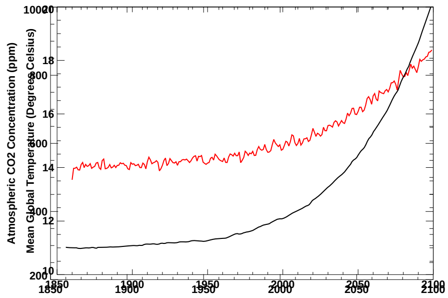
JULES Gridbox



Climate

- Hadley Centre GCM – HadCM3 with carbon cycle feedbacks
- Forced with an SRES A2 emissions scenario



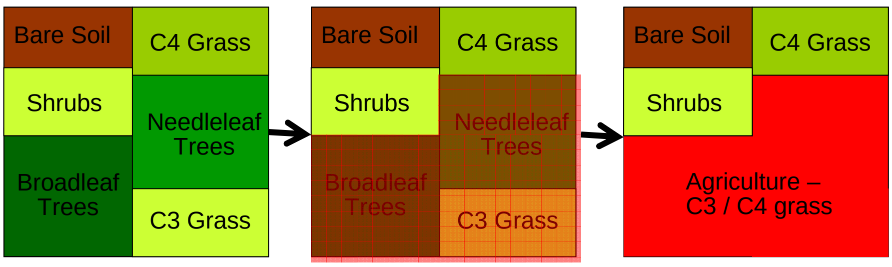


Incorporating land-use change

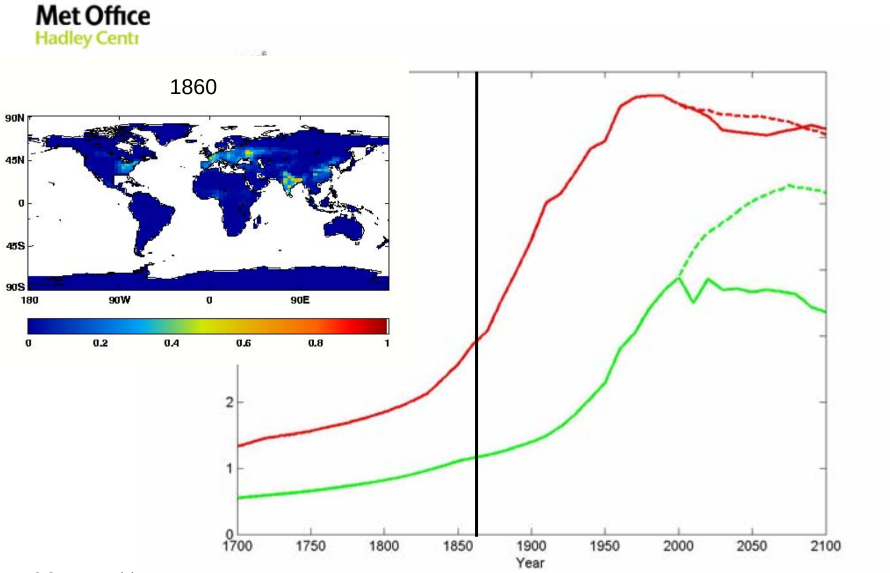
Only looking at changes in crop area (not pasture)

Updated annually

Land abandonment returns the grid box fraction to the dynamic vegetation model



Land-use change scenarios



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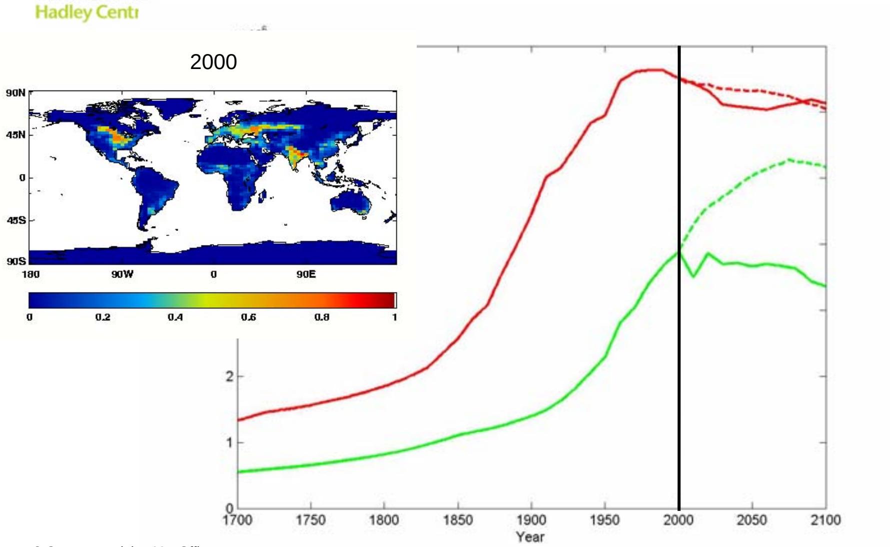

