Strengthening Community Engagement as a Pathway to Effective Forest Fire Management and Resilient Forests in Nepal

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Summary

Forest ecosystems are indispensable for planetary health. They provide sustenance for around a quarter of global population. Forest fire is an important ecological disturbance; however, it can cause ecological and societal harm due to anthropogenic mismanagement and natural adversities leading to long-term socio-economic and environmental consequences. Extreme wildfire events have increased worldwide over the last decade, and events in Nepal are consistent with this trend. Nepalese forestry practices have already set an example of successful forest management through local stakeholder and community participation and thus demonstrate precedent in effective community mobilization. However, recent reports suggest declines in community participation in forest management process and overall weakening people-forest relationships. Here, we argue on why Nepal should work on strengthening its long legacy of people-forest interactions

and how community engagement can support sustainable forest fire management. In our opinion, community led fire management is among the most viable approaches, with primary focus on preventive measures, i.e., reducing fuel loads in the forests. However, the Government of Nepal should provide clear policies and strategic frameworks to create such an environment where forest scientists, private sectors and non-profits can contribute to a national goal.

Keywords: wildfires; healthy forests; fire-resilient forests; sustainable forest management; community engagement; forest fuel reduction

Background and context

Forest ecosystems are vital hotspots for biodiversity and regulators of the global carbon budget. Globally, forests cover around one third of Earth's land surface yet support more than 80% of terrestrial biodiversity by providing a variety of habitats and resources for diverse organisms (CBD, 2024; FAO, 2022; Parajuli and Markwith, 2023; Stokland *et al.*, 2012). Forests also play critical role in regulating global carbon by absorbing atmospheric CO_2 and storing it as biomass as well as transferring it to the soil via various chemical and biological processes (FAO, 2022; Lorenz and Lal, 2010; Ryan *et al.*, 2010). However, various natural and anthropogenic disturbances influence forests' ability to regulate atmospheric carbon, and wildfires are chief among them (FAO, 2022; Williams *et al.*, 2016). Importantly, how forest management also determines whether they act as net carbon sinks or sources, suggesting the critical importance of management practices and anthropogenic influences for practical applications like forest carbon budgets, risk reduction and environmental restoration and mitigation (Kaarakka *et al.*, 2021; Parajuli *et al.*, 2025).

The overarching idea of forest management is to design and implement certain practices that are sustainable and appropriate for achieving specific economic, socio-cultural and environmental services from a given forest ecosystem (FAO, 2022). Similarly, one of the key ecological goals is to maintain healthy and resilient forests that can continue to provide optimal ecosystem services and can cope with disturbances (Cantarello *et al.*, 2024; Messier *et al.*, 2019; Mina *et al.*, 2022). With around 25% of the world population directly relying on forest resources for their livelihoods, rising demand for carbon sequestration and Nature-based Solutions to reducing atmospheric CO_2, and the ongoing climate crisis leading to unprecedented changes in global forests, sustainable management of forests has been more important than ever for planetary health and human wellbeing (FAO, 2022; Kaarakka *et al.*, 2021; UNFFS, 2021). Due to forests' potential as a natural climate solution (Griscom *et al.*, 2017), the Paris Accord and later United Nations conventions continued to highlight the importance of sustainable forest management to reduce carbon emissions and enhance sequestration as a fight against global warming and its worst impacts (IPCC, 2018; UNFCCC, 2015).

The last two decades have witnessed an increase in the frequencies and intensities of devastating wildfires globally, with recent years being most extreme (Cunningham *et al.*, 2024). While uncharacteristically large fires with extreme behavior were observed in the temperate conifer forests of the United States and boreal forests of North America and Russia, wildfires have generally became larger and more severe around the world

(Cunningham *et al.*, 2024; Hagmann *et al.*, 2021). In addition to an increasing pattern of frequencies and area burned, Nepal has also experienced some of the worst forest fires recently (Mishra *et al.*, 2023; Nepali Times, 2021). For example, the catastrophic wildfire in Gatlang area of Rasuwa district destroyed the forest stand with long-term effects on soil and vegetation still evident even after one and half decades (Dhungana *et al.*, 2024).

Wildfire behavior is governed primarily by three major elements, famously called the 'fire triangle', namely fuel (or vegetation), topography, and weather (or climate); and fuel is always a dominant factor controlling fire at different spatial and temporal scales (Keeley, 2009; Moritz *et al.*, 2005; Pyne *et al.*, 1996). Since fuels (i.e., vegetation, living or dead) are the components that humans can most directly influence, effective management of forest structure and vegetation plays a crucial role in reducing wildfire impacts (Parajuli *et al.*, 2025). Various management tools, technically referred to as 'fuel reduction treatments', are used to reduce fuel that helps to minimize the risk for devastating fires and associated hazards and maintain healthy forests. In developed countries such as United States and Canada, forest fuel reduction most commonly involves mechanical treatments such as thinning (tree removal), mastication (flailing, chipping and breaking), raking (collecting/piling), often combined with prescribed burning (Agee and Skinner, 2005). Whereas in developing countries, such as Nepal, India and Mexico, active community engagement for regulated resource extractions e.g., timber and fuelwood via thinning and pruning, and surface dead fuel and fodder collection, as well as some controlled or community-led burning are common and generally effective in fire management (Charmakar *et al.*, 2021; Dogra *et al.*, 2018; Pandey *et al.*, 2022; Van Vleet *et al.*, 2016).

