NSW GOVERNMENT Primary Industries

MFS MONARO FARMING SYSTEMS

Impacts of projected climate change on Monaro native pasture systems.

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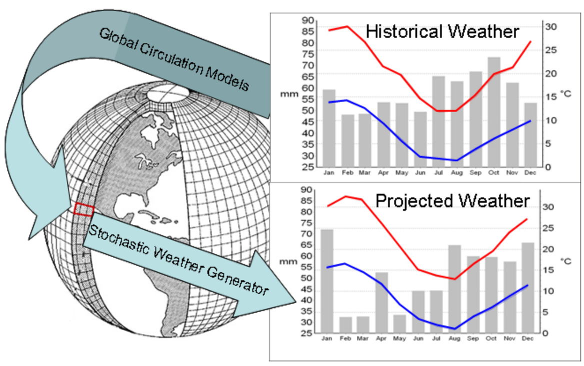
Introduction

Until recently the GrassGro decision support tool was not calibrated to simulate the common species found in native grasslands on the Monaro. Results of native pasture research conducted by NSW DPI and Southern Rivers CMA during the period 2004 – 2010 were used by CSIRO Plant Industry to construct two new pasture species parameter sets for the GrassGro decision support tool. The two major perennial grass species modeled at two localities on the central Monaro plateau are Spear / Corkscrew grasses (Austrostipa spp) and Snow grasses (Poa spp). The process of parameter development was conducted with the financial assistance of SRCMA by Dr Andrew Moore of CSIRO Plant Industry in collaboration with staff from NSW DPI and producer members of MFS. A copy of the report is attached.

The pasture parameters were used to construct a representative Merino breeding farm system for the Bungarby locality and this system was used to explore the potential impacts off and adaptations to projected climate change on the Monaro.

Method

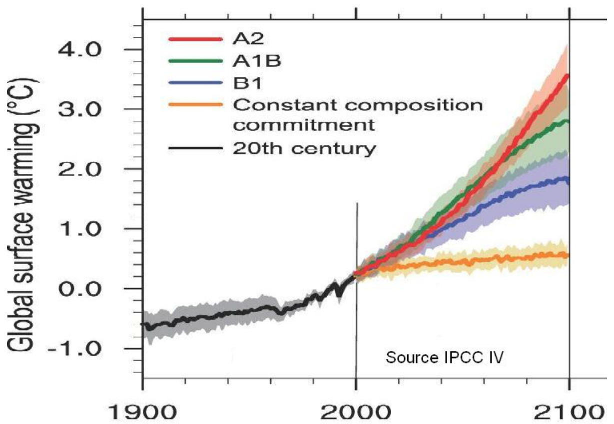
The farm system was run for the period 1971 – 2000 to provide a baseline against which to compare projections for the year 2030. Weather sets representing the projected climate at 2030 were generated using a bespoke stochastic weather generator (Weathermaker) provided by the Southern Livestock Adaptation 2030 project.



Weathermaker uses the regional monthly projections from a particular global climate model (GCM) output along with the characteristics of historical weather data at a locality to produce projected daily weather sets for that locality. Historical weather averages and distributions are shifted in line with the regional climate projections for particular GCM's and then a stochastic weather generator used to produce sets of weather data within these statistical boundaries.

Which emissions scenario?

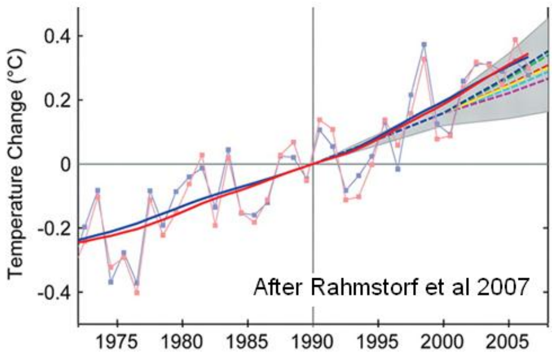
GCM outputs are significantly affected by the projections of global emissions. The IPCC fourth assessment report defined a range of future emissions scenarios which relied on a range of assumptions about population growth, the extent and speed of the shift to low emissions energy sources and other mitigation activity.



