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# Modelling dairy production in different regions of New Zealand

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## ABSTRACT

A whole-farm model is being developed at Dexcel for researchers to simulate whole-farm system trials. Climate and management information is entered and the model utilises published sub-models for pasture growth and cow metabolism. The model predicts pasture and animal production. A test of the model's validity in different New Zealand regions using climate, land and management information particular to each region was undertaken. Regions selected were; Northland, Taranaki, Canterbury and Southland. The model predicted 92-129% of per cow milk production and, while it followed observed pasture growth patterns, there was a tendency to over-predict annual growth (5-57%) especially during spring-early summer and more notably in the Northland region. Annual pasture growth in Southland was consistently under-predicted by approximately 20%. This variation is likely due in part to differences in pasture species, soil types and the method of collecting pasture data, influencing how well the model predicted growth. Using specific climate data and management information, the model successfully predicted dairy production in most regions of New Zealand.

**Keywords:** model; simulation; milksolids; pasture growth; dairy cows.

## INTRODUCTION

Many computer models have been developed to simulate farm systems. Commercial models such as Stockpol (Marshall *et al.*, 1991) and UDDER (Larcombe, 1994) are used as decision support tools for use on pastoral farms. Research often requires more detail than these management type models are able to provide. Component models such as MOLLY (Baldwin, 1995), which simulates the metabolism of a cow and pasture growth models (McCall, 1984; Woodward, 1999) provide detailed information, but are only part of a whole farm system. Because of the complexity, only a few attempts have been made to combine animal, pasture, climate and management models into a whole-farm-system scenario (Bright *et al.*, 2000).

Dexcel is developing a computer model, the Whole Farm Model (WFM), for agricultural researchers to simulate farm system trials. The WFM simulates pasture-based rotationally grazed dairy systems. The WFM is currently being validated against three years of production data, which includes a variety of stocking rates, from the Whole Farm Efficiency trial at No2 Dairy Dexcel Limited, Hamilton.

The purpose of this paper is to test the robustness of the WFM when using climate and management information from different regions in New Zealand, by comparing the model's predicted values with observed data. Two aspects of the WFM output were evaluated, pasture growth and milksolids (MS) production.

## METHOD

Four regions in New Zealand were selected: Northland, Taranaki, Canterbury and Southland. Simulations were run for three seasons, 1998-99, 1999-00, and 2000-01. Climate data were obtained from NIWA sites and included daily rainfall, minimum and maximum temperature, radiation, wind, sunlight, evaporation, as well as irrigation for the Canterbury data. Observed pasture growth data for each region and each year was calculated monthly, and are represented for each year. Regional stocking rates, calving and dry-off dates and MS production were obtained from LIC Dairy Statistics (1998, 1999, 2000). Information on pasture growth, supplementary feeding and rates of irrigation, were obtained by Dexcel Extension.

### Details for Each Region

#### Northland

The data used for this region came from the Kaikohe area in the far north. The climate data was collected from a meteorological station located at Kaikohe. Pasture growth was calculated monthly using cage cuts and was obtained from a farm site at Puketona, approximately 26km south west of Kaikohe. Stocking rate was 2.1 cows/ha for all three seasons and mean calving dates at 4, 8 and 6 August for 1998-99, 1999-00, 2000-01 respectively. Dry-off dates ranged from 7 through 31 May over the three seasons.

#### Taranaki

Data for Taranaki was collected from the Dexcel site WTARS at Normanby near Hawera. Climate data were obtained from a NIWA site in the Normanby area. Pasture growth data was calculated monthly by use of a calibrated rising plate meter. Stocking rate details for the Taranaki region were 2.9 cows/ha, and mean calving dates ranged from 16 to 20 August for all three seasons while dry-off dates were 2 to 28 June.

#### Canterbury

Data for this region were obtained from a research farm at Lincoln University. Climate details were collected from a station in the Lincoln area. Five mm/day irrigation (200 days from September to April) was added to the climate file. Pasture growth was calculated every 10 days from visual estimates that were calibrated by cutting plots, which were subsequently weighed and dried. Average stocking rate for this region was 2.8 cows/ha, mean calving dates were 29 and 31 August (twice), while dry-off dates ranged from 1 June to 11 June over the three-year period.

### Southland

Southland data were gathered from an AgResearch site at Woodlands. Climate data were collected at a site near the Invercargill airport. Pasture growth data were obtained by cage cuts on a fortnightly basis. Average stocking rate in this region was 2.7 cows/ha, mean calving dates were similar for each season being 29 and 31 August (twice). Dry-off dates were from 1 to 9 June.

