The Carbon Benefits of Climate-Smart Forest Management (III)

Summary of Research for Western Forests

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For each article, I describe its focus and key findings. For some, I add a short discussion to help interpret the findings. Where possible, the discussion includes an estimate the economic value of forest-related carbon stores. This value generally represents the decrease in climate-related damages that would follow from a change in forest management that would increase the amount of carbon stored in forest ecosystems and wood products.

The estimates of economic value come from multiplying the article's estimate of the increase in carbon stores (usually shown as the metric tons of carbon dioxide-equivalent, or $MtCO_2e$) times an estimate of the social cost of carbon dioxide ($SCCO_2e$), i.e., the benefits to society from sequestering one $MtCO_2e$. I primarily employ estimates of the $SCCO_2e$ from the most recent, comprehensive analysis: Ricke, K, L. Drouet, K. Caldeira, and M. Tavoni. 2018. Country-level social cost of carbon.

This analysis provides two estimates of the $SCCO_2e$. One, $417, represents the *expected* benefits from sequestering one $MtCO_2e$. The other, $800/$MtCO_2e$ shows the potential benefits *if climate change proves to be more harmful than was expected* at the time the study was completed. The true $SCCO_2e$ likely falls closer to the latter, insofar as 11,000+ scientists just stated that "The climate crisis has arrived and is accelerating faster than most scientists expected…. It is more severe than anticipated, threatening natural ecosystems and the fate of humanity…." Moreover, all current estimates of $SCCO_2e$ fail to incorporate all the harms resulting from GHG emissions, including, for example, the full costs of ocean warming and acidification.

Note: these summaries represent my understanding of the major findings of each article. Before incorporating a specific article into your work, I recommend you read the original to ensure that your efforts represent it accurately and comprehensively.

Please, let me know if you:

- Find any errors or ambiguities in the summaries.
- Have any suggestions for making the summaries more useful.
- Know of studies you think I should summarize.
- Have any questions.

Estimates of Forest Carbon: Western U.S.

W-1. Carbon credits for a small private landowner, with reduced or halted logging, western Washington[1]

Study's Focus	Estimate the carbon-credit payments to a small, non-industrial landowner for increases in forest carbon over the next 100 years from thinning 60-year-old even-aged forest every 40 years or leaving the forest unlogged, vs. clearcutting the forest every 40 years.
Findings	Carbon payments exceeding will \$80–\$100/MtCO_2 will be necessary to offset transaction costs and lost timber revenues.
Discussion	

W-2. Carbon possibilities in the Western Cascade Mountains[2]

Study's Focus	Describe the landscape-level possibilities for carbon storage across a range of forest management regimes, with joint consideration of impacts on timber harvest and habitat for seven wildlife species.
Findings	Simulations of disturbance intervals (25 to 500 years) showed that longer disturbance intervals correlate with increased levels of forest carbon. To a lesser extent, less-intensive harvests yielded similar outcomes. Scenarios showed the average store of forest ecosystem carbon ranged from 57 to 633 Mg C/ha: the lower bound represents clearcut harvests every 25 yr with site preparation by prescribed fire, and the upper bound reflects no harvests, prescribed fires, or other stand-replacing disturbances. The scenario with longest harvest interval (500 yr) stored 420 Mg C/ha more carbon than one with a 25-yr harvest interval.
Discussion	The analysis considered carbon stored in the forest ecosystem (live, dead, soil, and charcoal) and in all wood products (e.g., paper and short- and long-term structures, those in open dumps and landfills). It did not consider the indirect impacts on stored carbon resulting from the substitution of wood building materials for steel, concrete, and other materials that might have a higher carbon intensity. The omission of these impacts reflect ambiguity about the size and persistence of the substitution effects.[3]

[1] Rodrigues, L. 2011. A cost-effectiveness analysis of managing small forestland for carbon credits and timber.
[2] Kline, J.D., M.E. Harmon, T.A. Spies, A.T. Marzillo, et al. 2016. Evaluating carbon storage, timber harvest, and habitat possibilities for a Western Cascades (USA) forest landscape.
[3] *See*, for example, Law, B.E., and M.E . Harmon. 2011. Forest sector carbon management, measurement and verification, and discussion of policy related to mitigation and adaptation of forests to climate change; and Harmon, M.E. 2019. Have product substitution carbon benefits been overestimated? A sensitivity analysis of key assumptions.

