MINIMIZING RISK AND MAXIMIZING BENEFITS ASSOCIATED WITH WOOD BIOENERGY PRODUCTION

William Keeton

Professor of Forest Ecology and Forestry,

University of Vermont

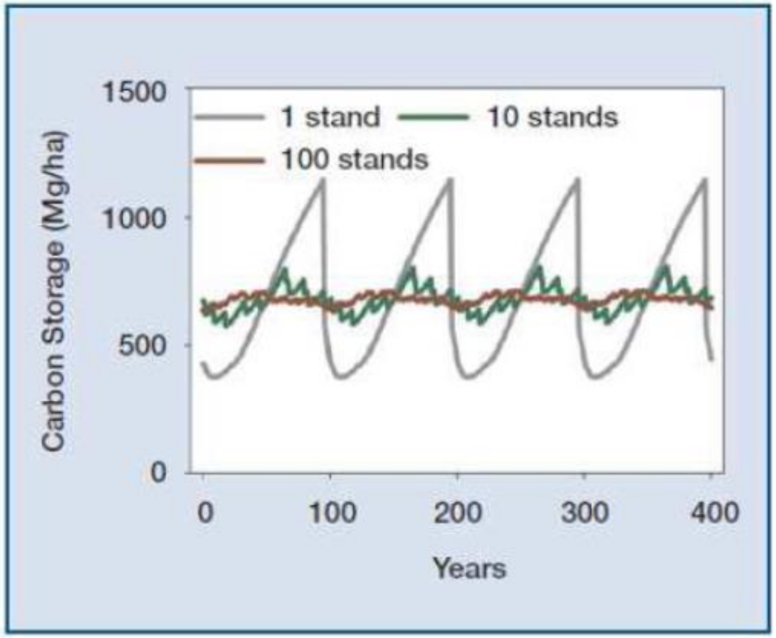
Like any carbon forestry approach, wood bioenergy carries risks.

Our objective needs to be minimizing these risks while maximizing potential benefits.

Let's start with the assumption of carbon neutrality…

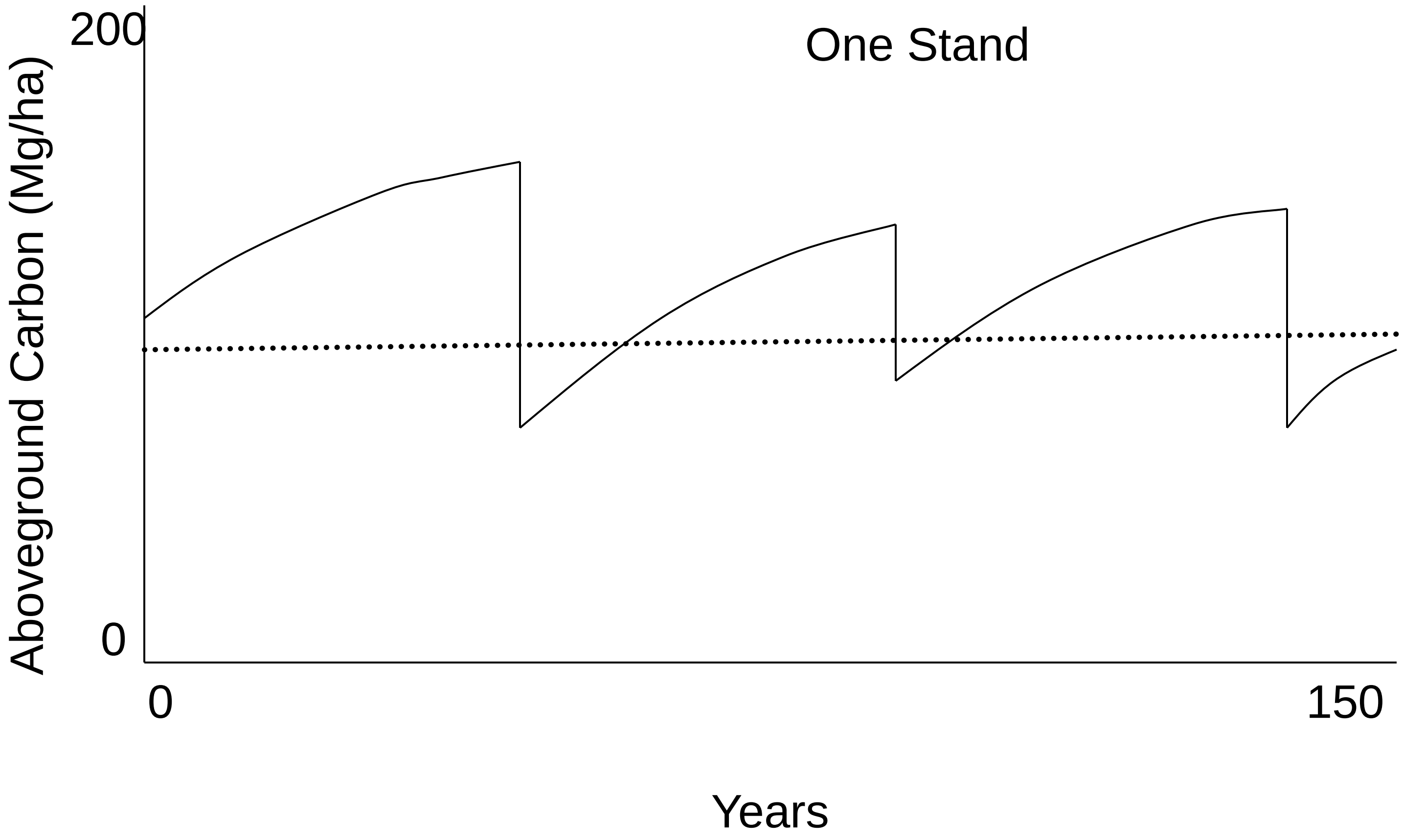
Hypothetical equilibrium carbon stocking with staggered, rotational timber/biomass harvesting

Is this valid?

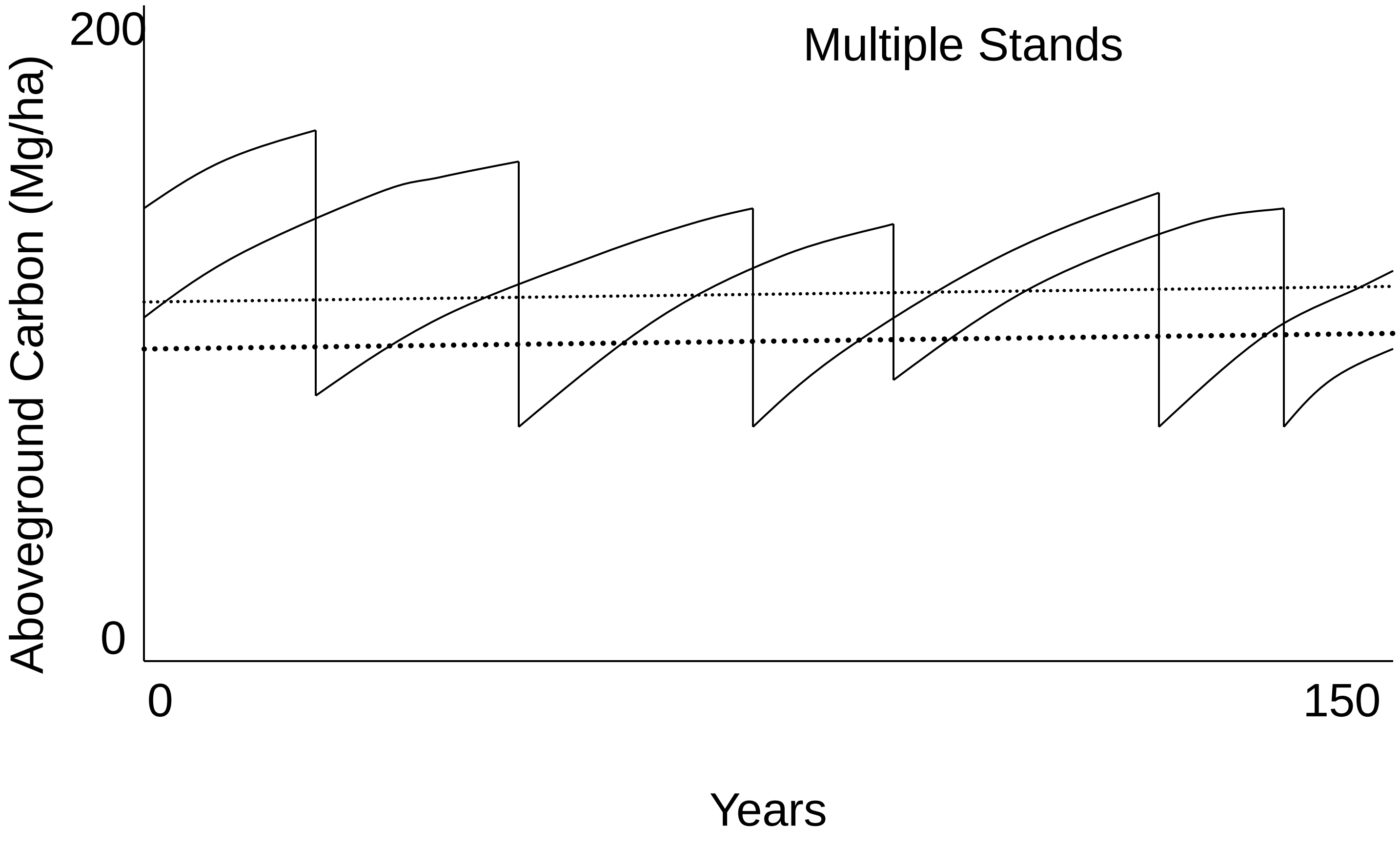


Source: Ryan et al. 2010

Understanding Effects on Landscape Scale Carbon Storage



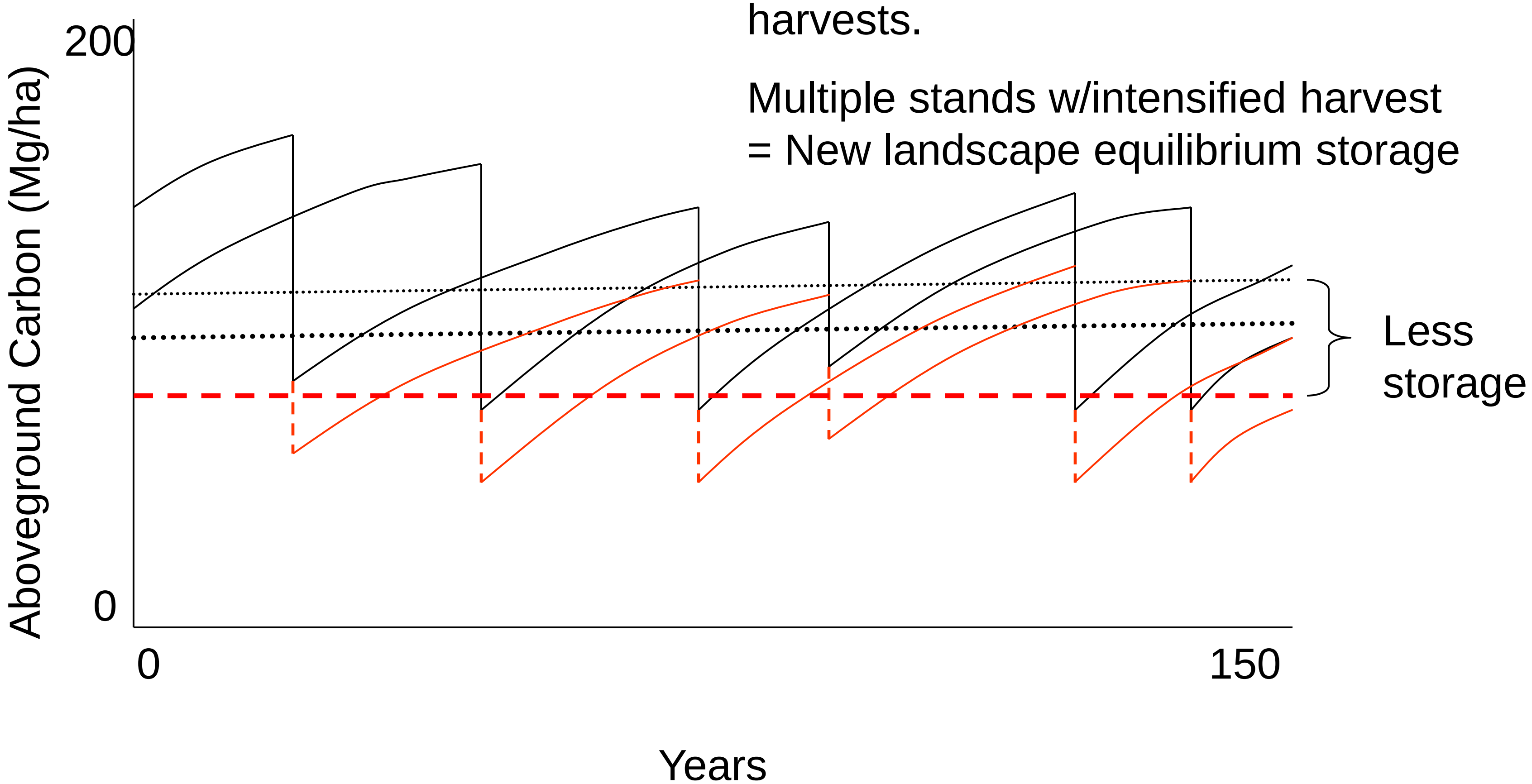
Understanding Effects on Landscape Scale Carbon Storage



Understanding Effects on Landscape Scale Carbon Storage

Biomass harvesting in the NE USA is almost always part of integrated harvests.

