Forests and the Climate Emergency–Possibilities and Imperatives

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Key Findings:

A. The amount of carbon dioxide U.S. forests remove from the atmosphere annually equals about 11 percent of the nation's net annual emissions from burning fossil fuels and other activities.

B. Additional sequestration can occur through *reforestation* (planting trees on lands where forests have recently been degraded or remove; *afforestation* (planting trees on lands that have not been previously forested), and *proforestation* (leaving existing trees unlogged so they can grow bigger). Proforestation in natural forests is especially important for increasing stores of forest carbon.

C. Forests' ability to store carbon is limited by deforestation and the short-rotation logging of forest plantations.

A. U.S. forests offset 11 percent of the nation's annual greenhouse-gas emissions

Forests in the U.S. cover 766 million acres, or 33 percent of the nation's total land area (Fig. 1).[1] As the trees in these forests grow, they remove carbon dioxide from the air, through the photosynthesis process, and convert it into wood, bark, leaves, and roots. Over time, some of the carbon enters the soil. The amount of carbon dioxide that U.S. forests remove from the atmosphere annually equals about 11 percent of the nation's net annual emissions from burning fossil fuels and other activities.[2]

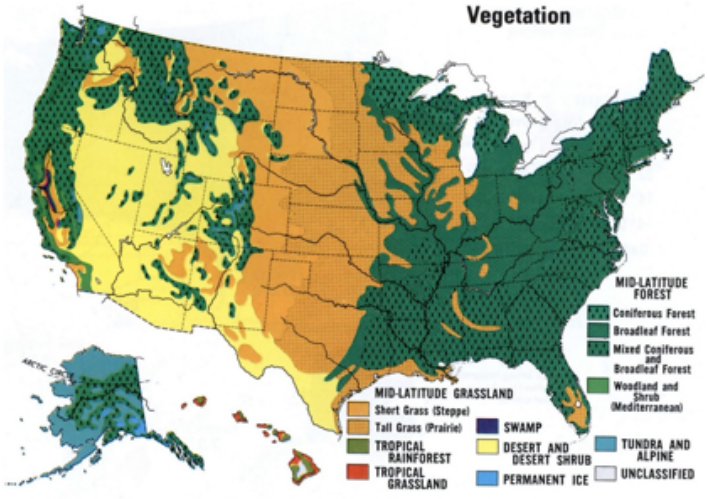

Figure 1. Vegetation resources of the U.S.

B. Reforestation, afforestation, and proforestation have the potential to offset even more

Most of us understand that we face a climate emergency and we want to do something meaningful to make it better. But what? One essential answer: grow more trees and bigger trees.

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[1] Oswalt, S. N., Smith, W. B., Miles, P. D., and Pugh, S. A. (2014). *Forest Resources of the United States, 2012: A Technical Document Supporting the Forest Service 2010 Update of the RPA Assessment*. United States Department of Agriculture, Forest Service, Washington Office. (Washington, DC), Gen. Tech. Rep. WO-91

[2] United States Environmental Protection Agency. 2019. Sources of greenhouse gas emissions.

This answer isn't meant to disrespect the countless other things we must do to reduce greenhouse-gas emissions from all sources. But it recognizes that past emissions, together with those in the foreseeable future, will result in global warming that exceeds the 1.5°C to 2.0°C targets specified in the 2015 Paris Agreement.[3] Hence, quick action is needed to remove carbon from the atmosphere. Trees offer some of the best alternatives for doing so.

Two-thirds of all land in the world—21 billion acres—is capable of supporting forest. More than 80 percent of this land already supports trees, or is used to grow food. That leaves more than 4 billion acres of previously degraded or sparsely vegetated land, including pastureland, that might be used to grow new forests.[4]

Our forests can do much more, via three pathways. Two of these involve planting tree seedlings to expand the acreage of land growing trees.[5] *Reforestation* does so on lands where forests have recently been degraded or removed; *afforestation* occurs through the planting of seedlings on lands that have not been previously forested.

Recent research shows the vast, global potential for planting trees to remove carbon dioxide from the atmosphere and store it as forest carbon.[6] "[I]t is overwhelmingly more powerful than all of the other climate change solutions proposed," said the lead researcher, Professor Tom Crowther. "It is available now, it is the cheapest one possible and every one of us can get involved."[7] Individuals could make a tangible impact by growing trees themselves, donating to forest restoration organisations and avoiding irresponsible companies." Using satellite imagery, the researchers identified 2.2 billion acres, outside cropland and urban areas, that have the potential to support new forests. Much of this land lies in the tropics, but more than one-third lies in the U.S., Canada, and Russia.[8] As they mature, these new forests potentially could remove from the atmosphere more than 750 billion metric tons on carbon dioxide, about two-thirds of the amount that humans have emitted so far, since the Industrial Revolution. About 250 million of these acres, or more than 10 percent, lie in the U.S. (Fig. 2).

