Global Land-Use Harmonization 1500-2300

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Introduction and Background

In preparation for the IPCC 5th assessment, the international modeling community is developing four Representative Concentration Paths (RCPs) using scenarios developed by four different Integrated Assessment Models (IAMs). These RCPs will be used as input for model runs by Earth System Models. The diversity of approaches and requirements among both IAMs and ESMs with respect to tracking land-use change presents a challenge for effectively passing data between these communities. In addition, the dependence of model projections on land-use history presents a challenge for smoothly transitioning from the historical estimates in ESMs to the future projections based on IAMs. Motivated by these challenges, we have initiated an interaction between IAMs and ESMs to provide a harmonized treatment of land-use data.

Prior Work on Global Land-use Modeling

Our previous research activities involved the development of a Global Landuse Model (GLM) to compute fractional landuse and landuse transitions past and future in 1 degree resolution gridcells , including the extent and spatial distribution of secondary/recovering lands. The model spatially allocates wood harvest and shifting cultivation activities using gridded historical crop and pasture data, national wood harvest demand, and region-based future data from IAM implementations of IPCC SRES scenarios as inputs.

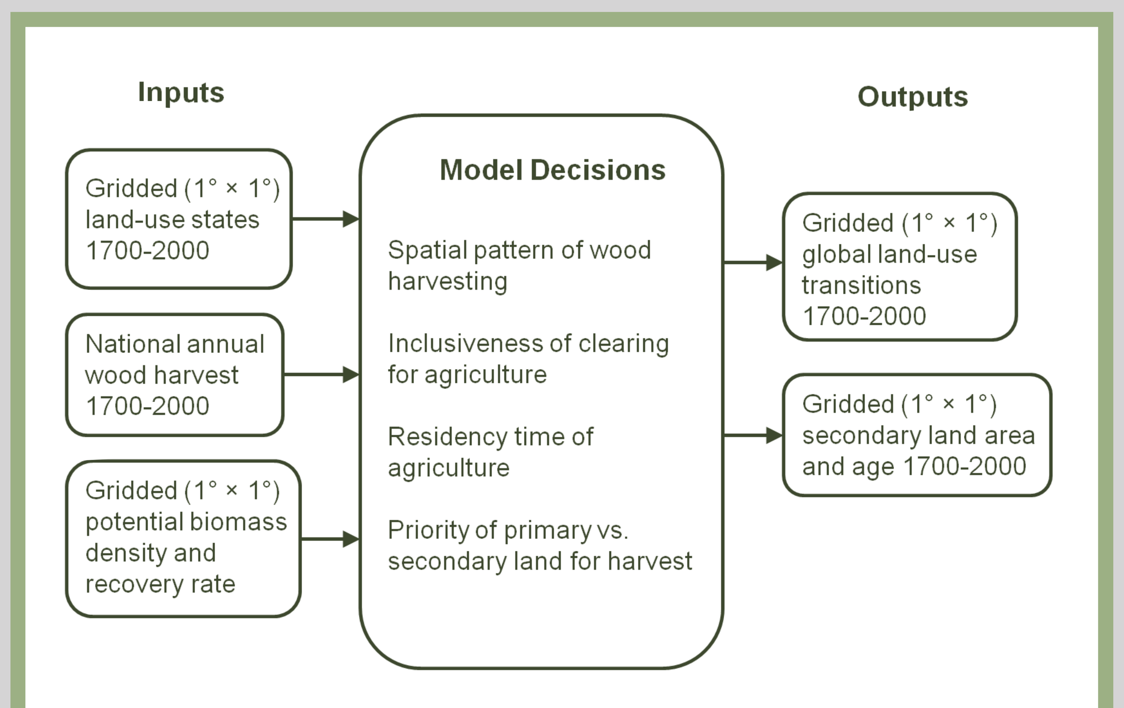

Figure 1: Flow diagram of inputs, outputs, and model decisions for our Global Landuse Model (GLM)

Key findings were:

- 40-60% of the Earth's surface has been modified by human activities
- Logging and shifting agriculture are primarily responsible for the creation of secondary/ recovering lands

A sample of our research results, based on the B1 storyline of the SRES scenarios, are shown in the figure below where the increasing area of global secondary lands can clearly be seen. For further details of our modeling approach and results, please refer to Hurtt et al. 2006.