Multiple stands w/intensified harvest = New landscape equilibrium storage



"Carbon Sequestration Parity"

Banking on foregone sequestration potential also carries risks

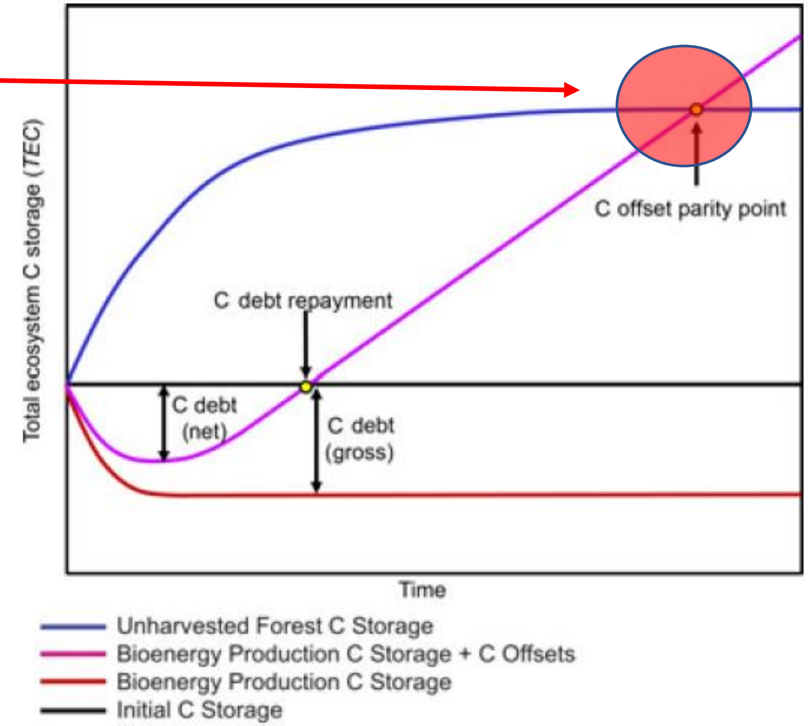


Fig. 1 Conceptual representation of C Debt Repayment vs. the C Sequestration Parity Point. C Debt (Gross) is the difference between the initial C Storage and the C storage of a stand (or landscape) managed for bioenergy production. C Debt (Net) is C Debt (Gross) + C substitutions resulting from bioenergy production.

"Since biomass harvesting reduces C storage but does not produce the same amount of energy that would be obtained from an equal amount of C emissions from fossil fuel combustion, recouping losses in C storage through bioenergy production may require many years."

- From: Mitchell, Harmon, and O'Connell. 2012. Carbon debt and carbon sequestration parity in forest bioenergy production. Global Change Biology: Bioenergy

Choice of baseline and forest management scenario determines emissions calculus

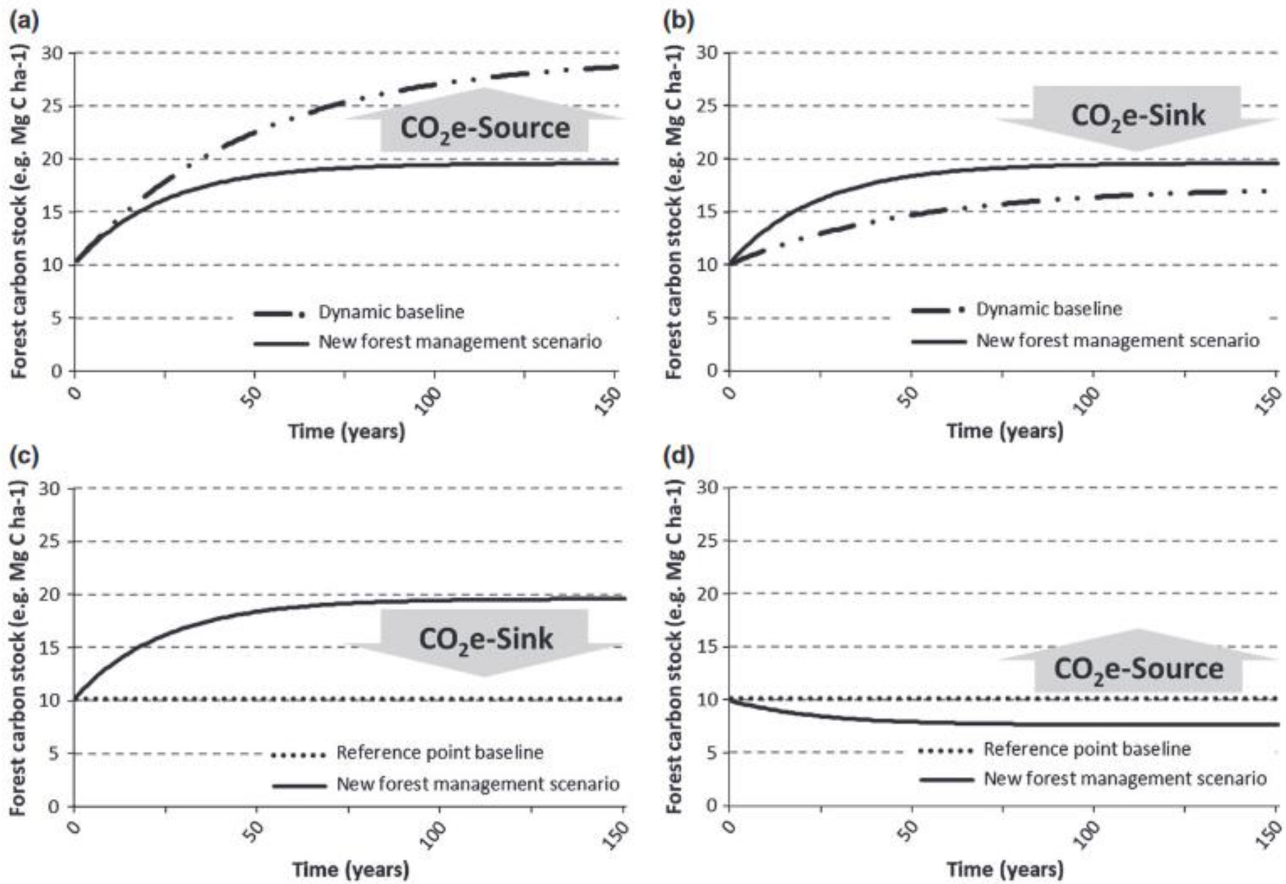


Fig. 1 With a dynamic or anticipated future baseline, future emissions are compared to a modeled baseline that assumes a given trend in forest carbon pools in the absence of the bioenergy activity (a, b). A reference point baseline is defined by the forest carbon stock in a given area at a given point in time. With a reference point baseline, future emissions are compared to this static point in time (c, d). The carbon balance of a particular bioenergy can change as a function of baseline type.

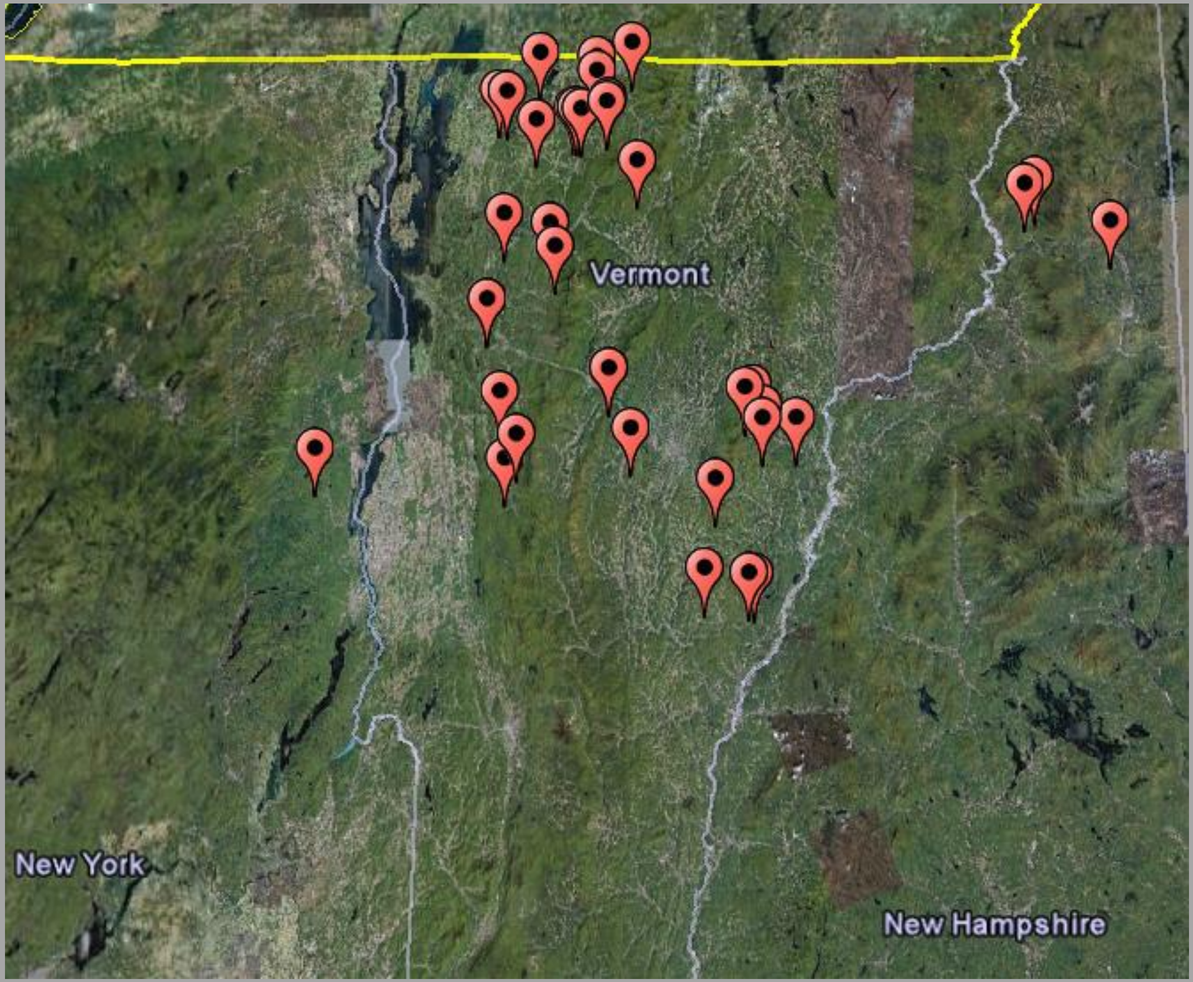
From: Zanchi et al. 2012. Global Change Biology: Bioenergy

My own research at UVM

- What are the net carbon fluxes at stand and landscape scales?
- What are the net fluxes post-harvest and long-term?

