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Editorial

Multiple Roles for Landscape Ecology in Future Farming Systems: An Editorial Overview

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1. Introduction—Challenges Facing Future Farming Systems

Farming faces new and urgent pressures, with an array of mounting social, environmental and economic challenges, and growing public and political expectations for improved stewardship of natural resources. Responses demanded of farming include changes that reduce greenhouse gas emissions, improve environment quality, restore and increase biodiversity, feed a growing global population, and support national economies, all while providing livelihoods for farmers themselves. Further, there is an immediacy and urgency to respond to an array of challenges as multiple planetary boundaries are exceeded or approached [1] while tackling important sustainable development goals which largely rely on sustainable future food production and livelihoods at local, regional and global scales.

Future farming systems need to respond to a recognition that a changing climate is impacting the capacity of farming and forestry across nations and regions [2]. This has implications for production and supply of food and fibre as the century progresses, with both flooding and drought events increasing in frequency [3], and water quality and quantity becoming increasingly problematic. We are also in an era where biodiversity and ecosystem services provided by the natural environment are declining, as land clearing continues to open up new land for cultivation and land cover change occurs associated with intensification of land use. Threats to biosecurity are proliferated with the movement of people and products, and are exacerbated by the implications of climate change. Market and consumer influences and preferences are changing as people become more aware of animal welfare issues, concerns about biodiversity loss and the need for sustainable production. Compounding this is a growing public awareness and dissatisfaction with the environmental impacts that result from high input and intensified agricultural production, and an increasing preference for products that identify as sustainable that are produced by businesses with environmental credentials. Agriculture also needs to respond to heightened concerns around the relationships between animal protein and human health issues, whilst recognising trends towards increased plant-based protein and flexitarian diets.

These pressures and demands challenge current patterns and practices of land use worldwide, and require development of sustainable agriculture and land-use practices that can address the climate, biodiversity, population, and water, energy, and food security issues [4,5]. Deliberate and directed change in land systems and practice requires clear and careful thought and guidance based on the best available evidence. Although farming continuously responds to market and other signals, it is perhaps less responsive to signals from factors typically considered as externalities, such as costs to natural capital. A growing body of information from a diverse set of disciplines and perspectives is being generated and has the potential to inform choices and decisions for future farming. Knowledge of

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the greenhouse gases associated with different farming types and activities have been established, the impacts of land clearing and intensification on biodiversity are well-known, although the specific details are contested, and the impacts of land management on erosion and water quality and quantity are becoming increasingly recognised. The task of assembling, synthesising and integrating these multiple evidence bases, objectives and priorities to make informed decisions about specific land, land uses and practice change, requires support.

Although this support will come from multiple sources, landscape ecology can play a particularly significant role. The interconnected variety of issues currently faced requires understanding based on "whole system" approaches. A number of authors have discussed the relationships, overlap and complementary perspectives of land systems science, landscape ecology, and political ecology, as well as their links to sustainability science [6–9]. All are interdisciplinary in scope and approach, recognise and address land as a coupled human–environment system, and all have a focus on land system dynamics. Landscape ecology also has a well-developed set of tools and methodologies for analysis across multiple spatial, temporal, and organisational scales. The holistic and interdisciplinary nature of landscape ecology positions it not only to address the specific human and environmental challenges facing agriculture, but also to offer advice on how to plan, design, modify and develop understanding for new land-use patterns and farming systems in specific geographic landscapes that can function with the best environmental, economic and social outcomes in mind [6]. Landscape ecology can provide appropriate tools, approaches and frameworks that can facilitate the action, knowledge and advice required to help work towards the creation of future farming systems that meet societal needs, respond to the environmental challenges and that can sit within sustainable landscapes and societies. However, it is important that these can be practically applied and are seen to be relevant for policy makers and farmers to be able to implement.

2. Contributions of these Special Issue Papers

The papers in this Special Issue explore the potential for these contributions and discuss the evolving roles for landscape ecology in future agricultural systems. Papers individually focus on specific parts of the challenges facing farming for the future. Biodiversity and its management and role in agricultural systems is examined in studies on the potential for improving land management to support pollination across Portugal, using approaches based on land cover data and modelling tools [10] and modelling impacts of habitat changes on Skylarks in Hungary [11]. Changes in land funds at regional scales in Russia [12] and exploration of the benefits of agroforestry systems in southern Brazil [13] address habitats and land covers associated with land uses, while other papers report on the roles and potentials for a new method of scaling from customary harvests at local scales to wider markets [14]. The concept of ecosystem services is used to assess the impacts associated with the transformation of agricultural landscapes in the European Alps [15], and the use of geodesign and the theoretical strengths of landscape ecology are explored to help to design multifunctional landscapes in New Zealand [16]. The ability to monitor and determine dynamics in farming systems is investigated for the Scottish pastoral and arable industries between 1867 and 2020 [17], illustrating both endogenous and exogenous drivers of change which provide important knowledge for managing future farming systems and understanding how they will respond to future stimuli. Although each of these case studies use a specific geographic location, they also establish principles that are of general application and provide useful foundational knowledge to input into the management of future farming systems that offer more sustainable solutions to food production. Pearson [18] builds on the theoretical strengths of landscape ecology in transformative agriculture, using the environments and agricultural activities in Aotearoa, New Zealand as a case study in linking theory and practice within farming, to cocreate future farming systems. The ability for farmers to have some control over the destiny of the systems in which they

operate will be key to maintaining resilient, functioning farm systems that respond to global environmental and population challenges.

