Editorial

Special Issue Editorial: Biodiversity and Ecosystem Services in Forest Ecosystems

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With the degradation and destruction of ecosystem structures and functions, humans are losing essential goods and services from forest ecosystems [1,2]. Essential benefits provided by forest ecosystems include provisional (timber and non-timber forest products), regulatory (carbon sequestration and water purification), and cultural services (recreational and spiritual characteristics). All such services that humans obtain from ecosystems, namely, ecosystem services (ES), are intricately dependent on biodiversity [3–7]. The biodiversity in the corresponding ecosystems may in turn sustain forest ecosystems and guarantee their continued viability. The ES perspective establishes a conceptual connection between ecological functions and processes, a diversity of intermediary and direct benefits, and human well-being. The ES concept has expanded its scope and values to support broader goals, such as livelihood development, climate change adaptation and mitigation, health provisioning, water and food security, natural disaster reduction, tourism and economy promotion, research and education, and the promotion of cultural values. It acknowledges the integration of ecological, sociocultural, and economic value systems and tradeoffs, bringing together conservation and development discourses to promote sustainable development.

The management of forest biodiversity and ecosystem services frequently encounters tradeoffs and compromises. The conservation of biodiversity frequently compromises the forest's capacity to meet human needs, especially for both timber and non-timber forest products. Drivers of deforestation vary regionally, and include agriculture, firewood collection, economic development, and other ecosystem service demands resulting in forest clearing and/or degradation [8–10]. Local communities that are dependent on forest resources, for instance, may be negatively affected by the implementation of conservation programs that exclude them from accessing essential resources [11]. To resolve these conflicts and ensure sustainable forest management, governments, nongovernmental agencies, and policymakers must consider the myriad facets of forest ecosystem services.

In recent decades, consistent frameworks have been developed aiming to relate human society and economy to biophysical entities while considering the effects of policy decisions. The primary objective of the Millennium Ecosystem Assessment was to determine how changes in ecosystems affect human well-being; to provide a current scientific assessment of global ecosystems' state and dynamics, as well as the services they provide; and to provide a solid scientific foundation for enacting measures to preserve and sustainably utilize natural ecosystems (MA, 2005). Other frameworks, like the Driver, Pressure, State, Impact, and Response (DPSIR) framework have been developed by the European Environment Agency [12]. It became a strategic tool for extensive reviews to report multi-scale socio-ecological changes from an interdisciplinary perspective [13–15]. Also, the Economics

of Ecosystems and Biodiversity (TEEB) framework describes the relationship between biodiversity, ecosystem services, and human well-being. This framework was created because mainstream economists believed that placing a value on ecosystem services (ESs) would lead to better policy integration. According to the TEEB paradigm, the total economic value (TEV) can be calculated by summing the values placed on use and non-use of an ecosystem's resources [16–19].

The value of ecosystem services has been integrated into policy decisions to support sustainable forestry through payments for ecosystem services (PES) to villagers to enact forestry-related protective measures. Further protecting forest reserves and enacting PES programs has the potential co-benefit of protecting biodiversity [20]. While PES programs are globally implemented, the assessments and evaluations are often constrained to evaluate a program's success based on land use and land cover change, with a majority of programs not assessing or reporting biodiversity gains [21,22]. Several studies have made specific attempts to evaluate the potential co-benefits of both vegetation and terrestrial vertebrate biodiversity as important indicators of success for areas receiving PES payments [23,24]. The ability to assess "degradation" under the United Nations Reducing Emissions from Deforestation and Degradation-plus (REDD+) [25], and to evaluate progress towards international biodiversity targets such as those set by the Convention on Biological Diversity (CBD) [26] and Sustainable Development Goals (SDG) [27–29], require the assessment of landscapes using robust and accurate biodiversity metrics and methods [30].

This Special Issue contains five papers that comprise a diverse representation of countries (Nepal, Kenya, Brazil, and Canada), as well as methods and approaches for addressing the issues of research on compromises between biodiversity and ecosystem services. One of them is a review article about the circular bioeconomy for deadwood conservation in Kenya, and the other four articles are research articles or case studies focusing on specific research areas such as participatory GIS for infrastructure projects in the Amazon, community forestry management concerns in Nepal, and cultural significance of carnivore conservation.