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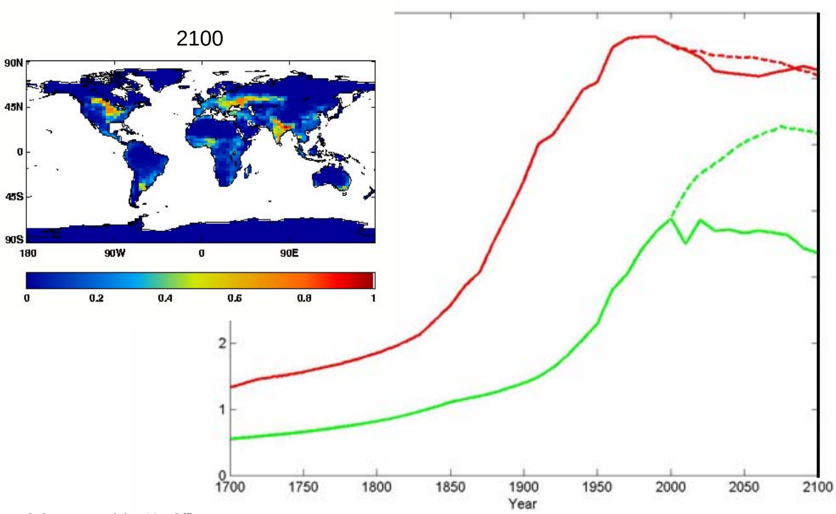
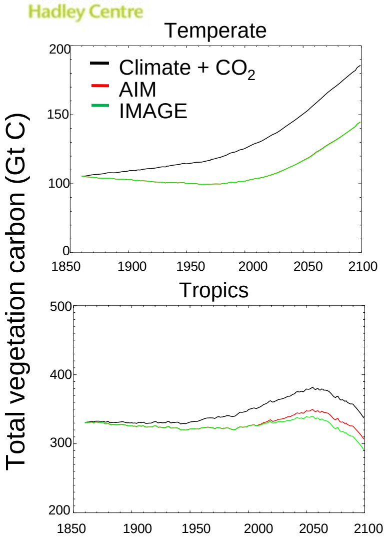


Impacts of land-use change on vegetation carbon

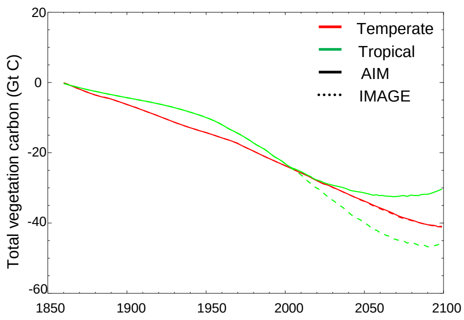


Climate change + CO_2 increases vegetation carbon.

Replacement of natural vegetation with crops reduces vegetation carbon.

Agreement between projections of land-use change also varies regionally

Impacts of land-use change on vegetation carbon



Land-use change reduced land carbon by similar amounts in the tropics and temperate regions despite lower area of cropland in tropical regions.

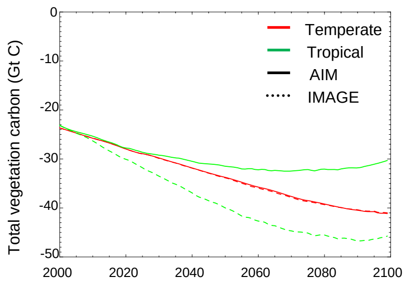
The IAMs differ significantly in projections of land-use change in tropical regions

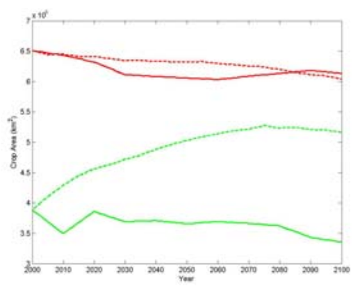
In the tropics there is a large potential for further carbon losses.

The impacts of land-use change are persistent.

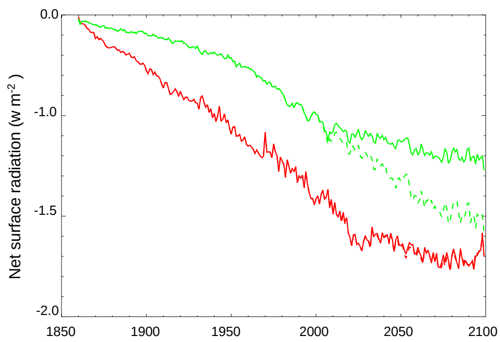
Replacement of natural vegetation with crops reduces the sink strength of the land surface thus the impacts of land-use change are persistent.

This has implications in terms of long term mitigation of climate change.





But it's not all about carbon…..



Replacement of trees with grasses increases the reflectivity (albedo) of the land surface

This has a local cooling effect. The impact is greater in the temperate region

Conclusions

Land-use change reduces vegetation carbon through direct emissions and reduced sink strength

Patterns of land-use change vary regionally but the impact of land-use change on vegetation carbon is comparable.

The IAM projections of future land-use change vary – What is the fate of tropical forests?

Impacts of land-use change on the carbon sink are persistent – Adaptation of agriculture is needed to mitigate climate change?