### Whole-Farm Model Simulations

For each region and each year, the WFM was set up with animal, land, management, and climate information. Animal information included calving date, dry-off date, and initial cow live weights.

Simulation herds consisted of animals over a normal age range. Land information included paddocks, area, and initial pasture cover. A management policy based on a set of decision rules (Macdonald & Penno, 1998) and climate data obtained for each specific region and year were entered. The decision rules management policy in the model incorporates algorithmic representation of farm management rules for grazing policy (e.g., next paddock to be grazed and area) and conservation policy (e.g., timing and selection of paddocks to be closed for conservation), (Bright *et al.*, 2000). The component models used were that of McCall (1984) for pasture growth, and an in-house energy-based cow model for animal production (unpublished).

## RESULTS

### Pasture Growth

The 1998-99 WFM calculations for pasture growth together with the 5–10 year average are shown in Figure 1. Pasture growth for Northland was over-predicted from September through to November, and for the rest of the season the WFM followed the observed data and predicted higher than average growth rates. Taranaki WFM calculations over-predicted in November, but closely predicted the remainder of the season. The WFM calculations for Canterbury over-predicted from October through to December and under-predicted from February to March. Southland WFM calculations followed the 1998-99 season closely, but under-predicted growth from January to February. The WFM correctly predicted the increase in growth in March.

As expected from the discrepancy in seasonal growth, annual pasture production for Northland and Taranaki were over-predicted from 9-57% (Table 1), whereas Canterbury was close to the observed data (1-24%), and Southland was under-predicted by approximately 20%.

**FIGURE 1:** Pasture growth (kg DM/day) for 1998-99 season using the McCall (1984) model, for Northland, Taranaki, Canterbury and Southland. Key: ▲ Observed data, — Whole Farm Model calculated values, —□— average of observed data over 10 years, (5 years for Southland).

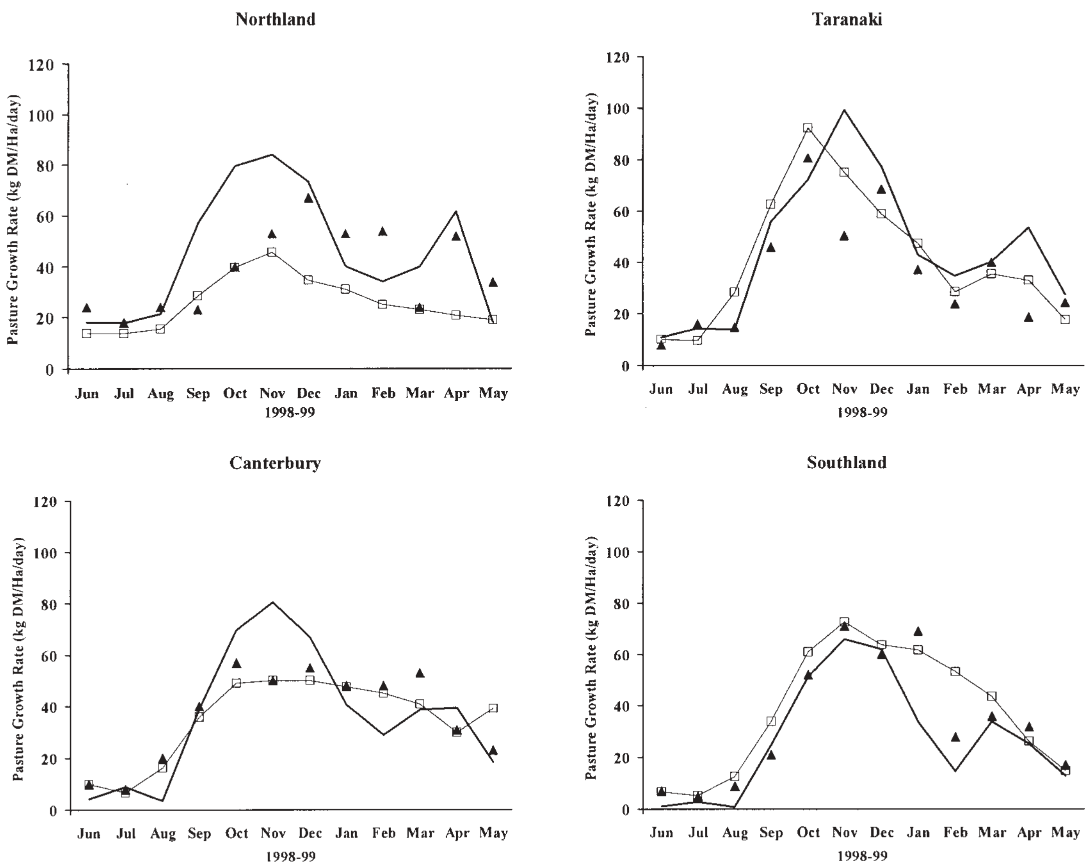


**TABLE 1:** Observed and whole-farm model (WFM) predicted annual pasture production (kg DM/ha/year). Ratio: WFM/Observed.