METHODS:

- 35 Sites
- Site matching criteria
- Paired reference at each location
- Harvested within last 3 years
- Range of harvesting intensities and product mixes



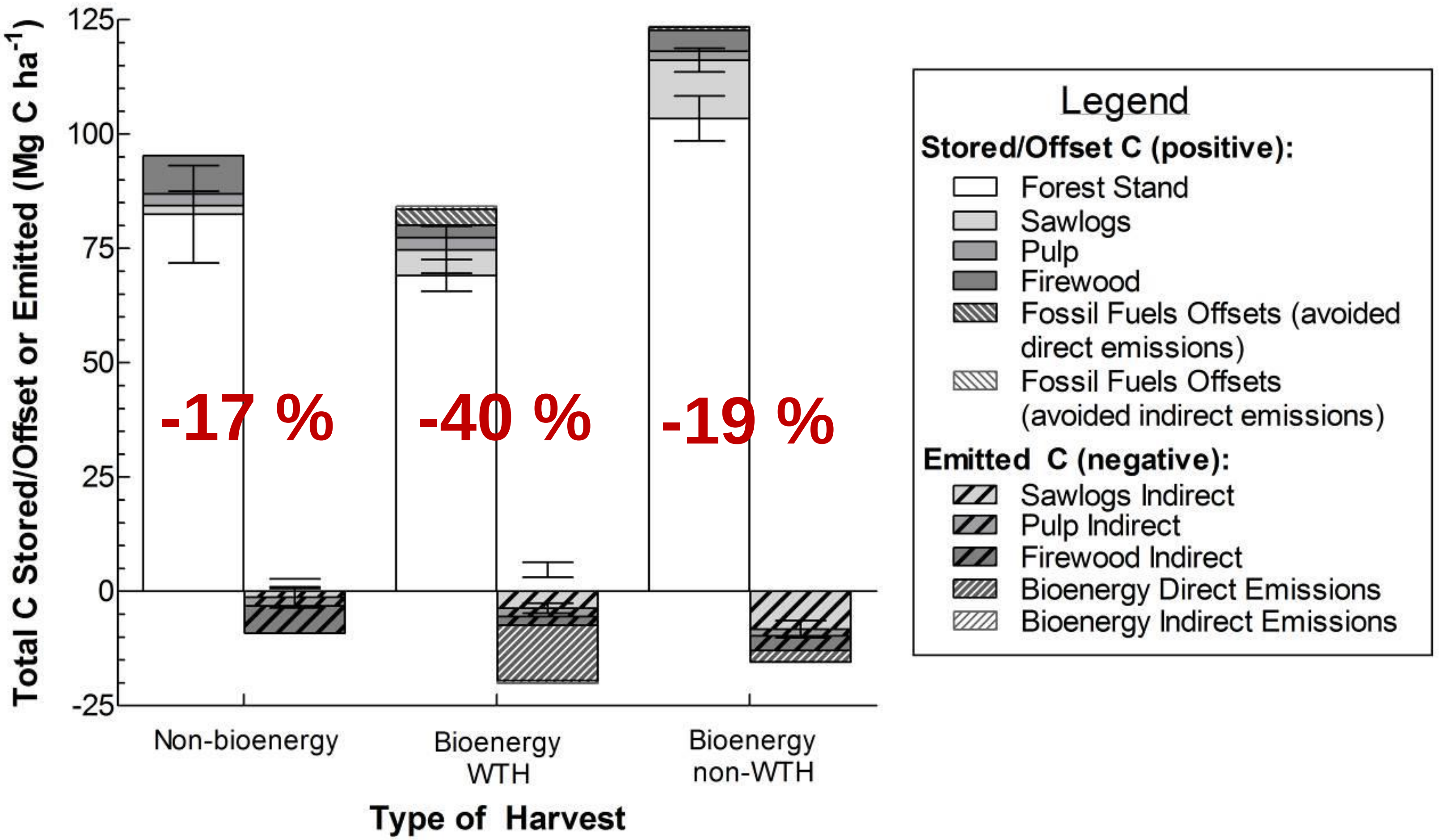
Emissions from Energy

- Energy emissions from electricity, heating, or co-generation

Type of Energy Generated	Assumed Efficiency (%)	Energy Content (GJ)		Emission Factor (CO_2e/GJ)	
		Bioenergy (per ton)	Fossil Fuel (per gallon)	Bioenergy	Fossil Fuel
Electricity	30%	4.80	-	0.38	0.11
Thermal	80%	12.80	0.09	0.14	0.08
Co-generation	80%	8.80	0.06	0.21	0.12

- Electricity from fossil fuels is assumed to be NEWE grid

Net C Flux Post-Harvest



From: Mika and Keeton 2013
Global Change Biology: Bioenergy

Simulation modeling in FVS:

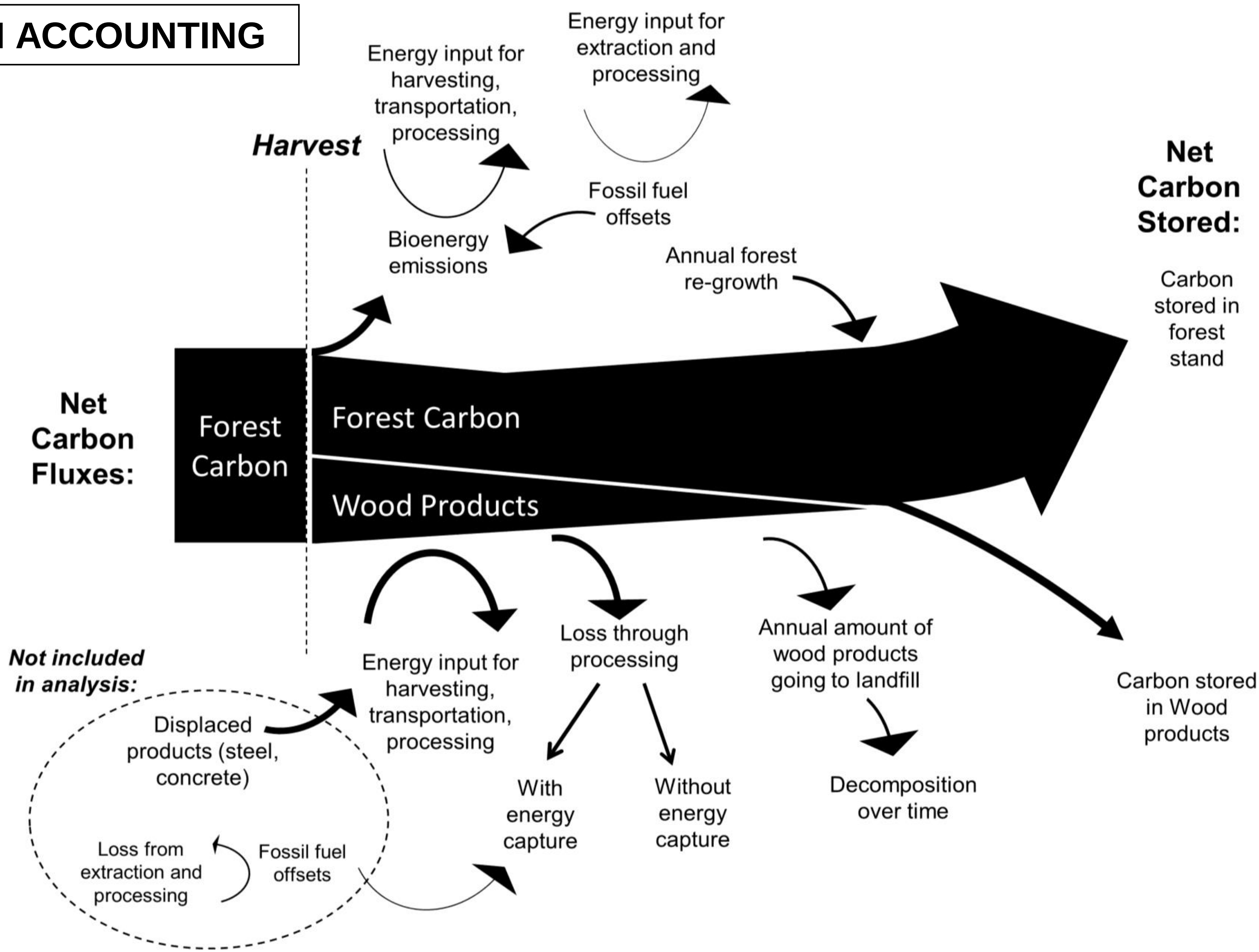
Data:

- 362 FIA plots from New York, Vermont, New Hampshire and Maine
- Randomly selected from 3,306 sites meeting criteria
- Representative of age class and stocking distributions for the Northeast

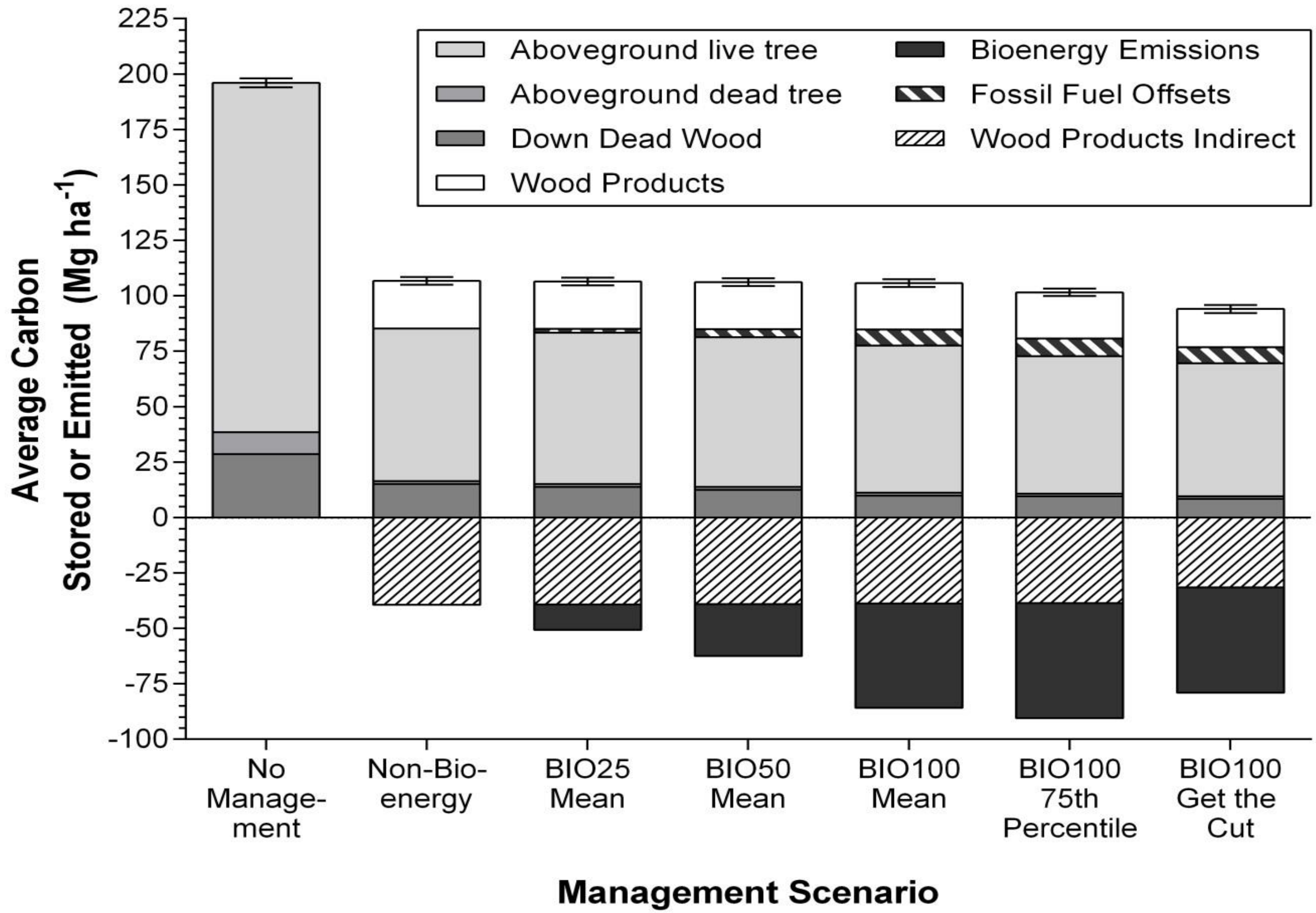
Scenarios and scheduling:

- Bioenergy intensification from Mika and Keeton (2012)
  - Mean and 75 percentile
- Silvicultural scenarios proportionate to use
  - Selection harvest
  - Shelterwood
  - Clearcut/patch cut
- Bioenergy scenarios applied to 25%, 50%, and 100% of landscape
- Minimum residual stocking threshold for some scenarios.
- Stands randomly selected for “cutting” when they attain harvestable stocking levels
- Regeneration inputs from Nunery and Keeton (2010)