Regular harvesting of surface biomass such as leaf litter and dead woody materials by local peoples, either as a part of the subsistence farming or for various innovative uses, contribute to reduced dry fuel loads in the Himalayan forests (Chandran *et al.*, 2011; Charmakar *et al.*, 2021). However, recent research shows declining community involvement, that is, a weakening people-forest interactions, in community managed forests of Nepal, contributing to increased fire events (Tiwari *et al.*, 2022), despite a recognized need to strengthen people-forests relationships (Baral *et al.*, 2025; Poudyal *et al.*, 2023).

Why is maintaining people's interaction with forests critically important?

Nepal's community forestry is a globally recognized success story of forest user groups' (i.e., local peoples') involvement in regenerating and conserving forests and at the same time supporting livelihood and local economy. Over 23,000 community forest user groups, largely self-governing local institutions, engage more than 16 million people to manage around 35% of country's forest resources (Gentle *et al.*, 2020). Being within the guidelines set by operational plans, users routinely harvest forest resources such as timber, fuelwood, fodder, dead leaves and beds, and non-timber products, and in return voluntarily contribute to various forest management activities. Such community-led forest biomass removal interventions, essentially equivalent to modern mechanical fuel reduction treatments in many developed countries that cost billions of dollars (Chang *et al.*, 2023; Wibbenmeyer *et al.*, 2025), contribute to lowering fuel loads and thus reduce forest fire hazards (Charmakar *et al.*, 2021; Markwith and Paudel, 2022; Pandey *et al.*, 2022; Parajuli *et al.*, 2025). For example, local people's regular harvesting of firewood from community forests in Dolakha has been shown to effectively reduce wildfire risk (Charmakar *et al.*, 2021).

The role of local communities in reducing forest fuel continuity – horizontal and vertical distribution of flammable materials – and supporting effective fire management is not unique to Nepal; similar patterns are observed in other countries such as India (e.g., (Chandran *et al.*, 2011), Mexico (e.g., (Van Vleet *et al.*, 2016), and historically in Australia (e.g., (Mariani *et al.*, 2024) and among Native American societies in the pre-Columbian era in North America (e.g., (Anderson and Moratto, 1996; Markwith and Paudel, 2022). Most importantly, the case of Mexico is worth highlighting here, as it illustrates how community engagement should extend beyond ecological goals to also include substantial economic benefits for local communities. Mexico's community forestry model, that integrates technical forest management, indigenous governance and community owned forest enterprises, has proven highly effective in ensuring the economic resilience of participating communities while simultaneously enhancing ecological resilience and promoting sustainable forest management (Cubbage *et al.*, 2015; Mitchell, 2006; Van Vleet *et al.*, 2016). For example, in Sierra Norte of Oaxaca, Mexico, community-managed forests supported increased biodiversity, experienced fewer large wildfires, and supported livelihoods and local economy (Farthing, 2024; Van Vleet *et al.*, 2016). The success story of this Mexican example could be relevant for Nepal, where similar enterprise-based community forestry approaches that maximize economic benefits for local communities may help strengthen peoples' engagement in forest management (Cook *et al.*, 2025). This approach could help address the issue to greater extent, as recent research from Nepal indicate that people's interest in managing community forests is eroding because of insufficient economic benefits and lack of employment opportunities (Cook *et al.*, 2025; Poudyal *et al.*, 2023). Additionally, with clear guidelines and policy frameworks for sustainable harvesting and processing, scientifically and socio-economically informed timber entrepreneurship could help meet national timber demand and reduce current imports (Dangi, 2025).

While Nepal's efforts in increasing forests and enhancing carbon sequestration, including a recent US$9.4 million carbon credits grant (World Bank, 2025), can be considered as a success, it is equally concerning that fuel loads are accumulating in Nepalese forests, especially in the mid-hills. Without timely interventions, these fuel loads could reach hazardous levels, and if burned, may release large amounts of carbon, negating decades of sequestration gains within weeks. Global evidence shows that elevated forest fuel loads, intensified by climate change, are driving uncharacteristically large and destructive wildfires that convert forests into net carbon sources and cause severe ecological and long-term socio-economic impacts (Jaffe *et al.*, 2020; Phillips *et al.*, 2022; Roces-Díaz *et al.*, 2022). Once a forest attains hazardous fuel conditions, restoring it to healthy and resilient status is very challenging and often requires substantially greater effort and cost than maintaining it through regular management and fuel treatments (Alcasena *et al.*, 2022; Chang *et al.*, 2023). This is evident in the United States, which is constantly fighting devastating wildfires each year and spending up to $7 billion annually on fire management interventions (US Congress, 2024).

