Big Data for Big Questions:
Global Soil Change and the National Soil Carbon Network

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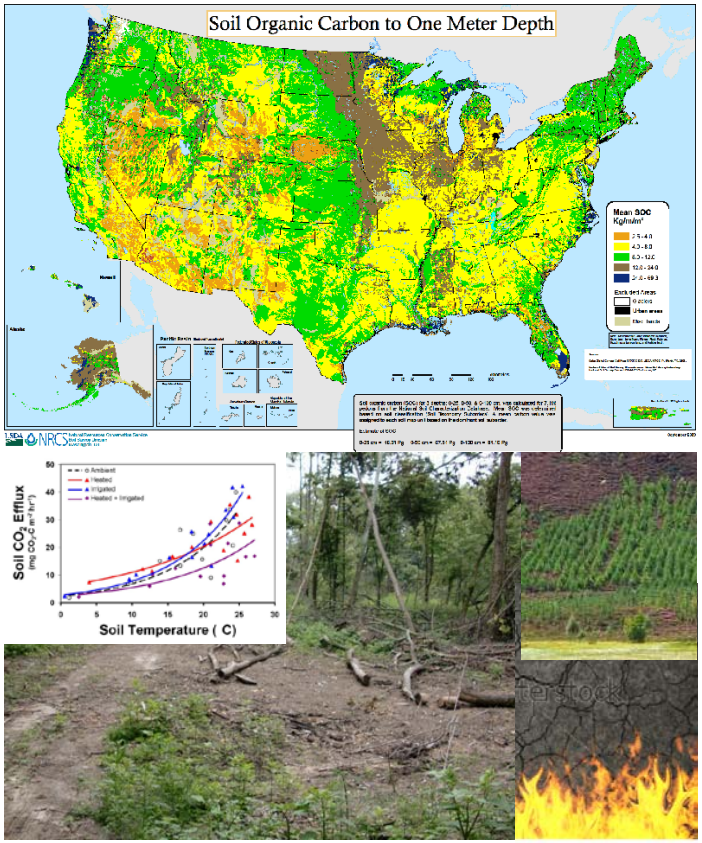
Session B33. Global Soil Change: New Frontiers for the Biogeosciences

Global Soil Change

The questions are as big as the topic.

- How much soil C exists and where is it stored?
- What are the direct effects of climate change on soil C stocks and turnover?
- How do indirect effects of climate change affect soil C?
- How do other human drivers affect soil C storage?



Studying Global Soil Change

<u>Many questions are **too large to answer working alone.**</u>

Soils are highly variable across space and time, so:

- Replication and resampling are important
- Large datasets are necessary to detect patterns, even in a single study
- <u>Individual studies</u> lack <u>broader perspective</u>

Good for understanding specific mechanisms

Vital for assessing larger patterns of change

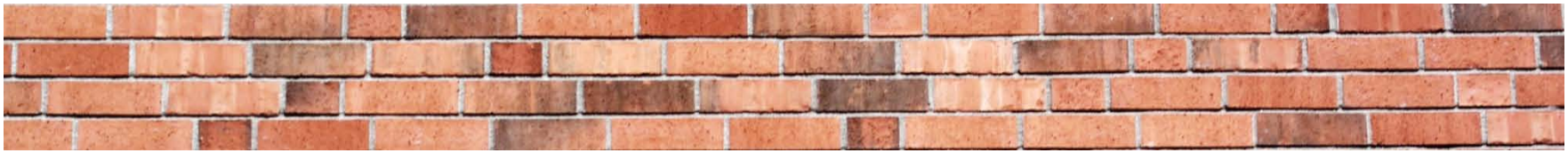
Synthesis and Networks

two ways to apply individual primary studies to bigger questions

- Synthesis: bring in basic data from individual studies, identify and quantify general patterns

- Networks: link isolated studies into larger frameworks; test generality of mechanisms developed from individual studies

These are effective means for addressing big questions of global soil change, but we must use them more if we want answers.