| | 1998-99 | | | 1999-00 | | | 2000-01 | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Observed** | **WFM** | **Ratio** | **Observed** | **WFM** | **Ratio** | **Observed** | **WFM** | **Ratio** |
| Northland | 14199 | 16634 | 1.17 | 12534 | 19718 | 1.57 | 16324 | 18510 | 1.13 |
| Taranaki | 13070 | 16582 | 1.27 | 14380 | 15734 | 1.09 | 11508 | 15391 | 1.34 |
| Canterbury | 13459 | 13358 | 0.99 | 12451 | 13076 | 1.05 | 10728 | 13293 | 1.24 |
| Southland | 12313 | 10001 | 0.81 | 12892 | 9837 | 0.76 | 11727 | 9535 | 0.81 |

### Animal Production

The WFM predictions of MS production for each region are shown per ha in Figure 2 and per cow in Figure 3. Taranaki, Canterbury, and Southland showed close agreement while Northland over predicted for all three seasons. Over the 1998-99 season for per cow MS production (Figure 3), the WFM predicted 129% of the observed production in Northland, 121% for Taranaki, 101% for Canterbury and 99% for Southland. The 1999-00 and 2000-01 seasons, for Taranaki, Canterbury and Southland WFM per cow MS calculations ranged from 92-107% of the observed values, while Northland was consistently over-predicted (119-127%).

## DISCUSSION

The WFM was able to predict the seasonal fluctuations in pasture growth and closely predicted MS production for three of the four contrasting regions in New Zealand.

Northland simulations were consistently over-predicting, both for pasture and MS production. Differences may be model and/or data related. The pasture model McCall (1984) used by the WFM is ryegrass-based and Northland pastures tend to be dominated by drought-tolerant grasses such as kikuyu and cocksfoot. In a study by Piggot (1997), it was found that these pasture species were out-performed by ryegrass. Ryegrass will yield more in the spring, than these other summer-dry type grasses.

**FIGURE 2:** Observed and whole-farm model (WFM) calculated milksolids production per ha. ☐ Observed, ■ WFM calculated.

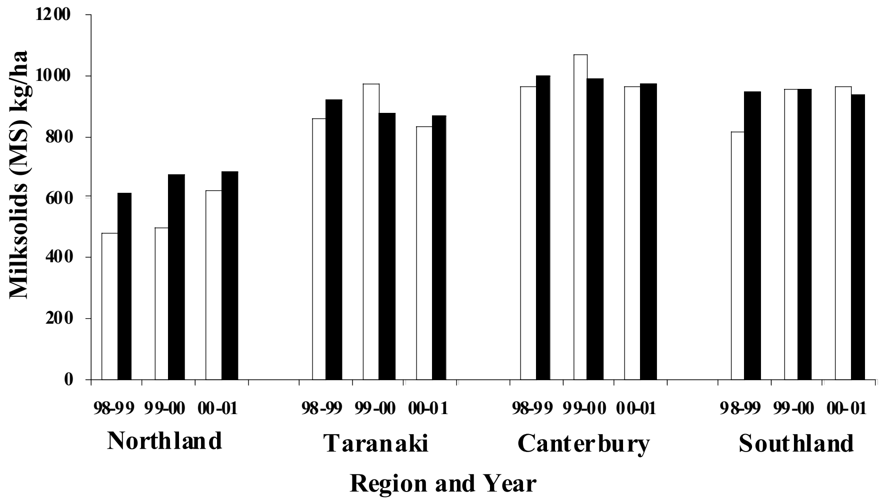
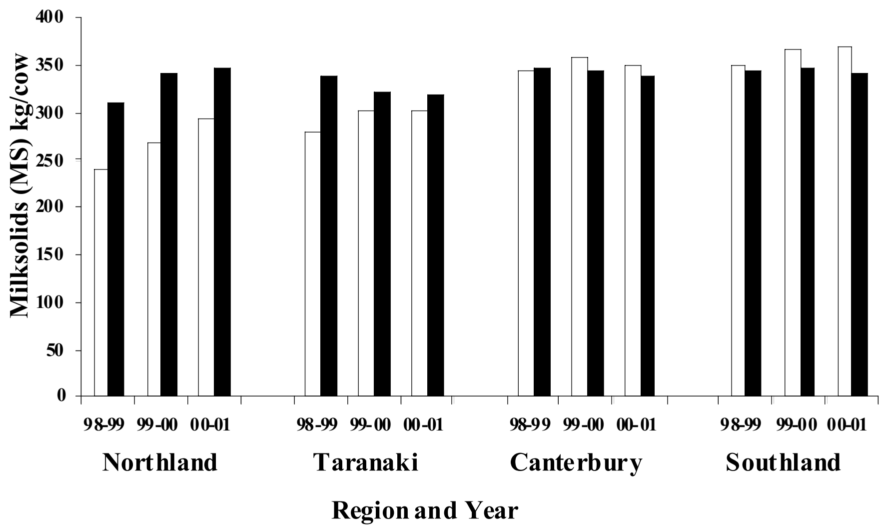



