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THE ECONOMIC IMPACT OF DESTOCKING ANNUAL PASTURE DURING SUMMER TO REDUCE SOIL LOSS

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Summary
In Mediterranean environments a reduction in ground cover during summer can increase the risk of soil loss from wind erosion. An industry recommendation is to destock annual pastures over summer whenever a threshold ground cover is reached but the likely economic and environmental impact of destocking has not been estimated. In this study the decision support tool GrassGro™ was used to investigate these effects over 34 years for an annual pasture either unstocked or grazed by Merino sheep at 1-11 wethers/ha. Various summer-autumn destocking periods were tested at a stocking rate of 9 wethers/ha. Risks of soil loss were evaluated and compared with the cost of destocking.

Introduction
A wool producer on the south coastal sandplain of WA wanted to test management options to minimise soil erosion and examine their impact on the profitability of a Merino wether enterprise. The susceptibility of a dry soil to erosion by wind depends on wind speed, plant cover and the texture and condition of the soil's surface. Wind erosion of agricultural soils occurs when wind speeds exceed 30km/h at 10m above the ground (Moore *et al*. 1998). However if about 50% of the soil surface is covered by vegetation, the potential soil loss is reduced to 10% of that predicted for bare ground (Findlater *et al*. 1990). In a Mediterranean climate the soil surface becomes very dry and powdery over summer and vulnerable to erosion (Moore *et al*. 1998). Grazing sheep loosen soil and can detach herbage at a rate of 0.3-1.0t/sheep/week on a range of soils in WA. To reduce soil disturbance, graziers are advised to reduce grazing pressure by sheep over summer to maintain ground cover above 50% (Department of Agriculture-WA 2000).

Materials and methods
The computer decision support tool GrassGro (Moore *et al*. 1997) was used to examine the economic returns for five stocking rates. Daily weather inputs over 1966-2000 at Hopetoun, WA, were based on historical data from the region. The soil on the property is classified as a loamy fine sand with a moderate to high susceptibility to wind erosion (Overheu 1995). Continuously grazed annual ryegrass-subterranean clover (*cv* Seaton Park) pastures were simulated. In each simulation, fine wool Merino wethers were shorn in mid-November and fed wheat in the paddock to maintain their live weight whenever their condition fell below score 1.0. Destocking over summer was tested for a high stocking rate (9 wethers/ha) that achieved gross margins greater than overhead costs (taken to be $100/ha) in most years. To test the seasonal destocking strategy, wethers were removed to a feedlot each year for a fixed period. Eight periods were tested (1 Dec-31 May, 1 Jan-31 May, 1 Feb-31 May, 1 Mar-31 May, 1 Apr-31 May, 1 May-31 May, 1 Jan-31 Mar, 1 Dec-30 Apr). Wethers were fed 0.45kg wheat/head/day in the feedlot, as the producer runs a specialist grazing enterprise and so has no access to stubbles for grazing over summer. An index of wind erosion risk was computed for each simulated system by combining the probabilities of high wind speed, low ground cover and dry surface soil.

Eight years of hourly wind data were available (for Bedford Harbour, approx. 40km east of the property being simulated). An index of the average erosive power of wind on each day of year was computed with the following equation:

$$EPW_i = \int_{v=8}^{\infty} \left[\alpha_i \beta_i^{\alpha_i} v^{\alpha_i - 1} \exp\left(-(v/\beta_i)^{\alpha_i} \right) \right] (v-8)^3 dv$$

where EPW_i is the index for day of year i, v is wind speed in ms^{-1}, the term in square brackets is the Weibull probability distribution (Skidmore & Tartako 1990) and the rationale for the cubic term is given by Findlater *et al.* (1990). The parameters of the wind speed distribution, α_i and β_i, were estimated from the hourly wind data. The actual frequency distribution of hourly wind speed in each month of the year was computed. These distributions were fitted to Weibull functions using least-squares minimization, and the α and β values of the twelve fitted distributions were then interpolated