Using Research Synthesis to Answer Big Questions

- First disclaimer: synthesis is not possible without lots of primary research!
- Second disclaimer: systematic review is a form of synthesis, but relies too much on expert judgment and narrative and not enough on quantitative statistics.

Conducting Quantitative Synthesis

Same steps as primary research, different data sources

1. Identify questions of interest
2. Protocol to define data collection procedure
3. Collect data: survey literature, make bibliography, build database
4. Analyze data: vote-counting, correlations, meta-analysis, ecosystem modeling
5. Answer questions, identify data gaps, and make predictions

Big Answers for Big Questions

(some examples)

- Topic: literature synthesis/meta-analysis, effects of forest management on soil C storage
- Support: USDA-Forest Service, Northern Research Station, 2006-present
- Participants: Peter Curtis, Alex Friend, Knute Nadelhoffer, Luke Nave, Chris Swanston, Eric Vance
- Scope: temperate forests; afforestation, fire, harvest, N inputs, >6500 references checked

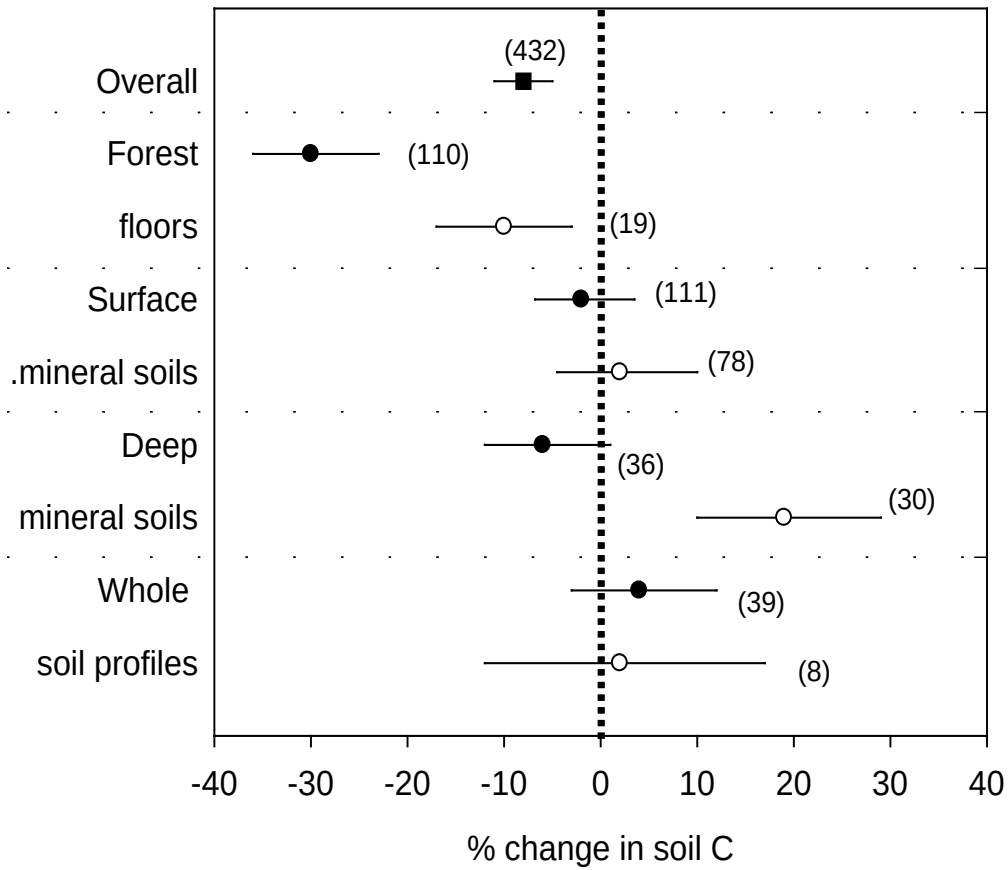
Nave LE, Vance ED, Swanston CW, Curtis PS. 2009. Impacts of elevated N inputs on north temperate forest soil C storage, C/N, and net N-mineralization. *Geoderma* 153: 231-240.

