Georgia Law Review

Volume 58 | Number 4 Article 7

6-10-2024

Resilient Forest Management and Climate Change

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RESILIENT FOREST MANAGEMENT AND CLIMATE CHANGE

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Climate change threatens the very existence of the world's forests as temperature increases outpace forests' ability to adapt. Society must implement adaptation policies aimed at making forests more resilient. This Article describes how we can better manage for more resilient forests by first detailing some of the scientific and policy complexity affecting our ability to do so. The Article then details the primary adaptation solutions for creating greater forest resiliency (reducing fire risk and integrating more climate resilient species into forests), some of the impediments to implementing those solutions (federalism, geographic and ecological differences in forests, and scientific unknowns), and how to overcome those impediments (incentivizing market development, increasing government investment, reforming federal administrative law, and harnessing expertise in regional forestry programs to build trust).

[*] Dean and Professor of Law, Cumberland School of Law, Samford University. I dedicate this Article to my sons, Campbell Hudson and Ridley Hudson, with hope that we will save the forests for them and for all future generations.

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> *"[We] need to better understand what type of ecosystems will replace these forests when regeneration fails . . . and the implications for carbon sequestration, hydrology, wildlife habitat, and other key ecosystem services on which society depends."*[1]

I. INTRODUCTION

It has been said that "[f]orests only exist in human minds," since forests "come together for a short time; then each species goes its separate way when conditions change."[2] Since forests first emerged on planet Earth, they have come and gone as conditions change—and they always will. During glacial-interglacial cycles, forests would often disappear, completely erased from the landscape as ice pushed them out of parts of North America and other parts of the globe.[3] Yet when the ice receded, forests reemerged and reestablished.[4] In short, the distribution of forests we see across the world today has never been static, and there is no reason we should expect forest distribution to remain static in the future.

The concern now, of course, is that while forests have been able to disappear and reestablish across the landscape in the past, they did so over extremely long time scales—hundreds of thousands of years. The rate of change we are seeing today with human-induced climate change—rapid increases in temperature over mere decades—is so great that forests may be unable to adapt, survive, and reemerge after disturbance.[5]

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[1] Kimberley T. Davis et al., *Reduced Fire Severity Offers Near-Term Buffer to Climate-Driven Declines in Conifer Resilience Across the Western United States*, 120 PROC. NAT'L ACAD. SCIENCES 1, 7 (2023).

[2] THOMAS M. BONNICKSEN, AMERICA'S ANCIENT FORESTS: FROM THE ICE AGE TO THE AGE OF DISCOVERY 15 (2000).

[3] *See* Jonathan Adams, *North America During the Last 150,000 Years*, OAK RIDGE NAT'L LAB'Y, https://www.esd.ornl.gov/projects/qen/nercNORTHAMERICA.html [https://perma.cc/DK5V-D244] (presenting data depicting the vegetation in North America and its changes over time due to the waxing and waning of glaciers covering the continent); *see generally* BONNICKSEN, *supra* note 2, at 15 ("Constant warming and cooling of the climate, and the ebb and flow of glaciers, caused the disassembly of old forests and the reassembly of new forests.").

[4] Adams, *supra* note 3.

[5] The average temperature in Oregon is expected to increase by five degrees Fahrenheit by 2050 relative to 1895. *See Northwest Reforestation, Planting to Suit Current and Future*

News articles declare: "Some forests aren't growing back after wildfires,"[6] "Is this the end of forests as we've known them?",[7] and "Wildfires are erasing Western forests. Climate change is making it permanent."[8] Even scientific articles, like one recently published in *Global Ecology and Biogeography*, proclaim: "A changing climate is snuffing out post-fire recovery in montane forests."[9] Referring to some western forests recently burned by wildfire, one researcher stated that "[w]e need to just start accepting that they're not going to become forests again, unfortunately."[10] Another asserted that "[n]ow's a good time to go visit national parks with big trees."[11] Studies have demonstrated that large parts of the southern Rocky Mountains will be unable to support tree species as the climate continues to warm.[12] For a stunning visual, consider the 2002 Hayman Fire near Colorado Springs, which left the area treeless nearly two decades later.[13]

Climates, U.S. DEP'T OF AGRIC., https://www.climatehubs.usda.gov/hubs/northwest/topic/northwest-reforestation-planting-suit-current-and-future-climates [https://perma.cc/LXJ2-4KNF]. Consider that the U.S. Department of Agriculture's "Hardiness Zone" map, a familiar tool used by those seeking to cultivate certain species of trees or other plants in certain regions, varies by five-degree increments. *See id.* (noting that the zones "differ by 5 °F per zone"); *2023 USDA Plant Hardiness Zone Map*, U.S. DEP'T OF AGRIC., https://planthardiness.ars.usda.gov [https://perma.cc/57Y7-ZFDH] (displaying plant hardiness based on temperature throughout the United States). So this would be a significant shift.

[6] Emily Chung, *Some Forests Aren't Growing Back After Wildfires, Research Finds*, CBC NEWS (Dec. 12, 2017, 5:55 PM), https://www.cbc.ca/news/science/forests-wildfires-1.4444998 [https://perma.cc/696P-9DDF].

[7] Alastair Gee, *Is This the End of Forests as We've Known Them?*, GUARDIAN (Mar. 10, 2021), https://www.theguardian.com/environment/2021/mar/10/is-this-the-end-of-forests-as-weve-known-them [https://perma.cc/696P-9DDF].

[8] Nathanael Johnson, *Wildfires Are Erasing Western Forests. Climate Change Is Making It Permanent*, GRIST (Nov. 29, 2021), https://grist.org/climate/climate-change-forest-loss/ [https://perma.cc/98RH-P6AX].

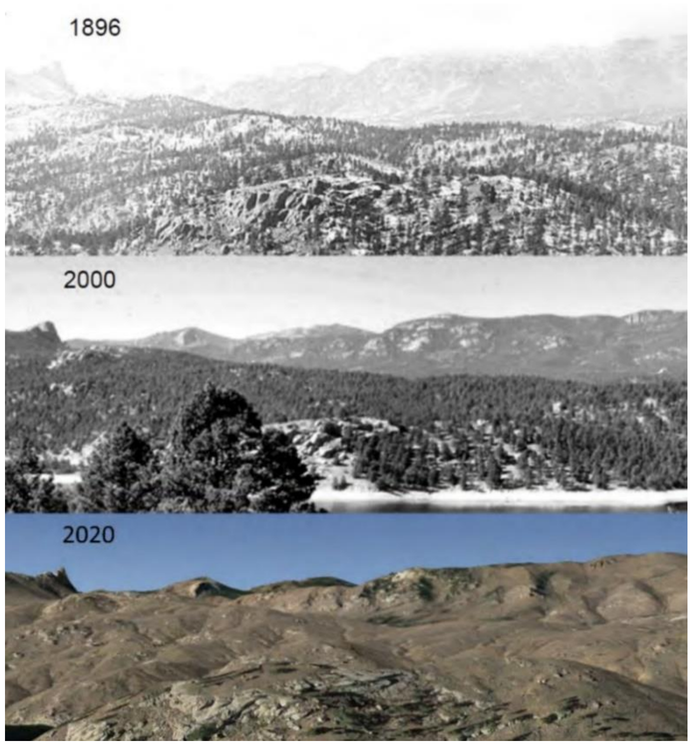
[9] Kyle C. Rodman et al., *A Changing Climate Is Snuffing Out Post-Fire Recovery in Montane Forests*, 29 GLOB. ECOLOGY & BIOGEOGRAPHY 2039, 2039 (2020).

[10] Chung, *supra* note 6.

[11] Gee, *supra* note 7.

[12] *See* Rodman et al., *supra* note 9, at 2049 ("Continued warming is likely to lead to increases in wildfire activity and declines in post-fire resilience throughout . . . the southern Rocky Mountains.").

[13] *See* Michael Elizabeth Sakas, *As Wildfires Grow More Intense, Iconic Western Forests May Not Come Back*, NPR (Sept. 13, 2020, 7:00 AM), https://www.npr.org/2020/09/13/911935457/as-wildfires-grow-more-intense-iconic-western-



U.S. Forest Service, taken by Kauffman and Mark Finney. The 1896 image from Denver Water Board.

“Landscape changes near Colorado’s Cheesman Reservoir over time. Frequent wildland fires historically sustained open ponderosa pine forests, but a century of fire exclusion produced dense forests. Devastated by the enormous Hayman Fire in 2002, the forests never recovered.”[14]

forests-may-not-come-back [https://perma.cc/7BPB-FAQW] (“These 18-square miles burned hot and fast in a single day, driven by how dense the forest was because of past fire suppression, high winds and extreme drought. . . . [N]early two decades later, something you’d normally see after a wildfire is missing: new trees.”).

14 *See Confronting the Wildfire Crisis*, U.S. FOREST SERV., https://experience.arcgis.com/experience/0fe032e92fad464fbcdc7faf12cd7928/page/Confronting-Wildfire-Crisis/ (last visited Feb. 25, 2024).

Ultimately, "while most forests have the potential to adapt to hotter, dr[i]er conditions, they aren't changing quickly enough to avoid the impending stress"[15] and species populations "exposed to a rate of environmental change exceeding the rate at which populations can adapt, or disperse, may be doomed to extinction."[16]

Forests contain about 50% of global terrestrial carbon stocks[17] but are at ever-greater risk of die off as the climate warms and drought conditions worsen.[18] This is especially problematic considering that nearly half of global forests have already been converted to agriculture or other land uses.[19] Climate change, therefore, presents a threat to forests on multiple fronts. Not only are forests themselves directly at risk due to drought and other climate change impacts, but they are indirectly at risk due to related climate-induced phenomena like sea level rise. Consider that 40% of the U.S. population lives within the coastal zone.[20] As sea levels rise, they will inundate coastal developments and spur new developments inland, increasing conversion pressures on existing forestlands. And not only will climate change damage forests environmentally, it will also cause great economic harm in the forestry sector. The forest-products industry employs nearly one million people in the United States, generates $200 billion of revenue, and makes up about 6% of domestic manufacturing gross

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[15] Harrison Tasoff, *Forests Can Adapt to Climate Change, but Not Quickly Enough*, U.C. SANTA BARBARA: THE CURRENT (July 10, 2023), https://news.ucsb.edu/2023/021113/forests-can-adapt-climate-change-not-quickly-enough [https://perma.cc/GN2Y-GJKB].