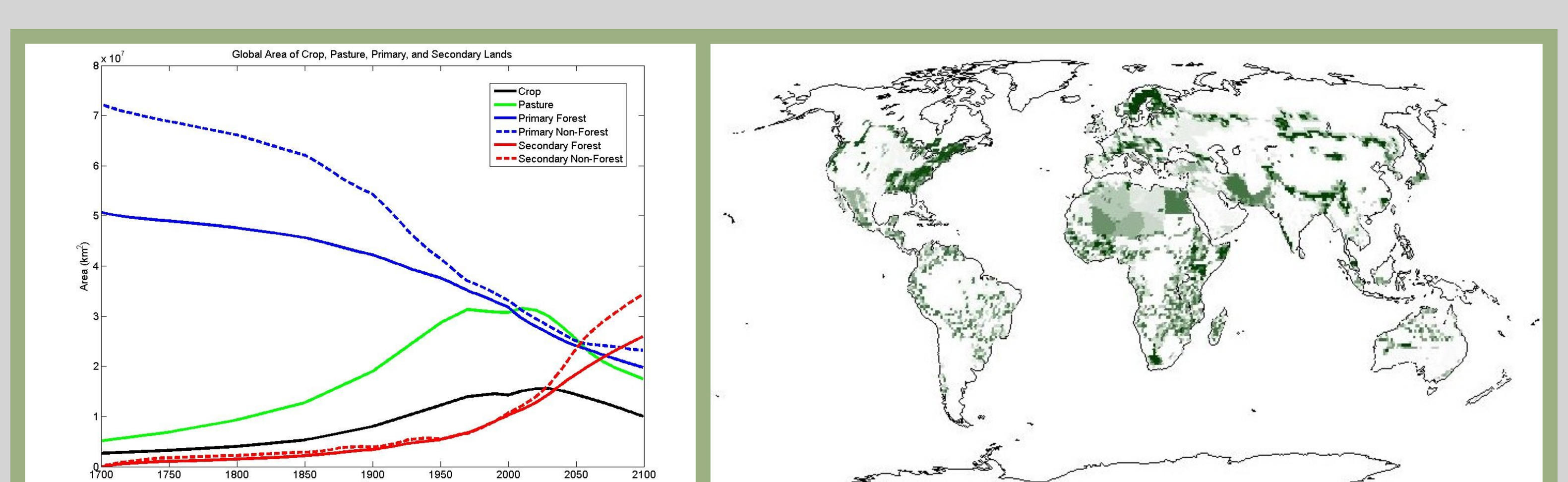

Figure 2: Results of previous GLM simulations showing (a) increasing area and (b) spatial extent of secondary lands. Future projections are based upon the IMAGE modeling team implementation of the IPCC SRES B1 storyline.

Harmonization Strategy

Based on the potential of our prior work with GLM we are now enhancing our abilities and working directly with IAM and ESM groups to harmonize land-use data between these communities. Our work process is shown in Figure 3 below. Climate and landuse are inherently coupled systems and although our GLM is not fully coupled to the ESM, in future research we plan to use ESM future climate data output in our models.