Nave LE, Vance ED, Swanston CW, Curtis PS. 2010. Harvest impacts on soil carbon storage in temperate forests. *Forest Ecology and Management* 259: 857-866.

Nave LE, Vance ED, Swanston CW, Curtis PS. In press. Fire effects on temperate forest soil C and N storage. *Ecological Applications*.

<u>Question 1.</u> Does forest harvesting have a consistent effect on temperate forest soil C storage?

- Obtained data from 75 papers (432 response ratios), performed unweighted meta-analysis.
- <u>Answer:</u> **Yes**. An overall effect is significant and detectable in spite of significant within and between study variation (-13 ±4%).

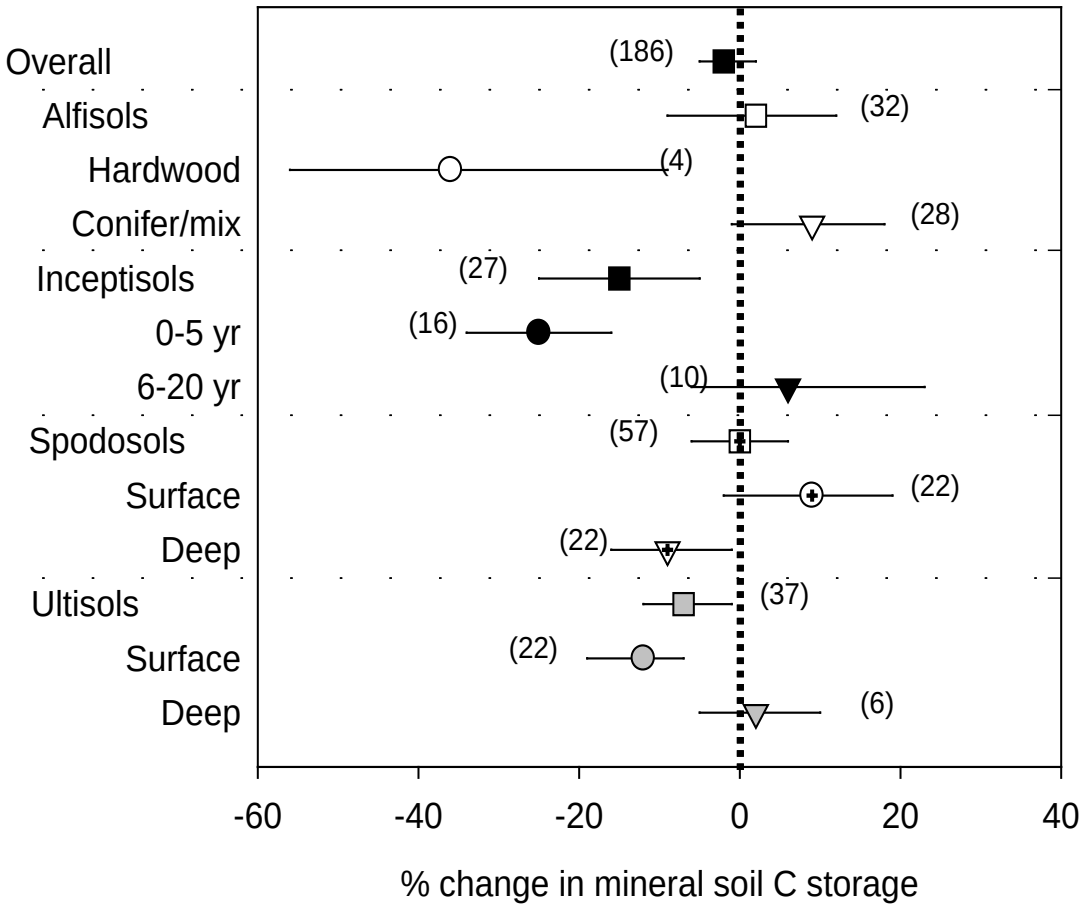


Filled circles = C pools; open circles = C concentrations

Question 2. What drives variation in harvest effects on soil C storage?