[16] Ian Thompson, Brendan Mackey, Steven McNulty & Alex Mosseler, *Forest Resilience, Biodiversity, and Climate Change: A Synthesis of the Biodiversity/Resilience/Stability Relationship in Forest Ecosystems*, 43 CONVENTION ON BIOLOGICAL DIVERSITY TECH. SERIES 1, 14 (2009).

[17] *Id.* at 25.

[18] *See* J. Au et al., *Forest Productivity Recovery or Relapse? Model-Data Integration Insights on Drought-Induced Tipping Points*, 29 GLOB. CHANGE BIOLOGY 5652, 5653 (2023) (stating that "'[h]otter droughts' are causing large-scale tree dieback globally.").

[19] Thompson et al., *supra* note 16, at 25.

[20] *What Percentage of the American Population Lives Near the Coast*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. (Jan. 18, 2024), https://oceanservice.noaa.gov/facts/population.html [https://perma.cc/XMG8-GVRN].

domestic product.[21] Fewer forests means lost economic opportunities.

Forests currently absorb 1.5 times more carbon dioxide than the United States emits each year.[22] They are critical carbon sinks in the battle against climate change. But what happens when a critical tool in the toolbox for fighting climate change disappears? What happens if we are unable to reforest areas that were once part of this vast network of carbon sequestration? Some have hung their climate hopes on planting a trillion trees.[23] Though this initiative has laudable goals, it has been criticized as greenwashing by some, and subject to a wide range of criticisms by others.[24] One of the most salient concerns is simply whether we will even be able to establish and maintain those forests under future climate conditions across many regions of the world. In other words, if landscapes become unsuitable for growing forests, then it matters very little how many you plant—they will not survive, and their utility as a carbon sequestration tool will be lost. As stated by one commentator, "much-touted proposals to plant millions of trees to suck up carbon and ameliorate the climate crisis are encountering skepticism; they won't work if conditions on Earth don't allow for forests to reproduce and thrive."[25]

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[21] *Climate Change Impacts on Forests*, EPA (Nov. 16, 2023), https://www.epa.gov/climateimpacts/climate-change-impacts-forests [https://perma.cc/7LBA-BVCU].

[22] *See* Nancy Harris & David Gibbs, *Forests Absorb Twice as Much Carbon as They Emit Each Year*, WORLD RES. INST. (Jan. 21, 2021), https://www.wri.org/insights/forests-absorb-twice-much-carbon-they-emit-each-year [https://perma.cc/4A7H-VCHB] (describing forest "carbon sinks" that absorb 7.6 billion metric tons of carbon dioxide annually).

[23] *See, e.g.*, *Why the World Needs a Trillion More Trees!*, PLANT FOR THE PLANET, https://www.plant-for-the-planet.org/trillion-trees/ [https://perma.cc/X7S2-NLR9] (discussing the goal of planting one trillion trees to help make up for the three trillion trees that have been cut down by humans).

[24] *See* Alexandra Heal, *The Illusion of Saving the Planet with a Trillion Trees*, FIN. TIMES (Apr. 12, 2023), https://ig.ft.com/one-trillion-trees/ (discussing criticisms of the trillion trees initiative including "greenwashing" concerns, in addition to other practical considerations such as a lack of space and the inconsistency of immature trees to store carbon).

[25] Gee, *supra* note 7. Not to mention that increasing density of any forests can lead to greater fire risk as the climate warms and droughts become more common and last longer. *See* Susan J. Prichard et al., *Adapting Western North American Forests to Climate Change and Wildfires: 10 Common Questions*, 31 ECOLOGICAL APPLICATIONS, July 4, 2021, at 19 (stating "dense tree plantations are highly susceptible to future wildfires and drought"). A

In this way forests present an ironic situation. On the one hand they are one of the key components for fighting climate change and probably the most cost-effective way to sequester carbon while also providing tremendous co-benefits in the form of cleaner air,[26] cooler local temperatures (due to evapotranspiration),[27] and increased water retention and flood control[28]—among other benefits. On the other hand, climate change will make it harder to keep forests intact. So, while offsetting emissions by investing in forest

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metaphor for how humans have dealt with the looming climate disaster comes straight from this story of western forests:

> When [scientists] told the Forest Service about . . . early observations, . . . officials shrugged off the concern. Back then, during President George W. Bush's administration, the idea that climate change was already producing changes was still somewhat taboo. It would probably just take a few years for trees to get reestablished, the government foresters said.
>
> But over the years, the evidence piled up. And new research has cemented the scientific consensus that climate change is making it much harder for forests of Western mountains to return after fires.

Johnson, *supra* note 8. Now, these areas are becoming shrublands. *Id.*

[26] *See Air Pollution Removal by Urban Forests*, NAT'L PARK SERV. (Jan. 7, 2022), https://www.nps.gov/articles/000/uerla-trees-air-pollution.htm [https://perma.cc/Z864-ATEG] ("Trees absorb gaseous molecules in the air. Tiny pores on tree leaf surfaces called stomata take in air that includes toxic pollutants.").

[27] *See Using Trees and Vegetation to Reduce Heat Islands*, EPA (Oct. 31, 2023), https://www.epa.gov/heatislands/using-trees-and-vegetation-reduce-heat-islands [https://perma.cc/5CJ9-UK9T] ("Trees and vegetation . . . lower surface and air temperatures by providing shade and cooling through evaporation and transpiration, also called evapotranspiration.").

[28] *See Soak Up the Rain: Trees Help Reduce Runoff*, EPA (Dec. 21, 2023), https://www.epa.gov/soakuptherain/soak-rain-trees-help-reduce-runoff [https://perma.cc/DB3M-62PQ] ("Trees are increasingly recognized for their importance in managing runoff. Their leaf canopies help reduce erosion caused by falling rain. They also provide surface area where rain water lands and evaporates. Roots take up water and help create conditions in the soil that promote infiltration.").

maintenance,[29] reforestation,[30] and afforestation[31] are useful market incentives to reduce the effects of climate change,[32] if those forests are likely to die, burn down, or not return because of climactic shifts, then an important tool for combatting climate change is eliminated. In that way, climate induced deforestation becomes a positive feedback loop,[33] making it even harder to combat climate change.

We must craft law and policy responses to help forests adapt more quickly and become more resilient. We must support assisted migration of tree species, so that we can begin to populate at risk areas with more drought and heat tolerant species, to maintain their carbon sequestration capabilities. We must also harness the power of science to invest in genetic modification of tree species that can survive future climate conditions.

This Article offers some thoughts on how we might pursue resilient forest management policies by first providing a brief

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[29] *See Why Manage Forests in the Face of Climate Change*, CONN. DEP'T OF ENERGY & ENV'T PROT. (Apr. 2022), https://portal.ct.gov/DEEP/Forestry/Climate-Change/Why-Manage-Forests-in-the-Face-of-Climate-Change [https://perma.cc/7ZJM-4PZ2] (discussing the impacts forest management has on climate change and societally).

[30] *See* R. KASTEN DUMROESE, JENNIFER A. BALACHOWSKI, DAVID FLORES & MATTHEW E. HORNING, XV WORLD FORESTRY CONG., REFORESTATION TO MITIGATE CHANGES TO CLIMATE: MORE THAN JUST PLANTING SEEDLINGS 1 (2022) ("Reforestation is considered the best (by far) natural method for mitigating changes to climate . . . . The social aspect of the reforestation contributions to adaptation could include, for example, diversified employment opportunities that provide economic sustainability . . . .").

[31] *See Afforestation Can Help to Tackle Climate Change. Here's How*, WORLD ECON. F. (Nov. 3, 2021), https://www.weforum.org/agenda/2021/11/afforestation-can-help-tackle-climate-change-heres-how/ [https://perma.cc/F8S6-SX67] ("Afforestation is establishing a forest, especially on land not previously forested. . . . Around the world, governments, the private sector, and local communities have started some work on promising projects.").

[32] Trina Kleist, *Can This Forest Survive? Predicting Forest Death or Recovery After Drought*, PHYS.ORG (Aug. 30, 2023), https://phys.org/news/2023-08-forest-survive-death-recovery-drought.html [https://perma.cc/R3SF-SL8G] (discussing the effects of prolonged drought on the ability of trees to trap gaseous molecules such as carbon dioxide and the reduction of this effect during periods of extreme drought).

[33] *See* Shanna Hanbury, *Scientists Measure Amazon Drought and Deforestation Feedback Look: Study*, MONGABAY (July 21, 2020), https://news.mongabay.com/2020/07/scientists-measure-amazon-drought-and-deforestation-feedback-loop-study/ [https://perma.cc/KFG8-ZULQ] (discussing the positive feedback loop of drought and deforestation in the Amazon rainforest and noting that "deforestation causes drought, which in turn worsens deforestation, and so on, intensifying the effect").

background on forest related climate impacts in Part II. Part III then describes what managing resilient forests looks like. Hereinafter, "resilient forest management" refers to fuel removal (woody debris on the forest floor and/or standing timber that is too dense), assisted migration of tree species, integration of more resilient species into current forests, and related measures. Part IV then describes some of the scientific and policy complexity that makes pursuing resilient forest management policies challenging. Part V describes some adaptation solutions and impediments to solutions, while Part VI offers some potential solutions to those impediments. Part VII concludes.

II. Background on Forest-Related Climate Impacts

While forests are critical to sequestering carbon, a changing climate affects long-term forest processes such as rates of photosynthesis and respiration, as well as short-term processes like the frequency of both storm damage and wildfires.[34] Pests, drought, and disease are expected to contribute to increased forest losses in North America as climate changes and global temperatures increase.[35]

The United States provides a great example of how climate change will impact forests differently based on regional conditions. In the dry, arid West, the impacts of climate change will be felt sooner and more severely as western forests become even drier and warmer.[36] Research has demonstrated the declining regeneration capacity of western forests over the last forty years.[37] Climate

[34] *See* Thompson et al., *supra* note 16, at 9 ("Climate has a major influence on rates of photosynthesis and respiration, and on other forest processes, acting through temperature, radiation, and moisture regimes over medium and long time periods. Climate and weather conditions also directly influence shorter-term processes in forests, such as frequency of storms and wildfires, herbivory, and species migration." (citations omitted)).

