



EcoAgroTex
RESEARCH JOURNALS

International Journal of **Eco-Agriculture** Sustainable Technologies



Publisher
Ecoagrotex Research Journals

 **editor.ecoagrotex@gmail.com**
 **<https://ecoagrotex.com/index.php/ijecoast>**

ISSN: 3143-6714

varied woods are cool: Encouraging varied forests to reduce climate change and carbon emissions

PE Adetyh¹, O Ebgnmyehi²

Department of Botany, Kumaun University, S.S.J. Campus Almora, Uttarakhand, India

Research Article

Date of Submission: 14-08-2025 Date of Acceptance: 20-10-2025 Date of Publication: 13-12-2025

Abstract

One of the biggest challenges to civilization is climate change, which raises global temperatures and increases the frequency of catastrophic weather occurrences. Global reforestation projects are suggested in light of this in order to absorb carbon and slow down climate change. Global restoration and forestry initiatives and their goals have sparked serious scientific critique and discussion about their viability and execution, as well as unprecedented global excitement. We agree that a comprehensive conversation and methodology are necessary for global reforestation projections and initiatives. In keeping with that, we want to highlight how expanding the variety of current forests may improve mitigation of climate change by boosting carbon storage both aboveground and belowground. Furthermore, we contend that emphasizing the planting of various forests in reforestation initiatives might lessen the impacts of climate change on ecosystems by buffering microclimatic conditions in both natural and urban settings and by boosting resistance and resilience to catastrophic climatic events. Reforestation initiatives and plantation diversification may not always be practical and are insufficient to address the climate challenge on their own. However, we point out that by encouraging sustainable land management, a focus on varied forests might optimize the advantages of reforestation initiatives.

KEYWORDS

Microclimate buffering, ecosystem services, carbon storage, climate mitigation, and biodiversity-ecosystem functioning

INTRODUCTION

down climate change. Global restoration and forestry initiatives and their goals have sparked serious scientific critique and discussion about their viability and execution, as well as unprecedented global excitement. We agree that a comprehensive conversation and methodology are necessary for global reforestation projections and initiatives. In keeping with that, we want to highlight how expanding the variety of current forests may improve mitigation of climate change by boosting carbon storage both aboveground and

International Journal of Eco-Agriculture and Sustainable Technologies

Volume 1 Issue 4, 2025

belowground. Furthermore, we contend that emphasizing the planting of various forests in reforestation initiatives might lessen the impacts of climate change on ecosystems by buffering microclimatic conditions in both natural and urban settings and by boosting resistance and resilience to catastrophic climatic events. Reforestation initiatives and plantation diversification may not always be practical and are insufficient to address the climate challenge on their own. However, we point out that by encouraging sustainable land management, a focus on varied forests might optimize the advantages of reforestation initiatives.

1 | CLIMATE CHANGE AND NATURE-BASED MITIGATION

Humanity and other species on Earth are at danger due to climate change.^{1, 2} According to the IPCC reports (2013, 2021), anthropogenic carbon dioxide (CO₂) emissions have a critical role in climate change, accounting for about 0.75° C of the 1° C global warming over the last century.^{1,2} In addition to global warming, climate change causes severe weather events like heatwaves and droughts to occur more often and with greater intensity. One of the best ways to slow down climate change has been proposed to improve photosynthetic carbon absorption via repairing damaged forests and expanding tree cover.^{3, 4} According to IPCC (2013) projections, 1 billion hectares of forest would be required by 2050 to keep global heat rises below 1.5° C. Bastin et al.³ downscaled this estimate, estimating that planting 0.9 billion ha could store 205 Gt of carbon while looking at global reforestation opportunities. Nevertheless, since their release, these figures have drawn harsh criticism.^{5, 6} The primary issue is that the analysis underestimated the amount of land required to meet existing carbon storage targets because it overestimated trees' capacity to store carbon. The idea that a worldwide reforestation project to store 205 Gt of carbon would compete with other land uses (such as farmland and urban areas) is therefore a significant subject of controversy.