[3] Paris Climate Agreement. 2015.
[4] Bastin, J-F, and others. 2019. The global tree restoration potential; Moomaw, W.R., S.A. Masino,and E.L. Faison. 2019. Intact forests in the United States: proforestation mitigates climate change and serves the greatest good; and Mackey, B. 2014. Counting trees, carbon, and climate change.
[5] National Academies of Sciences, Engineering, and Medicine. 2019. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda.*
[6] Bastin, J-F, and others. 2019. The global tree restoration potential.
[7] Carrington, D. 2019. Tree planting "has mind-blowing potential" to tackle climate crisis.
[8] Bastin, J-F, and others. 2019. The global tree restoration potential; Moomaw, W.R., S.A. Masino,and E.L. Faison. 2019. Intact forests in the United States: proforestation mitigates climate change and serves the greatest good; and Mackey, B. 2014. Counting trees, carbon, and climate change.

The third pathway, called *proforestation*, focuses on allowing existing trees to grow bigger.[9] This approach is important because, although afforestation and reforestation eventually have great potential to remove carbon dioxide from the atmosphere, their small size means the amount of carbon they can sequester in the near term is correspondingly small. A core aim of proforestation is to block the harvest of the forests that already exhibit the characteristics of intact natural ecosystems.

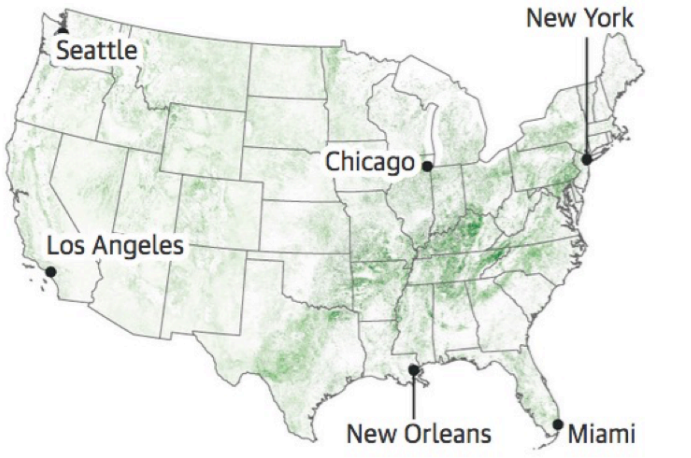

Figure 2. Potential tree cover

Allowing existing trees in intact ecosystems to continue growing is especially important because natural forests, and especially the oldest and biggest trees in them, store the most carbon. The largest 1 percent of trees in the U.S., for example, account for about 30 percent of all the nation's forest biomass.[10] Proforestation also entails allowing trees outside these intact natural forests to continue growing. This step is important because, although these trees grow more slowly than seedlings, as a percent of their existing mass, they pull much larger amounts of carbon dioxide from the atmosphere. A single tree with a trunk one-meter in diameter, for example, can annually sequester an amount of carbon equivalent to the amount stored in an entire tree with a trunk 10–20 cm. (4–8 inches) in diameter.[11]

The ability of existing forests to remove carbon dioxide from the atmosphere falls far short of the land's biophysical potential. The total number of trees in the world—more than 3 trillion—is less than half the number that existed prior to human civilization, and 15 billion trees are cut down each year.[12] Less than 20 percent of the world's forests remain intact; these are found primarily tropical forests and the boreal forests of Canada.[13] The percentage is much lower in the U.S. Just 6–7 percent for the nation as a whole, with a higher percentage in the West and a lower percentage in the East.[14]

Combined, the three strategies—reforestation, afforestation, and proforestation— have sufficient potential to offset a substantial proportion of current greenhouse-gas emissions. To

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[9] Moomaw, W.R., S.A. Masino, and E.K. Faison. 2019. Intact forests in the United States: proforestation mitigates climate change and serves the greatest good

[10] Lutz, J. A., Furniss, T. J., Johnson, D. J., Davies, S. J., Allen, D., Alonso, A., et al. 2018. Global importance of large-diameter trees. The percentage refers to aboveground biomass only.

[11] Stephenson, N. L., Das, A. J., Condit, R., Russo, S. E., Baker, P. J., Beckman, N. G., et al. 2014. Rate of tree carbon accumulation increases continuously with tree size.

[12] Crowther, T.W., H.B. Glick, … and M.A. Bradford. 2015. Mapping tree density at a global scale.

