Pasture performance under dryland and irrigated conditions in New Zealand: comparison of modelled and actual data

Pasture systems are highly complex, involving interactions between pasture growth, animal intake, soil water dynamics, plant nutrient dynamics and management systems. In addition, most grazed pastures include several plant species, with the composition of species varying with time.

These processes vary over time and across a paddock and the landscape of a farm. Experimental observation alone provides limited but essential information, and so there is benefit in using models to provide greater insight and understanding. This is especially so for long-term analyses that may include possible future scenarios, such as the impact of variability in weather or climate change, as well as the potential effects of alternative management strategies

EcoMod is a biophysical model that simulates a pastoral ecosystem on a daily basis. It comprises a range of sub-models for pasture growth and utilization by grazing livestock, including sheep, beef cattle, dairy cows and deer. It also includes sub-models of the dynamics of soil, water and plant nutrients, including organic and inorganic nutrient dynamics. There are a range of management options for irrigation and application of fertilizer, and also for grazing management in single and farm systems.

The structure of EcoMod allows the study of long-term system dynamics including, for example, pasture production and utilization in response to management, nitrate leaching, greenhouse-gas emissions (carbon dioxide, nitrous oxide and methane), and changes in soil organic matter content

The purpose of the study was to compare output from EcoMod with New Zealand's longest data set of information on pasture growth rate and composition, for both dryland and irrigated conditions. Issues associated with making valid comparisons between model output and experimental data were also examined.

Figure1: Winchmore Research Station, Mid Canterbury

The comparison

A long-term pasture growth experiment, based at AgResearch's Winchmore Irrigation Research Station Canterbury, New Zealand was used for comparison against output of pasture growth and composition from EcoMod. The experiment was established in 1958 to investigate the effect of irrigation on pasture production and composition.

Although the pasture was originally sown with perennial ryegrass, white clover and subterranean clover, these species became less dominant with time, particularly under dryland conditions.

Ideally, the considerations of plant growth would be estimated directly from experimental data but, as the data were not available, it was appropriate to adjust these to gain agreement with the data on growth rates of dry matter (DM). These were then used to determine growth characteristics of the species that were present in the pasture.

Each simulation comprised one grass and one legume. Perennial ryegrass (both dryland and irrigated) and subterranean clover for dryland, and white clover for irrigated simulations were the species used. To gauge the extent of improvement that the modifications to the parameters settings made, simulations were also performed using the default settings for those species.

Dryland Pastures

The pattern of growth rate of DM of dryland pasture described in the experiment is typical of many of the drier zones of New Zealand; low growth rates in winter because of cold temperatures; rapid increase in spring as temperatures rise and a large reduction in summer and autumn due to soil water deficits.

In winter, growth rates of DM are considerably less variable than in spring, summer and autumn. The general pattern of seasonal growth rates of DM from the model was very similar to that of the experimental data. In absolute terms, there was a good agreement between measured and modelled overall annual and monthly median growth rates of DM of dryland pasture based on the adjusted growth parameters.

Irrigated Pastures

Irrigation greatly increased measured growth rates of DM from November to May and reduced the variability in growth rates compared to the dryland pastures. Adding irrigation to the model resulted in a similar pattern of growth rates to that measured.

While growth rates in summer and autumn were significantly higher than that in dryland conditions, growth rates in winter and early spring were similar. For irrigated pastures the growth rates of DM of the model were similar to those measured.

Figure 2: Centre pivot irrigation, Canterbury

Discussion

Overall, the general patterns and behaviour of pasture growth generated by EcoMod agreed well with the experimental observations. There was generally good agreement between modelled and observed total annual and monthly growth rates of DM under both dryland and irrigated conditions.

The greatest difference between measured and modelled growth rates was in summer, particularly with dryland pastures. This possibly indicates that the model was more sensitive to rainfall events during this typically dry time of year, than the actual pasture.

The differences in the composition of pastures between model output and measured data were greater than the differences for DM pasture production.

Figure 3: High performing ryegrass white clover pasture.

Long-term data sets, with well described measurement and management protocols, are invaluable because they incorporate climatic variation and system transitions, and demonstrate with greater certainty a system's generalized behaviour and variance.

The simulated growth rates of pasture from EcoMod, and the measured data for both dryland and irrigated systems, were generally in good agreement. Although the experimental data set is New Zealand's longest and most robust pasture growth data set, there are challenges when assessing model performance by comparison against experimental data.

Having gained confidence in the model for this system, other scenarios and conditions, such as alternative grazing management, nutrient leaching, risk assessment in relation to climate variability and the impact of possible climate change, can be explored.

Further information

The full report is *Comparison of outputs of a biophysical simulation model for pasture growth and composition with measured data under dryland and irrigated conditions in New Zealand.* T. A. White, I. R. Johnson and V. O. Snow. In *Grass and Forage Science*, 63, 339–349, 2008. Blackwell Publishing Ltd. Link to abstract is available here: www.climatecloud.co.nz/CloudLibrary/modelled%20and%20measured%20pasture%20dryland%20and%20irrigated%20NZ.pdf

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Other information is available at http://www.climatecloud.co.nz