Large-scale and Systems Modelling

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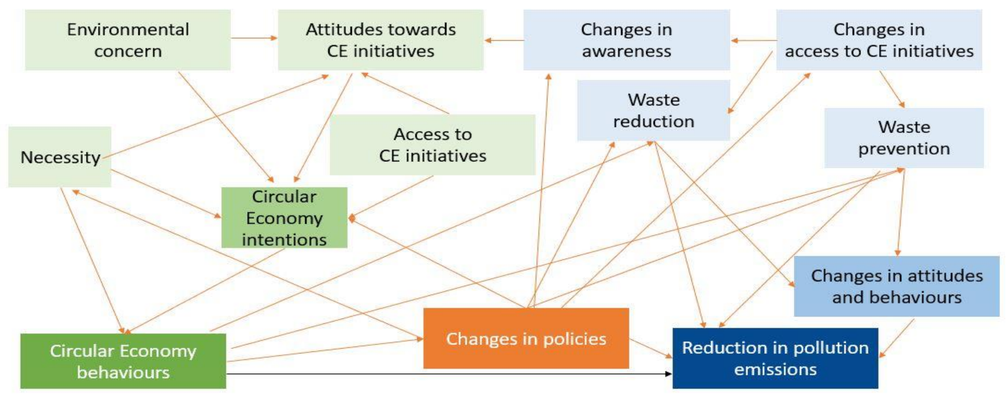
The BioSS SRP project "Large-scale and Systems Modelling" project is developing a powerful set of tools to better support decision-making related to key 21st century systems challenges. These include climate change, the biodiversity crisis, and building a restorative economy. Key applications highlighted in this poster include: modelling of circular economy dynamics to aid the green recovery in Scotland; design of statistical tools to aid model design, parameter fitting, and computational efficiency for complex ecological models; the development of digital twins of real-world livestock trading systems, and the role of farmer trading behaviour on the success of endemic disease control scenarios; and assessing the adaptive potential of Scottish forests under climate change.

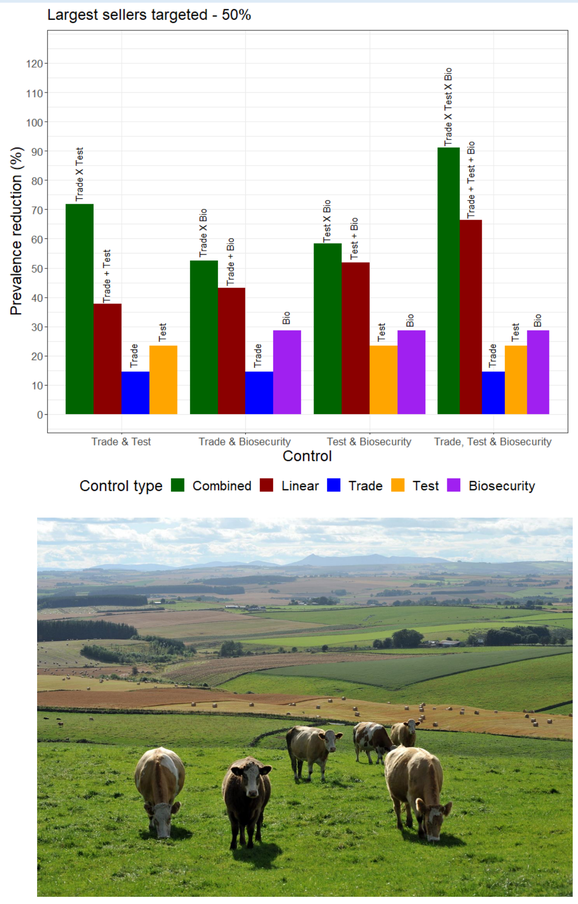
Causal inference for circular economy data[1]



- Moving towards a circular economy requires changing the complex patterns of use, waste, and emissions.
- These involve links between economic, environmental, socio-cultural, and institutional processes. At the individual level, patterns of behaviour are equally complex and interconnected.
- Thus, understanding causal relationships is vital to revealing the changes in behaviour that lead to sustainable outcomes.
- We propose a causality framework in the context of sustainable behaviours that reflects a more comprehensive picture of this complex system. This will help accelerate the green recovery in Scotland.

Impact on policy & practice: With JHI colleagues, Scottish data will be analysed to inform policy makers on attitudes and perceptions in an effort to promote circular economy behaviours and practices.