[13] Watson, J. E. M., Evans, T., Venter, O., Williams, B., Tulloch, A., Stewart, C., et al. 2018. The exceptional value of intact forest ecosystems.

[14] Oswalt, S. N., Smith, W. B., Miles, P. D., and Pugh, S. A. 2014. *Forest Resources of the United States, 2012: A Technical Document Supporting the Forest Service 2010 Update of the RPA Assessment*. United States Department of Agriculture, Forest Service, Washington Office. (Washington, DC), Gen. Tech. Rep. WO-91

accomplish this outcome, though, multiple hurdles must be overcome. Some of these are biophysical. Planting trees will not be effective, for example, in areas that lack sufficient water and soil nutrients.[15] In the U.S., the anticipated spread of 450 tree-damaging pests introduced from other countries threatens to slow tree growth and increase tree mortality. A recent examination of non-native forest pests—insects, pathogens, and organisms that eat tree sap—threaten 40 percent of the nation's forests.[16] And, already, climate change has stimulated increases in the acreage burned by wildfires, relative to past decades.[17]

C. Deforestation and industrial plantations limit the ability of U.S. forests to store carbon

Other hurdles arise from society's forest-management decisions. One entails decreasing the acreage of forest that is converted to other uses, i.e., deforestation. Deforestation occurs primarily through the conversion of forests to agriculture, urbanization, and transportation corridors (including pipelines and electricity transmissions lines). It has produced about 30 percent of total global emissions in recent years. The full extent of these emissions often remains hidden however, because reforestation globally has offset almost two-thirds of this amount, so that the net carbon emissions resulting from deforestation actions across the world currently exceed 10 percent of total global emissions.[18]

Within the U.S. the extent of deforestation is often similarly clouded. Forested area in the U.S. has increased slightly—about 3 percent—over the past 60 years.[19] This growth has not been distributed evenly across all regions, however, with notable losses resulting from rapidly growing urban centers surrounded by forests. A continuation of this trend would result in the deforestation of almost 30 million acres between 2000 and 2050.[20]

Realization of proforestation goals will require curtailing the suboptimal management of existing forests for carbon storage. With the cessation of deforestation globally, existing forests could, by the end of the century, remove from the atmosphere an amount of carbon dioxide 12 times the amount currently emitted annually by burning fossil fuels.[21]

Existing forests store less than the optimal amount of carbon largely because industrial timber producers have converted complex, natural forests to simplified, plantation forests that

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[15] Keith, K., Mackey, B. and Lindenmayer, D. 2009. Re-evaluation of forest biomass carbon stocks and lessons from the world's most carbon- dense forests; and Terrer, C., R.B. Jackson, I.C. Prentice, and others. 2019. Nitrogen and phosphorus constrain the CO_2 fertilization of global plant biomass.

[16] Fei, S., R.S. Morin, C.M. Oswalt, and A.M. Liebold. 2019. Biomass losses resulting from insect and disease invasions in US forests.

[17] National Interagency Fire Center (2019). *Total Wildland Fires and Acres (1926-2017)*. It is important to note, however, that wildfires in recent years have burned a much smaller area annually than was experienced in the early 20th Century.

[18] Le Quéré, C., Andrew, R. M., Friedlingstein, P., Sitch, S., Pongratz, J., Manning, A. C., et al. 2018. Global carbon budget 2017; Richard Houghten, quoted in Geiling, N. 2016. Reforestation doesn't fight climate change unless it's done right.

[19] Oswalt, S. N., Smith, W. B., Miles, P. D., and Pugh, S. A. (2014). *Forest Resources of the United States, 2012: A Technical Document Supporting the Forest Service 2010 Update of the RPA Assessment*. United States Department of Agriculture, Forest Service, Washington Office. (Washington, DC), Gen. Tech. Rep. WO-91

[20] Nowak, DJ and Walton, JT. 2005. Projected urban growth (2000-2050) and its estimated impact on the US forest resource.

[21] Moomaw, W.R., S.A. Masino, and E.K. Faison. 2019. Intact forests in the United States: proforestation mitigates climate change and serves the greatest good

emphasize one or just a few species, and log trees on short harvest intervals that kill trees well before they reach their full carbon-storage potential. Forests with a high degree of species diversity and a complex canopy absorb more sunlight and sequester carbon more rapidly.[22] This relationship indicates that forest-management strategies that preserve or promote structural complexity of the forest canopy, rather than monocultural simplicity, will result in higher levels of stored forest carbon.