2 | DIVERSIFYING FORESTS TO MITIGATE CARBON EMISSIONS

There is growing evidence that tree variety improves a number of ecosystem functioning metrics in forests (i.e., multifunctionality).^{7–9} Particularly diversified forests have been shown to boost carbon storage aboveground (10,11) and belowground (12,13) (Figure 1), for instance, by enhancing tree complementarity and decreasing soil carbon loss due to erosion.^{7,10,14} For example, species-rich forests with 20 different tree species per hectare store three times as much carbon than monocultures in subtropical regions.¹³ We contend that diversifying current forests and reforestation initiatives would boost and stabilise forest carbon storage, lowering the amount of land required for global reforestation initiatives and, therefore, the rivalry for land between reforestation programs and other significant land uses. To forecast the carbon storage capacity of locally diverse forests, however, more worldwide coverage of studies across biomes is required, even if these patterns seem to be constant globally. In this context, promising efforts include global restoration projects with a biodiversity emphasis (e.g., Restor: <https://restor.eco/>) and the growing availability of forest inventory data, such as the worldwide network of tree diversity experiments (TreeDivNet16). Similarly, encouraging plantings with a variety of species can improve managed forests' capacity to store carbon in addition to replanting initiatives. To comprehend both biodiversity and production constraints and goals, transdisciplinary studies are required.⁸ Here, we propose that in order to effectively address the real-world needs of land managers, practitioners, and restoration projects, biodiversity-ecosystem functioning (BEF) research should sharply shift toward transdisciplinary research.⁸ For example, Mao et al.¹⁷ established and implemented a comprehensive modelling framework to connect socioeconomic objectives with biodiversity protection in French mountain resort regions.

3 | DIVERSE FORESTS TO MITIGATE THE CONSEQUENCES OF CLIMATE CHANGE

Extreme weather events, such as drought, fire, and insect outbreaks, as well as biological reactions to them, are predicted to become more often and intense as a result of climate change, increasing tree mortality and decreasing forest health. By 2050, more than 200 million hectares of tropical forest cover might be lost due to climate change. Simultaneously, studies on tree variety have shown the great potential of varied forests to mitigate catastrophic weather occurrences (for context-dependencies, see Reference 19, 20). For instance, tree diversity increases the asynchronous response of tree species to climatic variability, which stabilises ecosystem services and reduces the impacts of drought on forest output.^{8,9} Similarly,

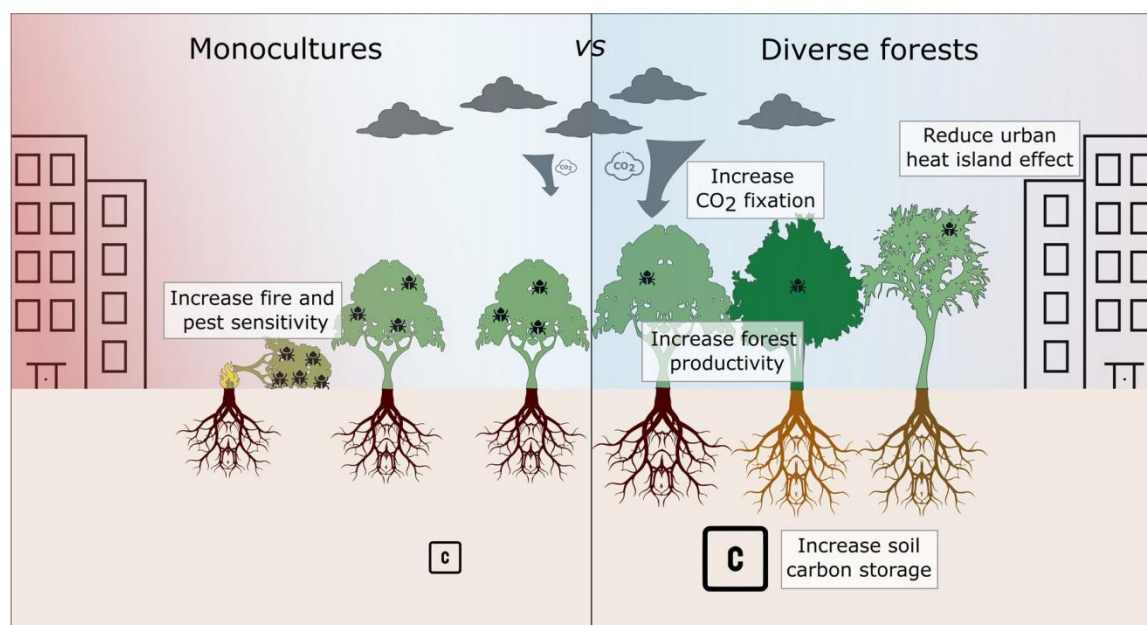


FIGURE 1: An illustration of how tree variety affects ecosystem characteristics linked to mitigating climate change. In summary, it has been demonstrated that diverse forests fix more atmospheric carbon, store more carbon above and belowground, reduce the probability and intensity of fires and pest outbreaks, and mitigate microclimatic conditions under climate change. Increasing tree diversity stabilises long-term carbon storage by decreasing the susceptibility of forests to fire and, consequently, the net release of carbon dioxide.⁸ Furthermore, since they promote multitrophic biodiversity, diversified forests are inherently resistant to severe insect outbreaks and herbivory pressure.^{7, 22} Promoting various forests in existing forests and in reforestation initiatives offers several benefits to safeguard forests from climate change in a sustainable manner, considering the many benefits that diverse forests provide (Figure 1).