[35] *See* Caren C. Dymond et al., *Diversifying Managed Forests to Increase Resilience*, 44 CAN. J. FOREST RSCH. 1196, 1196 (2014) (citing to a Canadian study that connected climate-change-induced pests, drought, and disease to forest damage and that projected an increase in pests, drought, and disease in the future).

[36] *See* Davis et al., *supra* note 1, at 1 (noting that the West's dry and warm climate makes the region "vulnerable to ecological transformation").

[37] *See id.* (finding "declining regeneration capacity across the West over the past four decades for the eight dominant conifer species studied").

change is expected to reduce the probability of post-fire tree regeneration across the region.[38]

In the southeastern United States, drought conditions tend to be less frequent and severe, and southeastern forests in particular are relatively balanced in the mix of drought tolerant and intolerant species.[39] But even in the Southeast climate models show risk and severity of dry conditions increasing in the future.[40] While some studies have shown that southeastern forests might actually experience enhanced plant growth under future climate scenarios, other studies suggest that "increasing extreme climate events and disturbances are likely to more than offset" these effects on growth.[41] Nonetheless, "[t]emperate deciduous forests should continue to provide most of the same goods and services under climate change as currently, although the state, especially the species composition, will be altered, suggesting at least ecological resilience."[42]

So, southeastern forests may very well prove to be more resilient than western forests. Indeed, while there is legitimate concern about whether forests can adapt at a rate that can keep pace with climate change, these forests do tend to have great genetic diversity which gives them an advantage to respond "reasonably rapidly" to environmental change.[43] The question remains: will it be rapid enough?

The degree to which climate change will affect forests is also impacted by historic forest management decisions made by humans. In western forests, we see climate change impacts intensified by

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[38] *See id.* at 3 (projecting that climate change "will increasingly limit postfire tree recruitment in the future").

[39] *See* Matthew P. Peters, Louis R. Iverson & Stephen N. Matthews, *Long-Term Droughtiness and Drought Tolerance of Eastern US Forests over Five Decades*, 345 FOREST ECOLOGY & MGMT. 56, 58 (2015) (finding that the Eastern United States has less severe and less frequent droughts and boasts a mix of species that are both tolerant and intolerant to drought conditions).

[40] *See, e.g.,* Robert J. Mitchell et al., *Future Climate and Fire Interactions in the Southeastern Region of the United States*, 327 FOREST ECOLOGY & MGMT. 316, 320 (2014) (discussing models used to simulate future climate and highlighting results that indicate increased fire risk for severe droughts, despite uncertainty with respect to precipitation forecasts).

[41] Thompson et al., *supra* note 16, at 39.

[42] *Id.* (citation omitted).

[43] *Id.* at 16.

historical fire suppression policies, removal of fire-resistant species, and related forest management decisions.[44] Western forests have simply become so dense that when fires do occur, they are far more severe than they would have been absent previous fire suppression efforts.[45] Severe fire, in turn, inhibits seedling regrowth, while less severe fires allow tree seedlings to effectively regenerate.[46] Reduced regeneration is due not only to higher severity and intensity fires causing fewer seeds to be available, but also from the postfire climate, which inhibits seedling reestablishment (because it is hotter and drier).[47] Studies have shown that just one year of moisture deficit within the first five years of a high severity forest fire seriously inhibits reforestation.[48] While in 2000 5% of western forests would be unlikely to see conifer regeneration after a severe fire event, by 2050 that percentage is expected to be 31%, "highlighting a limited time window over which management actions that reduce fire severity may effectively support postfire conifer regeneration."[49] One study, looking at 1,500 forest sites that had suffered a wildfire in the Rocky Mountains between 1985 and 2000, found that since 2000 only about one third of the sites were growing back, whereas before 2000 85% were reforesting.[50] The former sites had become warmer and drier, tracking the trend of a warming planet more generally.[51] It is expected that by as soon as 2050 as much as 15% of the forests in the western United States

[44] *See* Davis et al., *supra* note 1, at 1 (explaining that the impacts of climate change are "compounded by more than a century of wildfire suppression, exclusion of indigenous burning, logging of large fire-resistant trees, and other forest management practices").

[45] *See New UM Study Reveals Unintended Consequences of Fire Suppression*, UNIV. OF MONT. (Mar. 25, 2024), https://www.umt.edu/news/2024/03/032524fire.php [https://perma.cc/JYS7-SZG8] ("Fire suppression exacerbated the trends already caused by climate change and fuel accumulation . . . causing areas burned to increase three to five times faster over time relative to a world with no suppression.").

[46] *See* Davis et al., *supra* note 1, at 1, 3 (discussing the difference between high-severity fires which "set the stage for ecological transformation" and less severe burns).

[47] *See id.* at 1 ("Postfire regeneration is sensitive to high-severity fire, which limits seed availability, and postfire climate, which influences seedling establishment.").

[34] *Id.* at 5.

[49] *Id.* at 1.

[50] Chung, *supra* note 6; *see id.* (explaining that increasing fire intensity has caused the eradication of "all organic matter needed to help the soil retain nutrients and moisture required for trees to grow").

[51] *Id.*

will not grow back because of climate change, and by 2100, half of Alberta, Canada's forests may disappear.[52] While climate change will impact the ability of forests to regenerate, reduction in fire severity can mitigate this impact to a degree.[53]

The southeastern United States has, on the other hand, a history of utilizing prescribed burns to emulate fire regimes of the past.[54] Southeastern foresters have had the luxury of that management tool because of wetter conditions in the region.[55] Research has also shown that humid conditions like those in the Southeast are likely to result in faster growth rates than in more arid regions.[56] As a result, timber managers can readily remove fuels from the forest and plant new trees to re-sequester carbon lost from cultivation over relatively short time frames.[57] Yet, even southeastern forests are poised to experience drought and increased temperatures that may jeopardize the use of prescribed burns as a management option in the future.[58]

III. MANAGING RESILIENT FORESTS

Scholars have noted that a variety of challenges arise when planning forest management in a time of climate change: shifting societal expectations, such as increased recognition of the need to utilize forests to combat climate change; increasing fragmentation

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[52] Gee, *supra* note 7.

[53] *See* Davis et al., *supra* note 1, at 3 ("[R]eductions in overall fire severity or the size of high-severity patches could partially offset expected declines in postfire regeneration attributed to climate change alone.").

[54] Blake Hudson, *Fighting Fire with Fire? Adjusting Regulatory Regimes and Forest Product Markets to Mitigate Southern United States Wildfire Risk*, 33 J. ENV'T L. & LITIG. 33, 33–34 (2018); *see also* A. Sydney Johnson & Phillip E. Hale, *The Historical Foundations of Prescribed Burning for Wildlife: A Southern Perspective*, *in* THE ROLE OF FIRE IN NONGAME WILDLIFE MANAGEMENT AND COMMUNITY RESTORATION 11, 11–18 (W. Mark Ford, Kevin R. Russell & Christopher E. Moorman eds., 2002).

[55] Hudson, *supra* note 54, at 33–34.

[56] Jack Lautz, *Biological Growth Rates and Rates of Return*, 2 FOREST RSCH. NOTES, No. 3, 2005, at 1, 3.

[57] *See How Forests Store Carbon*, PENNSTATE EXTENSION (Aug. 22, 2023), https://extension.psu.edu/how-forests-store-carbon [https://perma.cc/ALA7-Y8M8] (discussing the role of fast-growing trees in forests and the role they play in carbon sequestration).

[58] Hudson, *supra* note 54, at 33–34.

of forests; gradual decreases in forest resilience; loss of historical reference conditions, also known as shifting baselines;[59] and increasing uncertainty in future environmental and socio-economic conditions.[60] These scholars have called for viewing forests as complex adaptive systems to foster forest resilience.[61] In the context of forests, the term "resilience" refers to "the capacity of a forest to withstand . . . external pressures and return, over time, to its pre-disturbance state. When viewed over an appropriate time span, a resilient forest ecosystem is able to maintain its 'identity' in terms of taxonomic composition, structure, ecological functions, and process rates. . . ."[62]

In forests, species diversity impacts the resilience of forest landscapes to pests and disease.[63] Pests like beetles bore through tree bark and, under normal conditions, are pushed back by gooey pitch emanating from the tree.[64] But with a lack of water during a drought, trees cannot make enough pitch, and the beetles kill the tree.[65] Having a more diverse set of species within a forest can help increase resilience against such pests.[66]

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[59] *See* Reagan Pearce, *Are You Suffering from Shifting Baseline Syndrome?*, EARTH.ORG (June 19, 2020), https://earth.org/shifting-baseline-syndrome/ [https://perma.cc/933R-A5TK] ("[Shifting Baseline Syndrome] has increased our tolerance to environmental degradation, including wildlife population decline, increased pollution and loss of natural habitats. This is because people will evaluate the severity of environmental degradation by referencing it back to their own cognitive baseline.").

[60] *See* Christian Messier et al., *The Functional Complex Network Approach to Foster Forest Resilience to Global Changes*, 6 FOREST ECOSYSTEMS, Apr. 9, 2019, at 1–2 (listing challenges to be incorporated into forest planning).

[61] *See id.* at 4–5 (describing how conceptualizing forests as a "complex adaptive system" can help foster an integrated approach to forest management).

[62] Thompson et al., *supra* note 16, at 7.

[63] Dymond et al., *supra* note 35, at 1203.

[64] *See Battle in the Bark*, GOV'T OF CAN. (Nov. 19, 2022), https://parks.canada.ca/docs/v-g/dpp-mpb/sec3 [https://perma.cc/M2CW-R82Y] (discussing the defense mechanisms of pine trees against beetles)

[65] *See* Gee, *supra* note 7 (describing how droughts can make even young, healthy trees susceptible to insects and other pests).