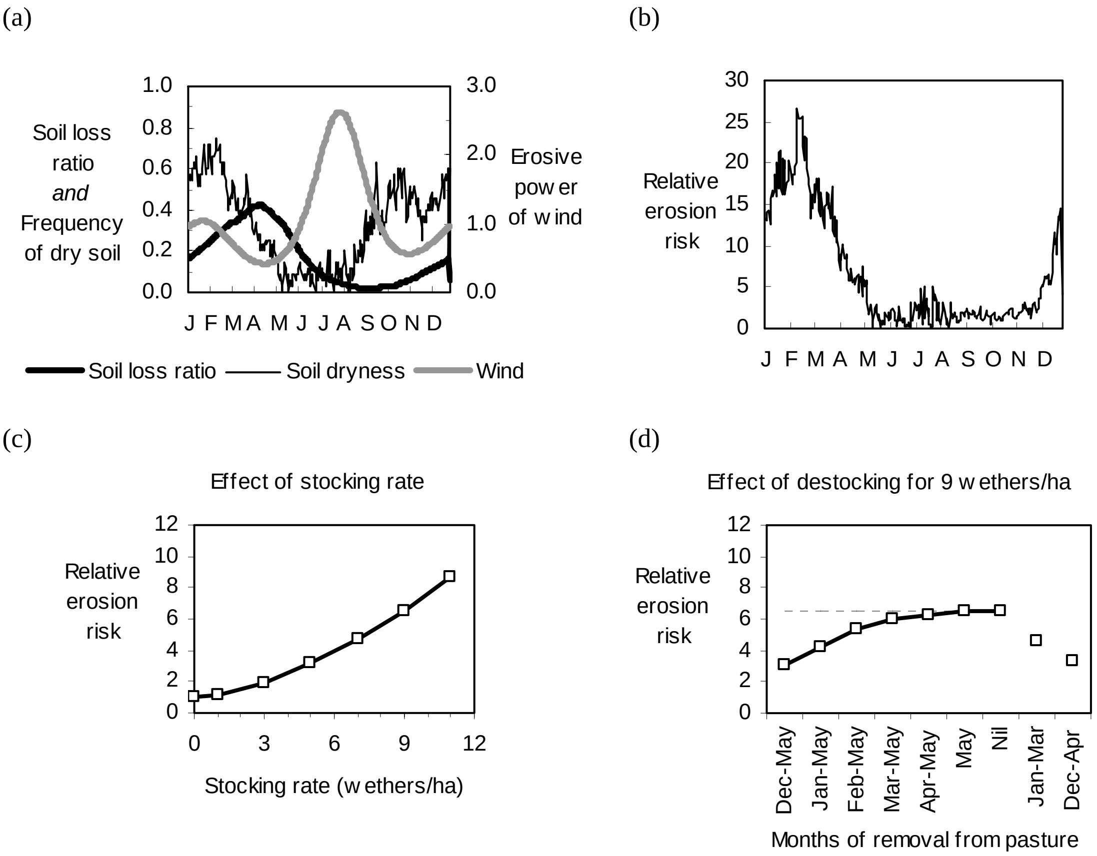

Figure 1. (a) The components of relative erosion risk throughout the year for a continuously grazed system at 9 wethers/ha: frequency of soil dryness, the soil loss ratio (ratio of erosion rate at a given ground cover to the rate when the soil is bare) and erosive power of wind (*EPW*). (b) Long-term (1966-2000) average relative erosion risk throughout the year for the same grazing system. (c) The predicted effect of continuous grazing at stocking rates of 0, 1, 3, 5, 7, 9 and 11 wethers/ha on the long-term average relative erosion risk. (d) The predicted effect of destocking for varying periods over summer each year for a stocking rate of 9 wethers/ha on long-term average relative erosion risk. Destocking was for the whole of the months indicated.

using Fourier series. The use of hourly wind data may have resulted in some under-estimation of actual erosion events but no finer-scale data were available.

