

EDITORIAL

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Current trends in forestry research of Latin-America: an editorial overview of the Special Issue

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Abstract

Mendoza city (Argentina) hosted the VIII Latin American Forestry Congress (CONFLAT) and the V Forestry Congress of Argentina (CFA) in 2023, where relevant issues were addressed, such as climate change, degradation, reforestation, management and forest industry, monitoring, environmental services, social issues, and governance, among others. The objective of this Special Issue was to present the main advances in Forestry Science for Latin-America in the context of changing governance and forest livelihoods for people. The fifteen articles emphasize the interdisciplinary nature of the forest management and conservation, and that multiple variables must be considered to achieve sustainability. The articles come from studies across Southern South-America (Argentina, Brazil, Chile, and Uruguay), and the collaboration of researchers of other countries (México, Canada, and Spain). Articles include research in tropical, Mediterranean and temperate Sub-Antarctic forests. Together, these articles provide a snapshot of new forestry research carried out locally and internationally to bring about beneficial ecological and environmental outcomes in a world facing the challenges of sustainable management and conservation amongst the threats and uncertainty of climate change and environmental degradation responsible for extensive loss of biodiversity and environmental services. We believe that this Special Issue will encourage more inter-disciplinary research focusing on management and conservation of forests.

Keywords Forest management, Conservation, Monitoring, Native forest, Forest plantation, Resilience

Background

Native forests provide a wide variety of goods and ecosystem services, offering different social and economic opportunities (Agimass Taye et al. 2021; Perevochtchikova et al. 2021). In this context, it is necessary to develop new management and conservation strategies

with broader purposes than just timber production, including non-monetary ecosystem services that ensure biodiversity conservation and maintenance of ecological processes (Hernández-Blanco et al. 2020; Rosas et al. 2022; Chivulescu et al. 2024), as well as food security through silvicultural strategies that promote sustainable silvo-agroforestry proposals (van Noordwijk 2021). Over the past decades, many initiatives have been undertaken to stop the deforestation of native forests across the South-America, e.g., Argentina enacted the Law “Minimum budgets for environmental protection of native forests” in 2007, which categorizes the natural forests and establishes policies for their use and conservation; Chile enacted the Law “Native forest recovery and forestry development” in 2008, which regulates the use of native forests and also promotes the sustainable forest

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management; and Brazil enacted the Law “Public forests management for sustainable production and other provisions” in 2006, which proposes a sustainable timber production with special attention on local community management, forest concessions, environmental licensing, and forest markets (Cordeiro-Beduschi 2020; da Cruz et al. 2020; Vallejos et al. 2021; West and Fearnside 2021; Mohebalian et al. 2022). However, the loss of native forest and its transformation to other agricultural and grazing lands (e.g., soybean, sugarcane, or livestock) continues across the region, and varies in magnitude according to forest types and countries (Heilmayr et al. 2020; Martínez Pastur et al. 2020a; Song et al. 2021; Potapov et al. 2022).

Management and conservation proposals for native forests must pursue three dimensions: persistence (quantity and quality of forest ecosystems), sustained production (economic, social, and ecological), and ecosystem services maintenance in the long term (Martínez Pastur et al. 2020b; Peri et al. 2022). In this context, the current challenge for South-America requires a new conceptual framework, including other research topics that are not previously considered. Peri et al. (2021) identified three challenges that society must face for the sustainable management and conservation of native forests in the forthcoming decades: (i) Development of multipurpose management proposals at different landscape scales: Proposals require the integration of different scientific disciplines (e.g., social and biological sciences), including the conceptual and methodological dimensions of socio-ecological systems (Berrio-Giraldo et al. 2021). These proposals cannot be addressed by classical silviculture, which focuses on local scales and considers dichotomous approaches between forest production and conservation ecology (Nocentini et al. 2017). For this, new tools are needed to achieve these multipurpose uses. (ii) Adaptation of native forest management and conservation to climate change: Climate change (e.g., increase of air temperature and changes in rainfall amounts) significantly impacts the dynamics of natural ecosystems. Therefore, a rethinking of static and inflexible management and conservation scheme is needed, and changes towards dynamic schemes must be developed (Malhi et al. 2020; Weiskopf et al. 2020). Climate change determines modifications in survival, growth, recruitment and resilience thresholds of the native forests against natural and anthropogenic threats (Falk et al. 2022). For this, management and conservation proposals require new scientific tools to implement an adaptive management that promotes greater resilience in native forests (McKelvey et al. 2021; Gaines et al. 2022). (iii) Implementation of more complex indicators and monitoring systems: In these new management and conservation scenarios that

involve forestry proposals with broader knowledge, it is necessary to include new variables related to socio-economic and environmental dimensions aimed at sustaining or improving the productive capacity and yield of native forest ecosystems, the integrity of the ecosystem functions and provision of ecosystem services, as well as the well-being of associated communities (O'Connor et al. 2020; Oettel et al. 2021). For this, defining good monitoring indicators is a complex task that requires updated scientific knowledge that responds to factors of change, and at the same time must be economically feasible to implement (Sparrow et al. 2020).