Taken together, the papers address a variety of questions about the nature of future farming systems, and the changes necessary to achieve those future systems, as well as the utility and capacity of landscape ecology as an approach to integrate and synthesize scientific information for effective regional and global landscape management. Since it is important that this integration and synthesis aims towards practical outcomes that create sustainable landscapes and futures for environments and people, landscape ecology needs to demonstrate its relevance and develop in basic, strategic and applied directions, and in participatory codesign of land management practices at various relevant scales.

Issues raised and discussed in these papers include: How can landscape ecology concepts be more practically applied to assist farmers and policy makers in facilitating sustainable land management decisions and planning and designing future farm landscapes? How can landscape ecology assist in the establishment of effective transdisciplinary projects that focus on the codevelopment of strategies to identify and address problems? How can knowledge and cultural connections and values that indigenous people associate with landscapes be incorporated into more western production systems for more sustainable outcomes? This includes exploring and better understanding how we determine the potential for diversification of agricultural production systems towards alternative practices, which integrate with customary knowledge and practice towards the growth and harvest of novel bushfoods and capitalize on organic practices which are nondestructive. Other questions raised in the Special Issue include: What are current potentials for geodesign and geospatial technology to propose and evaluate alternative patterns of farming land uses and create multifunctional landscapes? What lessons does a long view of land-use change in agriculture provide for understanding future change management? What are the implications of changes to the intensity associated with rural land use? What role do pollinators play in production and how can we incorporate the ecosystem services pollinators play into farm production? How can we improve agrobiodiversity by incorporating local ecological knowledge? What are the implications of losing productive land to urban and industrial use? How do we maintain important ecosystem services within future farming systems?

Key roles for landscape ecology that emerge from the papers in this Special Issue include the importance of landscape ecology in assisting in the design and creation of multifunctional landscapes that preserve important biodiversity and ecosystem services, and the ways in which this can help with the maintenance and preservation of vital landscape functioning and processes to ensure sustainable production into the future. The papers also demonstrate that landscape ecology can help with the development and application of relevant monitoring and evaluation tools to assist in quantifying the status and condition of farmland and the species that reside within it. Landscape ecology is also seen to have an important role in the creation of bottom-up approaches that consider farmers' and other stakeholders' world views and perspectives, and facilitate stewardship of the landscape by embracing cultural connections to landscapes and utilising indigenous and other forms of traditional knowledge. In doing this, landscape ecology has an important role to play in linking science and practice and in the coproduction of knowledge for sustainable futures. As a metadiscipline, landscape ecology can also have an important part to play in the integration of knowledge and approaches from a variety of disciplines and in solving agriculture-related environmental problems, thus facilitating transdisciplinary approaches for transformative outcomes. Further, by considering both socioeconomic as well as ecological considerations, landscape ecology can help to secure not only sustainable environmental outcomes but also, very importantly, sustainable business ones too.

3. Conclusions

Overall, the papers in this Special Issue highlight the challenges that farming systems and rural communities face whilst throwing down the gauntlet for a future landscape ecological research agenda that can support farming and farmers through important trans-

formative change, which will help to create future sustainable farming systems that can feed a growing population. It is hoped that this Special Issue will: inspire landscape ecologists to explore theory and practical tools that can assist in the planning, design, modification and development of new farming landscapes with the best environmental, economic and social outcomes in mind; contribute towards developing land systems and land management practices for specific landscapes that meet the goals of increased nutritious food production in the face of market and climatic variability whilst reducing environmental impacts and enhancing natural capital; and assist in driving and supporting the transformative changes required to the socioeconomic and environmental systems of rural areas and food production for the future.

By exploring these issues through developing research agendas, landscape ecologists can demonstrate their importance in providing the scientific guidance to ensure farm systems of the future meet environmental and production targets. By considering the farm within the broader landscape mosaic in which it sits, and by treating the farm as an important, coupled human–environment system, recognising important drivers of change and acknowledging the farmer/landowner as an important participant in future design making, it is possible to help farmers and policy makers to be able to address economic requirements whilst preserving important ecosystem services that ensure sustainable landscapes and livelihoods into the future.

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