[66] *See* Caleb J. Wilson, *Are Trees in Species-Rich Urban Plantings Less Susceptible to Pest Damage?*, ENTOMOLOGY TODAY (Nov. 17, 2023), https://entomologytoday.org/2023/11/17/urban-trees-species-diversity-less-pest-damage-scale-insects [https://perma.cc/RW75-DCFL] ("Trees in species-rich forests often suffer less damage from insect pests compared to trees in forests dominated by a few common species.").

Tropical, arid, and temperate forests are showing a significant decline in resilience due to climate change and associated impacts on water availability.[67] Boreal forests, on the other hand, are showing increased resilience in scattered areas, due to greater warming and increased growth from higher levels of carbon dioxide and longer growing seasons.[68] Even so, water availability stressors may very well cause declines in these forests in the future as well.[69] Nearly 25% of intact, undisturbed global forests are at risk of crossing "a critical resilience threshold" from which they will not be able to recover.[70]

Resiliency in forest ecosystems can be achieved along three fronts. The first approach is to "increase the compositional, genetic, and functional trait diversity of communities."[71] The second way is to "improve structural diversity,"[72] that is, to diversify the number of different physical landscapes within a forest habitat. The final way is to "foster landscape-level functional connectivity" between different habitats and landscapes.[73] Increasing diversity along these fronts is an example of the "insurance hypothesis," to bolster forest resilience by ensuring that one or more of the diversity variables will be able to withstand whatever disturbance poses the greatest risk at a particular point in time.[74] Nearly half of all planted forests (that is, not natural forests) rely on a single species.[75] In other

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[67] *See* Giovanni Forzieri, Vasilis Dakos, Nate G. McDowell, Alkama Ramdane & Alessandro Cescatti, *Emerging Signals of Declining Forest Resilience Under Climate Change*, 608 NATURE 534, 534 (2022) (arguing that "increased water limitations and climate variability" have led to a significant declines in resilience in tropic, arid, and temperate forests).

[68] *Id.*

[69] *See id.* at 535 ("[T]he pattern observed at the high latitudes could eventually change in response to the expected decline in water availability . . . .").

[70] *See id.* at 534 ("Approximately 23% of intact undisturbed forests . . . have already reached a critical threshold . . . .").

[71] Marco Mina, Christian Messier, Matthew J. Duveneck, Marie-Josée Fortin & Núria Aquilué, *Managing for the Unexpected: Building Resilient Forest Landscapes to Cope with Global Change*, 28 GLOB. CHANGE BIOLOGY 4323, 4324 (2022).

[72] *Id.*

[73] *Id.*

[74] Messier et al., *supra* note 60, at 5–6.

[75] *See* Christian Messier et al., *For the Sake of Resilience and Multifunctionality, Let's Diversify Planted Forests!*, 15 CONSERVATION LETTERS, July 16, 2021, at 2 (noting that of 290 million hectares of planted forests, 131 million hectares are monospecific planted forests).

words, these forests are “monospecific” or “monocultures.”[76] These types of forests are more susceptible to disturbance and the impacts of climate change.[77] So moving away from monospecific forests is critical to resilient forest management.

For some time, scientists have argued that, to avoid the worst impacts of climate change on forests, they should be managed “in an ecologically sustainable way that recognizes and plans for predicted future climates” and “reduce[s] the odds of long-term failure by apportioning some areas of assisted regeneration for trees from regional provenances and from climates that approximate future climate conditions, based on climate modelling.”[78] Scientists have also argued that forest managers should focus on resilient management, calling for increased species, genetic, ecosystem, and structural diversity, as well as the planned migration of tree populations.[79]

Indeed, the concept of assisted migration has gained traction in recent years. The term “assisted migration” is defined as “the human-assisted movement of plants or animals to a new habitat” by planting species adapted to a future climate.[80] The need to transition and accept species makeup changes is critical: “We need to be thinking about these forests not as static things—that need to exist just as they are right now—but as healthy things that need to change to keep up with the climate . . . .”[81]

While assisted migration and other mechanisms of changing forest species composition to adapt to future climates offer promise as a means of engaging in resilient forest management, there are some scientific and policy complexities that must be acknowledged and dealt with for such policies to be successful.

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[76] Messier et al., *supra* note 60, at 2, 3.

[77] *See id.* at 2 (“Although monospecific planted forests are important in providing timber, they harbor less biodiversity and are potentially more susceptible to disturbances than natural or diverse planted forests.”).

[78] Thompson et al., *supra* note 16, at 8.

[79] Dymond et al., *supra* note 35, at 1204 (citations omitted).

[80] *Northwest Reforestation, Planting to Suit Current and Future Climates*, U.S. DEP’T OF AGRIC., https://www.climatehubs.usda.gov/hubs/northwest/topic/northwest-reforestation-planting-suit-current-and-future-climates [https://perma.cc/F7SZ-P9F8].

[81] Tasoff, *supra* note 15 (quoting Professor Lee Anderegg).

IV. SCIENTIFIC AND POLICY COMPLEXITY

A. VERTICAL: FEDERAL VS. STATE CONTROL OVER FOREST MANAGEMENT DECISIONS

Only about 35% of the nation's forests are federally owned and managed.[82] About 5% of forests are state owned and managed, while the remaining 60% of forests in the U.S. are owned and managed by private landowners.[83] Private landowners are subject to state forest laws and policies,[84] and while the federal Endangered Species Act or section 404 of the Clean Water Act can impact private forest management under certain scenarios, currently there is no direct federal regulation of private forest management (e.g., riparian buffer zone, stand density, and clear-cut requirements).[85] It is unclear whether this divide in policymaking is political—meaning the federal government *chooses* to stay out of private forest management decisions as a matter of policy—or legal—meaning that the federal government is *constitutionally constrained* under the Tenth Amendment from regulating private forest management (though given the interstate commerce effects of the forest industry, the latter seems unlikely).[86] Because private forest management

[82] ARNOLDO CONTRERAS-HERMOSILLA, HANS M. GREGERSEN & ANDY WHITE, CTR. FOR INT'L FORESTRY RSCH., GOVERNANCE BRIEF NO. 39, FOREST GOVERNANCE IN COUNTRIES WITH FEDERAL SYSTEMS OF GOVERNMENT: LESSONS FOR DECENTRALIZATION 5 tbl.2.1 (2008).

[83] *Id.* A study of fifteen states found that about 80% of roundwood production occurs in private forests. CONSTANCE L. MCDERMOTT, BENJAMIN CASHORE & PETER KANOWSKI, GLOBAL ENVIRONMENTAL FOREST POLICIES: AN INTERNATIONAL COMPARISON 84 (2010). Forestland accounts for roughly 25% of the land area in the United States. U.N. ENV'T PROGRAMME, NORTH AMERICA'S ENVIRONMENT: A THIRTY-YEAR STATE OF THE ENVIRONMENT AND POLICY RETROSPECTIVE 110 (2002).

[84] *See* LAND USE LAW CTR., PACE UNIV. SCH. OF L., BEGINNER'S GUIDE TO LAND USE LAW 4 (n.d.), https://law.pace.edu/sites/default/files/LULC/LandUsePrimer.pdf [https://perma.cc/HGD5-A6YK] (discussing the basics of land use law that are largely prescribed by "local legislatures").

[85] *See* Paul Ellefson, Anthony Cheng & Robert J. Moulton, *State Forest Practice Regulatory Programs: An Approach to Implementing Ecosystem Management on Private Forest Lands in the United States*, 21 ENV'T MGMT. 421, 421–22 (1997) ("Although some federal laws do regulate the way in which private concerns apply forest practices . . . , most authority for regulating forest practices has been assumed by state and local governments.").

[86] Blake Hudson, *Federal Constitutions, Global Governance, and the Role of Forests in Regulating Climate Change*, 87 IND. L.J. 1455, 1464–68 (2012) ("Some have argued that the

policies have historically been within the purview of state and local governments, and because the federal government has never sought control over private forest management policy-making, the legal question has yet to be tested. [87]

As described in the next part, states vary greatly in how they manage private forests. The federal government's management of federal forestland overlaps with some states' policy preferences while diverging greatly from other state preferences. It seems that one coincidental positive of the current divide in authority over forests is that the forests most at risk of destruction due to climate change—western forests—are mostly under federal control.[88] This means that the federal government, first, has clear authority to act as it deems best and, second, can tailor policies as needed to bolster western forest resilience depending on geographic location.[89] While in theory this could allow the federal government to react more nimbly and responsibly with greater control over management decisions on these lands, the federal government also has rather burdensome administrative processes it must follow when promulgating regulations on private forests, with all the time-

Tenth Amendment of the Constitution places limits on Congress's regulatory authority 'in "traditional areas of state and local authority," such as land use . . . .'" (alteration in original) (quoting James R. May, *Constitutional Law and the Future of Natural Resource Protection*, *in* THE EVOLUTION OF NATURAL RESOURCES LAW AND POLICY 124, 132 (Lawrence J. MacDonnell & Sarah F. Bates eds., 2010))).

[87] Paul V. Ellefson, Anthony S. Cheng & Robert J. Moulton, *State Forest Practice Regulatory Programs: An Approach to Implementing Ecosystem Management on Private Forest Lands in the United States*, 21 ENV'T MGMT. 421, 421–22 (1997) (referring to the dearth of federal laws and regulations in the area of private land use).

[88] *See* Lauren Barnett, *Climate Change Threatens Global Forest Carbon Sequestration, Study Finds*, SCI. DAILY (Jan. 16, 2024), https://www.sciencedaily.com/releases/2024/01/240116131840.htm [https://perma.cc/Y5FC-X43A] ("Over the past two decades, the Western U.S., grappling with more severe climate change impacts, has exhibited a notable slow-down in productivity, while the Eastern U.S., experiencing milder climate effects, has seen slightly accelerated growth."); KATIE HOOVER & ANNE A. RIDDLE, CONG. RSCH. SERV., IF12001, U.S. FOREST OWNERSHIP AND MANAGEMENT (2021), https://crsreports.congress.gov/product/pdf/IF/IF12001 (providing data on the extent of the federal government's control of forestland throughout the United States).

[89] *See Managing Federal Lands and Waters*, U.S. GOV'T ACCOUNTABILITY OFF., https://www.gao.gov/managing-federal-lands-and-waters [https://perma.cc/RLJ9-QHBR] (discussing the authority of the federal government over its land holdings and the different agencies that manage federal land).

consuming notice and comment and other procedures that follow.[90] So while there is no question that the federal government has control over the western forestlands most at risk, the government may not be able to make decisions in as timely a manner as state-level policymakers directing the forest management activities of private landowners.