With declining community and stakeholder participation due to several factors including less reliance on forest resources, increased use of alternative sources of household energy, outmigration, weak governance, low financial benefits and lack of clarity on policies (Benedum *et al.*, 2025; Cook *et al.*, 2025; Poudyal *et al.*, 2023), if proactive early measures are not implemented, forest fires could be a major nationwide problem in near future. The recent increase in frequency and severity of forest fires in Nepal (Mishra *et al.*, 2023), has already signaled that we are already in that direction. Since Nepal currently has very limited technical and financial strength to manage catastrophic large wildfires, strengthening people's interactions with forests and mobilizing communities for forest and fire management appears to be the most viable strategy. India, the world's third largest economy, has also recognized community involvement as one of the top strategies for effective fire management, given that many rural people have close ties with forests and rely on forest resources for their livelihoods, making their engagement essential for the success (Dogra *et al.*, 2018).

Considering the changing socio-economic dynamics in Nepal associated with outmigration and remittance income, which affect affordability and promote alternative energy choices such as LPG, questions remain about whether strengthened community engagement can ensure full local utilization of forestry products. First, although firewood use may have declined and will likely continue to do so, it still remains a dominant source of household energy especially for cooking and heating (Kandel *et al.*, 2016; Paudel *et al.*, 2021). Second, recent technological advancements allow forest residues, including fine and coarse down woody materials, to be converted into carbon-friendly products such as biochar, biofuels and coco peat. Experiences from developed countries demonstrate that forest biomass conversion into biochar through the process called pyrolysis is cost effective and technically feasible (Cabiyo *et al.*, 2021; Shabangu *et al.*, 2014). This can be implemented through private sector and business entities; however, the Government of Nepal should provide clear policy guidance. Additionally, invasive species issues in forests can also be addressed using this approach, as any forest residue and waste can be converted into biochar via pyrolysis. Biochar soil amendments can store carbon for many years, help mitigate climate change, improve soil fertility in agricultural lands, and partially substitute chemical fertilizers (Bai *et al.*, 2022; Shyam *et al.*, 2025).

Should controlled burning be an option?

Traditionally, fire has been used as a management tool in different countries around the globe and stands as a successful strategy to maintain fuels, resources and services (Anderson and Moratto, 1996; Long *et al.*, 2021; Mariani *et al.*, 2024). Occurrence of fire is inevitable in ecosystems ranging from grasslands to forests with the variations in fire return interval (Lauvaux *et al.*, 2016; Mariani *et al.*, 2024). For example, grasslands are well adapted and can be burned on yearly basis while forested ecosystems such as conifers have average return interval of 11 years and that of shrubland of 25 years (Lauvaux *et al.*, 2016). There is rich evidence of how local people inherited the traditional knowledge of fire ecology to keep their natural areas adapted to specific type of fire frequencies and severities (Christianson *et al.*, 2022). This pattern of human interactions with fire ranges broadly from pine savannas of Florida and mixed-confers of California in the United States, bushland of Australia to forests and pastures of India and Nepal (Burrows *et al.*, 2020; Dogra *et al.*, 2018; Mukul and Byg, 2020; Paudel *et al.*, 2022, 2020).

There are examples in Nepal where people have been using fire as a tool to manage forests, rangelands, and pastures to promote various ethnobotanically useful plants, prepare agriculture land (e.g., shifting cultivation), regenerate palatable species and maintain overall ecosystem health (Lama *et al.*, 2001; Mukul and Byg, 2020; Paudel *et al.*, 2020). However, the complexity of using fire as a management tool and generalizing its role to all ecosystems and across forest types can be misleading. Here, Nepal can learn from the experiences of the U.S. Forest Service and the consequences of their decades-long fire suppression policy, which aimed to extinguish fires as quickly as possible, regardless of its ecological role (Pyne, 1982). This resulted in extreme changes in historical vegetation dynamics and fire regimes, creating a highly challenging situation despite continued efforts by U.S. federal agencies to introduce prescribed burning to mimic pre-Columbian Indigenous fire practices, manage fuel loads, and restore historical norms. In U.S., forest and fire management actions are often criticized for not making a significant difference in reducing fuels even though they are resource-intensive, and they are often constrained by safety concerns associated with the urban-wildland interface and risks to recreational and critical biodiversity areas (North *et al.*, 2015). Prescribed burning is also increasingly called into question for high pyrogenic emissions and negative impacts on air quality and public health (Campbell *et al.*, 2012; Ravi *et al.*, 2019). Therefore, given the country's high biological diversity and the long-standing interactions between people, forests, and rangelands, a landscape specific as well as ecologically and culturally informed approach to fire management is vital in Nepal, specifically weighing both the risks and benefits of fire.