CARBON ACCOUNTING

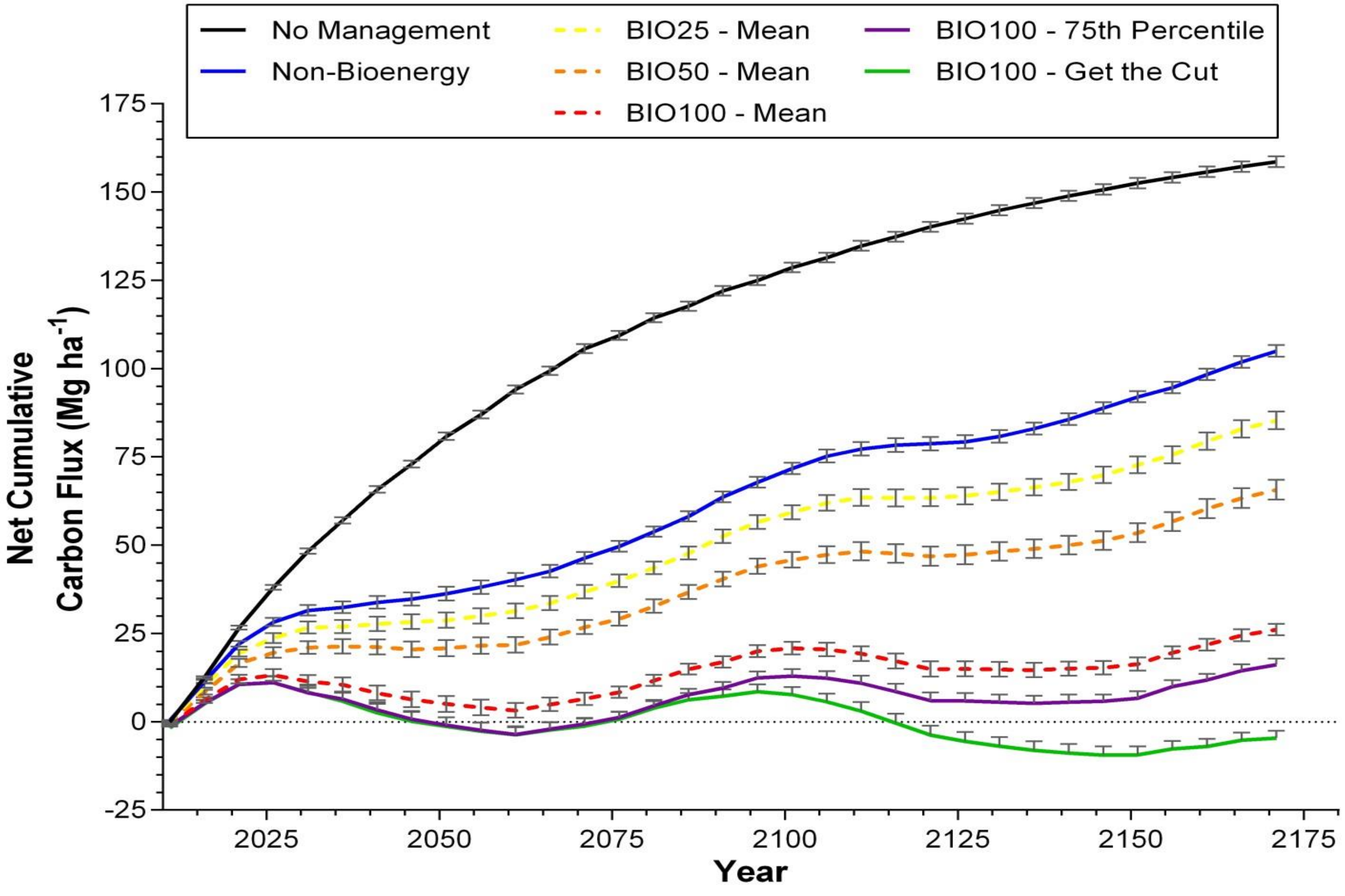


Average fluxes projected over 160 years in NE-FVS



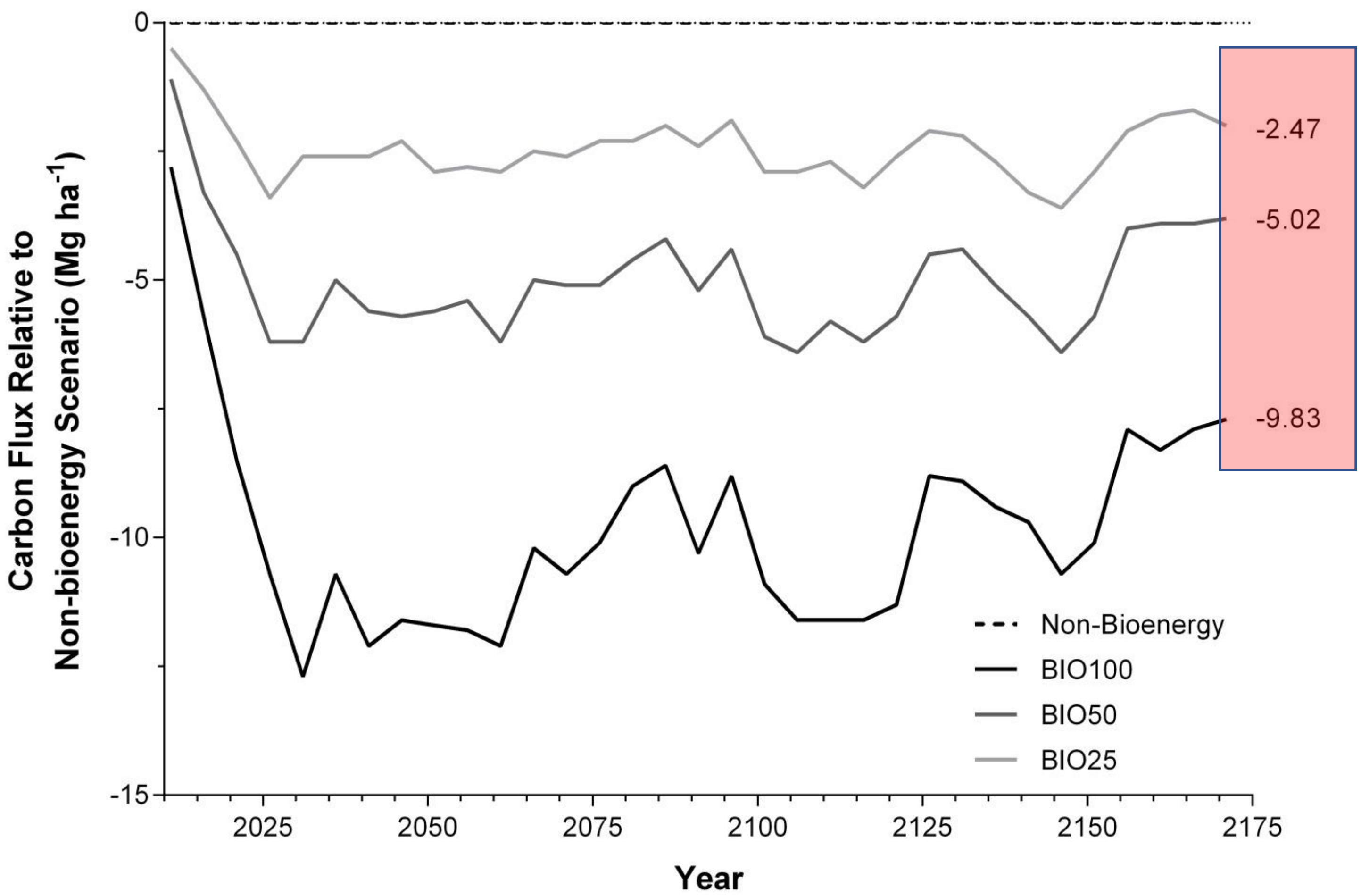
From: Mika and Keeton 2015.
Global Change Biology: Bioenergy.

Net carbon flux projected over 160 years in NE-FVS (N = 362)



From: Mika and Keeton 2015. Global Change Biology: Bioenergy.

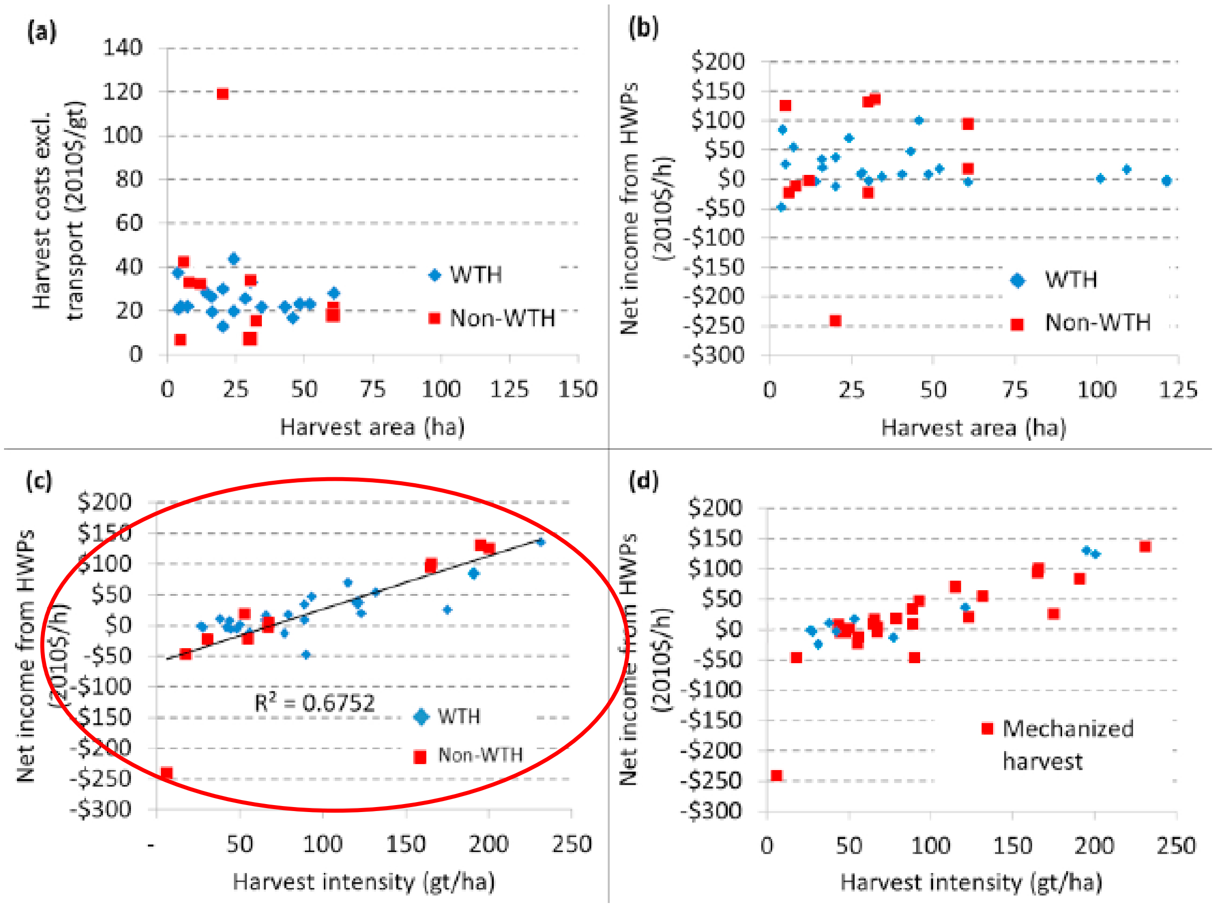
Projected net carbon flux compared to baseline (non-bioenergy harvesting)



From: Mika and Keeton 2015.
Global Change Biology: Bioenergy.

Do the economics of wood bioenergy favor intensification of forest harvests?