Longer logging intervals also will enable existing forest to store more carbon. Recent research in western Oregon illustrates the potential.[23] Over several decades, logging intervals on industrial timberlands in this region have declined from 120 years to 45 years and even less. These cycles are far shorter than those needed for Douglas fir and other coniferous species common to the region to reach their peak annual rate of carbon storage (net productivity), which typically occurs at an age between 80 and 125 years. This difference indicates that the current logging intervals significantly suppress the forests' ability to store carbon. Extending the logging interval on private lands to 80 years, for example, and reducing harvest on public lands in the region would increase carbon stocks in the region by 17 percent by 2100.[24] In addition, logging-related emissions would decline from the current level, 34 million metric tons per year, by 2 million metric tons per year.

Supporters of the timber industry sometimes claim that the conversion of natural forests to plantations and accelerated logging increases the amount of carbon stored in harvest-based wood products. This argument points to the carbon stored for long periods in the lumber and wood panels used for construction and to the specialty wood products used to make furniture. No doubt, some of these wood products can store carbon away from the atmosphere for long periods and, if that were the only outcome from industrial timber production, the argument for more plantations and logging might have merit. In reality, though, wood products account for only about 60 percent of the forest carbon affected by logging. The rest, e.g., limbs left behind at the logging site, is lost to burning or rapid decomposition. Of the carbon in the wood products, themselves, about 40 percent is in paper, which typically decomposes in less than 10 years, and 60 percent is in solid lumber, panels, and other products.[25] Most of these solid wood products are burned or decompose within a few years or decades. Only 4 percent of the original forest carbon ends up in solid wood products that withhold carbon from the atmosphere for more than 30 years. Carbon stored annually in wood products—lumber, wood panels, and paper—resulting from logging of US forests offsets less than 1 percent of the nation's total annual GHG emissions.[26]

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[22] Gough, et al. 2019. Canopy complexity and forest production.
[23] Law, B.E., Hudiburg, T.W., Berner, L.T., Kenbt, J.J., Buotte, P.C., Harmon, M.E., 2018. Land use strategies to mitigate climate change in carbon dense temperate forests; Oregon Global Warming Commission. 2018. Forest carbon accounting project report; Krankina, O.N., et al. 2012. Carbon balance on federal forest lands of Western Oregon and Washington: The impact of the Northwest Forest Plan; and Talberth, J., 2017. Oregon Forest Carbon Policy: Scientific and technical brief to guide legislative intervention. Portland, OR: Center for Sustainable Economy. Available online at: https://sustainable-economy.org/wp-content/uploads/2017/12/Oregon-Forest-Carbon-Policy-Technical-Brief-1.pdf.
[24] Law, B.E., Hudiburg, T.W., Berner, L.T., Kenbt, J.J., Buotte, P.C., Harmon, M.E., 2018. Land use strategies to mitigate climate change in carbon dense temperate forests.
[25] LeQuéré,C.,Andres,R.J.,Boden,T., and others. 2012. The global carbon budget 1959–2011.
[26] Johnston, C.M.T., and V.C. Radeloff. 2019. Global mitigation potential of carbon stored in harvested wood products.

It is important to recognize the relative magnitude of the different hurdles to expanded storage of carbon by U.S. In recent years, deforestation has accounted for just 3 percent of the forest carbon lost annually, and biophysical factors—winds, pests, drought, and fires—for 12 percent. The remaining 85 percent of annual forest-carbon loss has resulted from logging.[27]

Climate change, itself, can boost the amount of carbon stored by forests. In some areas, higher levels of atmospheric carbon dioxide and warmer temperatures may stimulate tree growth and, hence, the sequestration of carbon dioxide from the atmosphere. When appropriate levels of water, nutrients, and soil conditions are available, the higher concentrations of carbon dioxide in the atmosphere in 2100 might increase the amount of biomass by 12 percent.[28]

In sum, current research offers a positive, but not simple message. Growing trees—letting existing trees grow larger and planting seedlings—offers the only realistic opportunity for pulling meaningful amounts of carbon dioxide from the atmosphere in the next years and decades. A few countries have already recognized the importance of planting trees.[29] The U.S. has the potential to lead the world in capitalizing on using forests to ease the climate emergency.

[27] Harris, N. L., Hagen, S. C., Saatchi, S. S., Pearson, T. R. H., Woodall, C. W., Domke, G. M., et al. 2016. Attribution of net carbon change by disturbance type across forest lands of the conterminous United States.
[28] Terrer, C., R.B. Jackson, I.C. Prentice, and others. 2019. Nitrogen and phosphorus constrain the CO_2 fertilization of global plant biomass.
[29] See, e.g., Vidal, J. 2018. A eureka moment for the planet: We're finally planting trees again.