Developing digital twins of the Scottish cattle trade industry[3]



- The Scottish cattle trading industry is a complex, dynamic system in which individual farm trading behaviours give rise to large, time-varying networks.
- Trade also facilitates the spread of disease, leading to endemic persistence.
- As such, understanding the behavioural drivers which lead to observed trading patterns is vital in controlling disease.
- Leveraging large-scale trading data for Scotland, we have developed an Agent-Based digital twin of the Scottish cattle trade industry.
- This model has been used to identify key farms responsible for disease spread, the effectiveness of trade-based controls, farm-level behavioural adaptation in response to controls, and how these adaptations can amplify the effectiveness of traditional control measures.

Impact on policy & practice: With SRUC colleagues, data provided by Premium Cattle Health Scheme is being used to apply a digital twin of Scottish cattle trading to Johne's disease.

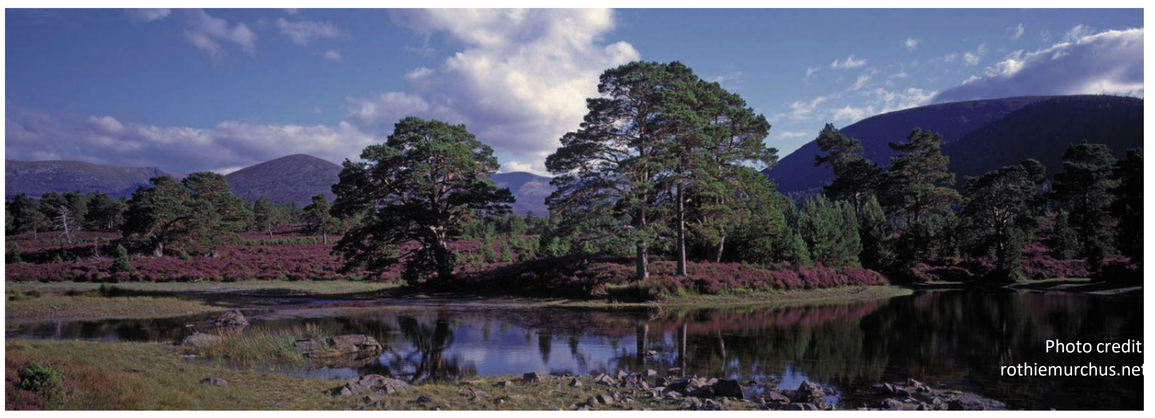
Statistical analysis of complex simulation models[2]

- To study complex dynamic processes, such as the change of phosphorus levels in streams over time, sophisticated simulation models, Simulators, have been developed.
- These can be uses to predict the effects of management actions and climate change.
- However, complexity comes at a cost: identification of which components have the most effect can be difficult, parameter fitting can be challenging, and computation time can be high.

- This work strand is applying components of DACE (Design and Analysis of Computer Experiments) to Simulators used by scientists at JHI and SRUC to combat these issues.
- By developing novel approaches for Sensitivity Analysis, History Matching, and Emulation.

Impact on policy & practice: Uncertainty tools were applied in Emerging Water Futures project to improve modelling for flood and drought forecasting for SEPA and Scottish Water.

Assessing adaptive potential of Scottish forests[4]



- Natural & human systems, including forestry, face unprecedented environmental change. Management requires better understanding of adaptive potential of species & ecosystems.
- Genomic tools are being applied to quantify adaptive potential of Scottish Scots Pine (*Pinus sylvestris*) populations – a culturally significant keystone species. This information is being combined with theory from quantitative population genetics to develop models to assess adaptation of Scots Pine under scenarios of climate change.
- This enables addressment of the key **forestry management challenge**: **local adaptation versus assisted migration under climate change.**

Impact on policy & practice: this project is informing work under *NERC's Future of UK treescapes* programme.

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Large-scale and Systems Modelling@BioSS is also: developing state-of-the-art tools to infer models from data; modelling species level vegetation dynamics e.g. applied to management of peatlands; understanding how behaviour impacts large-scale uptake of integrated pest management; building dynamic models to understand persistence of AMR; and developing statistical methods for soil mapping e.g. applied to quantify peatland area under converted grassland and associated emissions – **Please contact helen.kettle@bioss.ac.uk for more details**