4 | DIVERSE FORESTS TO INCREASE HUMAN WELL-BEING IN CITIES

The majority of people live in cities, where sealed surfaces and a lack of greenery amplify temperature increases (a phenomenon known as the "urban heat island effect"), worsening summer heatwaves and aggravating severe climatic consequences on human well-being.² It has been shown that establishing urban forests and increasing urban tree cover may both promote human well-being by shading surfaces and lessen the impact of the urban heat island. Up to 1% of the world's potential for reforestation might be found in urban forests, which are an effective way to

International Journal of Eco-Agriculture and Sustainable Technologies

Volume 1 Issue 4, 2025

enhance the lives of millions of people. Tree variety also boosts tree crown structural complementarity and aboveground production in forests (10,11).¹⁴. Therefore, under warm conditions, we anticipate that tree diversification will boost the canopy's ability to buffer macroclimatic fluctuations²³ and lower the microclimatic temperature under the canopy.²⁴. Forest cooling effects may be strengthened by increasing tree variety in and around the urban matrix (Figure 1), but more experimental research is required to fully understand this phenomena and its extent. Here, we argue that public policy should make use of urban areas to establish a variety of forests locally, mitigate climate change, and improve human well-being.

5 | OUTLOOK

We contend that growing a variety of forests via reforestation initiatives and diversifying already-existing forests would encourage forest carbon storage, which may help mitigate climate change. Increasing tree variety can also safeguard forest functioning from risks brought on by climate change (such as severe weather events and insect outbreaks). Finally, we recommend that urban tree variety be encouraged to improve human well-being and act as a local buffer against global warming. Initiatives for reforestation, such as the European Green Deal, the Bonn Challenge, and the UN Decade on Ecosystem Restoration (2021–2030), as well as sustainable forest management (see UN Sustainable Development Goals: 6, 11, 13, 15), are gaining significant traction. We recognise that reforestation is not always feasible and may present significant risks, such as decreased water supply or an increase in socioeconomic injustice.²⁵. Therefore, transdisciplinary methods are required to link scientists, land managers, and policymakers to address sustainable land use and climate change mitigation in order to maximise the possibility of these projects' success. To determine how diversified forests would maximise replanting capacity to counteract climate change, further study is necessary. Specifically, we must ascertain if it is possible to diversify forests²⁵, which tree community will provide the most advantages, and the extent to which varied forests may lessen the impacts of climate change and severe weather events.¹⁹.

REFERENCES

1. IPCC, editor. Climate Change 2013: The Physical Science Basis. Working Group I's contribution to the Intergovernmental Panel on Climate Change's Fifth Assessment Report. Cambridge University Press, Cambridge and New York, NY, 2013.
2. IPCC, editor. Climate Change 2021: The Physical Science Basis. Working Group I's contribution to the Intergovernmental Panel on Climate Change's sixth assessment report. Cambridge University Press, Cambridge, 2021.
3. The possibility for global tree restoration by Bastin J-F, Finegold Y, Garcia C, Mollicone D, Rezende M, Routh D, et al. 2019; 365(6448): 76–9. <https://doi.org/10.1126/science.aax0848>
4. Lewis SL, Wheeler CE, Mitchard ETA, Koch A. The most effective strategy to reduce atmospheric carbon is to restore natural forests. *Nature*. 568(7750):25–8. <https://doi.org/10.1038/d41586-019-01026-8>
5. Comment on "The global tree restoration potential" by Skidmore AK, Wang T, de Bie K, and Pilesjö P. *Science*. 2019; 366(6469):eaaz0111. Lewis SL, <https://doi.org/10.1126/science.aaz0111>
6. Comment on "The global tree restoration potential" by Mitchard ETA, Prentice C, Maslin M, and Poulter B. *Science*. 2019; 366(6463): eaaz0388.
7. Schuldt A, Assmann T, Brezzi M, Buscot F, Eichenberg D, Gutknecht J, et al. <https://doi.org/10.1126/science.aaz0388>. In highly diversified forests, multifunctionality is driven by biodiversity across trophic levels. *Nat Commun*. 2018; 9(1):2989. <https://doi.org/10.1038/s41467-018-05421-z>
1. Messier C, Bauhus J, Baeten L, Barsoum N, Auge H, Sousa-Silva R, et al. Let's diversify planted woodlands for resilience and multipurpose purposes! 2021. *Conserv Lett*.
2. Gamfeldt L,

