PROCEEDINGS OF THE AUSTRALIAN RANGELAND SOCIETY BIENNIAL CONFERENCE

Official publication of The Australian Rangeland Society

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The Australian Rangeland Society

CHANGING STOCKING RATES AND BURNING MANAGEMENT TO REDUCE GREENHOUSE GAS EMISSIONS FROM NORTHERN QUEENSLAND RANGELANDS.

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ABSTRACT

GRASSMAN, an agricultural decision-support model, has been modified to include sources, sinks and storages of greenhouse gases. The modified model was used to investigate the effects of changes in stocking rate and burning management on greenhouse gas emissions of northern Queensland rangelands. These rangelands are significant net emitters of greenhouse gases in their natural state, resulting in large differences between net and anthropogenic (man-made) emissions and hence, to different conclusions regarding emission reduction strategies. At moderate stocking rates, *anthropogenic* emissions could be reduced by about 20% with little loss of productivity. However, similar reductions in *net* emissions require larger management changes with substantial drops in productivity. At heavy stocking rates, reducing stock numbers reduced emissions whilst increasing cattle production.

Reducing burning frequency can reduce greenhouse gas emissions. However, recommendations to minimise burning have to recognise the benefits achieved through burning.

INTRODUCTION

Global climatic changes have been widely forecast as a result of increasing atmospheric concentrations of radiatively-active (or 'greenhouse') gases such as carbon dioxide and methane. Methods for evaluating and reducing greenhouse gas emissions are being sought for a range of Australian industries, including the northern beef cattle systems. Simulation models are necessary to analyse emissions from these rangeland grazing systems, because of the complexity of interactions between the system components. For example, cattle stocking rates affect burning regimes by controlling fuel loads, and burning influences the growth of shrubs and trees, which in turn affects grass growth and thus stocking rate. All of these affect net greenhouse gas emissions.

To calculate emissions from grasslands, Howden, (Howden *et al.* 1991) modified GRASSMAN (Scanlan and McKeon 1990), an agricultural decision-support model for beef cattle enterprises, to include sources, sinks and storages of greenhouse gases. The modified model does not yet include the effects of management on soil organic matter. This model is used to investigate the effects of changes in stocking rate and burning frequency on greenhouse gas emissions and productivity.

METHODS

A case study is made here of a pasture of native grasses growing on duplex soils with a medium density, mature woodland of Silverleaf Ironbark (*Eucalyptus melanophloia*) trees and a shrub understorey. The basal area of trees was 6.0 m^2/ha. Termite biomass was high (96 kg/ha). Pasture burning was carried out every third year if there was adequate standing dry matter to support a burn (the default burning treatment). This example was chosen as a general view of northern Queensland pastures.

Emissions are calculated in two different ways in this study: 1) *net* emissions where these are the differences between the sources and sinks for the greenhouse gases CO_2, CH_4, CO, N_2O and NO when they are all expressed in terms of CO_2 equivalents (Shine *et al.* 1990), and; 2) *anthropogenic* (man-made) emissions where this is the difference between the net emissions under any management option and the net emissions in the natural, ungrazed state with a three year fire frequency. All emissions are calculated on a per hectare per year basis. The index of productivity calculated here is animal production per unit area (kg liveweight gain/ha/year) for steers.

Two simulation studies were completed. The first investigated the effect of changes in stocking rate on emissions. The second investigated the effect of fire frequency on greenhouse gas emissions at a set stocking rate of 0.22 AE/ha. This rate gave both a safe summer pasture utilisation of 30% (approximately 40% utilisation of annual growth) and near maximum production and is used as a baseline for comparing management options for the stocking rate simulation. Simulation studies were conducted for 15 years of average climate.

RESULTS

The woodland grazing systems of northern Queensland investigated here are significant net emitters of greenhouse gases (261 kg CO_2 equivalents/ha/year; Fig 1a) in their natural state (i.e. with grazing only by native fauna).

Stocking rate had a substantial, non-proportional effect on greenhouse gas emissions (Fig 1a). For example, a 20% reduction in *net* emissions would require a 52% reduction in stocking rate from the "best" stocking rate. In contrast, a 20% reduction in *anthropogenic* emissions would require a 22% reduction in stocking rate. This reduction in stocking rate would result in about a 5% (1.2 kg LWG/ha/year) reduction in liveweight gain (Fig 1b). Increases in stocking rates above the estimated "best" stocking rate of 0.22 AE/ha resulted in increases in greenhouse gas emissions but decreases in liveweight gain (Fig 1a,b).