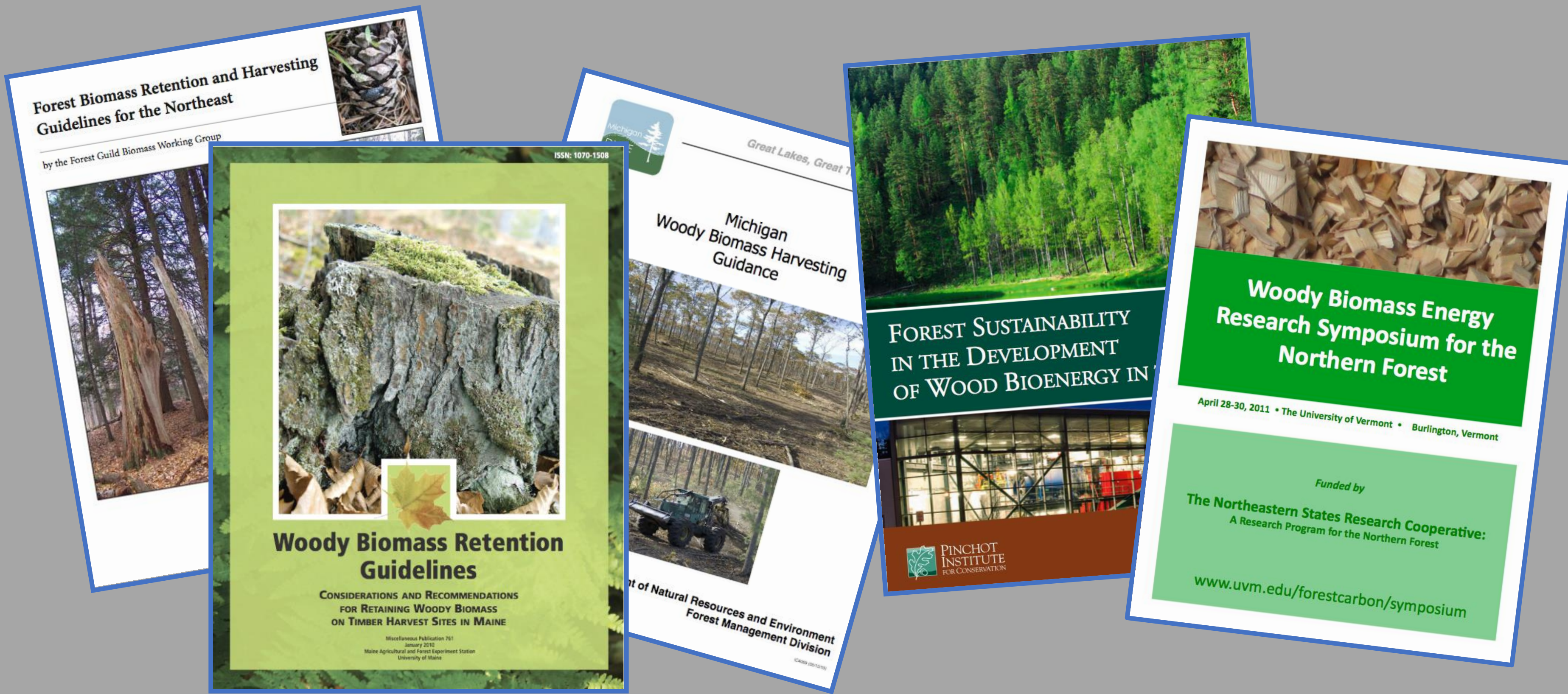
- Biomass is a marginal source of revenue in integrated harvests
- Most of the revenue comes from round wood, not tops or limbs
- Net contractor (not landowner) revenue enhanced by intensifying biomass harvest
- Intensification is independent of landowner targets, silvicultural objectives, or other variables



From: Buchholz, Keeton, and Gunn. 2019. Forest Policy and Economics

Role of Harvesting Guidelines

30 % of operators in VT and NH already meeting the Forest Stewards Guild's retention guidelines (Littlefield and Keeton 2012, Ecological Applications)



Climate Friendly Forestry: 4 Tests for Wood Bioenergy

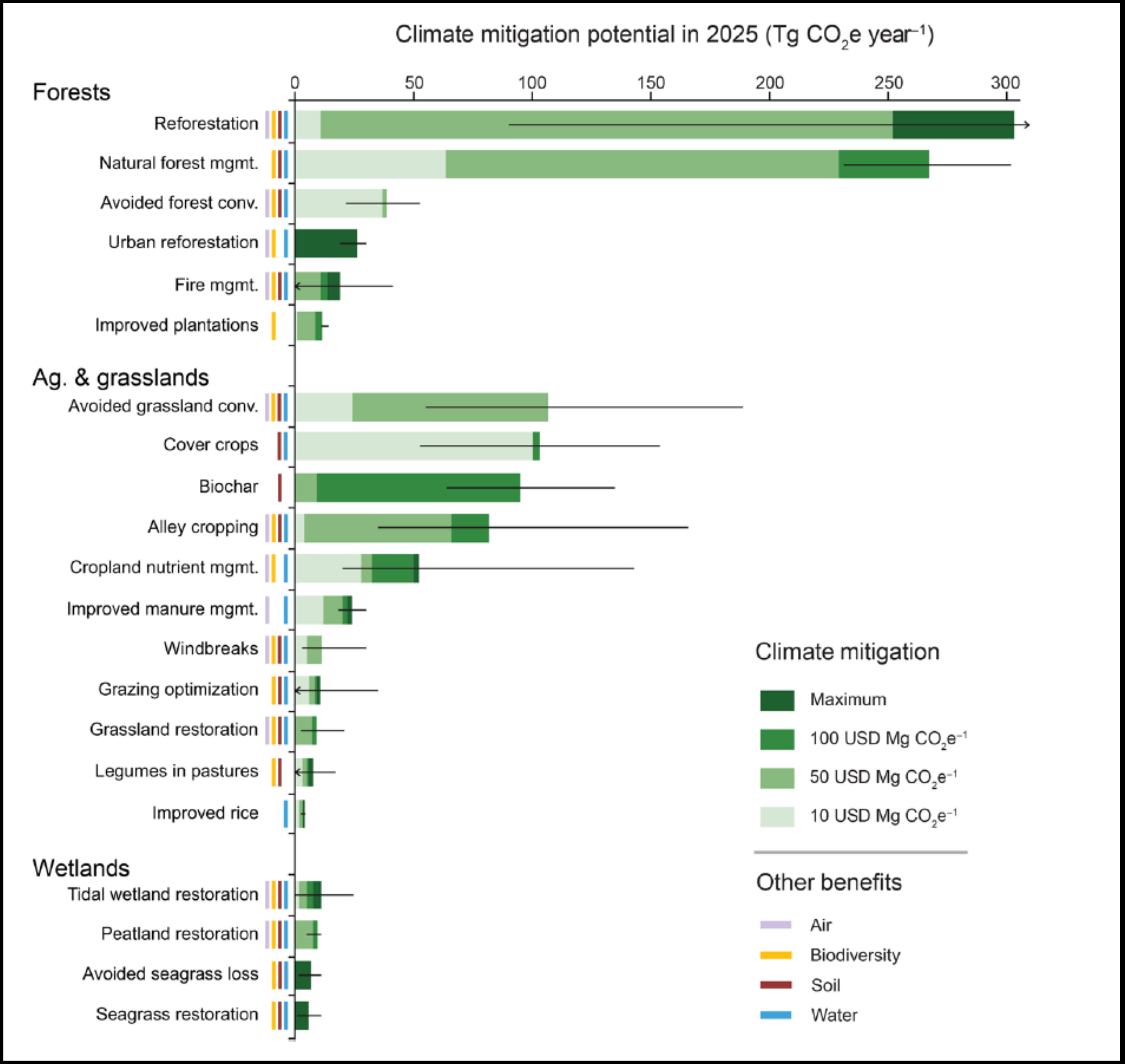
Bill Keeton, PhD.
Professor of Forest Ecology and Forestry
Director, UVM Carbon Dynamics Lab.

The UNIVERSITY of VERMONT

Carbon Dynamics Lab
University of Vermont
Rubenstein School of Environment and Natural Resources

Test # 1. Did the wood bioenergy compete with or complement other Natural Climate Solutions?

- **21 Natural Climate Solutions for natural and agricultural lands**
- **Max. potential of 1.2 Pg CO2e per year**
- **Equivalent to 21% of net annual emissions of the United States**



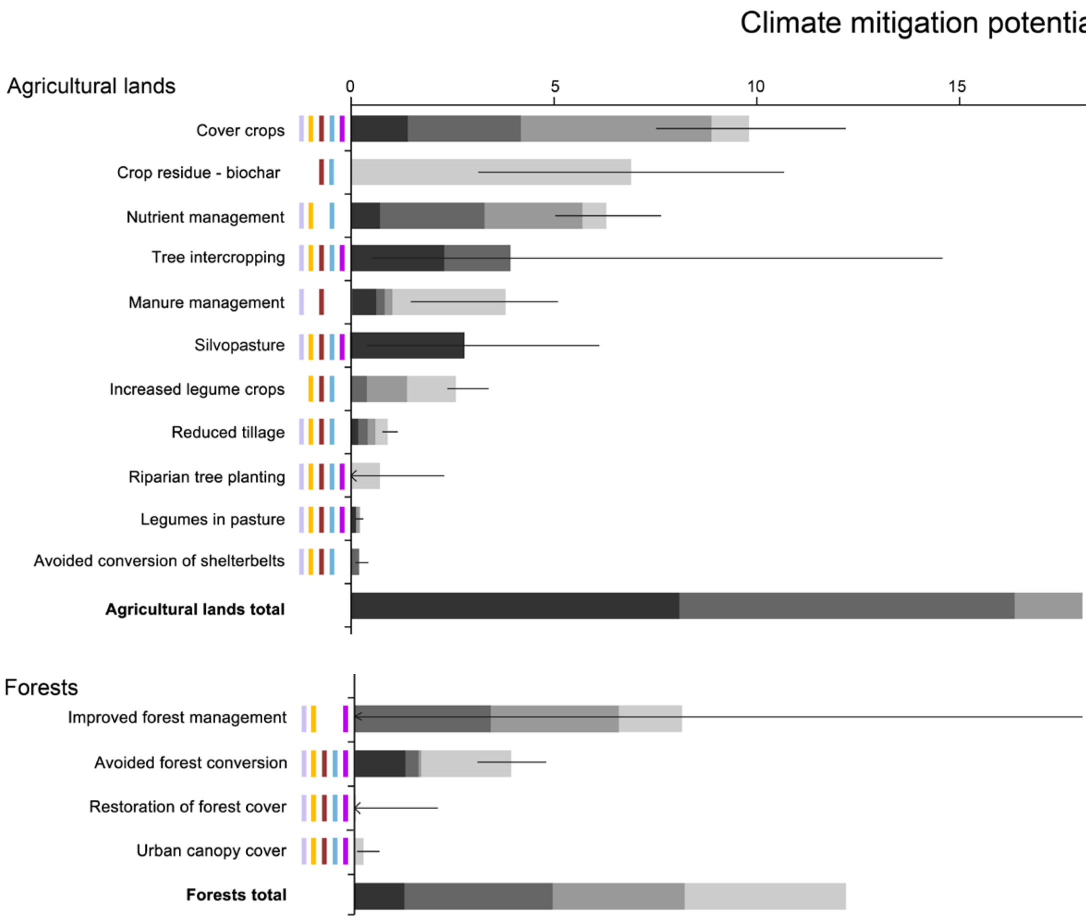
Fargione et al. 2019. Science Advances

SCIENCE ADVANCES | RESEARCH ARTICLE Drever *et al.*, *Sci. Adv.* 2021; **7** : eabd6034