B. HORIZONTAL: DIFFERENCES IN STATE POLICIES AND ENVIRONMENTS

1. State-Level Forest Policy Divergence. Not only is there a split between federal and state government control over forests, but there is also a wide range of approaches across various state jurisdictions managing forest resources.[91] In the southeastern United States, for example, there is very little in the way of prescriptive private forest management; instead, southeastern states almost exclusively use voluntary "best management practices" for forestry. So instead of a law or regulation declaring, for example, that "property owners must leave 30 feet of buffer along the riparian watershed," these voluntary best management standards would say "property owners *should* leave" a buffer.[92] In other words, there is no mechanism for enforcing riparian buffer zone establishment in the Southeast. States in the Southeast do have a variety of policies related to fire, however, and do seem more willing implement such policies when commercial timber resources are directly at risk of loss.[93] Another area where southeastern states

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[90] *See, e.g.*, *Commenting on Forest Service Rules and Directives*, U.S. DEP'T OF AGRIC., https://www.fs.usda.gov/about-agency/regulations-policies/comment-on-directives [https://perma.cc/PP9V-RW8W] (providing a number of Forest Service proposed rules that are or were open to public comment).

[91] Erin Clover Kelly & Mindy S. Crandall, *State-Level Forestry Policies Across the US: Discourses Reflecting the Tension Between Private Property Rights and Public Trust Resources*, 141 FOREST POL'Y & ECON. 102757, Aug. 2022, at 4–5 (discussing governmental control practices and considerations of different states).

[92] *See, e.g.*, S.C. DEP'T OF NAT. RES., GUIDE TO BEST MANAGEMENT PRACTICES FOR RIPARIAN LANDS 2–3 (2020) (providing best management practices that "should" be implemented).

[93] *See* Hudson, *supra* note 54, at 42 ("Southern states also maintain voluntary best management practices detailing the proper construction and maintenance of firebreaks, access to water supplies, location of timber staging areas, and methods of prescribed burning.").

are more likely to regulate is invasive species. An example is cogongrass,[94] an invasive grass species which has severe negative impacts on forestry operations in the southeastern United States (inhibiting the use of prescribed burns and causing other problems).[95] So it may be that states in these areas are willing to mandate policies aimed at making southeastern forests more climate resilient, especially if doing so makes southern forests less susceptible to fire risk. However, state governments in the Southeast are also less likely to implement climate policies as a general matter, particularly in the context of greenhouse gas emission targets, development of climate action plans, carbon pricing policies, and electricity portfolio and low carbon/alternative fuel standards.[96] The politics of the region—predominantly red states—are such that many politicians either doubt the veracity of climate science or have fundamental disagreements about whether prescriptive methods should be used to address climate change even if they accept the science.[97]

In other parts of the country, such as the Pacific Northwest, states are more likely to enact prescriptive forest management regulations on private lands.[98] There are various factors playing into a state's willingness to do so, but one factor is what is called the forest policy "spillover effect," where the extent of and proximity to

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[94] JOHN D. BYRD JR., VICTOR MADDOX & CHARLES T. BRYSON, MISS. STATE UNIV. EXTENSION, POD-02-18, COGONGRASS 1 (2018) ("Cogongrass is designated as the seventh worst weed in the world.").

[95] *See id.* at 2 ("Mowing or burning will remove above-ground cogongrass vegetation, but these methods open the plant canopy for emergence of seedlings and new stems from rhizomes.").

[96] *See State Climate Policy Maps*, CTR. FOR CLIMATE & ENERGY SOLS., https://www.c2es.org/content/state-climate-policy/ [https://perma.cc/CW6B-GJR8] (providing a visual representation of climate policies by state).

[97] *See* Alec Tyson, Cary Funk & Brian Kennedy, *What the Data Says About Americans' Views of Climate Change*, PEW RSCH. CTR. (Aug. 9, 2023), https://www.pewresearch.org/short-reads/2023/08/09/what-the-data-says-about-americans-views-of-climate-change/ [https://perma.cc/82U4-ZMTV] (presenting data regarding different views on climate change broken down by political party affiliation). I should note that there are clearly other regions of the U.S. with the same policy bent, such as the Midwest. But those regions do not contain a significant portion of the nation's forest resources.

[98] *See* Kelly & Crandall, *supra* note 91, at 5 (displaying data showing that northwestern states have enacted regulatory regimes and states outside of the northwest have adopted less stringent regimes).

federal/public forests—which tend to be managed more stringently—spills over into private forest management policy.[99] As a result, states with a greater percentage of forestlands in public ownership maintain a body politic more willing to send representatives to state legislatures that will place similar restrictions on private lands.

2. Geographic Differences in Forest Types: N/S/E/W. Regardless of what level of government is managing the forest, there are geographical scale complexities that complicate policies aimed at making forests more resilient. Forests, from the Pacific Northwest to the southern Rockies, to northern New England, and to the Southeast are very different in both species composition and susceptibility to climate change impacts. This means that policy responses must be tailored to specific regions of the United States.

Also, forests in different regions face distinct indirect climate change pressures. As noted in the introduction, sea level rise will cause development and infrastructure to move from coastal areas, and new development pressures will be placed on currently undeveloped forestlands. This is particularly true in the Southeast, where the shallow slope of Gulf Coast lands leads to higher rates of sea level rise.[100] In the same way, other forms of climate migration are likely to cause strain on forest resources. For example, as southern states suffer more as the climate changes,[101] populations may migrate north to escape more dangerous temperatures and other disaster events. That would cause new residential, commercial, and industrial development pressures on currently undeveloped northern forest lands.

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[99] MCDERMOTT, CASHORE & KANOWSKI, *supra* note 83, at 346.

[100] *See* Adam Zuvanich, *Gulf Coast Sea Level Rising at 'Unprecedented' Rate, Recent Studies Find*, HOUSTON PUB. MEDIA (Apr. 12, 2023, 4:48 PM), https://www.houstonpublicmedia.org/articles/climate-change/2023/04/12/449026/gulf-coast-sea-level-rising-at-unprecedented-rate-recent-studies-find/ [https://perma.cc/ED7L-YMAL] (reporting on a study showing that sea levels in the gulf coast have increased by approximately one-half inch annually, more than triple the global average for sea level rise).

[101] *See* Brad Plumer & Nadja Popovich, *As Climate Changes, Southern States Will Suffer More than Others* (June 29, 2017), https://www.nytimes.com/interactive/2017/06/29/climate/southern-states-worse-climate-effects.html ("[Researchers] found that the impacts [of climate change] could prove highly unequal: states in the Northeast and West would fare relatively well, while parts of the Midwest and Southeast would be especially hard hit.").

3. Scientific Unknowns. Climate models are just that, models. While scientists can predict with some degree of clarity climate change impacts on forest resources under certain temperature scenarios, there is no certainty.[102] For instance, precipitation changes in the southeastern United States are highly uncertain.[103] Will it be drier or wetter, and in which season of the year will it be drier or wetter? Even if precipitation technically increases, increased temperatures will cause droughts to be longer and drier.[104] Ultimately, managing for more resilient forests will require policy to be informed by the best scientific guesses available.

V. ADAPTATION SOLUTIONS AND IMPEDIMENTS TO SOLUTIONS

While vertical and horizontal federalism considerations, division of regulatory authority over federal and private forests, ecological differences in forests across geographic regions of the U.S., and scientific uncertainty in climate modeling all make adapting to more resilient forests challenging, there are adaptation solutions that should be pursued more aggressively at all levels of government. Some of these solutions are harder to implement, meaning we have less control over their efficacy, while others are easier (and we have more control over their success).

A. HARDER TO IMPLEMENT RESILIENT FOREST MANAGEMENT SOLUTIONS: PREVENTION OF FIRE

Alluded to earlier, preventing the risk of catastrophic fire is one of the major pillars of building resilient forests.[105] Fuel reduction treatments have been shown to reduce local wildfire severity,

[102] *See* U.S. GLOB. CHANGE RSCH. PROGRAM, REGIONAL CLIMATE TRENDS AND SCENARIOS: THE SOUTHEAST U.S. 2 (2013) (highlighting that there are different models of climate change because what will actually happen surrounding the climate is unknown).

[103] *Id.*

[104] Blake Hudson, *supra* note 54, at 36 ("Perhaps most importantly, both drier and wetter cycles will last longer in the future.").

[105] *See supra* notes 45–53 and accompanying text (discussing the damaging effects of severe fires).

particularly in areas that use prescribed burns.[106] But obviously prescribed burns are not available for many, if not most, forestlands in the West given the risk of catastrophic fire.[107] Other forms of reducing fuel loads are available, such as forest raking, thinning, and other means of actively removing standing and fallen woody material from the forest.[108]

Fire is inevitable, and many variables affect its frequency and severity[109]—the presence of drought, lightning strikes, campers who let a campfire get out of control, and similar variables.[110] While we have less control over those variables, we have more control over how dense the forest is and the presence of high fuel loads.[111] And we can choose to aggressively pursue forest thinning and fuel reduction policies.

I own an eight-acre piece of property in Colorado that backs up to a national forest. It is one of the unhealthiest forests I have ever seen. Just walking through the forest takes great effort because there is so much downed timber to step over and go around. I also spend a lot of time in Alabama forests, which gives me quite a contrast in perspectives. Western forests are so dry with very little

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[106] *See* Davis et al., *supra* note 1, at 2 ("There is substantial evidence that fuel reduction treatments, especially those using prescribed burning, effectively reduce local wildfire severity in dry forests." (citation omitted)).

[107] *See* Daniel L. Swain et al., *Climate Change is Narrowing and Shifting Prescribed Fire Windows in Western United States*, 4 COMMC'N EARTH & ENV'T, Oct. 3, 2023, at 2, 8 (noting the wildfire risks in the West and that "climate change will likely further complicate efforts to use prescribed fire as a wildfire risk management and ecological enhancement tool").

