## 1) Project Title

Comparing and improving model estimates of forest carbon storage in northeastern forests

## 2) Principal Investigator and Graduate Student names and emails

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## 3) Brief overview of project timeline, goals, and objectives and comments on progress related to each category

The overarching goal of this project was to **to modify, improve, and test carbon storage models for the northeastern US.** This was an extension of an existing NSRC project, which proposed to use existing carbon models for a historical assessment of landscape scale changes in carbon storage across the northeast. Because these existing methods for calculating carbon storage at a landscape scale can be highly inaccurate in heterogeneous landscapes, funding from this grant allowed MS candidate Adams to develop and compare several approaches to carbon storage, including field validation of each. Specifically this involved the following research objectives:

- Develop new species-level carbon storage tables to improve the accuracy of existing carbon storage models ***(completed Fall 2015)***
- Compare output from the existing and improved models to quantify how the inclusion of species specific tables, linked with detailed species maps alters carbon assessments ***(completed Spring 2016)***
- Test the accuracy of the modified model using existing field inventory data. ***(completed Summer 2016)***
- Produce a peer reviewed methods paper to enable others to utilize the new scripts created as a part of this project. ***(in preparation, submission expected July 2016)***

## 4) Brief description of project methods

We calculated and compared carbon stored across the northern forest region at a snapshot in time (2014) using four different configurations of input spatial imagery and associated carbon storage values. From fine- to coarse-levels of detail, this includes:

1. "**Relative Basal Area**" (RBA): *percent basal area* by forest type, matched with *weighted*, species specific carbon storage values (Smith et al. 2006)

2. "**Species Associations**" (SA): *dominant species* or forest type classes, matched with species specific carbon storage values (Smith et al. 2006)

3a. "**IPCC Style**" (IS): *coarse forest type classifications* (e.g. broadleaf temperate, boreal conifer, other conifers), matched with carbon storage estimates from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories ("2006 IPCC Guidelines for National Greenhouse Gas Inventories" 2006); this approach is repeated three times based on the low, middle, and high carbon storage estimates provided by the IPCC

3b. **"Smith-based IPCC style"** (SIS): IS is repeated with Smith et al. (2006) tables designed to match the IPCC categories in order to control for inherent differences between carbon storage tables and isolate the impact of species specificity on carbon storage estimates

An independent accuracy assessment was developed from full stand inventories from Vermont Monitoring Cooperative allowed us to understand which models are over- or under-predicting and by what magnitude. This informs landscape scale assessments of carbon storage as an ecosystem service and allowed us to identify the most accurate method for additional modeling projects.

## 5) Highlight of overall project accomplishments to date

To date, all of the data collection, model development, analysis and accuracy assessment is completed. Findings indicate that traditional methods based on general forest types significantly under-predict carbon storage in the northeast (Figure 1). The higher specificity models, and the modified forest type models based on the more detailed Smith based carbon storage tables produced more accurate results, with no significant difference among the three. This indicates that higher specificity, species based carbon storage tables are necessary to accurately reflect carbon storage across the landscape. However, this may not require acquisition of species specific forest cover type maps for generalized regional or global carbon storage estimates. If however, spatial specificity is required, the more detailed, species composition maps will be necessary (Figure 2).

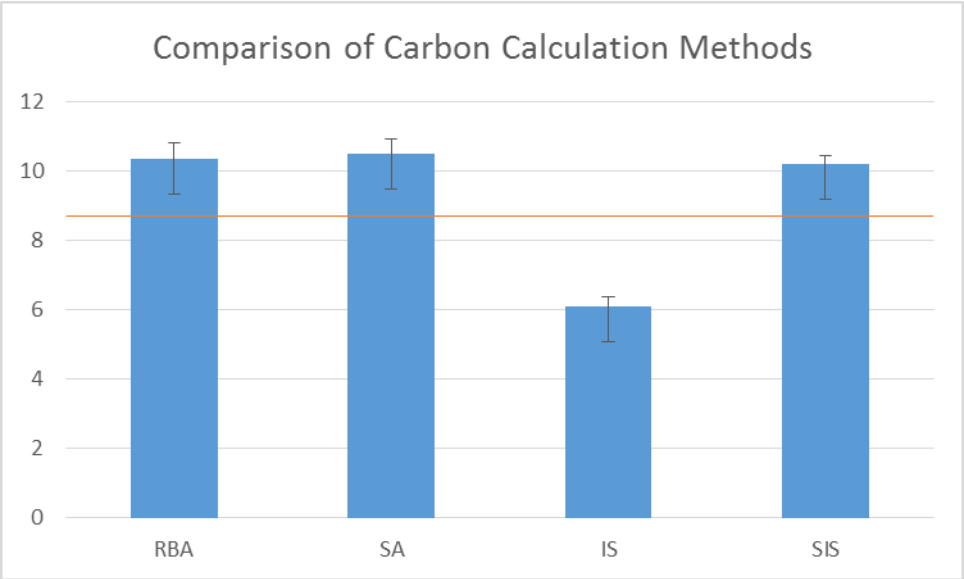


*Figure 1. Independent validation of mean Mg C predictions for each of the models compared. The orange line represents the actual (measured) mean carbon storage across all 26 plots.*