Historical community-led fire in Nepal is a deliberate and carefully managed technique that often tied to agropastoral livelihoods, seasonal grazing patterns, and Indigenous land-management systems that rely on intimate knowledge of vegetation cycles, microclimates, and fuel conditions (Mukul and Byg, 2020; Schmidt-Vogt, 1990). In this context, controlled or managed burning is not simply an operational activity; it is a culturally rooted practice integrated into community norms, collective decision-making, and generational ecological understanding. Where these traditions persist, there is strong justification for supporting their continuation as a management tool. Community-led burning can maintain open rangelands, promote fresh grass growth, limit encroachment by shrubs and invasive species, and enhance habitat heterogeneity. Community elders and traditional practitioners often possess tacit knowledge such as appropriate seasons, ideal humidity and wind conditions, burning intervals, and safe ignition patterns that allow them to manage fire in ways that align with local ecological dynamics. Safeguarding these practices helps preserve cultural and community identities while utilizing traditional ecological knowledge that modern fire management frameworks often undervalue.

In the global North, the United States has experienced forest destruction from devastating wildfires linked to historical fire mismanagement and disconnected people-forest interactions that recent research urges reviving for better fire management, risks reduction, and broader benefits (Markwith and Paudel, 2022; Parajuli *et al.*, 2025). On the other side, in global South countries like Nepal, India, and Mexico, there is rich evidence of communities utilizing their traditional ecological knowledge in maintaining healthy forests, promoting biodiversity and sustaining their livelihoods through regular engagement with forests, including the use of fire as a management tool (Dogra *et al.*, 2018; Farthing, 2024; Pandey *et al.*, 2022; Sharma *et al.*, 2021; Van Vleet *et al.*, 2016). By valuing its own traditions and strengthening the long-standing community-based practices, Nepal can set good examples of people led-sustainable forest fire management.

Closing remarks

The core principle of creating fire-resilient forests through various fuel-reduction activities aims to decrease biomass on the ground (i.e., surface fuel), in the crown (i.e., canopy fuel), and in the layers between (i.e., ladder fuel). Nepal's long legacy of community engagement, which blends traditional knowledge of sustainable resource extraction with technical assistance from government and other partner agencies including non-profit organizations, has ensured that these principles are applied and has helped prevent large devastating wildfires. It is vital to maintain the intricate ties between people and forests for mutual benefits: people contribute to healthy ecosystems that sustain essential services for humankind, and forests support local livelihoods and continue to provide diverse ecosystem services. Anthropogenic or controlled burning can help manage surface and ladder fuels and be ecologically beneficial in certain landscapes, and therefore, it should be continued where it has been historically practiced and informed by traditional and modern ecological knowledge. However, initiating new burning practices is generally not recommended, at least warrants well thought research and planning, because: a) not all landscapes are adapted to fires, and b) escaped fires can lead to severe impacts on biodiversity, carbon budgets, infrastructures and public health and safety. Moreover, experiences from developed countries show that the technical and financial resources required for managed burning are substantial, making such approaches economically less feasible for a developing economy like Nepal.

Nepal's forests are experiencing increased fire risks driven by multiple factors, including shifting fuel patterns and changing climatic conditions. Weakening people-forest interactions, partly due to low economic benefits and reduced dependence on forest resources, underscore the urgency of national strategies for sustainable forest and fire management. Here, we emphasize the need for collaborative action among government agencies, scientists, non-profits, the private sector, and local institutions to support communities through research, technical and financial assistance, and pragmatic policies that strengthen fire-resilient forest management, and most importantly, keep healthy people-forest relationships intact. In addition to acknowledging community-based forest management as an entrepreneurial endeavor, the Government of Nepal should timely introduce policies and regulations that create enabling environments for forest-based enterprises and private-sector investments in modern technologies capable of converting forest residues into net carbon-beneficial products such as biochar.

Acknowledgement

We thank Charles B. van Rees, Assistant Professor at Odum School of Ecology, University of Georgia (USA) for the constructive comments and linguistic corrections, which helped enhance the quality of the manuscript.

References

Agee, J.K. and Skinner, C.N. 2005 Basic principles of forest fuel reduction treatments. *Forest Ecology and Management*. **211**, 83–96 https://doi.org/10.1016/j.foreco.2005.01.034.

Alcasena, F., Ager, A.A., Belavenutti, P., Krawchuk, M. and Day, M.A. 2022 Contrasting the efficiency of landscape versus community protection fuel treatment strategies to reduce wildfire exposure and risk. *Journal of Environmental Management*. **309**, 114650 https://doi.org/10.1016/j.jenvman.2022.114650.

Anderson, M.K. and Moratto, M.J. 1996 Native American land-use practices and ecological impacts. Presented at the Sierra Nevada ecosystem project: final report to Congress, University of California, Centers for Water and Wildland Resources, pp. 187–206.