During 27–30 March of 2023, Mendoza city (Argentina) hosted the VIII Latin American Forestry Congress (CONFLAT) and V Forestry Congress of Argentina (CFA), with more than 1300 people actively participating in these events. These events were held considering the global concerns for the environment, because about 22% of the world's forests are located in Latin America and the Caribbean. The natural, planted and urban forests of South-America play an important role in the development of their peoples, the conservation of biodiversity and in worldwide climate maintenance. During these events, many conferences, symposia, workshops and technical visits were held to address relevant issues such as forests and climate change, degraded areas and reforestation, management and forest industry, monitoring, international markets, added value, environmental services, social issues and governance (<https://congresoforesta2023.org.ar>). In the context described before, and considering the presentations in both events, we developed the proposal of this Special Issue (SI). Our proposal aims to provide a platform for cutting-edge research on the sustainable forestry and people under climate change scenarios. The objective of the SI was to present the main advances in Forestry Science for the region in the context of changing governance and forest livelihoods for people. Native forests and plantations occupy a central role in the discussion of the international policy agenda during the last decades, focusing on the role of forests in addressing the global challenges for economic development and the effects of climate change and biodiversity loss on ecosystem services provision. Millions of people in South-America live near forests and trees in rural areas, with many relying on these resources for their livelihoods. In this context, the implications of the commitments that governments have made for livelihoods and well-being are not totally defined. Therefore, the scientific research can bring solutions and new perspectives to help for new policy proposal development. This SI explores these questions by showcasing the latest forestry research for the region. The SI's 15 articles showed a diversity of applications and new knowledge development that increase

the connection between forestry theory and practice. The articles also consider many of the wider challenges facing forestry and ecology as it progresses and evolves through the 21st Century.

Contributions of the Special Issue papers

The contributions presented in this SI are based on the opinion of researchers from Argentina, Brazil, Chile and Uruguay and other countries such as Mexico, Canada and Spain. The articles demonstrate various aspects of research in tropical, Mediterranean, and temperate sub-Antarctic forests. Together, these articles provide a snapshot of new forestry research carried out locally and internationally, providing useful ecological results and environmental outcomes, in a world facing the challenges of sustainable management and conservation as well as great losses of biodiversity, in the face of the threats and uncertainty generated by climate change and environmental degradation.

Contributions from Argentina

Nine papers were presented by researchers from Argentina, two of which were presented in collaboration with researchers from other countries (Chile and Brazil). Among these presentations, one of them analyzed the natural and anthropogenic wildfires, which burn large areas of arid and semi-arid forests with significant socio-economic and environmental impacts (Villagra et al. 2024), and projections of climate and land-use change suggested that these controlling factors will change, altering fire regimes in the near future. Other papers also dealt with the impacts of different drivers on the native forest cover, and the impact over variables with greater ecological importance, e.g., carbon stocks. Peri et al. (2024) analyzed the soil organic carbon stocks of Argentina, and related these stocks with spatial-temporal remotely sensed indices to determine biodiversity conservation concerns due to threats from high inter-annual climate variability. The presented outputs have been suggested to be incorporated into the annual National Inventory Report of Argentina to assist new forest management proposals in the framework of the Kyoto Protocol and REDD+ initiatives. Besides, the outputs bring insight into how native forests can be more resilient to reduce the impact of biodiversity loss. In the same line, Sione et al. (2023) investigated the key driving factors of tree biomass and soil carbon pools in xerophytic forests in northeastern Argentina, because the conversion of the native forests into agricultural lands can be a threat and the carbon stored could be a source of emissions. The outputs identified some key drivers of carbon gains and losses in the landscape, which can provide an important

reference for implementing forestry carbon sink projects into the Argentina policies.

Other contributions focused on the ecology, dynamics and environmental stress of native forests in a context of climate change. Papú et al. (2024) suggested that climate change can generate more intense water stress conditions, influencing forest dynamics in northern Patagonia. They introduced complementary techniques for better dendrochronological interpretations (e.g., X-ray densitometry and X-ray fluorescence) to demonstrate that some tree species are able to increase their structural components of the cell wall to prevent cavitation and introduce mineral imbalances, both factors allowing to maintain metabolism and cell growth, which would be related to early adaptive signals to avoid die-back under unfavorable environmental conditions. In the same context, Piraino et al. (2024) analyzed the effects of extreme drought events on tree growth and the resilience, resistance and recovery of *Araucaria araucana* that has recently undergone decay and mortality episodes in response to increasing dry climatic conditions. Using dendrochronological methods, they determined that sex influences only over the species resistance to climatic disturbance, where male individuals showed lower tolerance to extreme drought events. These findings are of special interest, because they provide novel and crucial information for conservation and management in current climate change scenarios.

