MODELLING THE LAND-USE RESPONSE TO CLIMATE-DRIVEN CHANGES IN PASTURE PRODUCTION

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Levente Timar
Motu Economic and Public Policy Research
levente.timar@motu.org.nz

Yields go up, and down
at times. But farmers respond
and now we know how.

INTRODUCTION

This paper estimates the relationship between pasture productivity and rural land use, and it incorporates the results of this estimation in the Land Use in Rural New Zealand (LURNZ) model. These changes enable LURNZ to show how land use might change in response to climate change at a local level.

Unlike economic drivers of land-use change which are typically determined at a national or international scale, climate drivers can display substantial spatial variation. Previously, we were unable to account for such spatial variation. The new model allows climate change to be modelled at a local level through its effects on pasture yields.

TECHNICAL ELEMENTS OF THE MODEL

This paper estimates an econometric model of land use that includes explanatory variables for net primary productivity under pastoral land uses. The model is similar to that specified in (Timar 2011) with three important differences:

- inclusion of yield variables,
- addition of horticulture to the choice set
- use of an updated land-use map in estimation.

Land-use choice is modelled as a function of variables characterising accessibility to markets, land tenure, land quality, and pasture yields. Yields under dairy use and yields under sheep-beef use are included as separate variables. The choice set is expanded from dairy, sheep-beef, forestry and scrub to also include horticulture (including arable, fruit, vegetable and grape farming activities). Other land uses are not modelled. The estimation is performed on a map of 2012 land use that combines land-cover data from the 2012 Land Cover Database 4 with land-use data from the most current Land Use in New Zealand map.

The model uses maps of net primary productivity for New Zealand pastures produced in the Biome-BGC model. When combined with projections of pasture yields under future climate, it can be used to predict the magnitude of the land-use response to climate change.

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THE LURNZ YIELD CHANGE MODULE

The Yield Change Module is developed based on the results of this land-use model; it is an auxiliary module in LURNZ that can be run on its own or in various combinations with the other modules. The main use of the module is in long-term modelling involving climate change scenarios. It can be used to perform simulations of overall land-use change in response to changing pastoral yields, and also to distribute that change spatially.

In this paper, the new LURNZ module is tested on an illustrative climate change scenario characterised by high greenhouse gas emissions (RCP 8.5). In general, pasture yields are projected to increase in this scenario, and the proportional increase in dairy yields tends to be larger than the proportional increase in sheep-beef yields. The paper considers mid-century and end-of-century land-use responses.

SIMULATION RESULTS

Dairy area grows by about 600,000 hectares and sheep-beef area shrinks by about 800,000 hectares by the end of the century. Although these changes are significant in proportion to existing land areas, similar amounts of land-use change took place within a decade in New Zealand's recent history.