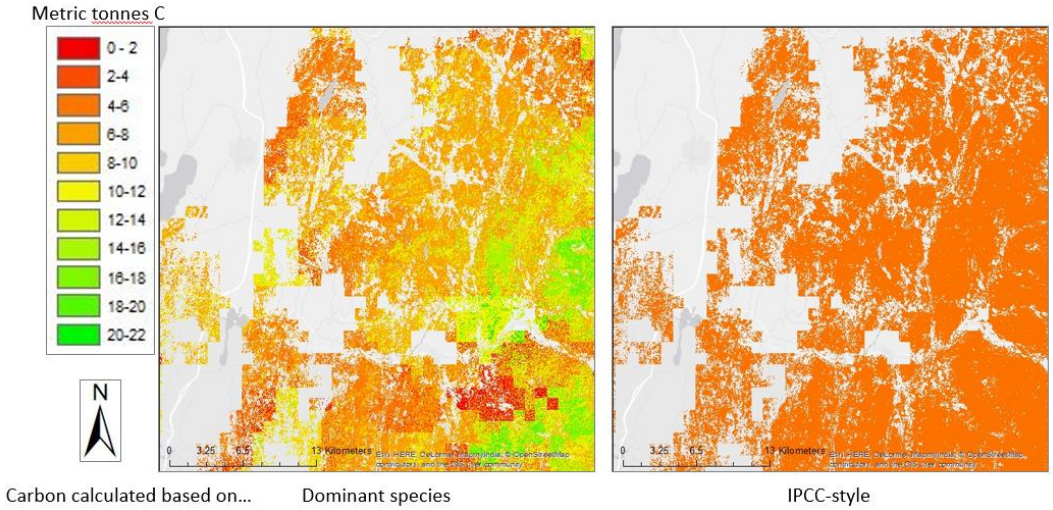


*Figure 2. Species specific models (left) vs. traditional gross forest type (right) models of carbon storage. If spatial variability in carbon storage assessments is desired, species specific models will need to be employed.*

Ongoing work includes the preparation of a peer reviewed manuscript, which is planned for submission in July of 2016. Model output maps of forest carbon storage for the northeast region are also nearing completion and should be available online at the VMC website by August 2016.

## 6) Project relevance for the Northern Forest region. What difference does this research make and to whom? (specify stakeholders)

Accurately measuring carbon stored in forested landscapes is crucial to understanding how changes in land cover may affect global carbon cycles. This work will be of interest to many researchers and modelers interested in improving regional and global carbon assessments. Improved carbon assessments can also inform decisions about land use by identifying valuable conservation areas of unusually high carbon storage. The maps produced as a part of this project will be made publically available via the Vermont Monitoring Cooperative web site by the end of August. Additionally, improved assessment of stored carbon could alter estimates of the value of conserved forestland in carbon markets, which could be of interest to forest managers, foresters and private land owners. These maps will also be incorporated into a spatial decision support tool currently under development via the UVM MacIntire Stennis research program and should be available for widespread use by early 2017.

## 7) List of any and all project products *and* outcomes (current and/or projected) such as publications, webinars, conferences, journal articles, brochures, policy changes, behavior changes, etc.

- **Completed Presentation:** Adams, A., Pontius, J., and Galford, G. 2015. Landscape-scale carbon storage in Vermont (poster). Ecological Society of America Annual Meeting. August 12, 2015. Baltimore, MD.
- **Completed Presentation:** Adams, A, Pontius, J., Galford, G., and D. Gudex-Cross. 2015. Calculating carbon storage in the Northern Forest: a methods comparison (presentation). Vermont Monitoring Cooperative Annual Meeting. December 11, 2015. Burlington, VT.

- **Completed Proceedings**: Adams, A. Calculating carbon storage in the Northern Forest: a methods comparison. 2016. In: Pontius, J., M. Pendleton, J. Rosovsky, J. Duncan, and C. Waite (Eds.) 2016. 25 Years of Forest Ecosystem Monitoring: Trends, Patterns and Lessons Learned. Proceedings of the December 11, 2015 Vermont Monitoring Cooperative Conference: Burlington, VT, Vermont Monitoring Cooperative. p. 61. Available online at http://www.uvm.edu/vmc/annualMeeting/2015/proceedings.
- **Peer Review Publication estimated submission July 2016.** Adams, A, Pontius, J., and G. Galford. In preparation. Calculating carbon storage in the Northern Forest: a methods comparison. Global Change Biology. xx(x): xx-xx.
- **Carbon mapping products estimated availability August 2016**. Adams, A, Pontius, J., and G. Galford. Forest carbon storage maps of the northeastern US. Vermont Monitoring Cooperative Database and Web Portal.