The graph above shows projections published by the IPCC in 2007 indicating the expected temperature rise (average of all 23 GCM's) across a range of emissions scenarios assuming mitigation action was taken at the turn of the century. The A2 scenario (essentially business as usual) was chosen to model climate change impacts to 2030 since very little mitigation action has occurred to date and world population continues to grow unchecked.

The following graph plots two independent records of global mean temperature (solid lines) against IPCC projections revealing that measured temperature is tracking near the top of the projected range again suggesting the A2 scenario may be our best indicator to 2030.

Actual temperature record since 1990 vs GCM projections



Which GCM's?

All 23 IPCC GCM's have been assessed for their ability to hind-cast Australian regional climate data. Hind casting is a process of running the GCM from a known set of start up conditions at a point in history and then comparing the model outputs with the actual weather record from that point forward. A subset of four GCM's with high hind-casting skill were used to create projected weather to represent the range in outputs covered by the best nine GCM's.

GCM	Warming	Drying
CCSM 3.0	Medium	Slightly Wetter
GFDL 2.1	Medium	About the same
ECHAM5-OM	High	Much Drier
HadGEM1	Low	Slightly Drier

The table above shows the GCM's chosen and the combination of warming and drying they project.

Application in GrassGro

The projected daily weather sets from each of the four GCM's were used to run a 30 year simulation representing the distribution of potential weather around the projected average climate. This enables an assessment of the impact on both the average chane in climate but also on the variability and extremes in the weather.

Results

Down Scaled Weather.

A projected weather set was generated for each of four GCM's. These GCM's have similar skill but cover a similar range of projected climate change as the full set of global climate models (GCM's)

Historical Period	Average Annual Rainfall	Annual Average Max / Min temperature
1971 to 2000	544 mm	18.3 C / 4.8 C
2000 to 2009	451 mm	19.1 C / 4.8 C
GCM	**2030 Rainfall**	**2030 Max / Min**
CCSM	605 mm	19.5 C / 5.9 C
HadGEM1	561 mm	19.1 C / 5.7 C
ECHAM5-OM	439 mm	19.7 C / 5.7 C
GFDL 2.1	488 mm	19.5 C / 5.9 C

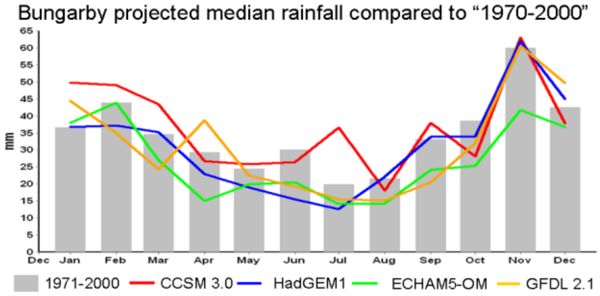
Seasonal Impacts on Climate

Changes in rainfall and temperature are not uniform throughout the year. Some GCM's project bigger changes in some months compared to others. This is of course reflected in the projected daily weather data.

Monthly Rainfall

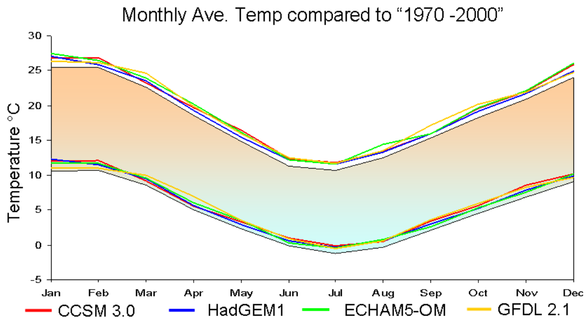
Monthly median rainfall is the amount of rain that 50% of years are above and 50% are below. Even at about the same annual average the HadGEM1 projects considerably lower median monthly rainfall in autumn / winter without significant improvements in the spring or summer.. By comparison the ECHAM5 model indicates severe rainfall deficit in autumn winter and spring compared to the base.

