

**Final Report for DOE Award # DE- SC0010039\*: Carbon Dynamics Of Forest Recovery Under A Changing Climate: Forcings, Feedbacks, And Implications For Earth System Modeling**

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\*Note: This award was initially through the University of Illinois (DE-SC0008085) and subsequently moved to the Smithsonian (DE-SC0010039).

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**Summary of Award Activity**

*Forest Carbon Database (ForC-db) Development*

To advance understanding of C dynamics of forests globally, we compiled a new database, the Forest C database (ForC-db), which contains data on ground-based measurements of ecosystem-level C stocks and annual fluxes along with disturbance history. This database currently contains 18,791 records from 2009 sites, making it the largest and most comprehensive database of C stocks and flows in forest ecosystems globally. The tropical component of the database will be published in conjunction with a manuscript that is currently under review (Anderson-Teixeira *et al.*, in review). Database development continues, and we hope to maintain a dynamic instance of the entire (global) database.

*Data Synthesis & Analysis*

We have used the tropical component of ForC-db to characterize C cycling in tropical forests varying in age and disturbance history (Anderson-Teixeira *et al.*, in review). Specifically, we present ensemble C budgets for young, intermediate, and mature tropical forests and examine age trends in biomass and other C cycle variables.

We expect that ForC-db will continue to prove useful for a variety of purposes related to model benchmarking and quantifying the contribution of forests to the global C cycle. For instance, we anticipate collaborations with the NGEE-tropics modeling team (e.g., Chonggang Xu, LANL) to use the tropical component of the database for model benchmarking.

*Forest Succession Modeling*

To understand how elevated CO<sub>2</sub> affect the long-term dynamics of forest regrowth, we modeled the dynamics of forest recovery using the mechanistic size- and age- structured Ecosystem Demography model (ED2; Miller *et al.*, in press). We applied the model to Duke Forest, drawing upon data from the FACE experiment, age chronosequence, and eddy flux towers for model parameterization and evaluation. We show that elevated CO<sub>2</sub> is likely to increase the rate of biomass accumulation and community turnover and to alter the successional pathway and mature forest composition. Model predictions of mature forest biomass and ecosystem-atmosphere exchange of CO<sub>2</sub> and H<sub>2</sub>O are sensitive to assumptions about nitrogen

limitation; both the magnitude and persistence of the ecosystem response to elevated CO<sub>2</sub> are reduced under N limitation. Regardless, our model simulations demonstrate that elevated CO<sub>2</sub> will result in a general acceleration of forest regeneration while altering the course of successional change and having a lasting impact on forest ecosystems.

### *Review Paper*

This award supported a review of evidence regarding the influence of climate and CO<sub>2</sub> on the dynamics of forest recovery (Anderson-Teixeira *et al.*, 2013). Multiple lines of evidence – including global-scale patterns in forest recovery dynamics; forest responses to experimental manipulation of CO<sub>2</sub>, temperature, and precipitation; forest responses to the climate change that has already occurred; ecological theory; and ecosystem and earth system models – all indicated that the dynamics of forest recovery are sensitive to climate. This implies that altered dynamics of forest recovery will result in positive and negative feedbacks to climate change.

### **Outcomes**

#### *Publications*

- Anderson-Teixeira, KJ, Wang, MMH, McGarvey, JC, LeBauer, DS (in review) Carbon dynamics of mature and regrowth tropical forests derived from a pantropical database (TropForC-db). *Global Change Biology*.
- Miller, A.D., Dietze, M.D., DeLucia, E.H., Anderson-Teixeira, K.J. (in press). Alteration of forest succession and carbon cycling under elevated CO<sub>2</sub>. *Global Change Biology*. DOI: 10.1111/gcb.13077
- Anderson-Teixeira, KJ, Miller, AD, Mohan, JE, Hudiburg, T, Duval, BD, DeLucia, EH (2013). Altered dynamics of forest recovery under a changing climate. *Global Change Biology*, 19, 2001-2021. DOI: 10.1111/gcb.12194

#### *Data Publication*

- Anderson-Teixeira, KJ, Wang, MMH, McGarvey, JC, LeBauer, DS (pending manuscript acceptance). Data from: Carbon dynamics of mature and regrowth tropical forests derived from a pantropical database (TropForC-db). Dryad Digital Repository.

#### *Conference Contributions*

- Anderson-Teixeira, K.J., Miller, A.D., Wang, M., McGarvey, J., Dietze, M, LeBauer, D, Duval, B.D., DeLucia, E.H. (April 2015) Carbon Dynamics of Forest Recovery under a Changing Climate: Forcings, Feedbacks, and Implications for Earth System Modeling. TES/SBR Joint Investigators Meeting, Potomac, MD.
- Wang, Maria, K.J. Anderson-Teixeira. (August 2015) ForC-db - A Global Forest Carbon Database. Smithsonian Conservation Biology Institute Student Research Symposium, Washington, D.C.
- Anderson-Teixeira, K.J., Miller, A.D., McGarvey, J., Dietze, M, LeBauer, D, Duval, B.D., DeLucia, E.H. (May 2014) Carbon Dynamics of Forest Recovery under a Changing

Climate: Forcings, Feedbacks, and Implications for Earth System Modeling. TES/SBR Joint Investigators Meeting, Potomac, MD.

Miller, A.D., Dietz, M., DeLucia, E., Anderson-Teixeira, K.J. (Dec 2013). American Geophysical Union Fall Meeting, San Francisco, CA.

Anderson-Teixeira, K.J., Miller, A.D., Duval, B.D., DeLucia, E.H. (May 2013) Carbon Dynamics of Forest Recovery under a Changing Climate: Forcings, Feedbacks, and Implications for Earth System Modeling. TES/SBR Joint Investigators Meeting, Potomac, MD.

Anderson-Teixeira, K.J., Miller, A.D., Mohan, J.E., Hudiburg, T., Duval, B.D., DeLucia, E.H. (Feb 2013) Altered dynamics of forest recovery under a changing climate. North American Carbon Program Meeting, Albuquerque, NM.

### *Organized Conference Sessions*

"Forest dynamics under a changing climate and their long-term context"; American Geophysical Union Fall Meeting (Dec. 2012) (Anderson-Teixeira, DeLucia, & Duval)

"Dynamics of global forests under a changing climate"; American Geophysical Union Fall Meeting (Dec. 2013) (Anderson-Teixeira, McMahon, & Detto)

"Global forest dynamics and interactions with a changing climate"; American Geophysical Union Fall Meeting (Dec. 2014) (Anderson-Teixeira, McMahon, & Detto)

### *Researchers Supported*

Adam Miller (postdoctoral research associate; August 2012- October 2015; UIUC and SI portions of grant)

Maria Wang (research assistant; July 2014-October 2015)

Jennifer McGarvey (research assistant; July 2013-July 2014)

Moein Azimi (undergraduate research assistant; May 2012-June 2014; UIUC portion of grant)