Managing Sources and Sinks of Carbon in Terrestrial and Coastal Ecosystems

Soils, plants, and coastal marshes remove about one-third of fossil fuel emissions from the atmosphere. Understanding this sink, and how to control it, is a Climate Grand Challenge: a challenge for climate science, and for mitigation and adaptation.

- Where does this carbon go and how long can the sink last?
- How can we best store more carbon in plants and soils?

Terrestrial and coastal ecosystems offer great carbon storage opportunities.

- We can employ photosynthesis and soils to sequester carbon at lower costs than artificial systems. Plants are self-replicating carbon-capture machines and soils are healthier when they store more carbon.
- These projects have great additional benefits, particularly for economically struggling communities:
  - Improved agricultural yields in more robust soils
  - Better habitat for fish and animals
  - Better-quality water and food prevention
  - Preservation of traditional ways of life
- The cost of increasing uptake (or decreasing emissions) can even be negative in some ecosystems.

We address the gaps and barriers to large-scale terrestrial carbon solutions:

- Gaps in scientific knowledge that limit our ability to predict how interventions alter carbon stores
- Inability to accurately measure changes in stored carbon
- Lack of coherent frameworks for comparing interventions across ecosystems — environments that have different biological and physical dynamics with differing magnitudes and timescales of response to intervention

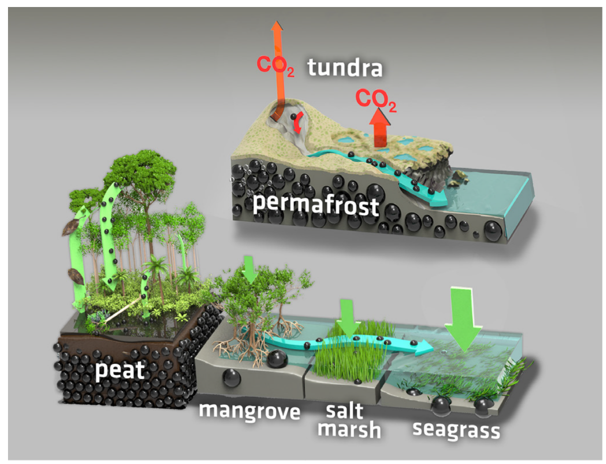
We will collect data and conduct experiments in targeted ecosystems:

- The Harvard Forest and agricultural sites in the Midwest provide testbeds for developing new scientific understanding, predictive models, and measurement methods.
- We target a Portfolio of Ecosystems because of their promise as carbon stores and because understanding their dynamics is important for understanding the global carbon cycle.

PORTFOLIO OF ECOSYSTEMS

Hydrologically Controlled Ecosystems

Huge fluxes of greenhouse gasses pass through wetlands, ecosystems that can be managed by engineering flows and vegetation.

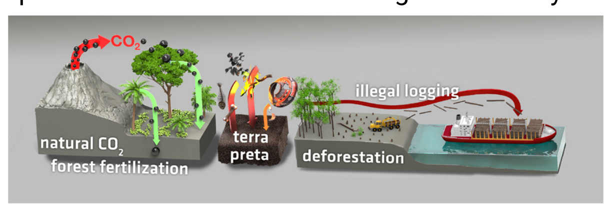


1. *Coastal marshes and seagrass* accumulate carbon produced in the ocean and upstream watersheds. We are working to restore coastal wetlands in Louisiana.
2. *Peatlands* sequester deposits of nearly pure organic carbon in slow-moving anoxic water. We will capitalize on MIT's unique field station in Borneo to develop schemes for increasing carbon stores in peatlands.
3. *Permafrost*: We are developing new approaches to predict potentially enormous releases of carbon from permafrost melting.

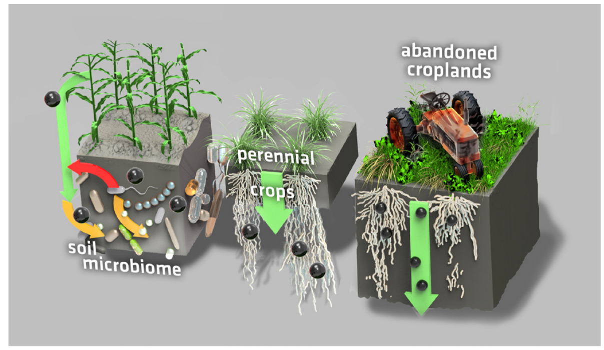
Forests

We are targeting three poorly understood aspects of forest carbon fluxes.

1. *Tropical forests* are largely absent from CO_2-manipulation experiments. We will take advantage of naturally occurring volcanic CO_2 to quantify CO_2 fertilization of above- and below-ground carbon in a Costa Rica rainforest.
2. *Illegal Deforestation*: We will develop schemes for controlling illegal deforestation by combining import/export data, satellite deforestation estimates, and game theoretic models of cheating.
3. *Terra Preta*: We will investigate the origin and biochemical explanation of Terra Preta, an ancient anthropogenic forest soil in the Amazon that stores huge quantities of carbon.



Agricultural Soils



Agriculture has severely depleted soil carbon, but may now offer the greatest potential for carbon sequestration

1. *Microbiome of Agricultural Soils*: We will leverage extensive field sites, stable isotope labeling, and high-throughput DNA sequencing to identify DNA biomarkers of effective soil regenerative practices and to seek probiotics for carbon uptake
2. *Aerobic/anaerobic Microbial Metabolisms*: We will identify management practices to maintain and increase soil carbon stocks by balancing aerobic and anaerobic microbial metabolisms.
3. *Perennial Agriculture*: We will develop perennial alternatives to commodity crops that create carbon sinks with deep and persistent roots and higher nutrient use efficiencies.
4. *Abandoned Agricultural Lands*: We will find the best strategies to maximize carbon sequestration across vast tracks of abandoned agricultural lands.

TEAM

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