APPLIED ECOLOGY

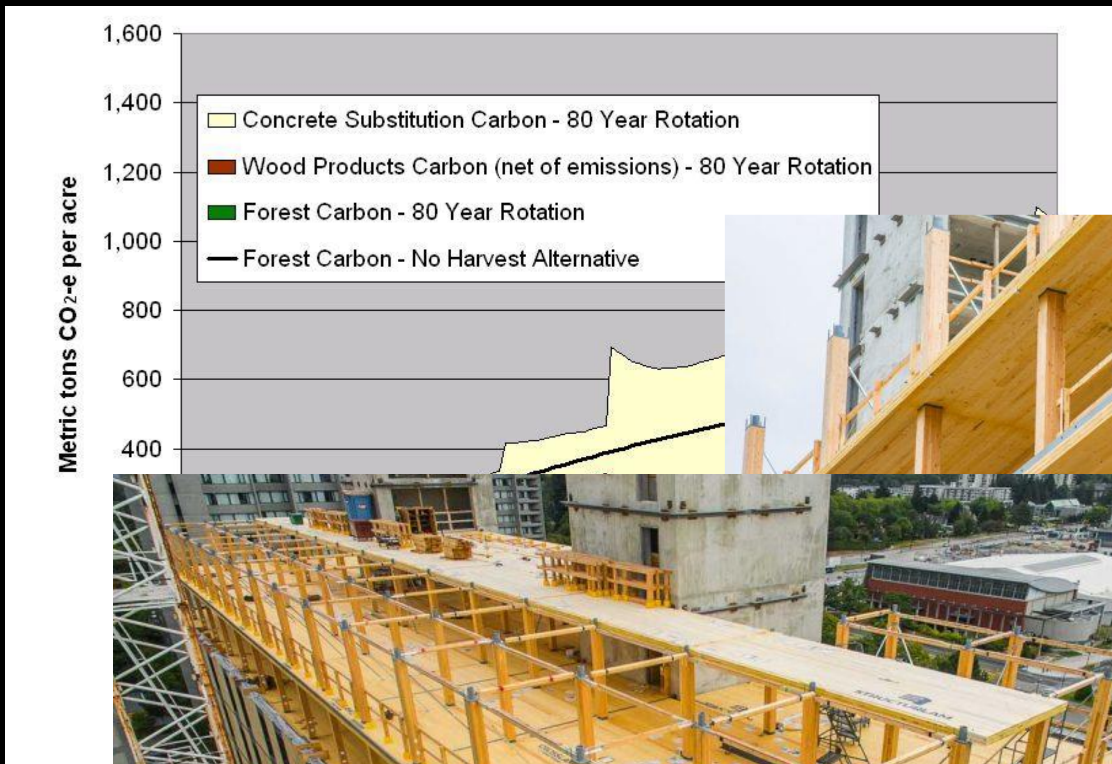
Natural climate solutions for Canada

C. Ronnie Drever[1*†], Susan C. Cook-Patton[2,3†], Fardausi Akhter[4], Pascal H. Badiou[5], Gail L. Chmura[6], Scott J. Davidson[7], Raymond L. Desjardins[8], Andrew Dyk[9], Joseph E. Fargione[10], Max Fellows[9], Ben Filewod[11], Margot Hessing-Lewis[12], Susantha Jayasundara[13], William S. Keeton[14], Timm Kroeger[2], Tyler J. Lark[15], Edward Le[16], Sara M. Leavitt[2], Marie-Eve LeClerc[9], Tony C. Lemprière[17], Juha Metsaranta[18], Brian McConkey[19], Eric Neilson[9], Guillaume Peterson St-Laurent[20], Danijela Puric-Mladenovic[11], Sebastien Rodrigue[18], Raju Y. Soolanayakanahally[4], Seth A. Spawn[15], Maria Strack[7], Carolyn Smyth[9], Naresh Thevathasan[13], Mihai Voicu[18], Christopher A. Williams[21], Peter B. Woodbury[22], Devon E. Worth[8], Zhen Xu[16], Samantha Yeo[2], Werner A. Kurz[9]



- 24 NCS for Canada
- Strength of NCS's will differ btw. regions due to available opportunities, forest types and growth rates, albedo effects, etc.
- Modeling included wood bioenergy from residues and logging slash
- Bioenergy CONTRIBUTED to emissions reduction WHEN it enhanced other NCS's, like improved growth, stocking, and durable wood products

To maximize bioenergy benefits, complement other substitution effects, like durable woodproducts



Full carbon accounting: optimize the CARBON FORESTRY PORFOLIO

Passive management, e.g.

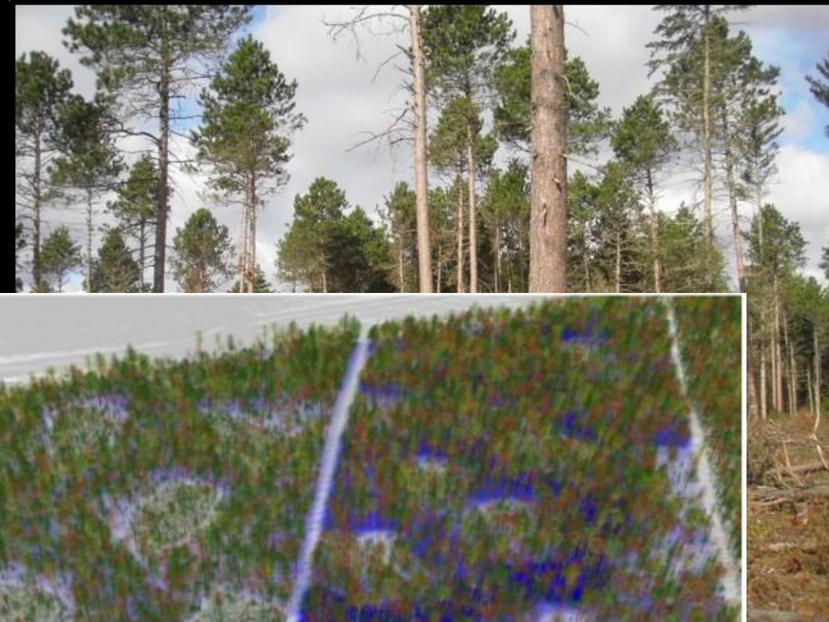
- High Conservation Value forests, like old-growth and rare habitats
- Unmanaged inclusions
- Wilderness areas

Reforestation, e.g.

- Riparian buffers
- Urban tree planting
- Soil stabilization

Improved Forest Management, e.g.

- Retention forestry
- Extended rotations
- Improved growth
- Durable wood products
- Emissions efficient bioenergy
- Fuels treatment and fire restoration



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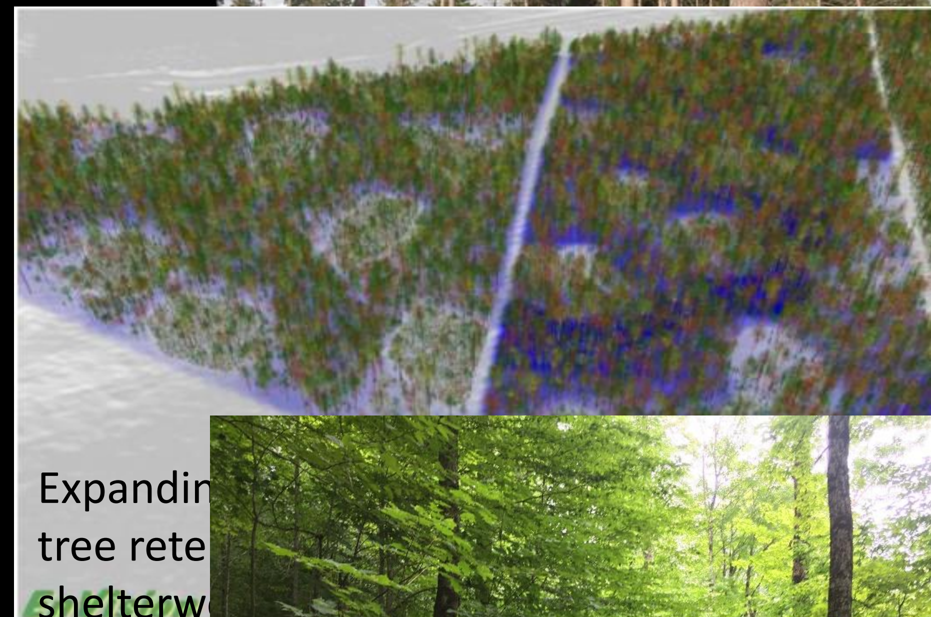
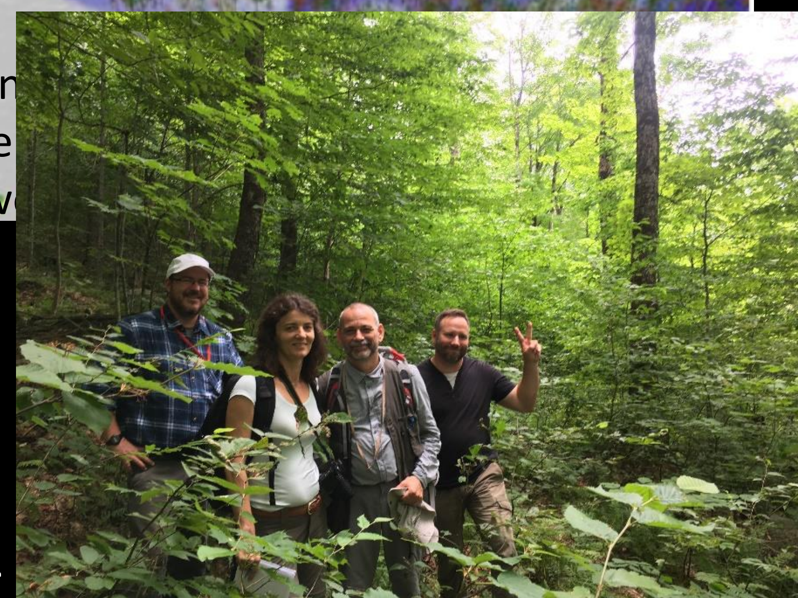
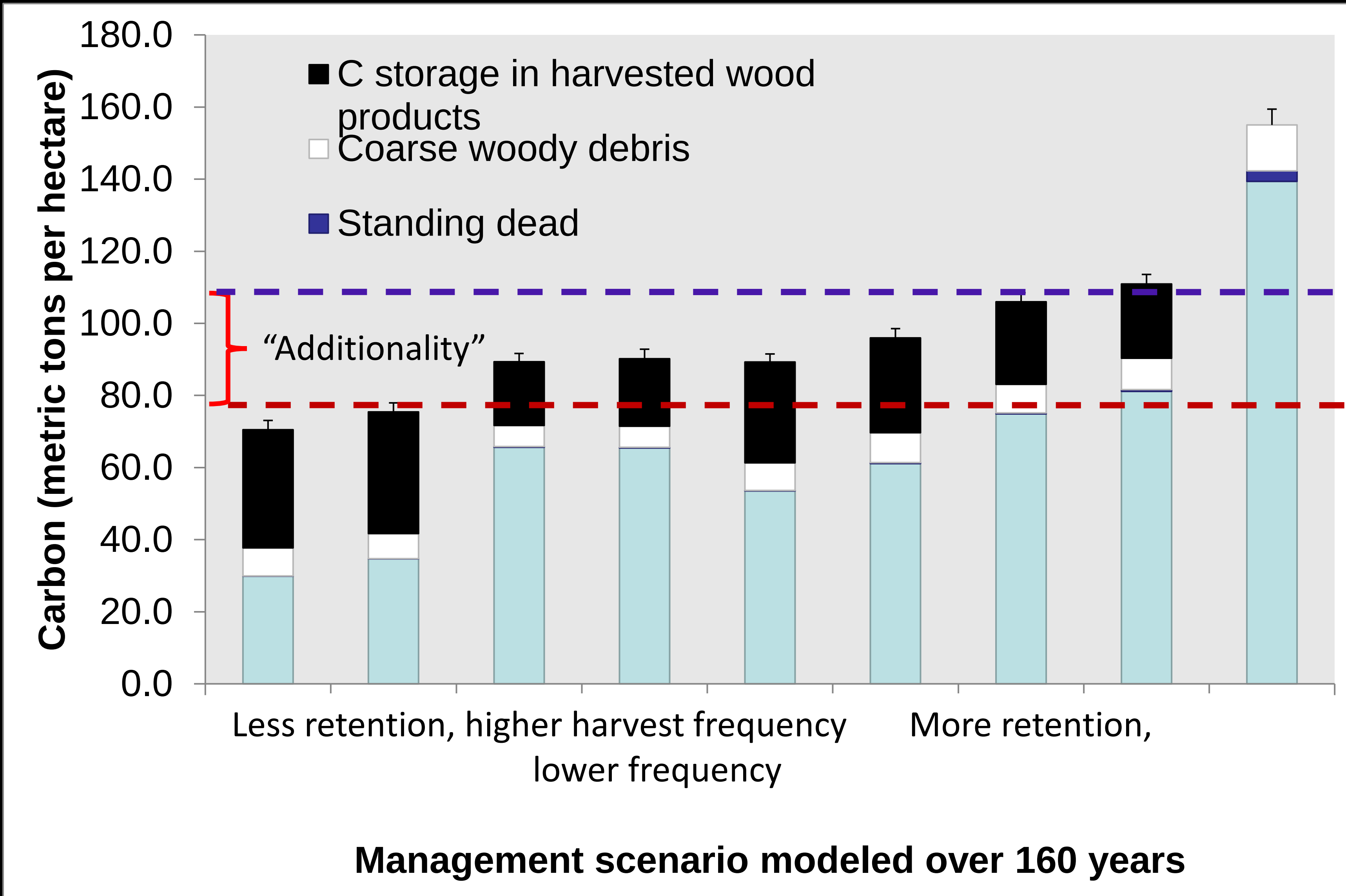