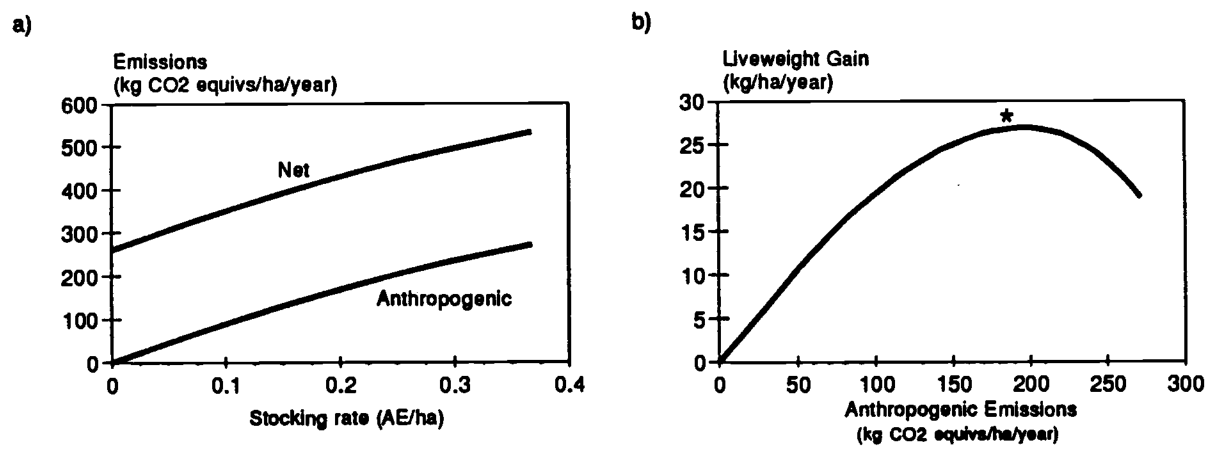

Figure 1. Relationships between; a) net and anthropogenic greenhouse gas emissions (kg CO_2 equivalents/ha/year) and stocking rate (AE/ha), b) liveweight gain (kg/ha/year) and anthropogenic emissions, for a native pasture woodland grazing system in northern Queensland. The mark (*) on figure b) indicates a stocking rate of 0.22 AE/ha.

When fire was excluded from the grazing system, net greenhouse gas emissions averaged 294 kg CO_2 equivalents/ha/year (Fig 2). Increasing the frequency of burning increased emissions such that when the pastures were burnt every year, average emissions were almost doubled (531 kg CO_2 equivalents/ha/year).

DISCUSSION

Northern Queensland rangeland systems are substantial net emitters of greenhouse gases in their natural, ungrazed states, and grazing with cattle increases emissions above this level. At moderate stocking rates, relatively minor changes in stock management can result in relatively large reductions in *anthropogenic* greenhouse gas emissions without large reductions in productivity. Hence, if anthropogenic emissions are considered, reducing greenhouse gas emissions from these pasture systems by about 20% over the next 15 years may be possible with little economic cost. Reduction of *net* emissions by the same amount will require larger management changes and would result in substantially lower animal production. The large differences between net and anthropogenic emissions are due to the substantial emissions occurring from these landscapes in the natural state. The results presented here show that emission definitions are of critical importance in determining feasible emission reduction strategies.

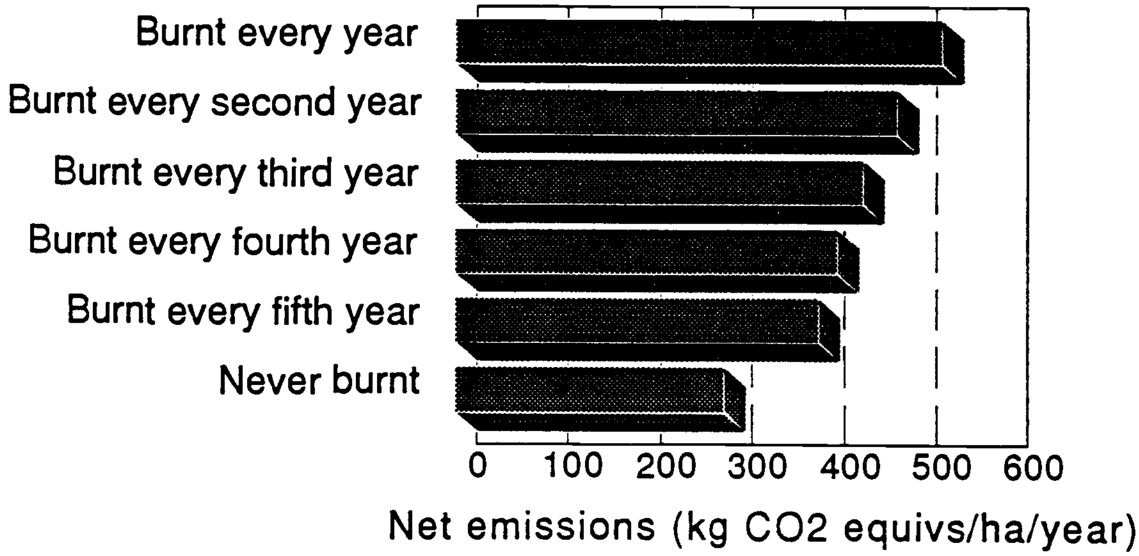

Figure 2. The effect of fire frequency on net emissions of greenhouse gases (kg net emission CO_2 equivalents/ha/year). Fire frequency was varied from nil to burning every year. Stocking rate was 0.22 AE/ha for all treatments.

Increases in stocking rate over the 'best' stocking rate calculated here by GRASSMAN, resulted in both increased emissions and reduced productivity. In heavily grazed systems, the relatively small reductions in stocking rate that are needed to reduce anthropogenic emissions significantly may also have the effect of reducing soil and vegetation degradation.

Emission reductions could also be achieved through minimisation of burning. However, burning is an integral part of the ecology and management of grazing lands in the north of Australia. For example, burning is used to control the growth of shrubs, trees (`woody weeds') and undesirable grasses (Orr *et al.* 1991), to provide livestock with high quality feed and to prevent patch grazing (Andrew 1986). Hence, recommendations to minimise burning to reduce greenhouse gas emissions have to be consistent with these high priority management objectives.

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