Bai, S.H., Omidvar, N., Gallart, M., Kämper, W., Tahmasbian, I., Farrar, M.B., Singh, K., Zhou, G., Muqadass, B., Xu, C.-Y., Koech, R., Li, Y., Nguyen, T.T.N. and van Zwieten, L. 2022 Combined effects of biochar and fertilizer applications on yield: A review and meta-analysis. *Science of The Total Environment*. **808**, 152073 https://doi.org/10.1016/j.scitotenv.2021.152073.

Baral, S., Subedi, S., Ford, R., Rai, R.K., Chhetri, B.B.K., Ojha, S., Tiwari, K.R., Kafle, G., Puri, L. and Rai, D. 2025 Resilience pathways through community- based forest management for navigating the triple planetary crisis. *Trees, Forests and People*. **22**, 100972 https://doi.org/10.1016/j.tfp.2025.100972.

Benedum, M.E., Cook, N.J. and Vallury, S. 2025 Remittance income weakens participation in community-based natural resource management. *Ecology and Society*. **30** https://doi.org/10.5751/ES-16436-300334.

Burrows, N., Rampant, P., Loewenthal, G. and Wills, A. 2020 Fire, plant species richness and plants of significance to Australian desert Aboriginal people. *Int J Wildland Fire*. **29**, 939–942 https://doi.org/10.1071/WF20057.

Cabiyo, B., Fried, J.S., Collins, B.M., Stewart, W., Wong, J. and Sanchez, D.L. 2021 Innovative wood use can enable carbon-beneficial forest management in California. *Proceedings of the National Academy of Sciences*. **118**, e2019073118 https://doi.org/10.1073/pnas.2019073118.

Campbell, J., Harmon, M.E. and Mitchell, S.R. 2012 Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? *Frontiers in Ecology and the Environment*. **10**, 83–90 https://doi.org/10.1890/110057.

Cantarello, E., Jacobsen, J.B., Lloret, F. and Lindner, M. 2024 Shaping and enhancing resilient forests for a resilient society. *Ambio*. **53**, 1095–1108 https://doi.org/10.1007/s13280-024-02006-7.

CBD. 2024 The Forest Factor: The role of protection, restoration and sustainable management of forests for the implementation of the Kunming-Montreal Global Biodiversity Framework. Secretariat of the Convention on Biological Diversity.

Chandran, M., Sinha, A. and Rawat, R. 2011 Replacing controlled burning practice by Alternate methods of reducing fuel load in the Himalayan Long leaf Pine (Pinus roxburghii Sarg.) forests. Presented at the 5th international wildland fire conference, South Africa.

Chang, H., Han, H.-S., Anderson, N., Kim, Y.-S. and Han, S.-K. 2023 The Cost of Forest Thinning Operations in the Western United States: A Systematic Literature Review and New Thinning Cost Model. *j for*. **121**, 193–206 https://doi.org/10.1093/jofore/fvac037.

Charmakar, S., Oli, B.N., Joshi, N.R., Maraseni, T.N. and Atreya, K. 2021 Forest Carbon Storage and Species Richness in FSC Certified and Non-certified Community Forests in Nepal. *Small-scale Forestry*. **20**, 199–219 https://doi.org/10.1007/s11842-020-09464-3.

Christianson, A.C., Sutherland, C.R., Moola, F., Gonzalez Bautista, N., Young, D. and MacDonald, H. 2022 Centering Indigenous Voices: The Role of Fire in the Boreal Forest of North America. *Curr Forestry Rep*. **8**, 257–276 https://doi.org/10.1007/s40725-022-00168-9.

Cook, N.J., Khatri, D.B., Poudel, D.P., Paudel, G. and Acharya, S. 2025 Dropping out of environmental governance: Why Nepal's community-based forestry program is losing participants. *Elementa: Science of the Anthropocene*. **13**, 00059 https://doi.org/10.1525/elementa.2024.00059.

Cubbage, F.W., Davis, R.R., Rodríguez Paredes, D., Mollenhauer, R., Kraus Elsin, Y., Frey, G.E., Gonzalez Hernandez, I.A., Albarran Hurtado, H., Cruz, A.M.S. and Salas, D.N.C. 2015 Community forestry enterprises in Mexico: Sustainability and competitiveness. *Journal of Sustainable Forestry*. **34**, 623–650.

Cunningham, C.X., Williamson, G.J. and Bowman, D.M.J.S. 2024 Increasing frequency and intensity of the most extreme wildfires on Earth. *Nat Ecol Evol*. **8**, 1420–1425 https://doi.org/10.1038/s41559-024-02452-2.

Dangi, R.B. 2025 Why is Nepal struggling to halt timber imports despite being rich in forest cover: A critical review from a theoretical lens? *Banko Janakari*. **35**, 62–70.