Modified selection systems

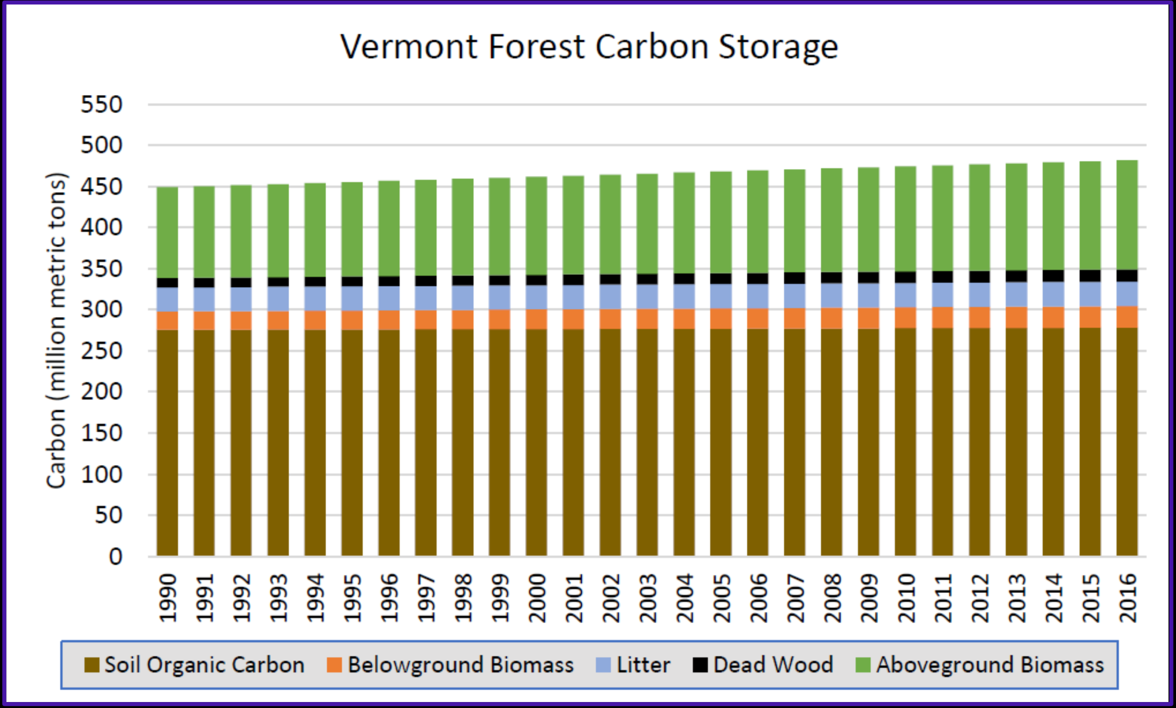
Test #2. Does production of wood bioenergy contribute to stable or increasing net carbon stocks at landscape scales? Is the climate benefit of expanded bioenergy production greater than the opportunity cost?



From: Nunery and Keeton. 2010. Forest Ecology and Mgt.

Vermont's forests currently are a "Natural Climate Solution"

- They store 480 million metric tonnes of carbon
- 264 MtC/ha (or 107 MtC/acre)
- > 60% is belowground
- Carbon stocks are increasing as forests mature
- They sequester 4.4 million metric tonnes per year



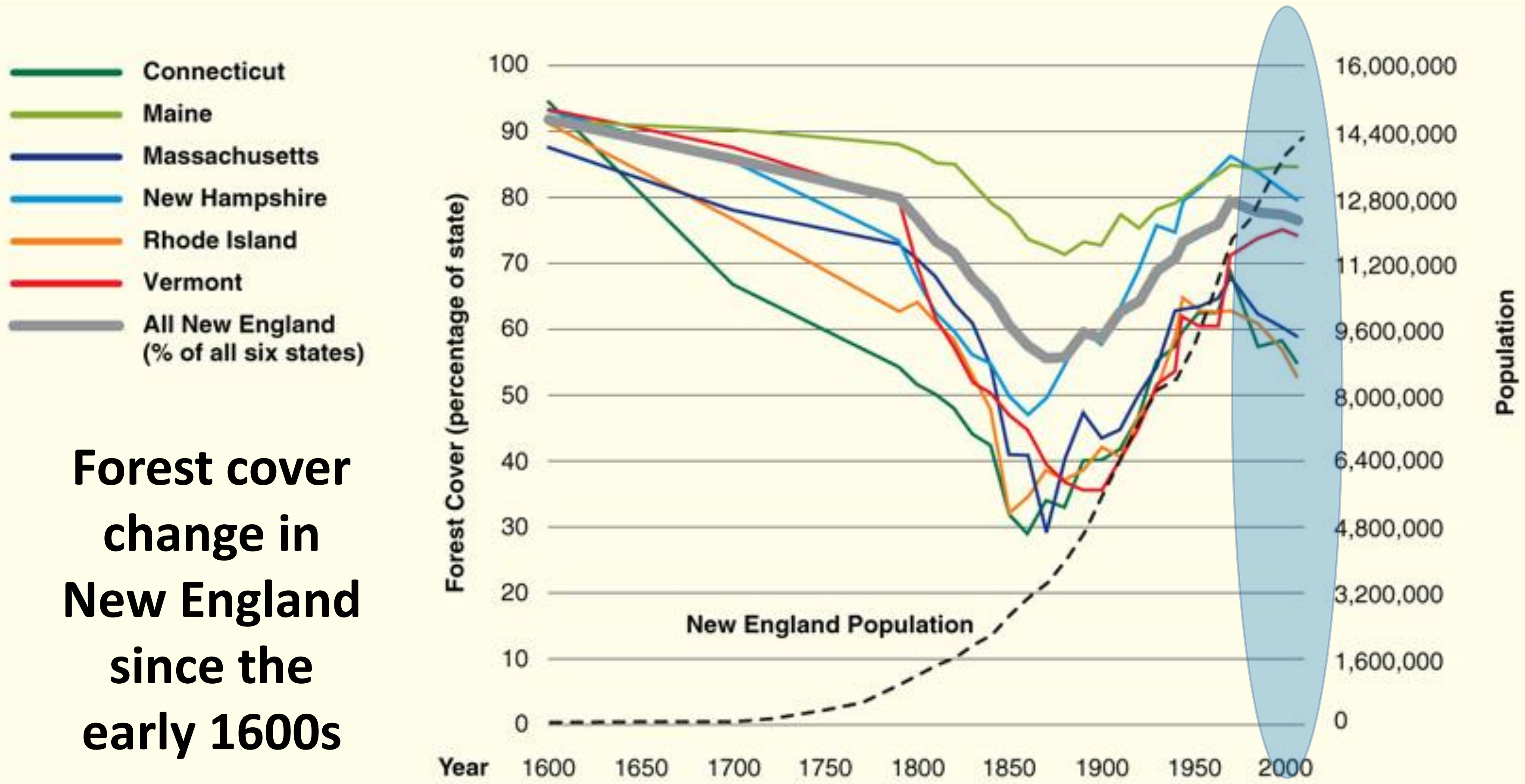
Source: Vermont Forest Carbon Assessment, 2017

Current biomass production is part of this mix!
Would intensified wood bioenergy production intensify harvests, leading to declines in Carbon stocking?

Test # 3. Is the production of wood bioenergy part of multi-functional forest management?

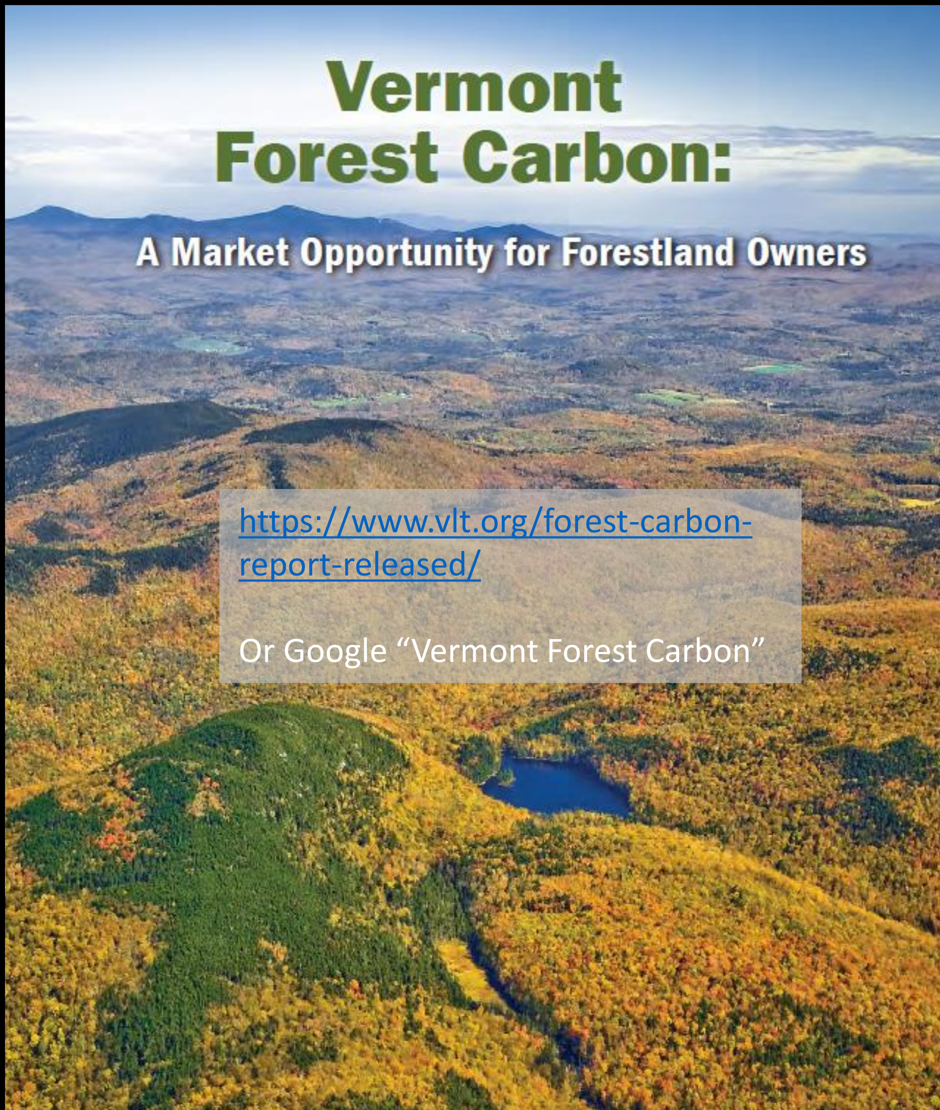
…e.g . Improved growth and stocking, flood resilience, biodiversity, *and* exceptionally high-quality stream habitats

Wood bioenergy as an incentive to sustain working forests



Forest cover change in New England since the early 1600s

From: Foster et al. 2010. Wildlands and Woodlands



https://www.vlt.org/forest-carbon-report-released/

Or Google "Vermont Forest Carbon"

Authors

William S. Keeton
Director of the Carbon Dynamics Laboratory,
Rubenstein School of Environment and Natural Resources, University of Vermont

William VanDoren
Senior Scientist, Spatial Informatics Group

Charles Kerchner
Senior Scientist and Director of Forest Carbon Projects, Spatial Informatics Group

Mackenzie Fuqua
Carbon Dynamics Laboratory, Rubenstein School of Environment and Natural Resources, University of Vermont

Advisory Committee

Charlie Hancock, *North Woods Forestry*
Phil Huffman, *The Nature Conservancy*
Ben Machin, *Redstart Consulting*
Christine McGowan, *VT Sustainable Jobs Fund*
Nancy Patch, *VT Department Forests, Parks & Recreation*
John Roe, *Upper Valley Land Trust*
Lisa Sausville, *VT Coverts*
Joe Short, *Northern Forest Center*
Peter R. Stein, *Lyme Timber Company*
Robert Turner, *R.J. Turner Company*
Kathleen Wanner, *VT Woodlands Association*
Kate Wanner, *Trust for Public Land*
Sandy Wilmot, *VT Department Forests, Parks & Recreation*

Acknowledgements

This report was prepared with funding from the High Meadows Fund, Vermont Housing and Conservation Board, and Vermont Land Trust. Support for graduate student participation was provided by a gift from Mr. Will Rapp.