Predicted ground cover on each day *i* and year *j* of each simulation was computed from outputs of GrassGro simulations as:

$$GC_{ij} = 1 - \exp\left(-1.1 G_{ij}\right)\exp\left(-0.6 D_{ij}\right)$$

where *G* is the total green herbage mass and *D* is the total dead herbage mass, both in t/ha. The mass-cover relationship for green herbage was estimated from data of Appila/Bundaleer Pasture Group (1996), while the relationship for dead herbage has been derived from assumptions made in the models used by GrassGro. Measurements of the mass-cover relationship for dry pasture residues are needed.

The effects of wind speed, cover and soil dryness were then combined into a final index of wind erosion risk:

$$WER = \tfrac{1}{N}\sum_j \sum_i EPW_i DRY_{ij} \exp\left(-4.7\, GC_{ij}\right)$$

where DRY_{ij} = 1 if surface soil moisture is at or below wilting point and is 0 otherwise (Moore *et al.* 1998), the ground cover term is taken from Findlater *et al.* (1990), and *N* is the total number of days. *WER* is a relative measure of the long-term erosion rate that might be expected in a grazing system, not a prediction of absolute erosion rates. *WER* values for the various management options are therefore presented relative to *WER* for an ungrazed pasture; we refer to this relative value as "relative erosion risk".

Results

The relative contributions of windspeed, soil dryness and ground cover to wind erosion risk throughout the year are shown in Figure 1a. The erosive power of the wind was greatest in winter (July-August) when there was least risk of dry soil and soil loss from inadequate ground cover. In late autumn (April-May) when bare ground was greatest, the frequency of dry soil was lower and erosive winds were at their minimum. When combined, the analysis showed that in this environment most wind erosion is likely to occur in the first three months of the year (Fig. 1b).

As expected, the relative erosion risk increased with increasing stocking rate (Fig 1c) and decreased with increasing length of summer destocking (Fig 1d). When stocked at 9 wethers/ha, summer removal from Dec-Jun reduced erosion risk by half. Decreasing the stocking rate from 9 to 5 wethers/ha also halved the erosion risk. Under continuous grazing, stocking rates must be reduced to very low levels if ground cover is to be maintained. Even at a low stocking rate of 3 wethers/ha, ground cover fell below the threshold value of 50% at some point in half of years, while at 9 wethers/ha, simulated ground cover fell below 50% in 90% of years.

There is an important trade off between the risk of erosion and the short-term profitability of the enterprise. Continuous grazing at 9 wethers/ha gave an average gross margin of $123/ha and exceeded the assumed level of overhead costs in over 90% of years (Fig.2). However, Figure 1c shows that this stocking rate carried a high erosion risk. The management options tested here to reduce erosion risk have different economic outcomes. For example, if the producer decided to graze continuously and reduce the stocking rate to 5 wethers/ha, the average gross margin would fall to $71/ha. At a stocking rate of 9 wethers/ha, destocking from December to May produced a comparable erosion risk and the same average gross margin but carried a small risk of very low gross margins in poor years. However, summer destocking carries higher price risk. If the price of wheat were $180/t, destocking from December to May would yield $20/ha/year less than continuous stocking at 5/ha.