[108] *See* Carolyn B. Brochez & Sonja E.R. Leverkus, *Assessing Feasibility of Wildfire Fuel Reduction Targets in North-Central British Columbia*, 22 J. ECOSYSTEMS & MGMT., Nov. 3, 2022, at 4–5 (noting some alternative fuel reduction strategies including raking, thinning, and pruning).

[109] *See* Harold S.J. Zald & Christopher J. Dunn, *Severe Fire Weather and Intensive Forest Management Increase Fire Severity in a Multi-Ownership Landscape*, 28 ECOLOGICAL APPLICATIONS 1068, 1068, 1075–76 (2018) (summarizing a study that sought to determine the factors that can best predict fire severity).

[110] *See e.g.*, *id.* at 1075 ("We found daily fire weather was the most important predictor of fire severity, but ownership, forest age, and topography were also important.").

[111] *See* Matt P. Plucinski, *Fighting Flames and Forging Firelines: Wildfire Suppression Effectiveness at the Fire Edge*, 5 FIRE SCI. & MGMT., Jan. 31, 2019, at 7 (discussing the use of laboratory testing to determine the efficacy of fire retardants due to the uncontrollable nature of fire weather); Brochez & Leverkus, *supra* note 108, at 4 (noting how much control we have over mechanical treatments of forests that decrease forest density via raking, thinning, and pruning).

microbial activity (unlike southeastern forests) that trees that fell decades or even a century ago simply do not decay.[112] The forest is a powder keg ready to ignite. Interestingly, the Forest Service has been very active in nearby Colorado communities thinning forest lands, particularly those near the local town twenty minutes away and near the wildland-urban interface, to reduce fire risk.[113] The problem with the forestland behind my property is that it is very difficult to access. Not only is it difficult to get machinery into and out of the area, doing so also takes human labor resources and immense financial resources.

Even if these obstacles are overcome, accessing this area will also require a reduction in administrative bureaucratic hurdles. The Forest Service is guided by the Multiple Use Sustained Yield Act[114] and the National Forest Management Act[115] when making management decisions for the national forests. And they must balance environmental protection with timber production, recreation, and other uses.[116] The process of making changes in policy can be quite slow. So that will be a challenge to overcome. Regardless of the difficulty in managing the vast range of federal forests, forest thinning and reduction of fuel loads must occur far more aggressively than current efforts if we are to reduce the risk of catastrophic fire and the negative impacts on forest regeneration that follow.[117]

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[112] *See* Rebecca A. Lybrand, Rachel E. Gallery, Nicole A. Trahan & David J.P. Moore, *Disturbance Alters the Relative Importance of Topographic and Biogeochemical Controls on Microbial Activity in Temperate Montane Forests*, 9 FORESTS 97, 108 (2018) (noting that western forests which have been hit by wildfire have "lower microbial biomass").

[113] *See* Bruce Finley, *Colorado Forest Lovers Brace as Feds Rev Up Multi-Billion Dollar "Wildfire Crisis" Logging Across West*, DENVER POST (Sept. 22, 2022, 5:17 PM), https://www.denverpost.com/2022/09/22/forest-cutting-willdfire-dilemma-50m-acres/# [https://perma.cc/5WXX-TTNK] ("In [one] Colorado area, roughly 100,000 acres will be thinned or burned . . . before 2027 . . . .").

[114] 16 U.S.C. §§ 528–531.

[115] 16 U.S.C. §§ 1600–1687.

[116] Multiple Use Sustained Yield Act, 16 U.S.C. §§ 528–531; National Forest Management Act, 16 U.S.C. §§ 1600–1687.

[117] *See Wildland Fire: What is Hazard Fuel Reduction?*, NAT'L PARKS SERV. (May 10, 2017), https://www.nps.gov/articles/what-is-hazard-fuel-reduction.htm [https://perma.cc/5EU6-RSMN] (explaining how fuel reduction through methods such as thinning trees ensure that wildfires are less severe and more manageable); *New Research: Hotter and Drier Conditions Limit Forest Recovery from Wildfires*, NATURE CONSERVANCY (March 5, 2023),

Southeastern forests present a different challenge. The challenge for southeastern forests will not be as much about difficulty in implementing policies as it will be in passing the policies in the first instance.[118] State legislatures can pass legislation readily to implement fuel load reduction policies on private forestlands, and many indeed already do address fire mitigation to a degree.[119] But it is likely that far more innovative mechanisms of forestalling severe fire events will be needed as drought conditions worsen and temperatures rise in the region.[120] Hopefully states in the Southeast will see the need to implement such policies if for no other reason than to protect timber production, an important industry in the region.[121]

B. EASIER TO IMPLEMENT RESILIENT FOREST MANAGEMENT SOLUTIONS: WHAT TO PLANT

Easier adaptation policies over which we have greater control include questions of what tree species we plant to create more resilient forests. Scientists have been working to develop a better understanding of which species of trees thrive in which temperature gradients and in which future climate.[122] In fact, the U.S. Forest

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https://www.nature.org/en-us/newsroom/new-research-wildfire-forest-recovery/ [https://perma.cc/7FPV-VYMX] (describing research findings that forest management techniques including thinning reduce fire severity thereby promoting regeneration after fires).

[118] *See* Hudson, *supra* note 54, at 39 (describing findings that the Southern U.S. "maintains some of the laxest regulatory policies on forest management of any global region studied").

[119] *See id.* at 42 (describing current regulations relating to forest management in the Southeast).

[120] *See Drought Early Warning System: Southeast,* NAT'L INTEGRATED DROUGHT INFO. SYS., https://www.drought.gov/dews/southeast [https://perma.cc/7R33-5FSB] (noting that the Southeast is increasingly experiencing drought conditions).

[121] *See* Mateusz Perkowski, *Northwest vs. Southeast: Timber Industry Grows Where It Thrives*, CAP. PRESS (May 12, 2022), https://www.capitalpress.com/ag_sectors/timber/northwest-vs-southeast-timber-industry-grows-where-it-thrives/article_866722ac-c7f6-11ec-9d5a-cb0aa7e052cb.html [https://perma.cc/E9PV-7Y9A] (detailing the multibillion-dollar timber industry in the southeast).

[122] *See* Cuiyin Wu, *How Choosing the Right Tree Can Help Adapt to Climate Change,* CHESAPEAKE BAY PROGRAM (May 8, 2020), https://www.chesapeakebay.net/news/blog/how-choosing-the-right-tree-can-help-adapt-to-climate-change [https://perma.cc/D3EN-SRPF]

Service has published projections[123] for 125 tree species in the eastern United States that will help determine "their potential to migrate naturally into suitable habitats as the climate changes over the next 100 years."[124] Policymakers and forest managers can use these projections to assist in migration of forests and in building forest resiliency to adapt to climate change over time. In other words, we are developing the capacity to cultivate seeds and seedlings and actively plant trees in a purposeful way to further their adaptive capacities and link those decisions with expected temperature changes over certain periods of time.

VI. SOLUTIONS TO COMPLEXITY AND ADAPTATION IMPEDIMENTS

While some adaptation policies are harder to implement and others easier to implement, those difficulties are compounded by the complexity and potential policymaking impediments discussed in Part IV. Whether it is regional politics, general distaste for prescriptive regulation, slow administrative processes, or otherwise, there are some paths to overcoming this complexity. Tying solutions to markets, increasing investments, simplifying administrative agency processes, and harnessing local academic, scientific, and private party expertise can assist in overcoming the problems created by the complexity and adaptation impediments described in Parts IV and V.

A. TIE SOLUTIONS TO MARKETS: ENERGY AND MASS TIMBER

Whether it is reducing fire risk, integrating more climate resilient species into current forests, or creating new forests out of those species, markets can provide critical economic incentives to do so. Climate is not at the top of voter priorities, thought it has risen

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(reporting on recent research into which tree species will be more suitable under future climate conditions).

[123] *See* Louis R. Iverson, Anantha M. Prasad, Matthew P. Peters & Stephen N. Matthews, *Facilitating Adaptive Forest Management Under Climate Change: A Spatially Specific Synthesis of 125 Species for Habitat Changes and Assisted Migration over the Eastern United States*, 10 FORESTS 989 (2019) (researching climate impacts of 125 tree species).

[124] Wu, *supra* note 122.

in the ranks of salient issues in recent years.[125] Even if it were at the top, government spending is already high and it is unlikely that government can effectively regulate all these policies into existence, much less pay for them, in the absence of market incentives.

Without the proper economic incentives, resources, and investments, it will be difficult to spur fuel removal in hard-to-reach, remote locations on federal lands. I have written extensively about how wood pellet markets can bolster forest management, forest restoration, and maintenance of a strong cycle of carbon recapture.[126] It seems counterintuitive to many environmentalists with whom I have come into contact that cutting trees can actually save them. Yet, in the absence of regulatory prescriptions requiring forest preservation, markets are the only thing incentivizing landowners to keep their forests forested in some regions of the U.S. like the Southeast.[127] Without such incentives, forests in that region (more than 86% of which are privately owned)[128] are under increased pressure to convert to farmland, housing developments, or some other use.[129]

Wood pellet facilities, like Drax Biomass in England, have converted some or all their fossil fuel-fired boilers to burn wood pellets, much of it shipped from the southeastern United States.[130]

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[125] *See, e.g., Most Important Issue for Voters in the United States as of February 2024,* STATISTA (Feb. 23, 2024), https://www-statista-com.eu1.proxy.openathens.net/statistics/1362236/most-important-voter-issues-us/ (presenting survey data revealing that climate and the environment is the most important issue to 8% of voters, the fifth-highest percentage of survey respondents).

[126] *See* Blake Hudson, *Harnessing Energy Markets to Conserve Natural Resources? The Case of Southern U.S. Forests*, 44 FLA. STATE U. L. REV. 995, 995 (2017) (calling for consideration of "whether the failure to develop [wood pellet] markets could contribute to forest conversions that will both reduce forest ecosystem services in the South and leave more carbon dioxide in the atmosphere than would utilization of southern forests as an energy source").

[127] *See id.* at 996 ("[U]sing trees for energy can create markets that incentivize property owners not only to reforest areas cultivated for energy production, but to expand into and regrow forests on currently unforested lands—leading to a net gain in the resource.").