**FIGURE 3:** Observed and whole-farm model (WFM) calculated milksolids production per cow. ☐Observed, ■ WFM calculated.



Thus, over-prediction by the WFM may be because the pasture model is based on ryegrass; other pasture species should be included in the model. An alternative explanation is that the low pasture growth in this region is soil related. Low pasture yields are associated with farms on clay hill country in Northland (Piggot, 1997), whereas the WFM currently assumes that soil fertility is not limiting.

Over-prediction occurred for Taranaki and Canterbury when pasture growth rate was rapid, i.e., during the spring. For Taranaki this may have been related to measurement technique. Lile *et al*. (2001) found that pasture growth measured during a farm walk by a rising plate meter was grossly under-estimated compared to visual assessment, particularly with higher pasture residuals.

For Canterbury, some of the difference between observed data and the WFM may relate to the irrigation schedule. An even pattern of irrigation over 200 days was assumed when modifying the precipitation input to the WFM. This is of course unrealistic in practice, however if a more detailed schedule had been available, the simulation may have been closer.

It is not clear why the WFM under-predicted growth in January/February in Southland. It may be that the cutting technique used for the observed data produced a different pattern of growth than grazing, as discussed by Rickard & Radcliffe (1976).

Data used in this study ranged from rising plate meter assessments to cage cuts. In a study by Webby *et al*. (1995) the importance of knowing how pasture is assessed when using models was stressed. Variations in technique may be of little consequence when monitoring changes in pasture cover on a farm, they are however, important when field measurements are related to model results (Webby *et al*., 1995). Although the rising plate meter is inaccurate when walking a farm (Lile *et al*., 2001), it is considered to be accurate with other methods, such as pasture cages. A study by Davis *et al*. (1998), found that the "difference" method (Lynch, 1966) using a rising plate meter and pasture cages produced a more realistic estimation of annual growth, and, in fact, pasture growth measured using the rising plate meter in this instance was greater than that measured by cutting pasture. Another factor that could influence the data is timing and frequency of the measurements. The observed data were collected from 10-day to monthly assessments, while the WFM calculated daily pasture growth and these were averaged at the end of each month. This may also explain some of the differences between the WFM predictions and the observed data.

MS production was close to the observed data even though pasture growth varied. This was because either pasture growth was sufficient to meet demand or demand was met from supplementary feed. Wastney *et al.* (2002) observed that when using the WFM against farmlet data in the Waikato region, there was a low pasture growth response compared to the observed data. This also resulted in lower than observed feed conservation. The WFM is climate driven and these results indicate that it has the ability to predict production outcomes with variable climatic conditions. It is important, however, to note that the management strategies need to be varied according to region in order to obtain realistic predictions. For example, the appropriate stocking rate, supplementary feeding and calving pattern for a region need to be simulated in addition to the climate.

In conclusion, the WFM predicted farm production in three of the four diverse regions within relatively close ranges. Production for Northland was consistently over-predicted by the WFM, and more work would be required with a pasture model that represents a wider variety of pasture species. Other cow models such as MOLLY (Baldwin, 1995), can be used which provide the user with more individual animal detail if required. The WFM will become an invaluable tool for researchers designing farm systems in different regions, and given various climatic scenarios (e.g., a wet or dry year), the WFM will provide users with very useful predictions of farm production.

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