cel will continue to feed back on ecological processes at both local and larger scales. In addition, farmers' response will determine the regional balance between forest loss and forest regrowth. Because of links between land in reserves and land outside of reserves, effective biodiversity conservation is in the balance (Vester et al. 2007). So too is the economic growth through tourism on which the Yucatan, Mexico, and the broader region depend.

References

Das, R., Lawrence, D., D'Odorico, P. and DeLonge, M. (Submitted). Land use change lowers atmospheric P inputs to a tropical dry forest: implications for ecosystem state shifts. *Journal of Geophysical Research-Biogeosciences*.

DeLonge, M., D'Odorico, P. and Lawrence, D. (2008). Feedbacks between phosphorus deposition and canopy cover: the emergence of multiple stable states in dry tropical forests. *Global Change Biology* 14: 154-160.

Eaton, J. and Lawrence, D. (Submitted). Effects of land-use history on the carbon budget of secondary forests in the Yucatan. *Forest Ecology and Management*.

Lawrence, D., D'Odorico, P., DeLonge, M., Diekmann, L., Das, R. and Eaton, J. (2007). Logical feedbacks following deforestation create the potential for a catastrophic ecosystem shift in tropical dry forest. *Proceedings of the National Academy of Sciences* 104 (52): 20696-20701.

Vester, H., Lawrence, D., Eastman, J.R., Turner, B.L., Calme, S., Dickson, R., Pozo, C. and Sangermano, F. (2007). Land change in the southern Yucatan and Calakmul Biosphere Reserve: implications for habitat and biodiversity. *Ecological Applications* 17 (4): 989–1003.

Vitousek, P.M. and Farrington, H. (1997). Nutrient limitation and soil development: experimental test of a biogeochemical theory. *Biogeochemistry* 37: 63–75.

Impacts of rangeland development on plant functional diversity, ecosystem processes and services, and resilience

Etienne Laliberté[1], David A. Norton[1] and David Scott[2]

[1]Rural Ecology Research Group, School of Forestry, University of Canterbury, New Zealand

[2]PO Box 115, Lake Tekapo 7945, New Zealand

Corresponding author: etiennelaliberte@gmail.com

The Mount John "grazing × fertilisation" trial, located in the New Zealand short-tussock grassland zone, is one of the longest-running ecological experiments in New Zealand (>25 years). Established in 1982, its initial aim was to evaluate the niches of different pasture species under contrasting fertiliser inputs and sheep grazing regimes. However, this experiment now provides an opportunity to study the long-term impacts of rangeland development on plant functional diversity, and how this in turn affects ecosystem biogeochemical processes, ecosystem services, and ecosystem resilience.

Pastures and rangelands are the most extensive land uses on earth and are expected to undergo rapid intensification to meet the forecasted doubling in global food demand by 2050. Because agricultural intensification is one of the main drivers of global environmental change, there is a need to explore how long-term changes to biodiversity brought on by land use change affect the functioning of ecosystems, the services they provide to humanity, and their resilience to future disturbances. Although earlier biodiversity-ecosystem function experiments using synthetic random assemblages of species have highlighted the significance of biodiversity for ecosystem functioning, there has been a call for long-term experiments that explore the consequences of changing biodiversity in a more realistic context. The main goal of our project is to assess the consequences of changing biodiversity in the context of agricultural intensification of rangelands.

Our research is conducted on the Mount John trial site (Fig. 1), west of Lake Tekapo in the Mackenzie Basin of New Zealand's South Island (820 m a.s.l.). The climate of the region is semi-continental. Following early Māori occupation 800-900 years ago, extensive rangeland sheep grazing was introduced to the area in the 1820s by European settlers and remains the most important land-use today. During this latter era, the dominant vegetation was short-tussock grassland (*Festuca novae-zelandiae*).

Fig. 1: A) Aerial view of the study area. The picture was taken from the summit of Mount John and shows the Mount John trial site in the foreground, with Lake Alexandrina and the Southern Alps in the background. B) Close-up view of the "grazing × fertilisation" experiment used in this research project. Each plot is 8 × 50 m. (Photo: Etienne Laliberté).

In 1982, a mixture of 25 grass and legume pasture species was over-sown within a 3-ha area of depleted short-tussock grassland dominated by the exotic herb *Hieracium pilosella*, a vegetation type that is representative of vast areas of the New Zealand South Island interior. Two spatial replications of three crossed treatments were then established in the sown area: fertilisation (0, 50, 100, 250, and 500 kg ha^{-1} yr^{-1} superphosphate), grazing intensity (low, moderate, and high), and stocking type (mob vs. sustained). The plots receiving the highest fertiliser level are also irrigated. Only plots corresponding to the mob stocking type are considered in this project. Grazing is still ongoing and is done annually in the period November-May (Fig. 2). Two ungrazed and undeveloped control plots located directly adjacent to the experimental area were also added. Previous results from the trial are reported by Scott (2007).

Our research project has four main goals. First, we are exploring the long-term (1983-today) patterns of plant functional diversity across the different treatments using the annual ranking of the ten most-abundant species together with a range of plant functional traits measured on 54 vascular plant species within the study plots in 2008.

Second, we are analyzing how agricultural intensification impacts plant functional diversity, and how this in turn affects some key ecosystem biogeochemical processes (above- and below-ground net primary production, litter decomposition, and soil respiration). This will allow us to quantify the relative strength of external factors (fertilisation, grazing, irrigation) vs. biotic factors (plant functional diversity) on ecosystem functioning. Furthermore, this will enable us to assess which component of plant functional diversity (value, range, or relative abundance) best predicts land use-induced changes in ecosystem functioning.

Third, we are measuring changes in the provision of important ecosystem services with agricultural intensification. The following three key ecosystem services are being considered: 1) native plant biodiversity conservation; 2) economic production values; and 3) soil carbon sequestration. This analysis will allow us to quantify particular trade-offs among ecosystem services associated with different land-use scenarios in New Zealand high country rangelands.

Fig. 2: Merino sheep grazing on some of the experimental plots. The grazing treatments were initiated in 1983 and have been maintained annually since then (Photo: Etienne Laliberté).

Finally, we are exploring how the diversity of plant functional response traits (mostly regenerative traits) varies within particular functional effect groups (groups of species that have a similar effect on ecosystem processes) across the treatments. This analysis will allow us to determine whether agricultural intensification makes the resulting ecosystems, and the services they provide, more vulnerable to future disturbances.

This research project is still at an early stage, and so results are yet unavailable. Upcoming publications for 2009-2010 include: 1) new methodology for calculating functional diversity indices; 2) analyses of the temporal patterns of plant functional diversity across the different treatments; 3) analyses of the links between agricultural intensification, plant functional diversity, and ecosystem processes; 4) assessment of the trade-offs among ecosystem services with agricultural intensification; and 5) analyses of plant response diversity with agricultural intensification.

References

Scott, D. (2007). Sustainability of high-country pastures under contrasting development inputs. 9. Vegetation dynamics. *New Zealand Journal of Agricultural Research* 50: 396-406.

Acknowledgements

This project is being made possible by scholarships to Etienne Laliberté from the University of Canterbury and the Fonds Québécois de Recherche sur la Nature et les Technologies (FQRNT), as well as by financial support from the Miss E. L. Hellaby Indigenous Grasslands Research Trust and the School of Forestry (University of Canterbury). Thanks to P. Fortier, R. Iles, J. Morgenroth, A. Williams for help in field work, and to L. Kirk, A. Leckie, and N. Pink and J. Tylianakis for logistical and academic support.