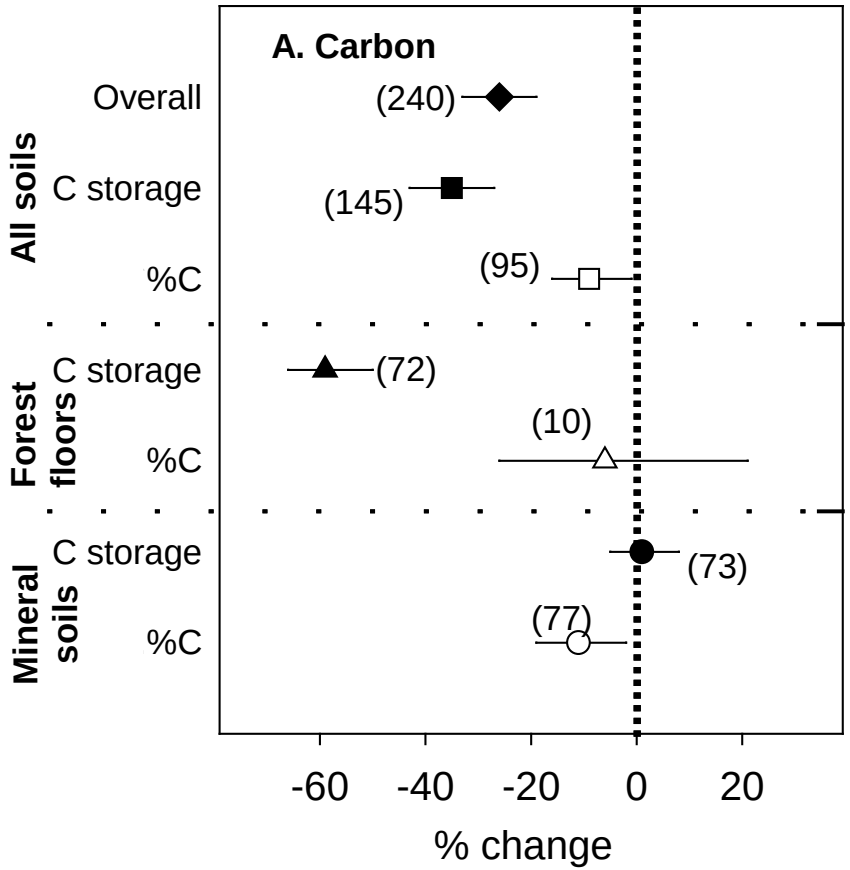
- Significant differences between soil layers: -30 ±6% in forest floor C, no overall change in mineral soil

- Primary sources of variation differed by soil layer: species composition in forest floor, soil taxonomic order for mineral soil



<u>Question 3.</u> How does fire affect temperate forest soil C storage?

- Found 57 papers, 240 response ratios
- <u>Answer:</u> **Fires reduce soil C storage by 35 ±8%.**
- As with harvest, a significant difference between soil layers **(-59 ±7% for forest floors**; no overall change in mineral soils)
- Also, different sources of variation between soil layers



