Will we ever be able to accurately predict the future land carbon sink?

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But we can probably figure out what observational constraints are needed to better project its impact on future anthropogenic climate change.
Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO$_2$ during the Past Decades

By ROGER REVELLE and HANS E. SUESS, Scripps Institution of Oceanography, University of California, La Jolla, California

(Manuscript received September 4, 1956)

Because of the peculiar buffer mechanism of sea water, however, the increase in the partial CO$_2$ pressure is about 10 times higher than the increase in the total CO$_2$ concentration of sea water when CO$_2$ is added and the alkalinity remains constant (Buch, 1933, see reference).
The Concentration and Isotopic Abundances of Carbon Dioxide in the Atmosphere

By CHARLES D. KEELING, Scripps Institution of Oceanography, University of California, La Jolla, California

(Manuscript received March 25, 1960)
Seasonal Carbon Dioxide
2014 - 2015

October
April

January
July

Carbon Dioxide (ppm)
390 395 400 405
Mauna Loa Carbon Dioxide Record

Trend expected from fossil-fuel burning
Global carbon budget

The cumulative contributions to the global carbon budget from 1870

Figure concept from Shrink That Footprint
Fate of anthropogenic CO$_2$ emissions (2006-2015)

Sources = Sinks

- **34.1 GtCO$_2$/yr**
  - 91%  
  - **16.4 GtCO$_2$/yr**  
  - 44%

- **9%**
  - **11.6 GtCO$_2$/yr**  
  - 31%

- **3.5 GtCO$_2$/yr**
  - **3.5 GtCO$_2$/yr**  
  - 26%

- **9.7 GtCO$_2$/yr**

annual mean growth rate of CO₂ at Mauna Loa

ppm per year


February 2017
The carbon sources from fossil fuels, industry, and land use change emissions are balanced by the atmosphere and carbon sinks on land and in the ocean.

Keenan et al 2016
Forests in Flux

A. Surface energy fluxes
   - Direct solar radiation
   - Reflected solar radiation
   - Absorbed solar radiation
   - Longwave radiation
   - Latent heat flux
   - Sensible heat flux
   - Momentum flux wind speed
   - Transpiration

B. Hydrology
   - Precipitation
   - Interception
   - Evaporation
   - Transpiration
   - Throughfall
   - Stemflow
   - Sublimation
   - Infiltration
   - Surface runoff
   - Drainage

C. Carbon Cycle
   - Photosynthesis
   - Autotrophic respiration
   - Litterfall
   - Heterotrophic respiration

D. Vegetation dynamics
   - Competition
   - Disturbance
   - Establishment
   - Growth

E. Land use
   - Deforestation
   - Farm abandonment

Bonan 2008
UMD) simulate a sink/source transition for the land carbon flux. The source arising in the UMD simulation is mainly due to the fact that this model already simulates a very weak land carbon uptake in the uncoupled simulation (uptake of 0.3 GtC yr\(^{-1}\) for the 1990s and 1 GtC yr\(^{-1}\) by 2100). These two models are also the ones that simulate the larger atmospheric CO\(_2\) concentration by 2100, as the land is a source of CO\(_2\) at that time. This

![Figure 1](image)

Friedlingstein et al., 2006
* Climate effects on ecosystem carbon fluxes are shown only in qualitative terms. Individual fluxes might be affected differently by climate extremes (see text).
Light

Schaefer et al., 2012
Potential influence on future carbon trajectory

- Seasonal and diel variability
- Disturbance-recovery
- Interannual variability
- Impacts of global change
- Nutrient delivery to euphotic zone
- Initial value
- Planktonic community composition
- Disturbance regime shift
- Parameter space
- Vegetation dynamics
- Boundary conditions
- Carbon intensity
- Energy intensity
- Population growth
- Wind forcing
- Buoyancy forcing
- Energy intensity
- Economic growth
- Nutrient delivery to euphotic zone

Model attributes

Predictability

Yiqi Luo et al., NACP meeting
boots on the ground: flux tower sites

D18: Barrow Environmental Observatory - BARR