Bungarby projected median rainfall compared to "1970-2000"



Temperatures

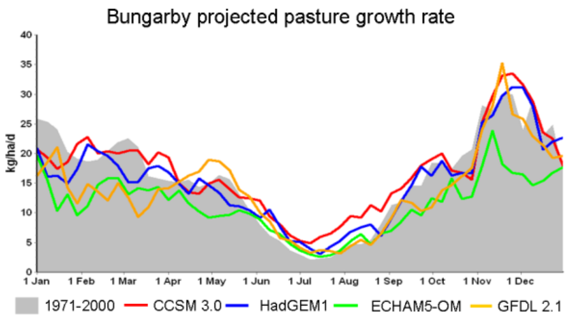
Monthly average temperatures are consistently higher for all GCM's. For GCM's with drier winters winter temperatures are only slightly warmer



Temperature increases are greatest in spring summer and autumn. The first and last frost day are likely to be later and earlier respectively.

Monthly pasture growth

Median weekly pasture growth was plotted for each of the four projections against the base period. While CCSM 3.0 projects better winter - early spring growth all other models showed little advantage over the base period.



All models show lower summer growth but ECHAM5 shows consistently less growth than the base file across spring summer and autumn.

Impact on sustainable carrying capacity

To protect soil and pasture and maintain a sustainable system, ground cover must be maintained above critical thresholds most of the time. GrassGro does not model soil loss so it is critical that the system parameters used do not breach sensible ground cover targets. As the climate becomes more erratic ground cover risks increase.

Ground cover targets

The relationship between soil loss and ground cover has been long established and depends on slope and soil texture. This table opposite shows data from the SOILLOSS model relating to a summer dominant rainfall.

For the Monaro target minimum ground cover was set to 80% and systems were only allowed to fall below this target three years in ten. This means daily ground cover remains above 80% more than 85% of the time over 30 years.

Effect of slope / soil type on target minimum ground cover

Soil Type	Slope		
	Gentle	**Moderate**	**Steep**
Sandy Loam	60	70	80
Red Loam	70	**80**	90
Black Clay	70	80	90
Granite (Duplex)	>70	**>80**	>90

To determine the sustainable stocking rate the farm system was run for each of the GCM's across a range of stocking rates to determine the highest rate that still maintained ground cover.

Stocking rates at Bungarby

Base	CCSM	HadGEM	ECHAM	GFDL
2.5 *	2.6	2	0.7	1.6

* Stocking rates in breeding ewes per hectare

Projected stocking rate for the ECHAM5 model fell by more than 70% at Bungarby. This was the result of lower total herbage production as well as longer drought periods and faster decay of litter in the warmer conditions.

Conversely projections for the CCSM model show that stocking rate can be maintained however at this location none of the GCM's projected an improved carrying capacity.

Profit and Risk

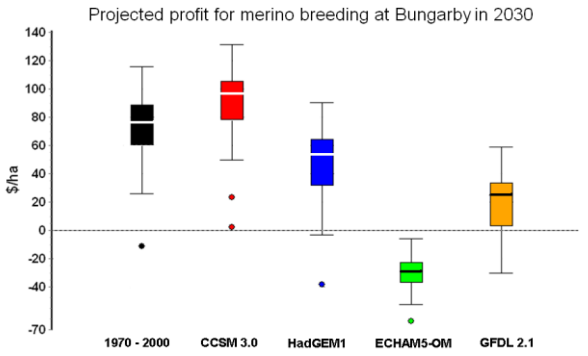
Production data from GrassGro is used to produce annual gross margin and profit. This modelling uses 5 year average costs and prices and these are used for both the base line simulation as well as for the 2030 projections. Overhead costs were set at $70/ha as indicated by Boyce and Co. benchmarking data over a similar period.

A 30 year simulation generates a profit distribution driven by seasonal conditions in each year of the simulation. This distribution is best displayed as a box plot. The coloured box on the plot shows the middle 50% of years simulated while the whiskers above and below this represent the remainder of the distribution. Small circles represent statistical outliers which are generally the very worst drought years. A distribution spanning a wider range than the base simulation indicates increased variability.

Profit and risk at Bungarby

For Bungarby the CCSM model projects a modest increase in profit compared to the base. This stems from the combined effects of a small increase in carrying capacity as well as higher lamb survival from the warmer drier winters.

For the ECHAM GCM the projected enterprise returns a loss in all years. The drastic reduction in carrying capacity completely overrides the positive impacts of improved lamb survival.