Dhungana, B.P., Chhetri, V.T., Baniya, C.B., Sharma, S.P., Ghimire, P. and Vista, S.P. 2024 Post-fire Effects on Soil Properties in High altitude Mixed-conifer Forest of Nepal. *Trees, Forests and People*. **17**, 100633 https://doi.org/10.1016/j.tfp.2024.100633.

Dogra, P., Mitchell, A.M., Narain, U., Sall, C., Smith, R. and Suresh, S. 2018 Strengthening forest fire management in India. *World Bank, Washington DC*.

FAO. 2022 *The State of the World's Forests 2022. Forest pathways for green recovery and building inclusive, resilient and sustainable economies.* Food and Agriculture Organization of the United Nations.

Farthing, L. 2024 Fewer wildfires, great biodiversity: what is the secret to the success of Mexico's forests? *The Guardian*.

Gentle, P., Maraseni, T.N., Paudel, D., Dahal, G.R., Kanel, T. and Pathak, B. 2020 Effectiveness of community forest user groups (CFUGs) in responding to the 2015 earthquakes and COVID-19 in Nepal. *Research in Globalization*. **2**, 100025 https://doi.org/10.1016/j.resglo.2020.100025.

Griscom, B.W., Adams, J., Ellis, P.W., Houghton, R.A., Lomax, G., Miteva, D.A., Schlesinger, W.H., Shoch, D., Siikamäki, J.V., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., Conant, R.T., Delgado, C., Elias, P., Gopalakrishna, T., Hamsik, M.R., Herrero, M., Kiesecker, J., Landis, E., Laestadius, L., Leavitt, S.M., Minnemeyer, S., Polasky, S., Potapov, P., Putz, F.E., Sanderman, J., Silvius, M., Wollenberg, E. and Fargione, J. 2017 Natural climate solutions. *Proceedings of the National Academy of Sciences*. **114**, 11645–11650 https://doi.org/10.1073/pnas.1710465114.

Hagmann, R.K., Hessburg, P.F., Prichard, S.J., Povak, N.A., Brown, P.M., Fulé, P.Z., Keane, R.E., Knapp, E.E., Lydersen, J.M., Metlen, K.L., Reilly, M.J., Sánchez Meador, A.J., Stephens, S.L., Stevens, J.T., Taylor, A.H., Yocom, L.L., Battaglia, M.A., Churchill, D.J., Daniels, L.D., Falk, D.A., Henson, P., Johnston, J.D., Krawchuk, M.A., Levine, C.R., Meigs, G.W., Merschel, A.G., North, M.P., Safford, H.D., Swetnam, T.W. and Waltz, A.E.M. 2021 Evidence for widespread changes in the structure, composition, and fire regimes of western North American forests. *Ecological Applications*. **31**, e02431 https://doi.org/10.1002/eap.2431.

IPCC. 2018 Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Intergovernmental Panel on Climate Change.

Jaffe, D.A., O'Neill, S.M., Larkin, N.K., Holder, A.L., Peterson, D.L., Halofsky, J.E. and Rappold, A.G. 2020 Wildfire and prescribed burning impacts on air quality in the United States. *Journal of the Air & Waste Management Association*. **70**, 583–615 https://doi.org/10.1080/10962247.2020.1749731.

Kaarakka, L., Cornett, M., Domke, G., Ontl, T. and Dee, L.E. 2021 Improved forest management as a natural climate solution: A review. *Ecological Solutions and Evidence*. **2**, e12090 https://doi.org/10.1002/2688-8319.12090.

Kandel, P., Chapagain, P.S., Sharma, L.N. and Vetaas, O.R. 2016 Consumption Patterns of Fuelwood in Rural Households of Dolakha District, Nepal: Reflections from Community Forest User Groups. *Small-scale Forestry*. **15**, 481–495 https://doi.org/10.1007/s11842-016-9335-0.

Keeley, J.E. 2009 Fire intensity, fire severity and burn severity: a brief review and suggested usage. *Int J Wildland Fire*. **18**, 116–126 https://doi.org/10.1071/WF07049.

Lama, Y., Ghimire, S. and Aumeeruddy-Thomas, Y. 2001 Medicinal plants of Dolpo: Amchis' knowledge and conservation. WWF Nepal Program, Kathmandu.

Lauvaux, C.A., Skinner, C.N. and Taylor, A.H. 2016 High severity fire and mixed conifer forest-chaparral dynamics in the southern Cascade Range, USA. *Forest Ecology and Management*. **363**, 74–85 https://doi.org/10.1016/j.foreco.2015.12.016.

Long, J.W., Lake, F.K. and Goode, R.W. 2021 The importance of Indigenous cultural burning in forested regions of the Pacific West, USA. *Forest Ecology and Management*. **500**, 119597 https://doi.org/10.1016/j.foreco.2021.119597.

Lorenz, K. and Lal, R. 2010 *Carbon Sequestration in Forest Ecosystems*. Springer Netherlands https://doi.org/10.1007/978-90-481-3266-9.