[128] DAVID N. WEAR & JOHN G. GREIS, U.S. FOREST SERV., THE SOUTHERN FOREST FUTURES PROJECT: SUMMARY REPORT 58 (2011).

[129] *See id.* at 62 ("The forest products industry divested about three quarters of its timberland holdings from 1998 to 2008 . . . . The largest gain in ownership was realized by timber investment management organizations and real estate investment trusts.").

[130] Neil Harrison, *UK Wood Pellet Market: Past, Present and Future*, BIOMASS MAG. (Mar. 20, 2020), https://biomassmagazine.com/articles/uk-wood-pellet-market-past-present-and-

As detailed further in my research, while it is true that wood pellet electricity generation releases carbon dioxide into the atmosphere, wood pellets are nonetheless not fossil fuels. The carbon released, at least from pellets produced from southeastern forests, can be recaptured in a relatively short period of time.[131] We might not justify timber operations of primary (standing) timber on western forestland under the same rationale, because those trees take a long time to grow back and recapture carbon (unless in the context of thinning primary western timber as a fuel reduction strategy).[132] But it could be an incentive for removal of woody debris and already downed timber from western forest floors. While woody debris in western forests takes a long time to decay,[133] it eventually decays nonetheless and therefore would inevitably get into the atmosphere anyway. In the Southeast, on the other hand, a primary timber market for wood pellets could incentivize preservation of current forestlands and drive forest expansion onto currently unforested lands. When faced with the choice between: a) catastrophic fire due to downed trees and high fuel loads in federal forests and/or conversion of southeastern forests to non-forest uses versus b) removing those trees and high fuel loads, reducing the risk of catastrophic fire, and displacing fossil fuel generated electricity by burning wood pellets, the latter may very well be the better option from a climate perspective.

While the long-term goal is to generate electricity based upon completely renewable, noncarbon emitting sources like solar and wind, there are carbon costs locked into those industries too. The production and materials required for panels and turbines have

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future-16876 [https://perma.cc/3ARJ-CCEW] ("Most of the cofiring power stations have either closed or converted since these early projects, with several making the move to 100% wood pellets for fuel. The largest of these is Drax Power Station in North Yorkshire . . . .").

[131] *See* Hudson, *supra* note 126, at 996 ("Forests are unique among natural resources because they provide enough material for large-scale energy generation, yet they grow back rather quickly, particularly in the southeastern United States . . . .").

[132] *See* Mikayla Mace, *Warming Will Reduce Ability of Trees to Slow Climate Change*, UNIV. OF ARIZ. (June 24, 2020), https://news.arizona.edu/story/warming-will-reduce-ability-trees-slow-climate-change [https://perma.cc/SJC6-DETL] (predicting a decline in tree-ring width or growth rate in the American Southwest and the Pacific Northwest).

[133] *See* Lybrand et al., *supra* note 112, at 108 (noting that western forests which have been hit by wildfire have "lower microbial biomass" which is required for decomposition).

carbon footprints of their own.[134] More importantly, the reliability of those sources of energy will always be intermittent until we develop sufficient battery storage.[135] Meeting peak electricity demand with "peaker plants" is traditionally accomplished by burning fossil fuels like coal or natural gas.[136] With high electricity demand, no batteries, and only wind turbines and solar, there may be insufficient resources to meet demand without the use of fossil fuels.[137] An alternative to fossil fuels would be a known quantity of wood pellets outside a boiler that can be readily burned to meet peak demand.[138] And if the wood used to generate electricity comes from thinned stands or the forest floor out West, thus reducing fire risk and catastrophic impacts of severe fire, or if it is cultivated from southeastern forests which are then replanted and quickly re-sequester carbon from the atmosphere, *and* fossil fuels are displaced as a source of electricity generation, many goals can be accomplished at once.

To create the most demand, it will take investment in infrastructure and a focus on the development of wood pellet plants

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[134] *See* Andrew Moseman et al., *Does the Steel and Concrete Needed to Build Renewable Energy Cancel Out the Benefits?*, MIT CLIMATE (Mar. 18, 2022), https://climate.mit.edu/ask-mit/does-steel-and-concrete-needed-build-renewable-energy-cancel-out-benefits [https://perma.cc/T44P-ULLY] ("It takes fossil fuels to build renewable energy infrastructure such as solar panels and wind turbines, but those emissions pale in comparison to the CO2 avoided by using renewable energy.").

[135] *See* *Intermittent Renewable Energy*, BONNEVILLE POWER ADMIN., https://www.bpa.gov/energy-and-services/efficiency/demand-response/intermittent-renewable-energy (last visited Feb. 23, 2024) (noting the rise of batteries in an effort to "improve grid reliability and open up new channels for storing renewable energy" but also stating that battery "technology is relatively new, [and] the industry is still navigating optimal sizing and integration").

[136] *See* Miriam Wasser, *What to Know About a Planned Natural Gas 'Peaker' Plant in Mass.*, WBUR (Apr. 8, 2022), https://www.wbur.org/news/2022/04/08/peabody-peaker-natural-gas-power-massachusetts [https://perma.cc/5ZBG-EHXJ] (stating that peaker plants "tend to operate a few hundred hours a year, and often are older, more polluting facilities").

[137] *See* Cornellis "Keys" van Kooten, *'Renewable' Energy Can't Replace Fossil Fuels*, FRASER INST. (Dec. 13, 2021), https://www.fraserinstitute.org/blogs/renewable-energy-cant-replace-fossil-fuels [https://perma.cc/8AT7-X5KT] (stating that a paper in favor of "a world without fossil fuels . . . relies on unrealistic assumptions and ignores important costs associated with renewable energy developments").

[138] *See* Hudson, *supra* note 126, at 995 ("Wood pellet production facilities have spread rapidly across the southeastern United States over the last decade, a market driven largely by electricity generators in Europe converting from coal-fired to wood pellet-fired boilers.").

in the U.S. to make this market fully mobilized to provide incentives to keep southeastern forests forested and reduce fuel loads in western forests. While some European and Asian nations have begun investing in this infrastructure, converting coal fired power plants to wood pellet electricity generating facilities,[139] the United States is not generating electricity via wood pellets at scale.[140] Even without a domestic wood pellet electricity market, a growing global market still provides some incentive to ship excess fuel loads and timber overseas. But the impacts are not nearly as great as they would be in a domestic market, which could capitalize on the efficiencies of transporting wood pellets over fewer miles to local electricity generating facilities rather than shipping them overseas.

For primary timber—that is, timber cut for the purpose of directing it to a market, like that in the Southeast—other markets already exist or are emerging. Home construction, though it displaces valuable ecological resources if not done with proper environmental controls on development, remains a source of carbon sequestration.[141] Linkages between resilient tree species and these markets can be critical to allowing managed forests of the future to remain lower catastrophic fire risks and maximize carbon sequestration capabilities.[142] There are tradeoffs, in that maximizing carbon sequestration can have negative impacts on, for example, biodiversity.[143] But without forests sequestering carbon, higher global temperatures threaten those resources anyway.[144]

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[139] *See, e.g.*, Harrison, *supra* note 130 (detailing the UK's switch to wood pellet electricity generating facilities).

[140] *See* Hudson, *supra* note 126, at 997 ("A century and a half ago, wood supplied up to 90% of the energy needs in the United States. Today that number stands at 2%." (footnotes omitted)).

[141] *See* Silvia Vilčeková et al., *Life Cycle Assessment and Indoor Environmental Quality of Wooden Family Houses*, 12 SUSTAINABILITY 10557, tbls.2 & 3 (2020) (providing the environmental impact of the life cycle of wooden homes).

[142] *See* Laura Tupenaite et al., *Timber Construction as a Solution to Climate Change: A Systematic Literature Review*, 13 BUILDINGS 976 (2023) (synthesizing research on the advantages of specific timber products used in construction).

[143] *See* Alejandro Caparrós & Frédéric Jacquemont, *Conflicts Between Biodiversity and Carbon Sequestration Programs: Economic and Legal Implications*, 46 ECOLOGICAL ECON. 143, 144 (2003) (discussing the relationship between carbon sequestration and biodiversity, including its potential dangers).

[144] *Id.*

Mass timber provides another market opportunity for primary timber. International standards have increased to allow structures as high as eighteen stories to be made from wood.[145] These structures provide a two-fold climate benefit: displacing carbon intensive industries and materials like concrete and steel, while sequestering carbon into new structures.[146] The global mass timber construction market was valued at $857.1 million in 2021 and by 2031 is projected to reach $1.5 billion—a 6% annual rate of growth from 2022 to 2031.[147] While this market may not significantly impact the reduction of forest floor debris in western forests, there may be opportunities presented by the thinning of primary timber in western or southeastern forests to reduce forest density.[148] As it stands now, while the U.S. has several mass timber structures, such as an eighteen story structure in Oakland, California and a twelve story structure in Madison, Wisconsin,[149] the market is most strong in Europe.[150] Policymakers should require or incentivize greater investment in mass timber utilization in the U.S. to get a four-fold carbon benefit of reducing the risk of catastrophic fire from overly dense forests, displacing carbon intensive concrete and steel, sequestering carbon in built structures, and providing a path for reforestation efforts with more resilient tree species.

B. RAMP UP INVESTMENTS

The U.S. recently invested $3 billion into a ten-year plan to reduce forest fuels across 20 million acres of forest.[151] That sounds

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[145] *Tall Mass Timber*, WOODWORKS, https://www.woodworks.org/learn/mass-timber-clt/tall-mass-timber/ (last visited Feb 22, 2024).

[146] *See Mass Timber Construction Market Size, Share & Forecast, 2031*, ALLIED MARKET RSCH., https://www.alliedmarketresearch.com/mass-timber-construction-market-A16621 [https://perma.cc/PW3D-YWN6] (noting the benefits of displacing other materials used to construct high-rise buildings).

[147] *Id.*

[148] *See* Davis et al., *supra* note 1, at 5 (identifying forest thinning as a management activity that effectively reduces fire severity).

[149] *Tall Mass Timber*, *supra* note 145.

[150] *See Mass Timber Construction Market Size, Share & Forecast, 2031*, *supra* note 146 (detailing "the growth of the market in Europe during the mass timber construction market forecast period").

