

Mathematical and Statistical Challenges in Landscape Decision Making

BACKGROUND

Land is a critical resource to society. We depend on land resources for urban settlement, employment, and transportation, as well as the many assets we gain from the natural environment including food, timber, energy, recreation and aesthetic benefits. We also require these land resources to be resilient to environmental change and changing demands. In the UK, leaving the EU will necessitate the introduction of many new policies connected to land use, implying an urgent need to develop better tools and methodologies for decision making.

In September 2018, the Newton Gateway, in partnership with the Natural Environment Research Council (NERC) and the Department for Environment, Food and Rural Affairs (Defra), ran a two-day scoping workshop on evidence-based decision making for UK landscapes. This resulted in a one-month Research Programme, funded by NERC, at the Isaac Newton Institute (INI) during July 2019, focusing on the mathematical and statistical challenges involved in landscape decision making. A key aim of the programme was to develop a new community from the diverse research base to help stakeholders involved in the planning, management, and policy of land use in the UK make better evidence-based decisions.

CHALLENGES



Landscapes are complex systems, involving interactions between ecological and environmental processes and human decision making. Mathematical sciences are integral to the development of tools and methodologies which are needed to capture the complexity and uncertainty inherent in landscape decision making. A critical challenge was to identify where mathematics could significantly advance the modelling of landscape systems, and

ultimately enable decision makers to make better evidence-based decisions that take a holistic view.

Specific questions addressed in the Programme included:

- What is the simplest useful model of the landscape?
- How do we robustly model human behaviour without assuming that people act as perfectly rational economic agents?
- Where are the nonlinearities and sensitivities to policy inputs, and how could these be used to produce transformative changes in land-use?
- How do we couple processes operating on different spatial and temporal scales with the scale at which landscapes are managed in the same model?

“Given that the Strategic Priorities Fund (SPF) aims to foster interdisciplinary working, the workshop brought together researchers with different disciplinary backgrounds and skills, many of whom had not previously collaborated, to devise innovative solutions to current and future landscape decision-making challenges.”

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RURAL LAND USE SYSTEMS

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ACTIVITIES

The one-month interdisciplinary Research Programme began with a three-day workshop, the first day of which was an “Open for Business” knowledge exchange event. This day comprised talks from key governmental bodies including Defra, the Forestry Commission and the Environment Agency, which described how landscape decisions in the UK are currently made and outlined the most important challenges. Frequent contact with Defra during the month helped to ensure the relevance of the research to principal stakeholders.

Another three-day workshop, synthesising the new research frontiers and synergies identified, concluded the month of interdisciplinary research. A second stakeholder-focused Open for Business event, attracting representatives from Defra, the Joint Nature Conservation Committee, Woodland Trust, The National Trust, the Department for Business, Energy and Industrial Strategy (BEIS), Natural Resources Wales, NERC, the National Physical Laboratory and the Royal Town Planning Institute, formed the final day. A series of talks facilitated discussion, and posters disseminated the novel approaches and tools developed, and their relevance for policy and practice.

IMPACTS

The Programme brought together over 65 mathematicians, statisticians, economists, and environmental scientists, with principal stakeholders to explore current research in, and different approaches for modelling uncertainty across landscapes. Major benefits included a better understanding of the common challenges faced by the different communities, and the initiation of new collaborations. Many of those who attended the closing Open for Business event reported that they had made new relevant contacts and/or potential collaborators. These stemmed from new multidisciplinary, cross-sectoral, collaborations formed during the month.

The main outcomes of the Programme included:

- Over ten proposals were submitted to the UKRI Strategic Priority Fund (SPF) “Landscape Decisions: Toward a new framework for using land assets” mathematical and statistical challenges call, on wide-ranging topics including modelling forest demography and building landscape resilience to plant disease outbreaks.
- The identification of long-term mathematical and statistical challenges, which will help inform the next phase of the Landscape Decisions SPF research agenda. Areas include:
 - uncertainty quantification for spatial agent-based modelling,
 - applying graph theory to habitats,
 - linking remote sensing technology with Artificial Intelligence and Machine Learning techniques to provide near real-time models for supporting decision making, and
 - decision making against very complex backgrounds- a theme common to multiple application areas, for example resource allocation in environmental policy and high-level energy and climate policy.

To complement the programme, the Newton Gateway carried out a Stakeholder Survey, to better understand the models and tools currently in use, as well as the barriers to using modelling approaches in developing a decision-making framework.

A follow-up workshop is likely to be planned, with the possibility of a second INI programme in the coming years. Two areas which were raised as potential areas to explore at future meetings were the economic challenges and the human/social science of landscape decision making and modelling. The Newton Gateway is also enabling collaboration with the Landscapes Decisions SPF multidisciplinary programme coordination team at the University of Leicester.