Mariani, M., Wills, A., Herbert, A., Adeleye, M., Florin, S.A., Cadd, H., Connor, S., Kershaw, P., Theuerkauf, M., Stevenson, J., Fletcher, M.-S., Mooney, S., Bowman, D. and Haberle, S. 2024 Shrub cover declined as Indigenous populations expanded across southeast Australia. *Science*. **386**, 567–573 https://doi.org/10.1126/science.adn8668.

Markwith, S.H. and Paudel, A. 2022 Beyond pre-Columbian burning: the impact of firewood collection on forest fuel loads. *Canadian Journal of Forest Research*. **52**, 365–371.

Messier, C., Bauhus, J., Doyon, F., Maure, F., Sousa-Silva, R., Nolet, P., Mina, M., Aquilué, N., Fortin, M.-J. and Puettmann, K. 2019 The functional complex network approach to foster

forest resilience to global changes. *Forest Ecosystems*. **6**, 21 https://doi.org/10.1186/s40663-019-0166-2.
Mina, M., Messier, C., Duveneck, M.J., Fortin, M.-J. and Aquilué, N. 2022 Managing for the unexpected: Building resilient forest landscapes to cope with global change. *Global Change Biology*. **28**, 4323–4341 https://doi.org/10.1111/gcb.16197.
Mishra, B., Panthi, S., Poudel, S. and Ghimire, B.R. 2023 Forest fire pattern and vulnerability mapping using deep learning in Nepal. *fire ecol*. **19**, 3 https://doi.org/10.1186/s42408-022-00162-3.
Mitchell, R.E. 2006 Environmental governance in Mexico: Two case studies of Oaxaca's community forest sector. *Journal of Latin American Studies*. **38**, 519–548.
Moritz, M.A., Morais, M.E., Summerell, L.A., Carlson, J.M. and Doyle, J. 2005 Wildfires, complexity, and highly optimized tolerance. *Proceedings of the National Academy of Sciences*. **102**, 17912–17917 https://doi.org/10.1073/pnas.0508985102.
Mukul, S.A. and Byg, A. 2020 What Determines Indigenous Chepang Farmers' Swidden Land-Use Decisions in the Central Hill Districts of Nepal? *Sustainability*. **12**, 5326 https://doi.org/10.3390/su12135326.
Nepali Times. 2021 Wildfires ravage Nepal mountains [WWW Document] URL https://nepalitimes.com/news/wildfires-ravage-nepal-mountains (accessed 11.4.25).
North, M., Brough, A., Long, J., Collins, B., Bowden, P., Yasuda, D., Miller, J. and Sugihara, N. 2015 Constraints on Mechanized Treatment Significantly Limit Mechanical Fuels Reduction Extent in the Sierra Nevada. *Journal of Forestry*. **113**, 40–48 https://doi.org/10.5849/jof.14-058.
Pandey, H.P., Pokhrel, N.P., Thapa, P., Paudel, N.S. and Maraseni, T.N. 2022 Status and Practical Implications of Forest Fire Management in Nepal. *Journal of Forest and Livelihood*. **21**, 32–45 https://doi.org/10.3126/jfl.v21i1.56583.
Parajuli, R. and Markwith, S.H. 2023 Quantity is foremost but quality matters: A global meta-analysis of correlations of dead wood volume and biodiversity in forest ecosystems. *Biological Conservation*. **283**, 110100 https://doi.org/10.1016/j.biocon.2023.110100.
Parajuli, R., Paudel, A. and Markwith, S.H. 2025 Integrating the physical harvesting of dead wood into fuel treatments to reduce wildfire hazards and enhance carbon benefits. *Journal of Environmental Management*. **376**, 124535 https://doi.org/10.1016/j.jenvman.2025.124535.
Paudel, A., Coppoletta, M., Merriam, K. and Markwith, S.H. 2022 Persistent composition legacy and rapid structural change following successive fires in Sierra Nevada mixed conifer forests. *Forest Ecology and Management*. **509**, 120079 https://doi.org/10.1016/j.foreco.2022.120079.
Paudel, A., Markwith, S.H., Konchar, K., Shrestha, M. and Ghimire, S.K. 2020 Anthropogenic fire, vegetation structure and ethnobotanical uses in an alpine shrubland of Nepal's Himalaya. *Int. J. Wildland Fire*. **29**, 201–214 https://doi.org/10.1071/WF19098.
Paudel, D., Jeuland, M. and Lohani, S.P. 2021 Cooking-energy transition in Nepal: trend review. *Clean Energy*. **5**, 1–9.
Phillips, C.A., Rogers, B.M., Elder, M., Cooperdock, S., Moubarak, M., Randerson, J.T. and Frumhoff, P.C. 2022 Escalating carbon emissions from North American boreal forest