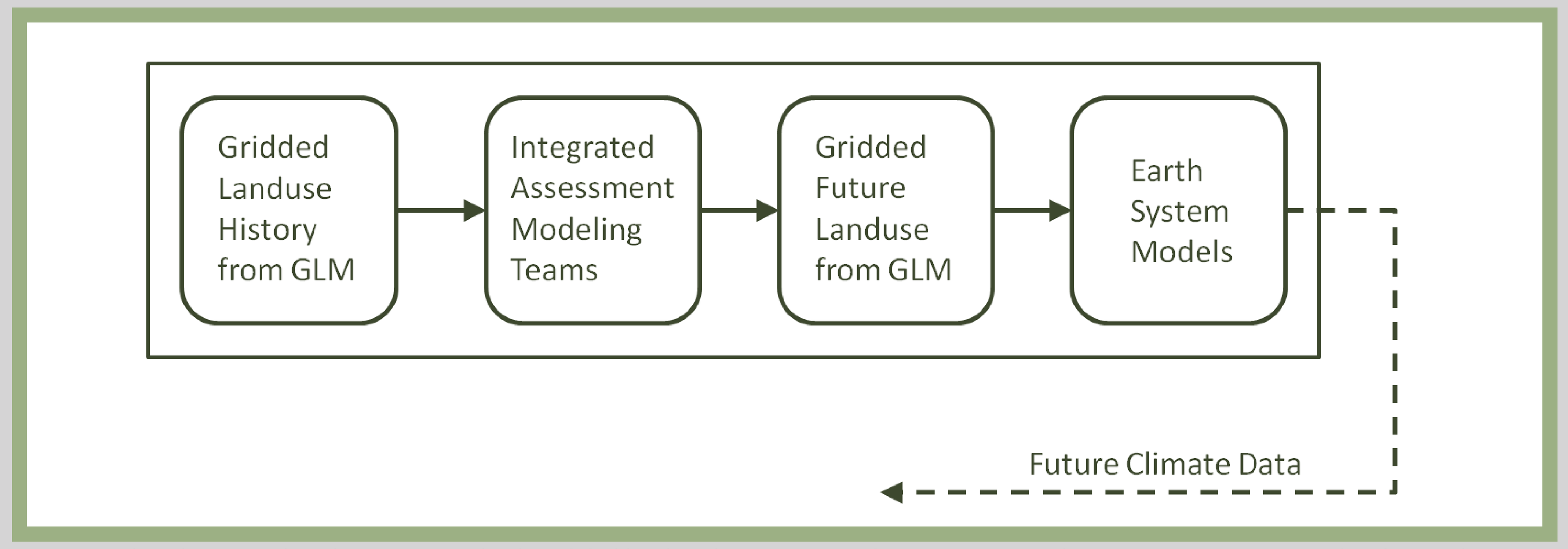

Figure 3: Flow diagram of work process involved in global landuse harmonization between IAMs and ESMs, using GLM. Note that future climate data output from ESM could be used as inputs into further GLM simulations.

Our harmonization strategy builds upon the method of Hurtt et al. 2006. Specifically it will,

- use gridded historical maps of crop and pasture data from HYDE 3.0 (Klein Goldewijk 2008);
- use new historical national wood harvest and shifting cultivation estimates, similar to Hurtt et al., 2006;
- use future crop, pasture, and wood harvest data from IAMs (maps and/ or regional data);
- use future climate and CO_2 data from IAMs;
- compute a set of gridded maps of land-use and underlying transitions using above inputs following the method of Hurtt et al. 2006, smoothly progressing from past, through present, to future.

Preliminary Results

Our preliminary work has focused on historical reconstructions of land use and land use transitions (including the effects of wood harvest and shifting cultivation) so that we could provide IAMs with gridded historical data for use as inputs to their models for generating future scenario data. Advances that have already been made upon prior work include

- Incorporating the new HYDE 3.0 data crop and pasture data
- Computing at half degree resolution (prior work was at 1 degree)
- Extending our historical computations back as far as 1500
- Creating an improved national wood harvest demand for 1500-2000

Our historical wood harvest reconstructions were computed by country and based upon data from FAOSTAT 2008, Houghton and Hackler 2000 (for USA) , Houghton and Hackler 2003 (for China) and Zon and Sparhawk 1923 (for 1920 wood harvest values). The wood harvest algorithms in GLM then use this wood harvest demand and spatially allocate harvesting activities by determining the overall suitability of each site for wood harvest and then harvesting from each, in order of suitability, until the wood demand for each country has been met. Preliminary results are shown in Figures 4 and 5.