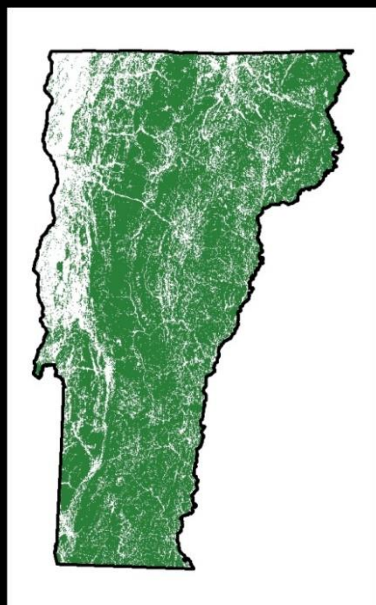
Final Report – March 2018

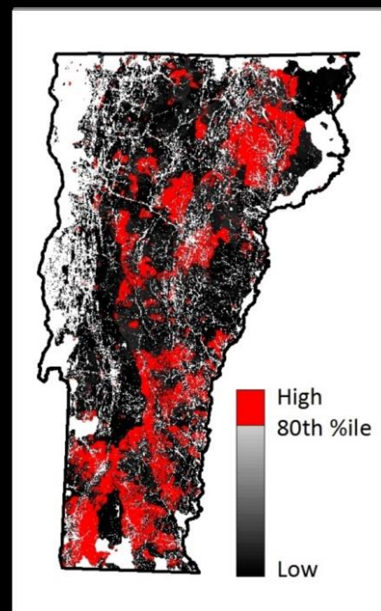
Spatial Informatics Group

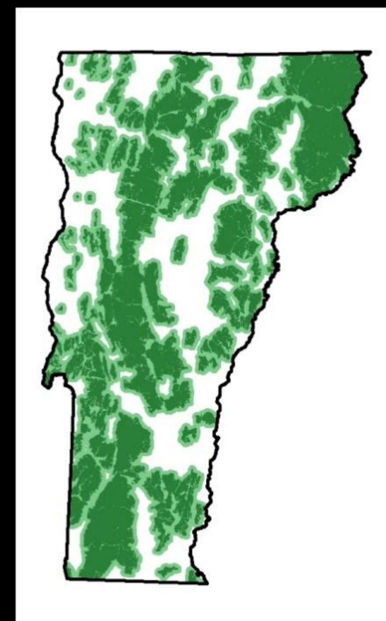
Carbon Dynamics Lab
University of Vermont

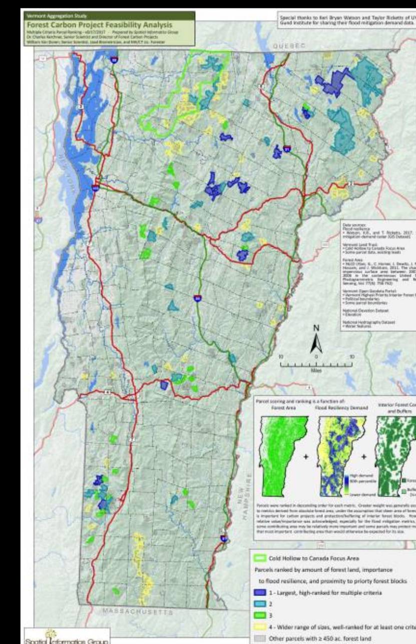
Vermont Land Trust
Conserving Land for the Future of Vermont

Most eligible parcels for carbon projects in Vermont; greatest co-benefits









Forest area

+

Σ FLOOD

Σ $FLOOD_{RESID}$

Σ $FLOOD_{80}$

+

Interior forest cores

Buffers

= 285,00 acres

Flood mitigation demand data credit:
Watson, K.B., and T. Ricketts, 2017. Flood mitigation demand raster [GIS Dataset]

Test #4. Does production of durable wood products help make forests future adapted? Resilience to climate change and disturbances?

INTERESTING ENGINEERING

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SCIENCE / ENERGY & ENVIRONMENT

Older Forests Resist Climate Change Better

New research is finding that older is better when it comes to forests.

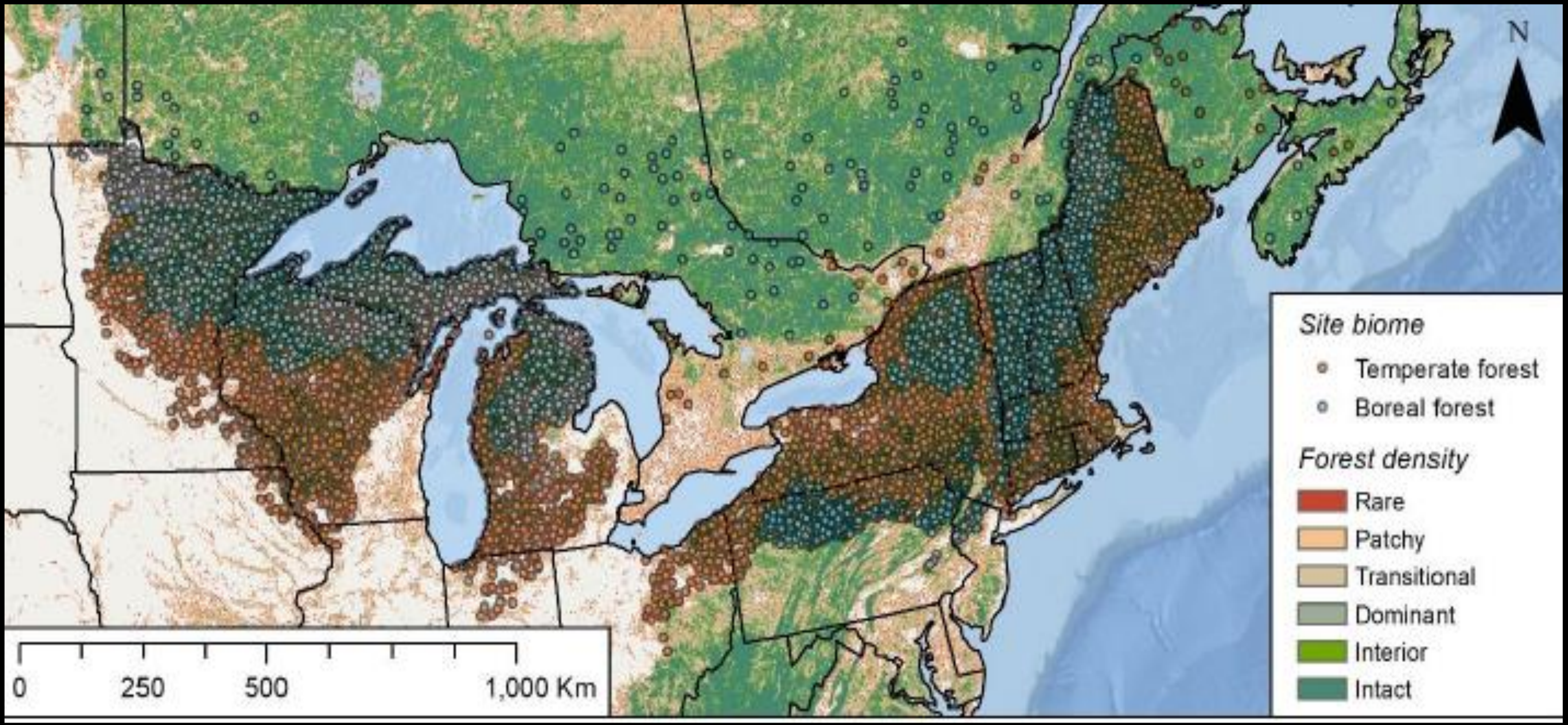
By Loukia Papadopoulos

June 09, 2019

The mix of services forests provide will shift as the climate changes…this includes C sequestration

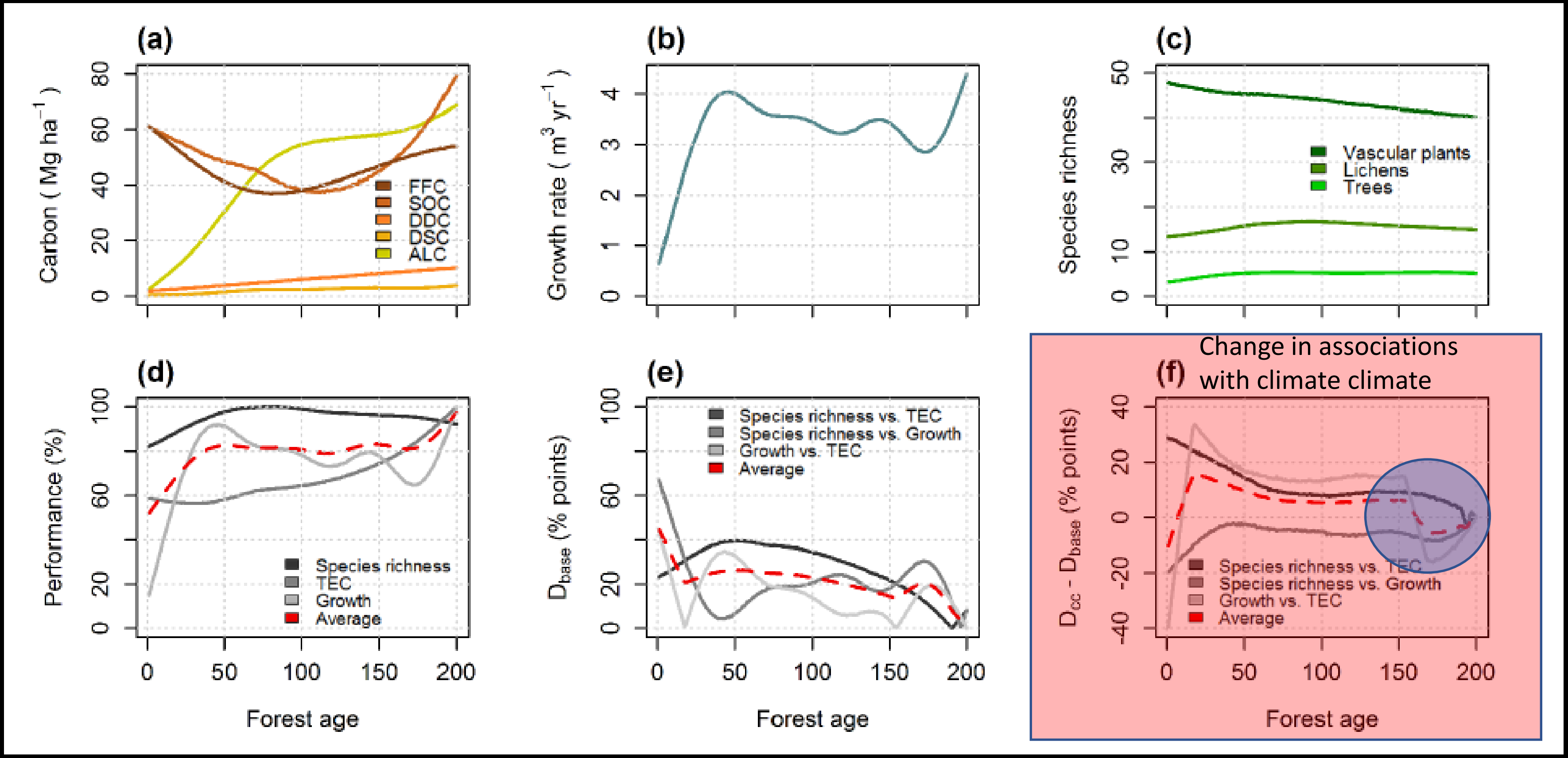
"Services" and biodiversity:

- Relative to forest age
- Relative to one another
- With climate change



Thom…Keeton et al. 2019. Global Change Biology

…increased production of wood bioenergy could increase or decrease future carbon storage depending on interactions with climate resilience



Thom…Keeton et al. 2019. Global Change Biology

How do we maximize the benefits of wood bioenergy?

THE CONVERSATION

Academic rigor, journalistic flair

https://theconversation.com/if-we-burn-wood-for-energy-we-cant-have-our-cake-and-eat-it-15634

COVID-19 Arts + Culture Economy Education **Environment + Energy** Ethics + Religion Health Politics + Society Science + Technology

If we burn wood for energy, we can't have our cake and eat it

Published: July 8, 2013 1.33am EDT

Whether more power stations should switch to burning wood or biomass is debatable. David Cheskin/PA

"Getting this right is vital, because we have a window of only the next few decades to stabilise atmospheric greenhouse gases, beyond which some scientists believe climate disruption will be irreversible."

- Favor thermal or combined heat and power over electricity generation only
- Favor small scale, high efficiency applications
- Practice excellent forestry that maintains high carbon stocking and retains key elements of stand structure
- Ensure that wood biomass production meets the four tests


Thank you
Old-growth hemlock-hardwood forest, Adirondack State Park, New York