wildfires and the climate mitigation potential of fire management. *Science Advances*. **8**, eabl7161 https://doi.org/10.1126/sciadv.abl7161.
Poudyal, B.H., Khatri, D.B., Paudel, D., Marquardt, K. and Khatri, S. 2023 Examining forest transition and collective action in Nepal's community forestry. *Land Use Policy*. **134**, 106872 https://doi.org/10.1016/j.landusepol.2023.106872.
Pyne, S.J. 1982 *Fire in America: A Cultural History of Wildland and Rural Fire*. University of Washington Press, 681 pp.
Pyne, S.J., Andrews, P.L. and Laven, R.D. 1996 *Introduction to wildland fire.* John Wiley & Sons.
Ravi, V., Vaughan, J.K., Wolcott, M.P. and Lamb, B.K. 2019 Impacts of prescribed fires and benefits from their reduction for air quality, health, and visibility in the Pacific Northwest of the United States. *Journal of the Air & Waste Management Association*. **69**, 289–304 https://doi.org/10.1080/10962247.2018.1526721.
Roces-Díaz, J.V., Santín, C., Martínez-Vilalta, J. and Doerr, S.H. 2022 A global synthesis of fire effects on ecosystem services of forests and woodlands. *Frontiers in Ecology and the Environment*. **20**, 170–178 https://doi.org/10.1002/fee.2349.
Ryan, M.G., Harmon, M.E., Birdsey, R.A., Giardina, C.P., Heath, L.S., Houghton, R.A., Jackson, R.B., McKinley, D.C., Morrison, J.F. and Murray, B.C. 2010 A synthesis of the science on forests and carbon for US forests. *Ecological Society of America: Issues In Ecology. 13: 1-16.* 1–16.
Schmidt-Vogt, D. 1990 Fire in high altitude forests of the Nepal Himalaya. In *Fire in Ecosystem Dynamics. Mediterranean and Northern Perspectives.* The Hague: SPB Academic Publishing, pp. 191–199.
Shabangu, S., Woolf, D., Fisher, E.M., Angenent, L.T. and Lehmann, J. 2014 Techno-economic assessment of biomass slow pyrolysis into different biochar and methanol concepts. *Fuel*. **117**, 742–748 https://doi.org/10.1016/j.fuel.2013.08.053.
Sharma, L.N., Tamang, S.R., Poudel, Y.B., Subba, A., Timsina, S., Adhikari, B., Shrestha, H., Gautam, A.P., Kandel, D.R., Watson, M.F. and Paudel, N.S. 2021 Biodiversity Beyond Protected Areas: Gaps and Opportunities in Community Forest. *Journal of Forest and Livelihood*. **20**, 45–61 https://doi.org/10.3126/jfl.v20i1.59634.
Shyam, S., Ahmed, S., Joshi, S.J. and Sarma, H. 2025 Biochar as a Soil amendment: implications for soil health, carbon sequestration, and climate resilience. *Discov. Soil*. **2**, 18 https://doi.org/10.1007/s44378-025-00041-8.
Stokland, J.N., Siitonen, J. and Jonsson, B.G. 2012 *Biodiversity in dead wood*. Cambridge university press.
Tiwari, S., Paudel, N.S., Sze, J. and Karki, R. 2022 Unravelling the local dynamics of increasing fires in community forests of mid-hills of Nepal. *Journal of Forest and Livelihood*. **21**, 60–71.
UNFCCC. 2015 The Paris agreement [WWW Document]. *United Nations Framework Convention on Climate Change, 2015* URL https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (accessed 11.4.25).
UNFFS. 2021 The Global Forest Goals Report 2021. United Nations Department of Economic and Social Affairs, United Nations Forum on Forests Secretariat.

US Congress. 2024 Funding for Wildfire Management: FY2024 Appropriations for the Forest Service and Department of the Interior [WWW Document] URL https://www.congress.gov/crs-product/IF12398 (accessed 11.17.25).

Van Vleet, E., Bray, D.B. and Durán, E. 2016 Knowing but not knowing: Systematic conservation planning and community conservation in the Sierra Norte of Oaxaca, Mexico. *Land Use Policy*. **59**, 504–515 https://doi.org/10.1016/j.landusepol.2016.09.010.

Wibbenmeyer, M., Zhu, Y. and Wear, D.N. 2025 The Costs of Achieving Forest Resilience in California. Resources for the Future.

Williams, C.A., Gu, H., MacLean, R., Masek, J.G. and Collatz, G.J. 2016 Disturbance and the carbon balance of US forests: A quantitative review of impacts from harvests, fires, insects, and droughts. *Global and Planetary Change*. **143**, 66–80 https://doi.org/10.1016/j.gloplacha.2016.06.002.

World Bank. 2025 Nepal Receives $9.4 Million for Forest Carbon Credits Under the Forest Carbon Partnership Facility [WWW Document]. *World Bank Group Press Release* URL https://www.worldbank.org/en/news/press-release/2025/11/16/nepal-receives-9-4-million-for-forest-carbon-credits-under-the-forest-carbon-partnership-facility (accessed 11.17.25).