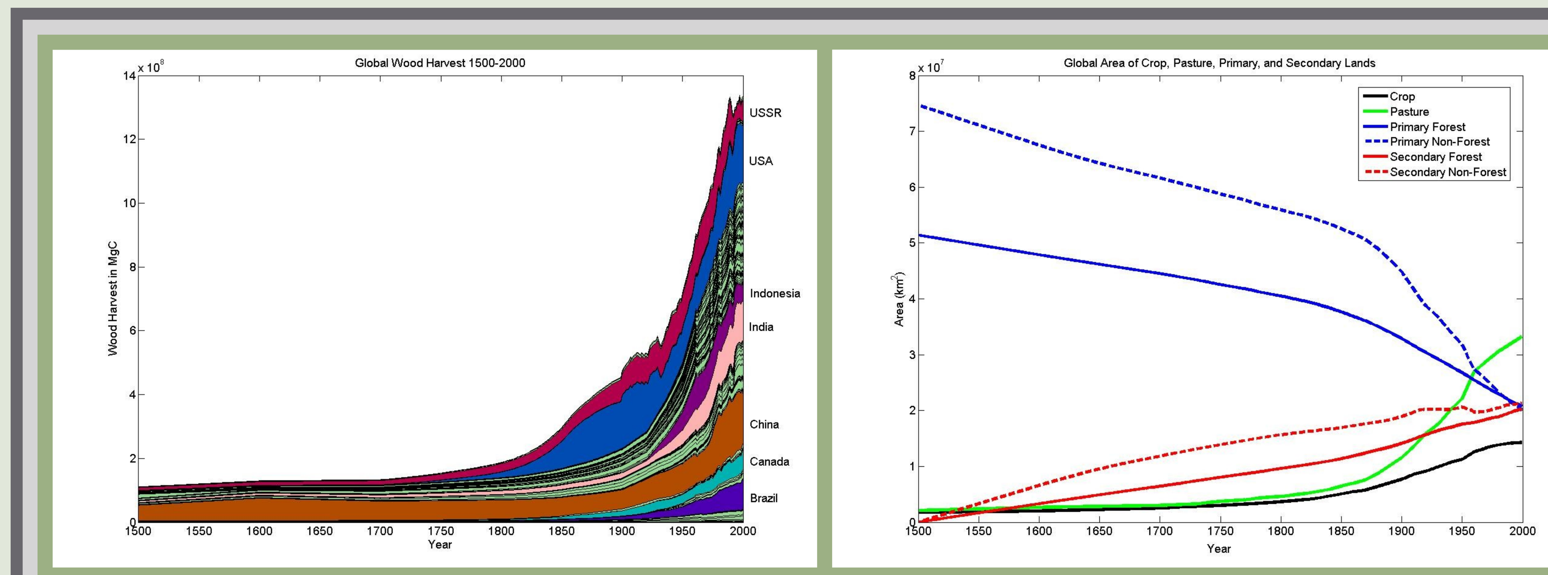

Figure 4: (a) Annual national wood harvest 1500-2000 showing the top seven wood harvesting countries in the year 2000.
(b) Time series of global land area of cropland, pasture, primary, and secondary lands 1500-2000