[151] Davis et al., *supra* note 1, at 2.

like a lot, but it is only 0.3% of the total $1.2 trillion that was allocated under the Infrastructure and Jobs Act signed into law in 2021.[152] Building forest resilience will require greater investment in forest fuel removal and facilitation of markets to incentivize resilient forest management efforts.[153]

Scientific investment will also be critical, and in particular investments in tree breeding and genetics.[154] In other words, harnessing genetic innovations will be critical to molding forests of the future into ones that can survive a changing climate.[155] Tree breeders "link the evolutionary potential of tree species using knowledge of genetic diversity and adapted phenotypes with acclimation potential."[156] Genetic modification can lead to its own challenges. Consider that in the Southeast, hybrid pines are more susceptible to beetle infestation ,[157] whereas native Longleaf pine is more resilient.[158] Even so, Longleaf pine habitat has been reduced

[152] *Bipartisan Infrastructure Law (BIL) / Infrastructure Investment and Jobs Act (IIJA),* U.S. DEP'T OF TRANSP. PIPELINE & HAZARDOUS MATERIALS SAFETY ADMIN. (Feb. 16, 2023), https://www.phmsa.dot.gov/legislative-mandates/bipartisan-infrastructure-law-bil-infrastructure-investment-and-jobs-act-iija [https://perma.cc/N4SQ-LNQN].

[153] *See* Davis et al., *supra* note 1, at 5 (noting the investment needed to yield longer-term results).

[154] Duncan Ray et al., *Transformative Changes in Tree Breeding for Resilient Forest Restoration*, FRONTIERS IN FORESTS & GLOB. CHANGE, Oct. 10, 2022, at 2.

[155] *See* Jade Prévost-Manuel, *Genetically Engineered Trees Could Help Fight Climate Change – Here's How*, CBC NEWS (Dec. 20, 2020), https://www.cbc.ca/news/science/genetic-modification-trees-climage-change-1.5837766 [https://perma.cc/QZZ7-3GFD] (discussing the potential for genetically enhancing trees as carbon sinks).

[156] Ray et al., *supra* note 154, at 2.

[157] *See Southern Pine*, HQPLANTATIONS, https://www.hqplantations.com.au/our-plantations/species-we-grow/southern-pine [https://perma.cc/NAP9-CCJ3] ("The engraving bark beetle, Ips grandicollis is abundant in harvesting residues in [southeast Queensland] and can cause the death of trees under stress, such as following severe scorch associated with a wildfire."); Mary Esch, *Pine-Killing Southern Beetle May Be More Deadly in North*, PHYS.ORG (June 10, 2018), https://phys.org/news/2018-06-pine-killing-southern-beetle-deadly-north.html#google_vignette [https://perma.cc/89PG-T628] ("An outbreak of southern pine beetles in the southeastern United States between 1999 and 2002 caused more than $1 billion in losses for the timber industry . . . .").

[158] *See* DAVID COYLE & LISA LORD, LONGLEAF RESILIENCY: INSECTS AND DISEASES 1 (n.d.), https://americaslongleaf.org/media/4n0bzaf2/longeaf-resiliency-to-insects-and-diseases.pdf [https://perma.cc/T5FC-QW3L] (noting "all southern pines are susceptible to the southern pine beetle," but that "longleaf pine is considered the least vulnerable of the major timber-producing pine species").

by 95% across the Southeast.[159] Scholars have argued that "[w]e need a mix of forestry objectives into an uncertain future—proportions of natural regeneration, plantation woodlands, as well as a more diverse range of tested genotypes for use in new environmental conditions under climate change."[160] These scholars argue that tree breeding can be critical to these efforts.[161] And we will need greater levels of investment to achieve these goals.

C. MAKE FEDERAL ADMINISTRATIVE LAW REFORMS RELATED TO FORESTS

To be able to act quickly to reduce fuel loads and density in western forests, federal administrative regulations related to forests must be amended and processes streamlined. There has been a modest push to do this with other federal statutes, like the National Environmental Policy Act.[162] Administrative processes will need to be simplified to allow for quick removal (even "emergency removal") of fuel loads and dense timber so that agencies are not prevented from acting in a timely manner because

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[159] *See* Jennifer Winger, *Pine Country*, NATURE CONSERVANCY (Aug. 26, 2022), https://www.nature.org/en-us/magazine/magazine-articles/longleaf-pine/ [https://perma.cc/DJW3-9Y9E] (reporting that less than 5% of longleaf pine forests remain today).

[160] Ray et al., *supra* note 154, at 12.

[161] *See id.* ("Tree-breeding is considered a lever to meet socio-economic challenges in forestry. The development of tools and knowledge in tree breeding have made available information about the degree of genetic variation and plasticity among and within different tree species. Breeders can therefore select material (genotypes) with a known degree of phenotypic plasticity across environmental gradients and continue to review the genetic diversity of seed orchard material, offering ways to maintain and improve the diversity of the pool. Breeders have climate and site data to assess the suitability and the risk of deployment of different phenotypes under a changing climate while keeping a check on the economic value of material deployed across suitable sites within the range of timber processing facilities in the bioeconomy." (citation omitted)).

[162] *See* James Rusk & Bella Spies, *NEPA Amendments Aim to Streamline Environmental Review but Largely Codify the Status Quo*, REAL EST. LAND USE & ENV'T L. BLOG (June 23, 2023), https://www.realestatelanduseandenvironmentallaw.com/nepa-amendments-aim-to-streamline-environmental-review-but-largely-codify-the-status-quo.html [https://perma.cc/D84T-5LDL] (reporting the recent amendments to the National Environmental Policy Act).

of concerns about roadless areas[163] or other laudable but disruptive policies when attempting to act aggressively and quickly to reduce catastrophic fire risk.

In addition to administrative procedure and regulation changes, Congress should act to amend the National Forest Management Act, the Multiple Use and Sustained Yield Act, and other relevant statutes to specifically direct agencies to implement resilient forest management policies. Needed policies may conflict with other federal requirements, like those under the Clean Water Act or Endangered Species Act. And though it may be a controversial proposition, when water and biodiversity resources are arguably at greater risk from climate change, ensuring that our forests remain intact to combat climate change may need to take temporary precedence over the rules and regulations protecting water and endangered species.

D. HARNESS THE SCIENCE OF FORESTRY SCHOOLS AND OTHER "LOCAL" ACTORS TO BUILD TRUST

One way to break through to reticent state governments to achieve resilient forest management policies may be to harness the expertise of state university forestry programs, and to put more emphasis on messaging out of those programs and their extension agents. Auburn University, the University of Georgia, the University of Florida, Texas A&M University, and other prominent southeastern universities maintain forest programs with a wealth of scientific knowledge and expertise.[164] These universities already do outreach, but they need to do more—and the messaging needs to be more aggressive.

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[163] *See 2001 Roadless Rule,* U.S. FOREST SERV., https://www.fs.usda.gov/main/roadless/2001rule [https://perma.cc/9JEE-P6AA] (defining roadless areas and describing the Roadless Rule, which is intended to provide protection for 58.5 million acres of inventoried roadless areas).

[164] For examples of these programs, see *College of Forestry, Wildlife and Environment*, AUBURN UNIV., https://cfwe.auburn.edu/ [https://perma.cc/9B6L-B9N5]; *Warnell School of Forestry & Natural Resources*, UNIV. OF GA., https://warnell.uga.edu/ [https://perma.cc/W7P6-TQJN]; *School Of Forest, Fisheries, & Geomatics Science*, UNIV. OF FLA., https://ffgs.ifas.ufl.edu/; TEX. A&M FOREST SERV., https://tfsweb.tamu.edu/ [https://perma.cc/7N65-LTJS].

Dan Kahan and other researchers have put forth the "vouchers" theory of risk communication; that one way to create change in a skeptical community is to have the message bearer be a person from that community or with close ties to it (i.e., not an outsider).[165] University forestry programs working with local extension agencies should engage in robust information campaigns to help communities of private forest owners and their legislators understand the need to build resiliency into their forests. The case will be easier to make to large corporate forest holders, like International Paper, who have shareholders and sophisticated economic incentives.[166] But there are thousands of smaller forest owners who, in the absence of regulatory requirements, will need to be convinced that building resiliency into their forests is in their best economic and management interest.

VII. CONCLUSION

The world's forests are in the midst of one of their most challenging climate epochs, as rapid temperature increases threaten to outpace their ability to evolve and adapt. While society must grapple with the fact that some forests are already lost for good—perhaps never to return for hundreds or thousands of years—we must not lose hope in adaptation policies that can help forests become more resilient. The problem is not whether it is technologically or scientifically achievable, though there are some technological and scientific unknowns and limitations. Rather, the question is of political will—are federal and state governments willing to reform laws, increase investments, and cultivate markets that can help retain forests as critical systems for combatting climate change? Are private actors willing to integrate more

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[165] *See* Dan Kahan, *Fixing the Communications Failure*, 463 NATURE 296, 297 (2010) (describing in-group bias and providing that, generally, people take their cues about what to believe "from the cheers and boos of the home crowd"); *see also* Robert R.M. Verchick, *Culture, Cognition, and Climate*, 2016 U. ILL. L. REV. 969, 982–83 (referencing Dan Kahan's research and describing why audiences may distrust "expert panels," and stating that audiences react more favorably when information is presented "in a way that upholds their commitments").

[166] *International Paper Co.*, CNBC, https://www.cnbc.com/quotes/IP [https://perma.cc/QW3R-SA37] (providing securities market information on International Paper).

climate-focused resilient forest management approaches into their forestry plans?

Climate mitigation policies remain of critical importance for the world's forests. As one scientist stated "[t]he earlier we start dealing with the root problem, climate change, the better chance we have . . . . If you want to keep these forests, keep fossil fuels in the ground."[167] But given that a degree of harmful climate change is already "baked in" at current levels of atmospheric carbon dioxide concentrations, we must take more seriously climate adaptation policies to protect forests and help them transition to the new climate normal. Only then can we ensure that forests do not only exist in human minds,[168] but also in the global landscapes that we so heavily depend upon for our well-being.

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[167] Johnson, *supra* note 8 (quoting Tom Veblen, a forest ecologist at the University of Colorado, Boulder).

[168] BONNICKSEN, *supra* note 2.