Ecosystem carbon balance in the Hawaiian Islands under different scenarios of future climate and land use change

Paul C. Selmants[1,6], Benjamin M. Sleeter[2], Jinxun Liu[1], Tamara S. Wilson[1], Parker C. Trauernicht[3], Abby G. Frazier[4], Gregory P. Asner[5]

Affiliations:

[1]U.S. Geological Survey, Moffett Field, CA, USA

[2]U.S. Geological Survey, Seattle, WA, USA

[3]University of Hawai'i at Mānoa, Honolulu, HI, USA

[4]The East-West Center, Honolulu, HI, USA

[5]Arizona State University, Tempe, AZ, USA

[6]Author to whom correspondence should be addressed

Email: pselmants@usgs.gov

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Abstract

The State of Hawai‘i recently passed legislation setting a goal to be carbon neutral by 2045. Meeting this goal will partly depend on carbon sequestration by terrestrial ecosystems, yet the future direction and magnitude of the land carbon sink in the Hawaiian Islands is highly uncertain. We used simulation modeling to assess how projected future changes in climate and land use will influence ecosystem carbon balance in the Hawaiian Islands under four unique scenarios over a 90-year timespan. Net ecosystem carbon balance declined under all four scenarios. Moving from a high to a low radiative forcing scenario reduced net ecosystem carbon loss by ~21%, and net carbon losses were reduced by a total of ~55% under the combined scenario of low radiative forcing and low rates of land-use change. A sensitivity test of the CO_2 fertilization effect on plant productivity revealed it to be a major source of uncertainty in projections of ecosystem carbon balance. Reconciling this uncertainty in how net photosynthesis will respond to rising atmospheric CO_2 will be essential to better constrainment of models used to evaluate the effectiveness of ecosystem-based climate mitigation strategies.

Introduction

Methods

Study area

The study area encompassed the terrestrial portion of the seven main Hawaiian Islands, a total land area of 16,464 km^2 (Figure 1). This land area was subdivided into a grid of 250 x 250 m simulation cells. Each simulation cell was assigned to one of 210 possible state types based on the unique combination of three Moisture Zones (Figure S1), seven Islands, and ten discrete land cover classes (Figure 1).

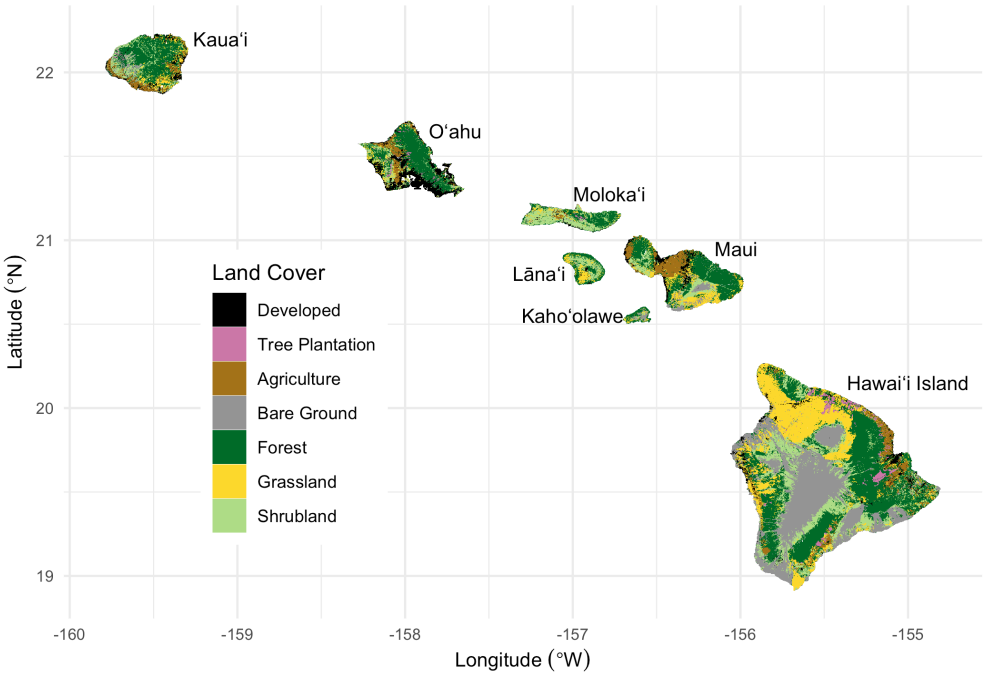

Figure 1: Land cover map of the seven main Hawaiian Islands, adapted from Jacobi et al. (2017). Agriculture in this map combines herbaceous and woody crops, but these two crop types are treated as separate land cover classes in the simulation model. Water and Wetland land cover classes are not shown.

States and transitions

Carbon stocks and flows

Initial conditions

Scenario simulations

Results

Discussion

Conclusion

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