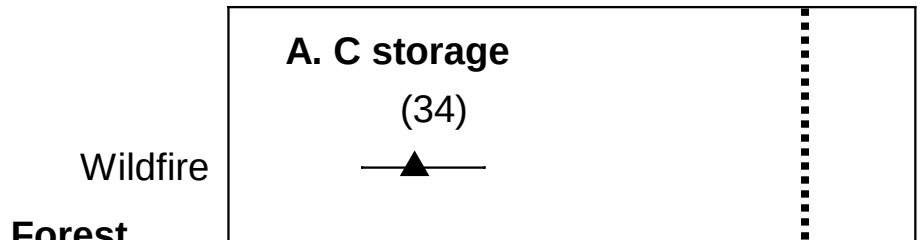
Forest floor C responses to fire

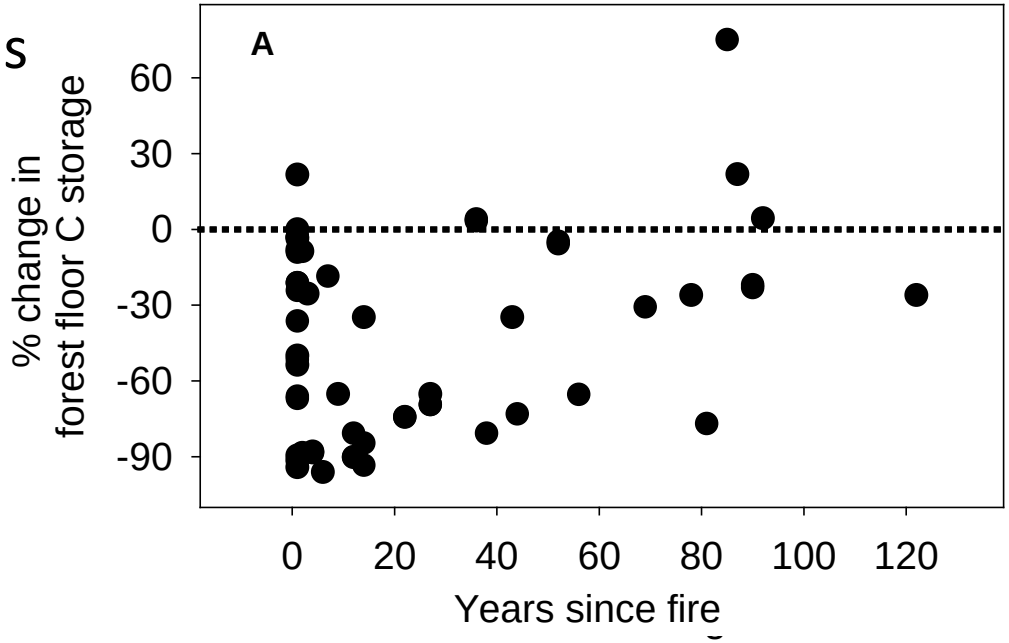
Several sources of variation:

1. Species composition: hardwoods mitigate C loss

2. Fire type: greater losses following wildfire

3. Time since fire: 128 year recovery time





How Does Management Affect Soil Carbon? A Broader Perspective

- No single-site study can answer these questions
- 10 years ago there weren't enough data to answer these questions using the same quantitative methods (Johnson and Curtis, 2001)
- Assembling large databases from many studies allows us to answer global-scale questions with quantitative synthesis
- Databases expose data gaps that, when closed, will improve our estimates of overall management effects on soil C
- Databases identify specific opportunities to test mechanisms underlying the general trends detected with synthesis

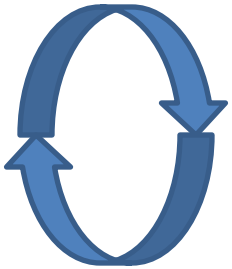
But, we need more data sharing to encourage scientific progress through synthesis!

The National Soil Carbon Network

http://www.soilcarb.net

A major goal: assemble databases to answer big-picture questions about soil C distribution and vulnerability, identify and fill data gaps standing between the research community and the answers

NSCN: Approach



An iterative cycle for approaching large-scale questions:

1. Synthesis: assemble existing data on soil C distribution and turnover across multiple spatial scales; identify and quantify potential sources of variation (metadata)
2. Prediction: forecast how soil C stocks change in response to specific forcings using analytical methods and models derived from data synthesis
3. Measurement: fill data gaps identified during prediction, using targeted sampling archive analysis
4. Measurements inform and feed back to synthesis, whether cumulative or novel

NSCN: Data Sharing and Collaboration

<u>Guiding principle:</u> our science will be better off if we work together.

Sharing data, sites, archives, and lab infrastructure will allow us to address bigger scientific challenges, including those comprising global soil change.

NSCN: Membership and Community

- Membership in the NSCN: Just sign up! Give something to the community to get something in return (*e.g.*, give data, get database access).
- The NSCN is a facilitator, a coordinator, and an entity that is attempting to link existing resources rather than reinvent them.
- The NSCN is above all about collaboration and not competition.

Contact NSCN Network Coordinator (lukenave@umich.edu) to join

Please attend the NSCN Database Town Hall Meeting!
Thursday 16 December, 1230-1330, 2011 Moscone West