

Projections of Land-Use Change and the Carbon-Cycle

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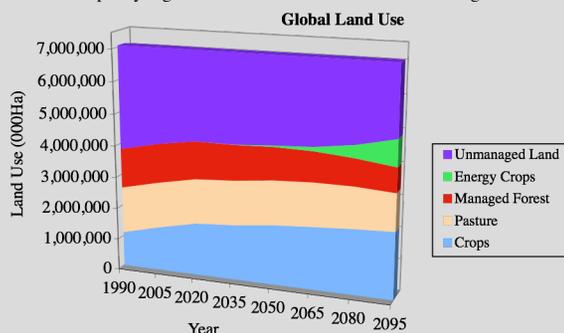
Project Summary

The carbon cycle has been substantially altered by human activities and this alteration is continuing globally. Projecting the future behavior of the carbon-cycle, and analysis of carbon management options requires a coupled analysis of the carbon-cycle and the socio-economic forces driving land-use changes.

This project will use remote sensing data products to improve the representation of the carbon-cycle within the O^bJECTS-MiniCAM framework (see center box). This will enable global and regional analysis of carbon dynamics, carbon sequestration potential, and coupled dynamics of the carbon-cycle and socio-economic systems. Both parametric uncertainty and uncertainty due to different model spatial definitions will be quantified. This project will:

- allow flexible analysis of different regions and sub-regions as needed;
- provide a capacity for analysis of regional carbon stocks under different technological, socioeconomic, and policy regimes;
- provide a consistent set of input data that can be easily updated;
- produce improved long-term emissions projections in terms of spatial and temporal detail, consistency with remote sensing data, and integration with socio-economic drivers; and
- allow analysis of the interactions between of carbon-cycle uncertainties and climate policy choices.

Below is a projection of global land use changes over the next century. This project will enable estimates, for example, of North American carbon stocks under different policy regimes consistent with these land-use changes.



Data Processing Tools

This project requires a method for translating spatially explicit data into the political regions and sub-categories (geographic, bio-geophysical, economic) needed by the integrated assessment model. Existing tools proved to be insufficient for this task so a new tool built on open-source and publicly available Java software components was constructed. This tool allows data in multiple input formats to be analyzed and output into model categories in a flexible fashion. An example analysis is shown at right (data sources include: Hansen *et al.*(1998); Ramankutty and Foley (1999), and Foley *et al.* (2003). Analysis results such as these can be output by the data tool in the form of regional and sub-regional values needed by the integrated assessment model.

The O^bJECTS Framework

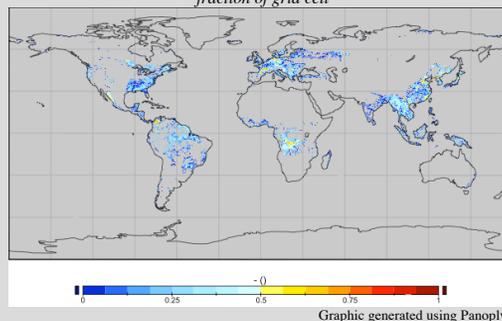
Integrated assessment models (IAMs), a class of decision support tools, draw together knowledge across disciplines as well as across multiple spatial and temporal scales. These tools (IAMs) are used to address issues such as: how much climate change is likely to occur in the future, quantification of the drivers of climate change (anthropogenic emissions, land-use changes, etc.), analysis of the mitigation costs, and the identification of technologies and policies that can reduce costs.

The philosophy behind the IAMs used at JGCRI is to implement representations of relevant economic and physical processes that are sufficiently detailed to provide a realistic representation of the relevant dynamics but simple enough that assumptions can be easily communicated. This allows the simulation of the complex behaviors that result from interactions among component systems, but enhances transparency and allows scenarios to be run in minutes, not hours or days.

Integrated assessment at JGCRI now uses the Object-oriented Energy Climate and Technology Systems, or O^bJECTS, Framework. The object-oriented model architecture (in C++) of the O^bJECTS framework is coupled with flexible XML (eXtensible Markup Language) data structures. This allows the structure of any given model run to be defined by input data rather than model code. While earth-systems models generally operate on a uniform spatial grid, our integrated assessment models operate in discrete geographical regions or sub-regions, corresponding to political rather than ecological or climatic boundaries. We will use the flexible architecture of the O^bJECTS Framework to incorporate spatially explicit input data to drive more aggregate regional (or sub-regional) land-use and carbon-cycle models. The effect of spatial resolution (for example the number of biomes or climatic zones represented per region) on model results will be examined.

Potential areas for re-forestation activities

fraction of grid cell

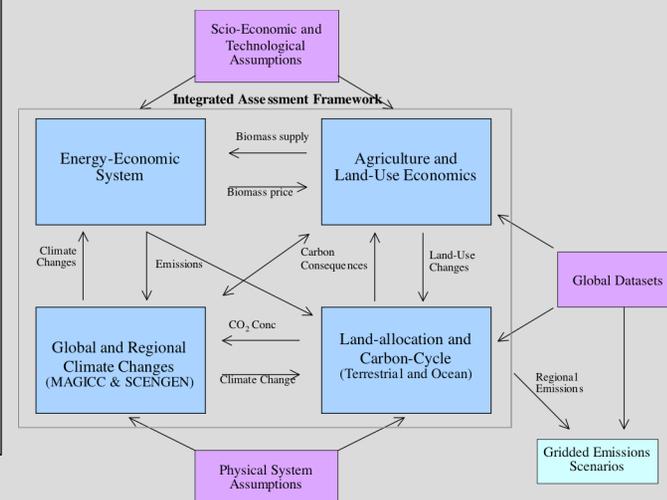


Technical Approach

The first phase of the project is the development of the carbon-cycle model. The requirements of this model include:

- 1) ability to reproduce within reasonable accuracy the results of more detailed models;
- 2) flexibility in terms of representing a range of potential carbon-cycle behavior;
- 3) fast enough to allow a coupled 100-year socio-economic and land-use scenario to run on a personal computer in seconds to a minute; and
- 4) integrated with (and ultimately extending) our energy, agriculture and land-use model components.

A schematic of the integrated system is shown below.



Different approaches will be tested and compared with the results of more detailed models such as VEGAS (Zeng *et al.* Umd). Sensitivity to model resolution and structure will be examined. One of the advantages of a relatively simple carbon-cycle model is that a wide range of uncertainties can be easily explored. Calibration to historical data will be used to constrain allowable parameter sets (including an ocean-carbon cycle component). In addition to parametric uncertainty, variations due to interaction with the socio-economic components of the system will also be explored.

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