Other contributions focused on forest dynamics after harvesting and the influence of climate change over the key drivers, which are generally considered as constant across the management cycle. Rodríguez-Souilla et al. (2024) emphasized the critical role of seeding in natural regeneration and long-term structural preservation, and that climate change may affect phenology, seeding and seed quality (e.g., viability). They concluded that seed quality varied among harvesting treatments and years with different levels of seeding, which were linked to climatic events. Besides, Sola et al. (2024) evaluated the natural regeneration across managed stands and climate gradients. They found a strong correlation of the site conditions with the natural regeneration dynamics, and recommended that management prescriptions should be adjusted in order to consider the environmental variation occurring through the entire landscape. In both cases, adaptive management must be considered to achieve the proposal objectives, generating greater resilience in the impacted natural forests.

Finally, two contributions increased the local knowledge in variables that were not enough explored in native forests, and in consequence were rarely included in management and conservation proposals, nor in monitoring programs. One of them studied the genetic architecture

to drought tolerance (Lopez Laphitz et al. 2024), recognizing candidate genes identification responding to water stress in Patagonian forests. This topic has been barely treated for South American forest ecosystems, which is necessary to better understand the pressure of climate-change on forests. The second one analyzed the interaction of bark beetles and fungi through the production of volatile organic compounds. This study presented a comprehensive insight into these insect-fungi interactions, allowing to identify proxies for pest control and monitoring in the framework of management and conservation studies (Ceriani-Nakamurakare et al. 2024).

Contributions from Chile

Three papers were presented by researchers from Chile, two of which were in collaboration with researchers from other countries (Argentina, Brazil, and México). Drought is one of the main threats for the northern Chilean Mediterranean forests, and two contributions give some clues about the impact of the climate variations over different forest metrics. Santini Jr et al. (2024) focused on the physiology of woody plants in response to long-term drought. The outputs revealed coordinated shifts in vessel size and frequency and water-use efficiency in response to extreme events of drought, recognizing that some species increased their abilities to tolerate these novel climatic conditions. In the same context, Loewe-Muñoz et al. (2024) monitored hourly stem diameter variations in *Pinus* plantations under different management practices (e.g., fertilization). Their findings showed that the input of fertilizers can contribute to the mitigation of climate change effects in semi-arid environments. Finally, Donoso et al. (2024) studied the synchronization events in seed production for one Patagonian tree species, which can contribute to reduce the natural predation by different animal species. Their findings showed that annual fluctuations in seed production is a determining factor in the natural forest dynamics, and can greatly influence sustainable uses and conservation actions. These three contributions provide evidences that integrate physiological and ecological variables, contributing to the understanding of resilience mechanisms of native forests and plantations to face of increasing drought stress, and other natural and anthropogenic threats.

Contributions from Uruguay and Brazil

Three papers were presented by researchers from Uruguay and Brazil, including in collaboration with researchers from other countries (Argentina, Chile, Canada, and Spain). Native forest loss and degradation are one of the most influencing factors for the local extinction of biodiversity and losses of ecosystem services across the region. The native forest remnants confront different threats,

both of natural (e.g., climate change) and anthropogenic origins (e.g., impact of invasive species). Toranza et al. (2024) analyzed the geographic pattern of tree richness of the last remnants of Paranaense forests of Uruguay, evaluating the water-energy and environmental heterogeneity hypotheses. The outputs support both hypotheses, emphasizing the role of climate variation over the habitat availability on the hillside forest diversity. Brazeiro et al. (2024) focused on the invasion ecology of *Ligustrum lucidum* across the landscapes of Uruguay. They found that the establishment is mainly facilitated by human infrastructures improving propagule pressure and dispersion, while domination is enhanced in small or fragmented forest patches with rich-nutrient soils on terrain elevations, suggesting that ecosystem resistance is also operating. Finally, Ortega Rodriguez et al. (2023) studied the effects of increase in the frequency and intensity of droughts on the biogeochemical cycles in the Amazon basin. They analyzed these impacts using novel techniques based on tree-ring nutritional evidences in the long-term. The findings suggested that *Cedrela fissilis* presented alterations in the concentration, use and redistribution of nutrients associated with increasing wood density and decreasing growth over time, due to the increase of drought frequency in the southern Amazon.

Final remarks

Overall, the papers presented in this SI emphasize the interdisciplinary nature of the forest management and conservation, and that multiple variables must be considered to achieve sustainability. The different contributions described the advantages of including different disciplines dimensions to better understand the natural and anthropogenic threats. Besides, the contributions showed the importance of understanding the dynamics of patterns and processes at different landscape scales and climate change scenarios, which were relevant to land use and land cover change in different forest types and countries. Many of the contributions explored new techniques and studied many variables and topics with scarce development for South-American native forests. These findings can contribute to developing more efficient monitoring systems, with the expansion of the universe of variables, facilitating a greater understanding of the influence of stress factors on the resilience of forests. The contributions also emphasized the significant interactions that people have with forest landscapes, which influences not only their appearance and sustainability but also how government policies can be improved in different future scenarios (e.g., climate change). We believe that this SI will encourage more inter-disciplinary research focusing on management and conservation of forests, both native and planted, and inspire researchers

and managers to achieve a more resilient sustainable management to address the impacts of climate change.

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