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Editorial

The Role of Complex Agroecosystems in Climate Change Mitigation

The burning of fossil fuels in developed nations and the conversion of natural grasslands and forests to intensely managed agricultural production systems are the single most important anthropogenic sources of greenhouse gases (GHGs) contributing to global warming. Such activities do not only contribute to the accumulation of GHGs in the atmosphere, but also lead to the depletion of the global soil organic matter (SOM) pool, further impacting soil fertility and crop productivity. Climate change will likely affect the distribution and productivity of life-sustaining agricultural crops and livestock in different regions of the world, including temperate and tropical biomes. As a result, the United Nations Development Program suggested that millions of people may be facing shortages of food and continued degradation of their agricultural resources. Therefore, one of the challenges is to maintain agricultural productivity to meet current and projected trends in food production, while at the same time minimizing GHG emissions, increasing C (C) sequestration and maintaining soil fertility. This, coupled with large-scale land, soil, and water degradation, will challenge the long-term and sustainable production of agricultural resources that promote food security.

Traditional coping mechanisms, such as conventional agroecosystem management practices may not be an economically feasible adaptation strategy, especially for those already experiencing socioeconomic adversity. Therefore, improvement and refinement of ecologically-based land management practices are essential. Soft-path agricultural technologies such as the complex agroecosystems, including agroforestry systems, may make a substantial contribution in the mitigation of GHGs, the sequestration of C, and other ecological services while maintaining a long-term sustainable production of agricultural products. Due to their multipart structure, complex agroecosystems are likely more resilient to climate change and provide a sustainable alternative to conventional land management practices.

This special issue of the *Agriculture Journal*, on the role of complex agroecosystems in climate change mitigation, encapsulates research from temperate and tropical biomes, with a special focus on agroforestry systems. In tropical regions, Chesney *et al*. investigated the performance of cowpea (*Vigna unguiculata* L.) on alley cropping agroforestry systems with *Gliricidia sepium* (Jacq.) Kunth ex Walp. and *Leucaena leucacephala* (Lam.) de Wit and a no-tree control on an infertile acidic soil in Guyana. Their goal was to evaluate the ability of fast-growing nitrogen (N_2)-fixing trees (*G. sepium*, *L. leucocephala*) on cowpea yield. Such practice would maximize the cowpea crop yield but minimize the need for an external source of N fertilizers. They suggested that such practices provide a sustainable source of food, and conserve soil resources but it will also reduce the potential production of the GHGs over the long-term. They noted that these agroforestry practices would curb N_2O emissions, which has a global warming potential 296 times greater than that of CO_2. Smith and Oelbermann used a qualitative approach to evaluate the perception and knowledge of climate change by landowners in a remote Costa Rican agricultural community. They also evaluated the type of sustainable agricultural practices already implemented that could also serve as a strategy to climate change adaptation. Their study showed that community members were aware of climate change and already observed changes in local weather patterns over the past decade that affected the distribution of vegetation and wildlife. As a result, agricultural producers were continually striving to implement agroforestry practices which were viewed as more robust and resilient to climate change by helping to maintain agricultural productivity while also providing economic and socioecological needs.

In temperate regions, Evers *et al*. provided an overview of the potential of tree-based intercropping (agroforestry alley cropping) systems in climate mitigation through the reduction of GHG emissions. They outlined the most recent research results from southern Ontario and Quebec and found that agroforestry systems could lower N_2O emissions by 1.2 kg ha^{-1} y^{-1} compared to a conventional (monoculture) agroecosystem. They also suggested that the potential of agroforestry systems to sequester C in the soil and tree component was greater than in conventional agroecosystems, especially if fast-growing tree species for bioenergy production were used. Such practices may also provide an opportunity to receive payment for the ecological services provided by the agroforest, making these production systems a better option than conventional systems for agricultural producers in temperate regions. Isaac *et al*. investigated the internal accumulation and retention of nutrients in nutrient-spiked pine seedlings commonly used in temperate agroforestry systems and hypothesized that nutrient-spiking would lower seedling transplanting stress and reduce pressure on native soil resources and proposed that nutrient spiking would also lead to an increase in nutrient availability for the growing crop and also minimize competition between trees and crops. They found a favorable response in tree and crop root biomass accumulation in nutrient-spiked treatments and found that N, phosphorus (P) and potassium (K) significantly increased in the pine tissue and resulted in a steady or increased uptake of these nutrients by the crop (maize). Isaac *et al*. suggested that such specialized practices may be required when establishing agroforestry systems for the benefit of nutrient regulation and enhanced capacity to sequester C for the long-term mitigation of climate change.

The Argentine Pampa is one of the most fertile regions in the world and natural grasslands and forests continue to be converted to intense agricultural production systems. Such practices have led to large losses in soil organic carbon (SOC) and

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contributed to the accumulation of GHGs in the atmosphere. The paper by Posse *et al*. outlines the absence of precise quantitative data on the emission and sequestration of GHG, which impedes a better understanding of the mechanisms driving CO_2 emissions from agroecosystems. Although the paper by Posse *et al*. does not investigate CO_2 fluxes from complex agroecosystems, but instead it provides vital information on the emission of this GHG in one of the most rapidly expanding agricultural frontiers in the world, which is also experiencing the effects of global warming on crop productivity. Posse *et al*. aim to characterize the exchange of CO_2, using eddy covariance techniques, in a monoculture soybean system during an extreme dry summer which resulted in a high crop loss. They found that the greatest emission of CO_2 occurred during premature crop senescence (due to drought) but the field became a CO_2 sink once the soil as covered by weeds. As such, changes in crop phenology and botanical composition (weeds) coincided with changes in the flux of CO_2.

The papers presented in this special issue of the *Agriculture Journal* provided an important insight into the potential of decreasing GHGs and maximizing C sequestration. These papers have also provided an important stepping stone by outlining the future direction of research to further understand the importance and role of complex agroecosystems in mitigating climate change. This research field is in its infancy but results are favorable by indicating that complex agroecosystems not only enhance the cycling of nutrients and the productivity of agricultural crops and show greater resilience to climate change, but they can also play an important role in the mitigation of climate change.

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