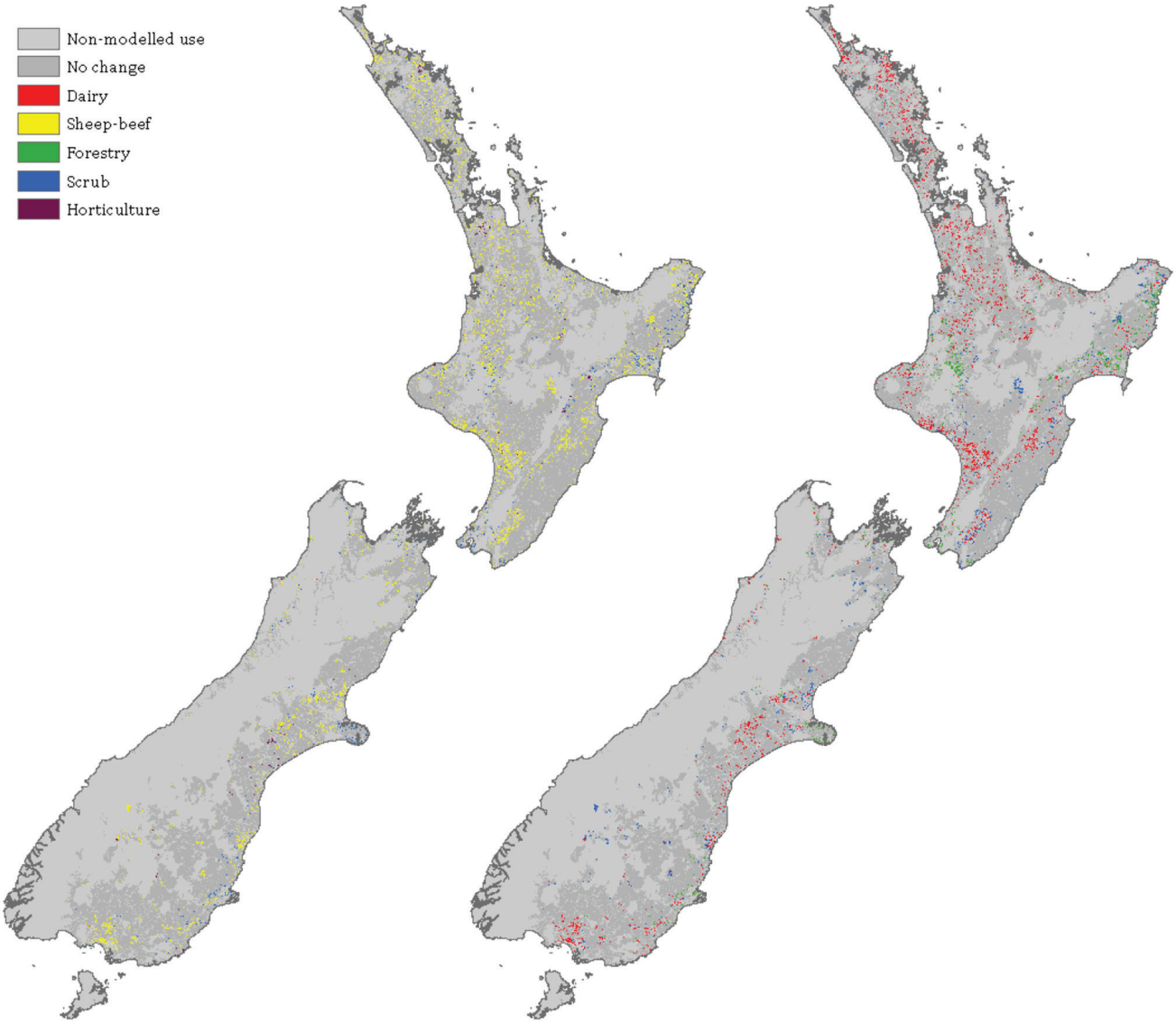
Forestry and scrub areas also expand, but the changes to these land uses are smaller in magnitude. These land-use transitions occur in areas where one would expect to observe them. See Figure 1 for simulated land-use transitions by 2100.

LIMITATIONS OF THE MODEL

Neither the yield model nor the land-use choice model are able to account for the potential of irrigation. Therefore, the importance of yields in land-use decisions (and hence the land-use response to yield changes) may be underestimated. In addition, the results are based on changes in mean climate only. Climate variability, which is expected to increase under RCP 8.5, could potentially also have a large impact on yields and consequently on rural land use and economic outcomes.

In the long term, a host of factors including changes in production technology and adaptation to climate change can alter the nature of the current relationship between yields and land use, and the model also cannot account for such changes.

Figure 1: Simulated land-use transitions by 2100: initial (left) and final (right) land use



POLICY IMPLICATIONS

Over the next century, economic drivers are expected to have a larger effect on land use than climate change itself. Nonetheless, the simulations suggest that land use may continue to intensify as a result of a changing climate (under RCP 8.5). This would put further pressure on New Zealand's water resources and could contribute to further increases in the country's atmospheric greenhouse gas emissions.

CONCLUSION

This paper uses a discrete choice model to estimate the relationship between pasture yields and rural land use. Land-use predictions from the model respond to climate change through its effects on pasture yields. This econometric model provides the foundation for the development of a new module of the LURNZ model, the Yield Change Module. In addition to enabling simulations of overall land-use change under different climate scenarios, the module also draws on the estimation results to allocate land-use change spatially.

The Yield Change Module is used to perform illustrative mid-century and end-of-century simulations of land use in a climate scenario characterised by a high level of greenhouse gas emissions (RCP 8.5). At a national level, in both absolute and relative terms, the two pastoral land uses experience the largest response to climate-driven changes in pasture production. These changes are not out of the ordinary when compared to the rate of historical land-use change in New Zealand.

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