The tradeoff between forest biodiversity and ecosystem services in Kenya's public forests for deadwood use and conservation is a complex issue. In the "Paradox of Deadwood Circular Bioeconomy in Kenya's Public Forests" review study by Chisika et al., these tradeoffs are explored and recommendations are provided for sustainable forest management. According to global studies, deadwood is essential to the bioeconomy, the environment, and sustainable development. This article emphasizes the forest-based circular bioeconomy as a tool for deadwood conservation, as a lack of specific rules for deadwood protection disturbs the natural equilibrium in public forests. On the one hand, deadwood is a valuable resource for the conservation of biodiversity because it provides a habitat and reproductive site for birds and insects, as well as substrate and nutrients for fungi. On the other hand, the demand for deadwood for energy purposes is increasing, driven by the need for household fuel, particularly in rural regions with limited access to alternative energy sources. With the current trend, 70% of the population consumes deadwood for household use, and the demand is predicted to increase—there will soon be a severe quandary regarding whether deadwood should be conserved for biodiversity or energy. This research addresses a knowledge gap in the field by suggesting policy choices for Kenya's long-term forest resource management. The results of recommendations and intensive research suggest a cultural and behavioral shift in energy usage to avert an ecological imbalance and maximize the value of deadwood.

The Amazon is renowned for its diverse ecosystem and the societal benefits it provides. Numerous plant and animal species are lost when forests are cleared for large infrastructure, upsetting the delicate balance of the ecosystem. Nonetheless, these extensive infrastructure projects have a substantial impact on the economy and the overall gross domestic product (GDP), playing a crucial role in the provision of societal goods obtained through extraction processes. In the paper "Participatory Mapping for Strengthening Environmental Governance on Socio-Ecological Impacts of Infrastructure in the Amazon: Lessons

to Improve Tools and Strategies" by Mere-Roncal et al., the Amazon basin was viewed as a source of economic expansion through the construction of large-scale infrastructure projects, including roads, dams, oil and gas pipelines, and mining. Environmental groups are tasked with conserving the Amazon's various ecosystems and indigenous peoples, but they regularly clash with national and international policies that support the Amazon's development. Negative social, economic, and environmental effects may be mitigated by the implementation of innovative environmental governance strategies. The Governance and Infrastructure in the Amazon (GIA) initiative suggests establishing a "community of practice and learning" (CoP-L) on infrastructure governance techniques and tools to study and address governance effectiveness challenges. This study used participatory mapping exercises in workshops in four distinct Amazonian regions to visualize and reflect on (1) areas of value, (2) areas of concern, and (3) proposed actions to mitigate infrastructure development's adverse effects and enhance governance. Mixed approaches were used to study textual analysis, regional multi-iterative stakeholder conversation, participatory mapping, and geospatial integration. By enhancing communication and cooperation and disseminating data based on local knowledge, this novel strategy can increase transparency in infrastructure development and promote good governance.

In the case of community forestry in Nepal, tradeoffs arise from the need to balance the economic benefits derived from timber income with the preservation of forest biodiversity and ecosystem services. In the manuscript "The implications of community forest income on social and environmental sustainability" by Bohnett et al., community forestry (CF) is an alternative to the traditional top-down strategy that places forest management in the hands of local people. This study examines the effects of variations in timber income and the cost of supporting forest regeneration on the social and ecological viability of CF. Their research in the three management zones of Chitwan in Nepal revealed a significant income and expenditure disparity between the biological and socioeconomic benefits and resilience of community forest user groups. In regions with lower timber incomes, there was a lack of economic stability and resources to implement the necessary regulations. Consequently, these districts imposed more stringent restrictions on the quantity of wood that community forest members could harvest. In turn, these restrictions on timber extraction influenced the ability of low-income CFs to improve forest regeneration, with lower economic viability and fewer community rights. These results suggest that the pursuit of economic sustainability through income from community forests may occur at the expense of social and environmental sustainability and viability between CF groups in Nepal.