W-3. Lower levels of logging on federal lands, western Oregon, 2016[4]

Study's Focus	Support decision-making and explain to the public the potential effects of alternatives for managing more than 2 million acres of forest in western Oregon managed by the Bureau of Land Management (BLM).
Findings	Relative to the Preferred Resource Management Plan, Alternative D would, during the first ten years:[5] • Store more carbon (a benefit of = $35,400/ac/yr) • Produce less timber (a cost of = $8,600/ac/yr)
Discussion	These data indicate that the value of the additional carbon that would be stored under Alternative D exceeds the value of the forgone timber (stumpage revenue) by more than 4-to-1. The carbon value reflects the $SCCO_2e$ associated with the level of climate damages expected by federal agencies in 2015.[6] The most recent estimate of the social cost (Ricke, et al 2018) indicates that the expected climate-related costs from the logging would be about ten times the estimate from the BLM and, hence, the ratio would be at least 40-to-1. If, however, climate change proves to be more damaging than expected by the BLM, the upper bound for the ratio rises to more than 80-to-1. These numbers indicate that the climate-related benefits from not logging will exceed the forgone stumpage revenue by about $350,000 per acre.

W-4. Timber–carbon tradeoffs in the Pacific Northwest under alternative forest management systems, 2018[7]

Study's Focus	Quantify impacts on carbon stores, timber output, and landowners' cash flow from managing forests to meet a subset of standards for Forest Stewardship Council (FSC) certification, relative to business-as-usual management consistent with the minimum requirements of Oregon/Washington Forest Practices Act (FPA) rules.
Findings	Extending harvest rotations from 40 to 75 years would increase average annual growth in timber volume 7% and carbon storage (forest and wood products) by 23%, but reduce the net present value of cashflow by 25%. The average reduction in landowners' revenues could be offset by a payment of $37 per additional ton of CO_2 stored, or a 10% premium on the price of wood products. Adoption of the selected FSC requirements would increase the stored carbon by 1.0–2.1 tCO_2e per thousand board feet (MBF) of timber produced. Adoption of the selected FSC requirements also may enable landowners to store more carbon have lower transaction costs for landowners wanting to receive remuneration for storing more carbon with lower transactions costs than participating in carbon-credit programs.
Discussion	Ricke, et al (2018) found that the expected $SCCO_2e$ is $417 per metric ton, rising to $800 if climate change proves more harmful than expected. These values indicate that increases in stored carbon of 1.0–2.1 tCO_2e per thousand board feet (MBF) of timber produced would have a value of about $417–1,700. In comparison, inputs to the analysis show landowners would receive about $500/MBF (delivered value of $800 minus logging and hauling costs of $300) and incur additional costs for site preparation, etc.

[4] U.S. Bureau of Land Management. 2016. Resource Management Plan and Final Environmental Impact Statement: Western Oregon.
[5] Id., pp. 541 and 657.
[6] Interagency Working Group on Social Cost of Carbon, United States Government. 2015 (revised). Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866.
[7] Diaz, D.D., S. Loreno, G.J. Ettl, and B. Davies. 2018. Tradeoffs in timber, carbon, and cash-flow under alternative management systems for Douglas-fir in the Pacific Northwest.

W-5. Carbon impacts and costs of extending harvest rotations of industrial forests in western states, 2008[8]

Study's Focus	Describe the potential quantity and costs of sequestered carbon from extending rotation ages in softwood forests of western states (California, Oregon, and Washington).
Findings	A 5-year increase in harvest rotation increases average sequestration by about 50 tons of CO_2 per hectare, and the average marginal cost by $28 per ton CO_2. Increasing the harvest rotation by 10 and 15 years would sequester 82 and 106 tons of CO_2 per hectare, with marginal costs of $32 and $35 per ton CO_2, respectively. Marginal costs increase by $0.68 per ton CO_2 for every $1/$m^3$ increase in timber prices. An increase in annual wood production (site index) of 1 m^3/yr reduces the marginal cost by $0.42 per ton CO_2.
Discussion	Ricke, et al (2018) found that the expected $SCCO_2e$ is $417 per metric ton, rising to $800 if climate change proves more harmful than expected. These values indicate that the climate-related benefits from extending the harvest rotation by 5, 10, or 15 years would exceed landowners' costs.

