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Agroforestry for sustainable production and resilient landscapes

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Abstract The contents of this Special Issue of Agroforestry Systems are from selected papers presented at the 16th North American Agroforestry Conference of the Association for Temperate Agroforestry held at Oregon State University in Corvallis, Oregon, from June 24–27, 2019. The conference attracted over 150 participants and the event included oral presentations with seven concurrent sessions, poster presentations, a pre-conference tour, one full day of field tours, plenary keynotes, and Agroforestry Working Groups and Regional Meetings. The seventeen manuscripts included in this Special Issue have been derived from temperate agroforestry research projects, outreach, and development. Papers were selected from temperate regions in North America, including the United States, Canada, and Mexico as well as manuscripts from sub-tropical systems in India. Overall, the conference papers addressed multidisciplinary topics in agroforestry including, accessing resources, accessing markets, managing risks, advances in technology applications, production science, environmental benefits, adoption, implementation, evaluation, education, outreach and community engagement, policy practice, climate change opportunities and challenges, and special forest products.

Keywords Adoption · Alley cropping · Home garden · Resilient landscape · Riparian buffer · Silvopasture · Sustainable production · Woodland grazing

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Introduction

Agroforestry is a sustainable land-use system that addresses the production needs of farmers and landowners while providing environmental benefits to society. AFTA defines agroforestry as an intensive land management system that optimizes the benefits from the biological interactions created when trees and/or shrubs are deliberately combined with crops and/or livestock (AFTA 2021). According to the

USDA National Agroforestry Center, there are five basic types of agroforestry practices today in North America: windbreaks, alley cropping, silvopasture, riparian buffers, and forest farming. Within each agroforestry practice, there is a continuum of options available to landowners depending on their own goals (e.g., whether to maximize the production of crops, animals, forages, or trees) (USDA-NAC 2021). The conference theme for the 16th NAAC was "Agroforestry for Sustainable Production and Resilient Landscapes." Thus, finding the balance between maximizing the productive capacity of farming systems, while at the same time, maintaining the environmental benefits are the challenges for agroforestry practitioners to promote sustainable agriculture and agroecosystems.

Today, landowners and farmers are trying to address various challenges to make their farms and forestlands profitable, productive, and environmentally sustainable. However, there are many problems, such as farmland conversion, urbanization pressures, reduction in water quality and availability, soil erosion, irregular cash flows, climate change, and increased governmental regulations that impact family farms or private forests a difficult task (Workman et al. 2014). These challenging agricultural settings require new and innovative approaches to address various problems faced by farmers, landowners, and their communities. The collection of papers in this Special Issue provides the scientific knowledge, practical approaches, and recommendations for adoption of agroforestry as a practical, profitable, and climate-resilient land-use system.

The 16th North American agroforestry conference (NAAC)

The 16th NAAC was held on the campus of Oregon State University, Corvallis, Oregon from June 24 to 27, 2019, and attended by more than 150 participants. The event included oral presentations with seven concurrent sessions, poster presentations, a pre-conference tour, one full day of field tours, plenary keynotes, and Agroforestry Working Groups and Regional Meetings.

This biennial conference brought together university researchers, educators, extension professionals, public-policy makers, farm operators, private landowners, and graduate students from across North America, Europe, and Africa. The conference theme was "Agroforestry for Sustainable Production and Resilient Landscapes." The conference addressed topics related to agroforestry: accessing resources, accessing markets, managing risks, advances in technology applications, production science, environmental benefits, adoption, implementation, evaluation, education, outreach and community engagement, policy practice, climate change opportunities and challenges, and special forest products. There were 105 oral presentations and 32 poster presentations with rich contents for manuscripts that highlighted the latest scientific findings, tools, technologies, and thoughts across ecological, social, and economic dimensions of agroforestry. Additionally, this conference brought together 10 Agroforestry Working Groups in North America to acquaint members, increase interactions, exchange experiences, and discuss regionally important agroforestry issues. This has helped strengthen networking among agroforestry researchers, extension professionals, and landowners in North America.