The effect of adaptation

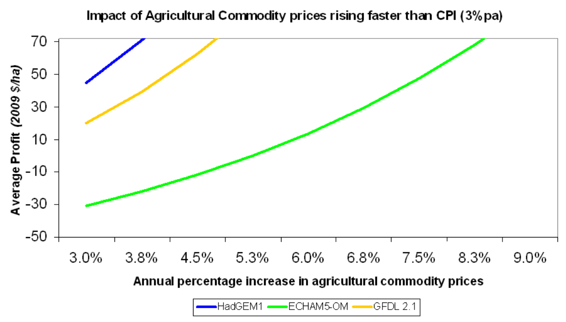
GrassGro provides the facility to alter a wide range of enterprise management and the MFS GrassGro core group was asked to identify potential adaptation to management that might serve to mitigate the impact of projected climate change. While the list of possible adaptations were wide ranging not all of them could be analysed within the constraints of the GrassGro model. Those that could be analysed included

- Fertiliser
- Drought lots (ground cover management)
- Genetic improvements
- Lambing time

Also of interest was the possibility that with reduced productivity,increased demand could lead to a considerable shift in the relativities of commodity prices and the major agricultural inputs.

Altered market conditions

It is widely believed that with increased world population, demand for agricultural commodities will reverse the cost price squeeze leading to a period where prices received will increase faster than input costs. It is often assumed this will be sufficient to offset the potential negative impacts of climate change.



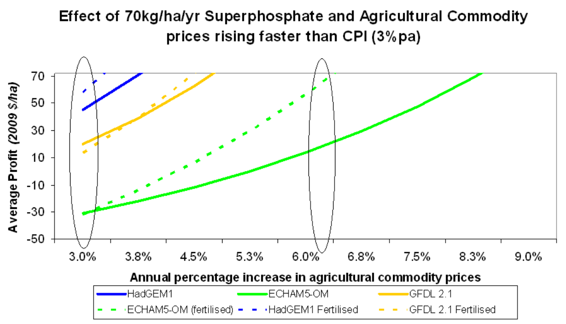
The graph above shows economic modelling for the three negative climate projections while adjusting the relative change in input costs and prices received. Input costs are assumed to rise at a constant 3%pa (inflation) while the rise in prices received has been modelled to increase between 3% (base inflation) and 9%(rising three time faster than base inflation). The graph is truncated to the historical profit figure of $72/ha (corrected to 2009 dollar values).

To fully offset the negative impacts of the HadGEM1 projections, prices need only increase at 3.8% pa (25% faster than inflation) but for the ECHAM5-OM projections prices would need to increase at 8.5%pa (almost 3 times the base rate of inflation) or 5.3%pa (75% faster than inflation) in order for the enterprise to simply break even. Clearly this scale of change in market conditions is far less likely and active adaptation to this level of climate change would still be required.

Adding Fertiliser

Work reported by the Monaro Grasslands Research and Development Project indicates considerable improvement in both production and profit from employing fertilizer strategies to increase the productivity of native grasslands.

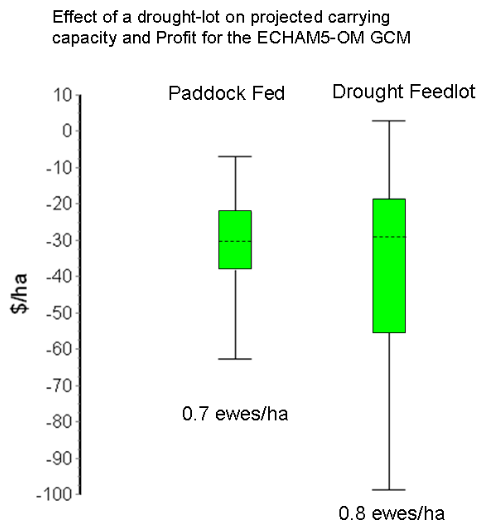
The baseline for the climate change modeling was an unfertilized system so the soil fertility scalar was altered in a manner similar to that reported in the parameterization work described in the introduction.