[8] Sohngen, B., and S. Brown. 2008. Extending timber rotations: Carbon and cost implications.

W-6. Carbon impacts from extending the harvest-rotation age for forests, 2009[9]

Study's Focus	For 20 different forest types in western regions of the U.S., estimate the amount of additional forest carbon (live tree, standing and down deadwood, understory, forest floor, and wood products) that would be sequestered by extending the harvest-rotation age by 5 years or 100 years.
Findings	All western forest ecosystems showed an increase in the amount of carbon (metric tons of CO_2e, or $MtCO_2e$) sequestered with longer rotations, estimated with three commonly used estimation methods. These results come from using the Verified Carbon Standard (VCS), which yields the lowest estimates:

Additional Sequestration (VCS Protocol) with a 5-Year Extension of Rotation Age ($MtCO_2e$/ha/yr)

Pacific Northwest East States		**Pacific Southwest States**	
Douglas Fir	0.22	Fir-Spruce-Mtn Hemlock	0.11
Fir-Spruce-Mtn Hemlock	0.12	Mixed Conifer	0.06
Lodgepole Pine	0.10	Western Oak	0.16
Ponderosa Pine	0.06	**Rocky Mountain North States**	
Pacific Northwest West States		Douglas Fir	0.15
Alder-Maple	0.44	Fir-Spruce-Mtn Hemlock	0.15
Douglas Fir	0.55	Lodgepole Pine	0.10
Fir-Spruce-Mtn Hemlock	0.32	Ponderosa Pine	0.10
Hemlock-Sitka Spruce	0.46	**Rocky Mountain South States**	
		Aspen-Birch	0.09
		Douglas Fir	0.11
		Fir-Spruce-Mtn Hemlock	0.09
		Lodgepole Pine	0.05
		Ponderosa Pine	0.06

Discussion

Results for three western forest ecosystems compare the additional sequestered carbon and forgone timber from a 100-year extension of the rotation age. The data, combined with the social cost (Ricke, et al 2018) that would result from carbon dioxide emissions over the next few years ($417/Mt CO_2e), suggest the timber prices that would be needed to exceed the value of the carbon gains:

	per m^3	per thousand board feet*
Pacific Northwest Douglas-fir:	$1,300	$3,000
Pacific Southwest Fir-Spruce-Mtn. Hemlock	$4,100	$9,700
Rocky Mtn. South Ponderosa Pine	$4,000	$9,500

The timber prices would have to be roughly twice as great to exceed the social cost of carbon emissions if climate change proves to cause damages higher than general expectations. Combined, this information strongly suggests that failing to extend the harvest-rotation age for eastern plantation forests U.S. would impose carbon-related harms that likely would exceed the value of the forgone timber production.

*Assumes 1 m^3 = 424 board feet.

[9] Foley, T., D.deB. Richter, and C. Galik. 2009. Extending forest rotation age for carbon sequestration: a cross-protocol comparison of carbon offsets of North American forests.

W-6. Net carbon sequestration with extended harvest rotations in a coastal Douglas-fir firest, 2010[10]

Study's Focus	Estimate the relative carbon stocks (forest ecosystem and wood products) produced with 100-year simulations of a no-harvest scenario and scenarios with clearcut harvests or variable-retention harvests at age 30, 50, 70, and 90 years.
Findings	The no-harvest scenario showed the largest carbon stocks, with all harvest scenarios showing reductions of more than 40% in forest carbon for plots starting with a standing forest. Among the harvest scenarios, those with a 50-year rotation stored the least carbon, 130 tons per acre, while 70- and 90-year rotations averaged 161 tons of carbon per acre.
Discussion	

[10] Foster, B.C., T.A. Robards, and W.S. Keeton. 2010. Carbon dynamics associated with uneven-aged forest management.