There are numerous dynamics at play in community forestry in Nepal, where economic and social factors intersect with forest management concerns. The article titled "Influence of Rural Out-Migration on Household Participation in Community Forest Management? Evidence from the Middle Hills of Nepal" by Bista et al. examines the effects of rural–urban migration on forest user participation in community forest planning and management in Nepal. The researchers modeled the effects of rural outmigration on household participation in community forest management using data from 415 families in 15 community forest user groups in two districts of Nepal's Mid-Hill region. In total, 72% of Nepalese households included a migrant, but only 20% and 29%, respectively, participated in forest management or decision-making. Household size, internal migration, resources, and institutions influenced participation. In Nepal, gender segregation of forest activities is typical, but this study found no correlation between gender and participation categories. The study found that Dalit users participated in decision-making at a higher rate than higher caste groups, presumably because of the abundance of forest products and the diversity of their livelihood activities. More frequently, households with more livestock units participated in forest activities. The demographic dynamics of community forestry, the definition of roles and responsibilities, and the support of active members have policy implications. This research can be used to inform future community forestry policy decisions aimed at mitigating the effects of rural out-migration on community forestry, as well as future research on the cascading effects of out-migration on forest biodiversity

and ecosystem services. Future research should investigate the effect of outmigration on forest sustainability.

In the manuscript "Evaluating Attitudes towards Large Carnivores within the Great Bear Rainforest" by Leveridge et al., the authors explore the complex relationship between biodiversity and ecosystem services in the Great Bear Rainforest (GBR), with a particular focus on people's attitudes towards large carnivores and inquiry into human–animal coexistence. It examines the ecological and interpersonal perspectives of the residents of Prince Rupert, a city in the GBR, using the New Ecological Paradigm questionnaire concerning the protected rainforest and the large mammals that live there. Researchers investigated the respondents' ecological beliefs, focusing on their attitudes toward forest biodiversity and ecosystem services for cultural, spiritual, and recreation services. The Great Bear Rainforest (GBR) was the most significant location for the responders because of its significance to First Nations indigenous culture. Eighty-nine percent of respondents noted the relevance of carnivores to local First Nations. First Nations and non-First Nations respondents did not significantly differ in their NEP scores, despite the importance of the local ecosystem and animals to First Nations spiritually and culturally. Most respondents reported experiencing a sense of wonder or excitement at the sight of carnivores. The lack of a significant difference in attitudes between First Nations and non-First Nations respondents may be attributable to several factors, including the cultural influence of the local First Nations, the economic significance of these carnivores, and a strong sense of place (associated with the area and the carnivores that inhabit it). The respondents' vehement opposition to trophy hunting and their lamentation over the lack of a conservation officer in Prince Rupert provide additional evidence of the spiritual and cultural significance of carnivores in the GBR. The research also indicated that communities and officials need to engage in two-way conversations on conservation and avoiding human–carnivore conflicts.

A loss of forest biodiversity can have detrimental effects on the functioning of forest ecosystems and their ability to provide ecosystem services. Information on services that humans obtain from the corresponding ecosystem is crucial for a sustainable landscape, and its present and future scenarios will likely play an essential role in natural resource management and biodiversity conservation. More recently, there has been an increasing need for various initiatives, policies, and laws that can adopt the importance of ecosystem services into on-the-ground planning—for instance, the United Nations launched the 2030 Sustainable Development Goals, and its Goal 15 (i.e., conserve life on land) contains an emphasis on ecosystems and the services they provide [31]. On the other hand, the U.N. recently approved the Post-2020 Global Biodiversity Framework [32]. Community forestry, fuelwood extraction, and human–wildlife coexistence and conflicts are all topics covered in this issue, but there have been few attempts to integrate or evaluate tradeoffs between biodiversity and ecosystem services. The research provided in this editorial demonstrates that there are linkages and tradeoffs between ecosystem services and biodiversity in forest ecosystems, presenting studies that also reveal the diversity and complexity involved in forming research projects and the practical implementation around these goals. These findings highlight the importance of maintaining and conserving forest biodiversity to ensure the continued provision of ecosystem services.

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