The Special Issue brings increased interest in agroforestry practices to diversify farming systems and the renewed attention to traditional agroforestry systems in North America. In addition, this Issue presents an updated account of current adoption trends, technological advances, and challenges in agroforestry. The objectives of this Special Issue are to: (1) disseminate state-of-the-art basic and applied knowledge on agroforestry among practitioners, scientists, extension professionals, students, and policy makers; (2) present conceptual approaches to address potentials and limitations of diverse agroforestry practices; and (3) document current agroforestry developments in a region of the world where agroforestry practices have grown in number and diversity.

Papers contained in this special issue

The selected papers in this Special Issue cover a wide range of agroforestry practices such as home gardens, traditional agroforestry practices, silvopasture and woodland grazing, riparian buffers, alley cropping, agroforestry economics, and agroforestry adoption and extension. A summary of the findings from this collections of papers are in the following paragraphs.

Home gardens and traditional agroforestry practices

Roy et al. (2022) discussed home garden agroforestry practices in the Eastern Himalayan Region of India to overcome the fuelwood shortage. The study inventoried the fuelwood-species diversity and estimated the amount of fuelwood consumption and resulting carbon emission. The home gardens of the study area have a great potential to ensure the year-round supply of fuelwood to the households without additional cost and act as a tool to conserve the forest ecosystem. In addition, home garden satisfies small land holder's domestic energy needs while, avoiding deforestation and thus offsetting carbon emission.

Reang et al. (2022) discussed about Homestead Forests or Traditional Agroforestry Systems (TAFS) to achieve sustainable production and address biodiversity conservation as well as climate change. The result from this study showed the highest tree species richness, basal area, and diversity in home gardens followed by piper and pineapple-based systems. The study revealed a greater number of tree species under the TAFS providing fuelwood, timber, and meeting other economic needs. The study also considered the environmental services provided by most tree species.

Jiang et al. (2021) quantified the relationships between environmental factors and growth of four tree species and developed functional soil maps for each species of trees in an agroforestry practice. Results from their study showed tree size and terrain attributes were driving factors affecting tree growth rate relative to soil properties.

Gómez et al. (2021) presented the diagnosis and analysis of production systems that included traditional agroforestry in rural areas of Mexico. The main objective of this research was to find the method of diagnosis of the Traditional Agroforestry System (TAS) for the necessary intervention for sustainable development. The method highlights the importance and complexity of TAS and the need to address them with a system approach.

Silvopasture and woodland grazing

Bhattrai et al. (2021) assessed the vegetation utilization pattern of small ruminants in woodlands containing understory vegetation at different heights and animal performance in southeast U.S. Meat goats and hair sheep were rotationally stocked in woodlands with southern pine overstory. Browsing height and animals' preference for different plant species were monitored. This study found goats browsing from higher vegetation strata than sheep, and both species showed desirable performance for their age and type in woodlands.

Karki et al. (2021) evaluated the soil quality and growth of southern pine trees in silvopastures and woodlands in southern U.S. The study developed a silvopasture from the existing woodlands by removing non-pine vegetation, thinning pine trees, and planting suitable cool-and warm-season forages. Tree height and diameter at breast height were measured; soil bulk density and moisture were evaluated. Results from this study showed silvopasture offering better environment for faster growth of southern pine trees versus woodlands, when the understory vegetation present in both systems was managed with small ruminants.

Mayerfeld et al. (2021) explored how silvopasture performed in Midwestern United States on key environmental measures compared to common practice of woodland grazing. The study investigated the impacts of grazing management approaches on soil quality and forest health in a mixed hardwood in Wisconsin. Results showed tree growth measured by plot basal area increment was not significantly different by treatment. Increase in soil penetration resistance and decrease in infiltration did not exceed levels of environmental concern.

Wilkens et al. (2021a) explored livestock producers' perspectives and characteristics associated with silvopasture adoption in Virginia, USA. Operational characteristics such as size in hectares, type and number of livestock, and preliminary and secondary occupation were considered. Data classification was based on operational characteristics and operational perspectives. Authors found out that silvopasture interest differed significantly among classification based on the operational perspectives, but not operational characteristics. The study recommends engaging stakeholders should focus on matching perspectives to practice regardless of operational scale and scope.

On another study, Wilkens et al. (2021b) explored producers' interest to establish a silvopasture by planting trees in pasture and assessed tree and pasture performance in Virginia, USA. The study provided guidelines that maintain stand health and productivity when thinning trees to establish silvopasture and

improve tree protection and growth in pastures when plantings are needed.