International Journal of Eco-Agriculture and Sustainable Technologies

Volume 1 Issue 4, 2025

- Snös T, Bagchi R, Jonsson M, Gustafsson L, Kjellander P, et al. Forests with a greater variety of tree species provide higher levels of certain ecological services. *Nat Commun.* 4(1):1340 (2013). <https://doi.org/10.1038/ncomms2328>
3. Huang Y, Chen Y, Baruffol M, Brezzi M, Castro-Izaguirre N, Lang A, et al. Productivity in a large-scale subtropical forest experiment is affected by species richness. 2018; 362(6410):80–3. <https://doi.org/10.1126/science.aat6405>
4. Godwin CM, Cardinale BJ, Duffy JE. In the wild, the impacts of biodiversity are frequent and just as powerful as major production factors. *Nature*, 549(7671), 2017:261–4. <https://doi.org/10.1038/nature23886>
5. Xu S, Eisenhauer N, Ferlian O, Zhang J, Zhou G, Lu X, et al. Biodiversity–ecosystem functioning tests show that species richness enhances ecosystem carbon storage. 2020; 287(1939):20202063, *Proc Biol Sci.* <https://doi.org/10.1098/rspb.2020.2063>
6. Tree species richness enhances ecosystem carbon storage in subtropical forests (Liu X, Trogisch S, He J-S, Niklaus PA, Bruehlheide H, Tang Z, et al.). 2018; 285(1885):20181240; *Proc Biol Sci.*
7. Williams LJ, Paquette A, Cavender-Bares J, Messier C, Reich PB <https://doi.org/10.1098/rspb.2018.1240>. Overyielding in species combinations is explained by spatial complementarity in tree tops. *Nat Ecol Evol.* 2017;1(4):63. <https://doi.org/10.1038/s41559-016-0063-0>
8. Craven D, Meyer C, Gerstner K, Bennett JM, Gilling DP, Sande MT, et al. A cross-scale evaluation of the relationships between productivity and variety. *Glob Ecol Biogeogr.* 29(11):1940–55. 2020.
9. Verheyen K, Vanhellemont M, Auge H, Baeten L, Baraloto C, Barsoum N, et al. Contributions of a worldwide network of tree diversity trials to sustainable forest plantings <https://doi.org/10.1111/geb.13165>. *Ambio.* 2016; 45(1): 29–41. <https://doi.org/10.1007/s13280-015-0685-1>
10. Mao Z, Stokes A, Gaucherel C, Pommereau F, Centanni J. The multifunctionality of social–ecological systems—a comprehensive concept of a mountain system—is encouraged by maintaining biodiversity. *Ecosyst Serv.* 47:101220, 2021. 2020.101220
11. Partner H-O, Scholes RJ, Agard J, Archer E, Bai X, Barnes D, et al. <https://doi.org/10.1016/j.ecoser.2021.101220>. scientific findings from the biodiversity and climate change workshop co-sponsored by IPBES and IPCC. Zenodo, 2021, 1:1–234.
12. Grossiord C. <https://doi.org/10.5281/zenodo.4782538>. Having the proper neighbours: how the variety of tree species influences the effects of drought on forests. <https://doi.org/10.1111/nph.15667>
13. Schnabel F, Schwarz JA, Dănescu A, Fichtner A, Nock CA, Bauhus J, et al. *New Phytol.* 2020;228(1): 42–9. Diversity in the neighbourhood lessens the effects of drought on tree growth. *J Ecol.* 108(3):865–75, 2020. <https://doi.org/10.1111/1365-2745.13353>
14. Productivity drivers and their temporal stability in a tropical tree diversity experiment, Jactel H, Moreira X, Castagneyrol B. *Glob Change Biol.* 25(12):4257–72, 2019. <https://doi.org/10.1111/gcb.14792>
15. Jactel H, Moreira X, Castagneyrol B. Patterns, processes, and prospects of tree diversification and forest resistance to insect pests. 2021; *Annu Rev Entomol.* 66(1):277–96. <https://doi.org/10.1146/annurev-ento-041720-075234>
16. Forest microclimates and climate change: significance, motivators, and future research agenda Gottschall F, Davids S, Newiger-Dous TE, Auge H, Cesarz S, Eisenhauer N. *Glob Change Biol.* 27(11): 2279–97, 2021. This link: <https://doi.org/10.1111/gcb.15569>
17. Gottschall F, Davids S, Newiger-Dous TE, Auge H, Cesarz S, Eisenhauer N. The microclimatic impacts of tree species identity dictate wood decomposition. *Ecol Evol.* 9(21):12113–27, 2019. <https://doi.org/10.1002/ece3.5665>
18. Holl KD, Brancalion PHS. Planting trees is not an easy fix. *Science*, 2020, 368(6491):580–1. <https://doi.org/10.1126/science.aba8232>