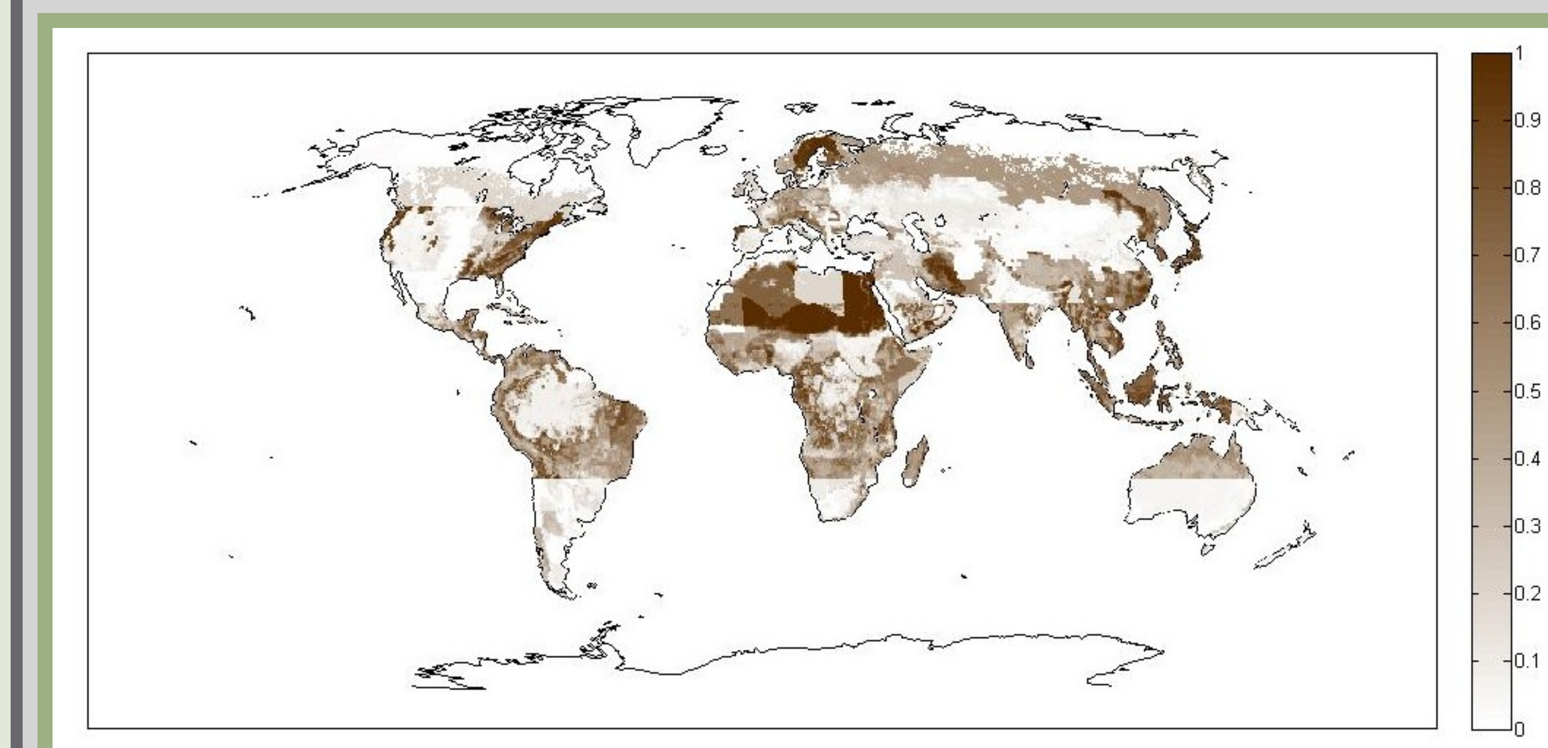

Figure 5: Global map showing fraction of each gridcell occupied by secondary land in the year 2000

Next Steps

By the early fall we aim to have generated gridded land use and landuse transition data for the years 1500-2300 (at half degree resolution). This data will then be used as inputs to various Earth System Models. Our future projections will be based upon data provided by several IAMs from implementations of the four Representative Concentration Paths. Challenges will involve ensuring that landuse data and landuse categories are consistent between the historical and future data and ensuring a smooth transition between them. The IAM future data can vary between region-based data and geographically explicit information and we will explore how this data can be used as inputs into our grid-based model —the various options available range from grid based anomaly methods to allocation procedures for regional data. In addition, we plan to implement an improved shifting cultivation algorithm, extend our projections to the year 2300, and include urban and plantation forest landuse categories.

Key References

Houghton and Hackler 2000, *Global Ecology & Biogeography*, Vol. 9
Houghton and Hackler 2003, *Global Biogeochemical Cycles*, Vol. 17
Hurtt et al. 2006, *Global Change Biology*, Vol. 12
Klein Goldewijk et al. 2008, in prep. http://www.mnp.nl/hyde

Acknowledgements

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