Dibala et al. (2021) explored the impacts of climate change on future animal agriculture and forage production. They investigated the potential of white mulberry for its fodder potential to stand climate change and gathered information on the native variety that tolerate shade. The results indicated the production of mulberry fodder could be optimized by 66% on Global Site Factor that corresponds to around 500 trees/ha.

Lechuga et al. (2022) investigated the depletion of natural regeneration in temperate forests, and the effect of grazing with sheep on the survival of *Abies hickelii* seedlings in Mexico. They used two sites for regeneration of the vegetation, one with natural regeneration and the other for transplantation of *A. hickelii*. The impacts of grazing on both regeneration sites on vegetation cover was significant in both sampling sites. However, the survival of *A. hickelii* seedlings remained more than 80% in both sites. The study concluded that the negative effects of sheep grazing on *A. hickelii* seedlings were low and promoted silvopasture systems with sheep in temperate forests.

Ballesteros, J. and Torres, J. P. (2022) discussed the loss of tropical dry forests and proposed silvopasture as a strategy to curb deforestation and loss of biodiversity in the Colombian Caribbean Region. The objective was to evaluate the effect of silvopasture and the conventional livestock management systems with fragmentation of dry forests. The study found that bats were abundant in the silvopasture systems with extensive livestock management that generated temporal stability of bat populations.

Riparian buffer

Shahariar et al. (2021) evaluated the impacts of land-use practices on soil-organic carbon (SOC) in Canadian prairie pothole region. They addressed the potential concern of carbon sequestration and soil health in riparian areas. They studied the potential of short-rotation willow plantations in marginal riparian areas in sequestering carbon in comparison to annual crop and pasture. The SOC was higher in pasture sites. The abundance of SOC was higher in subsoil and suggested better SOC stability and potential advantage of C sequestration in the Prairie.

Ofosu et al. (2021) explored the soil-organic carbon (SOC) sequestration with different riparian systems in southern Ontario, Canada. This study investigated SOC sequestration potential in the upper 0–60 cm soil layer in Riparian Buffer System (RBS). The result from this study showed that RBS types and management within the buffers could influence the C sequestration in soils. Tree buffers revealed better potential for soil C sequestration than grass buffers.

Agroforest and alley cropping

Penkauskas et al. (2021) explored the pest management potential of Oregon White Oaks and Hazelnuts (Agroforest and Alley Cropping) in the Willamette Valley, Oregon. They used hogs to eat the oak seed to reduce pest population that affected Hazelnut orchards. The oak woodland was serving as a good habitat for the intermediate host of filbertworm. Breaking the lifecycle of filbertworm by grazing hogs reduced the level of infection of the hazelnut orchards. Prescribed foraging in oak patches can be an effective strategy to reduce filbertworm source population.

Agroforestry economics

Shah et al. (2021) compared sole horticulture (Mango) plantation and agroforestry practices (Mustard crops + Mango) in Jabalpur, India. They concluded that the highest yielding variety was Arpan mustard. The economic evaluation found the cost of cultivation in agroforestry systems was higher than in sole-horticulture system. The benefit/cost ratio was not significantly different but found highest with Arpan mustard in one-year plantation.

Agroforestry adoption

Romanova et al. (2021) acknowledged the wide range of agroforestry benefits such as economic, ecological, and social aspects and so a suitable alternative to contemporary agriculture. They recognized the limited adoption and dissemination of agroforestry in the U.S.A. The study explored factors influencing agroforestry adoption and dissemination as well as the temporal aspects of agroforestry adoption. The study suggested using innovation-to-confirmation instead of innovation-to-decision periods for more accurately reflecting the adoption dynamics.

Conclusion

Articles in this Special Issue cover numerous biophysical, environmental, economic, and social aspects of agroforestry and reflect the multi-disciplinary nature of this system. Moreover, the potential of agroforestry in carbon sequestration, climate change mitigation, and adaptation have also been addressed. This Issue contains valuable scientific knowledge and experiences that help farmers and landowners make informed decisions in adopting agroforestry practices more readily than before. Editors of this Issue greatly appreciate all authors for their patience in waiting for the publication of this Issue, which took longer time than originally expected due to the unforeseen circumstances of COVID19. We also thank the Editor-in-Chief and staff of Agroforestry Systems Journal for working with us diligently in bringing this Special Issue into publication.

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