If fertilizer and commodity price relationships remain as in 2009 then there is little to be gained from fertiliser for either the GFDL 2.1 or the ECHAM5-OM GCM projections. However if there is some reversal of the cost price relationships (as described above) then fertiliser will garner a greater advantage. This of course assumes that fertiliser prices as an input are simply tracking the base inflation rate (probably unlikely given current known supplies of phosphate rock). Never the less if the value of agricultural products rises twice as fast as inflation (6%) the use of fertiliser would bring the ECHAM5-OM projections back up to the historical base compared to a requirement to rise by nearly three times inflation without the use of fertiliser.

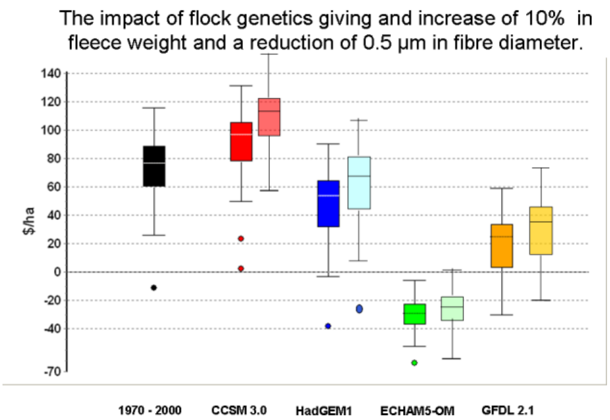
Drought lots

Although drought lots show promise in other climate change modeling in regions that are seasonally dry the impact is far less promising for the ECHAM5-OM GCM projections at Bungarby. The timing of events when ground cover was threatened was highly variable in the projected simulation for the ECHAM5-OM GCM. This variability and the extent of the drought periods meant that the sustainable stocking rate could not be increased substantially and that even though the average profit could be increased slightly the variability in profit was increased to such an extent as to nullify any benefit from this minor increase.



Genetic Improvement

While genetic improvement is not strictly an adaptation to climate change it is useful to consider how much of the decline in profit could be arrested by making significant genetic gain between now and 2030. The Combined wether trial analysis shows just how much variation there is between current sheep flocks indicating that there is great potential for many flocks to make considerable and rapid gain in the performance of there flock.

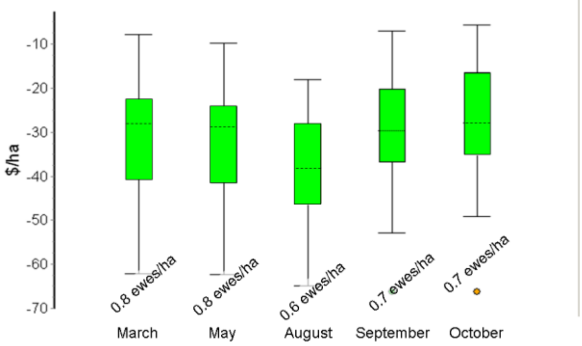


Unfortunately while the gains from genetics are significant they are most substantial for GCM's for which profit still remains positive. While there is a gain to be made from better genetics for the ECHAM5-OM GCM the enterprise still remains in a loss position in most years.

Changing lambing time

Profit is often quite sensitive to lambing time and certainly in some environments potential stocking rate can also be improved by a judicious choice of lambing time. Since the ECHAM5-OM model showed the greatest threat to production the impact of a change in lambing time was tested for this GCM to explore the impact on bothe carrying capacity and profit.

Effect of changing lambing time for the ECHAM5-OM projection.



Lambing one month later (October) did serve to increase the average profit and slightly reduced the overall variation in profit between years however this impact was minor and was not able to return th enterprise to a profitable level. Lambing later did not change the sustainable carrying capacity. Lambing in winter both reduced profit and carrying capacity while lambing in autumn increased the carrying capacity in ewes/ha but reduced the average profit as well as increasing the downside risk in the profit distribution.

Conclusion

GrassGro modelling suggests that while the range in possible climate change impacts is wide on balance the impact is likely to be a reduction in sustainable carrying capacity. For the worst case scenario the impact was quite sever and no single adaptation was able to recover the enterprise from this impact. For the worst case (ECHAM5-OM) changes in market conditions are very unlikely to be sufficient to offset the impacts but some favourable change in market conditions along with a combination of a number of active adaptation strategies may be sufficient to recover a significant proportion of the impact.

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