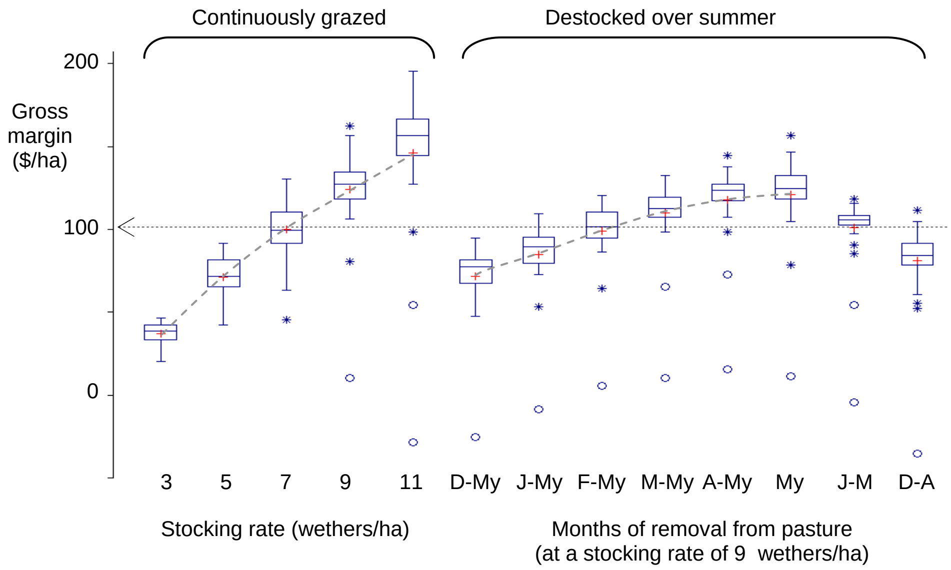

Figure 2. Distribution of gross margins from 1967-1999 for a Merino wether enterprise continuously stocked at 3-11 wethers/ha or grazed at a stocking rate of 9 wethers/ha and destocked over summer. Destocking was for the whole of the months indicated (M=March, My=May). Supplement cost was $150/t. The length of the boxes show the interquartile range and contains gross margins from half the years. The horizontal line in each box represents the median gross margin and the cross (+) represents the mean. The lines extending beyond the ends of a box (whiskers) include gross margin values that are within 1.5 times the interquartile range. Gross margin values beyond this range are indicated by asterisks. Values more than 3 times the interquartile range are indicated by open circles. At stocking rates above 5/ha, the lowest gross margin occurred in 1980. The grey dashed line joins mean gross margins for each treatment. The black dashed line shows overhead costs of approximately $100/ha.

For a wool enterprise grazing annual pastures at 9 wethers/ha, managing erosion risk by either halving the stocking rate or destocking over summer for 6 months was financially unsustainable. Destocking over summer for a shorter period (1 Jan-31 Mar), which coincided with the period of greatest erosion risk, reduced erosion risk by 30% while maintaining average gross margins at $98 and $85/ha when grain prices were $150 and $180/t respectively.

Discussion

Soil erosion by wind is considered one of the most serious of Western Australia's soil problems (Department of Agriculture-WA 2000). However, maintenance of ground cover may conflict with the high rates of pasture utilization which are required for a grazing enterprise to be profitable. The conflict is greatest for grazing enterprises based on annual pastures in regions with a high risk of wind erosion. The challenge for the producer is to manage wind erosion risk profitably. Our analysis suggests that taking the shifting probabilities of erosive winds and of dry soil into account may modify recommendations for pasture management based on ground cover alone. The GrassGro simulations predicted that ground cover fell below the 50%-threshold frequently, even at low stocking rates; Figure 1 shows clearly that low ground cover during summer should be of greater concern than low ground cover in autumn.

Although this study examined only very simple management options, it has helped a specialist wool producer to assess the potential effectiveness and costs of grazing management recommendations to reduce wind erosion in his environment. In mixed farming systems where crop stubbles provide cheap fodder over summer, the relative cost effectiveness of seasonal destocking as an erosion control strategy may be higher. In other parts of Australia the pattern of windspeeds and soil moisture will be different and the period of maximum erosion risk is therefore likely to change. GrassGro has provided a means of assessing this risk for a specific location and grazing system.

Estimates of the absolute quantities of soil eroded by wind and the associated costs due to lost pasture seed, soil nutrients and structure were beyond the scope of this analysis. Full accounting of these costs may alter the value of seasonal destocking. Nevertheless it is clear that soil erosion risk should be taken into account when setting the long term stocking rate policy for a property.

This study highlights the fact that high priority should be given to finding ways to maintain ground cover other than by destocking because of the high associated costs. On a paddock scale, windbreaks may provide some protection and reduce wind speed below the threshold for wind erosion and permit higher stocking rates without the accompanying increase in wind erosion risk. On the south coastal sandplain of WA, summer-growing perennial pastures such as kikuyu and lucerne may enable farms to maintain both economically viable stocking rates and adequate ground cover during summer.

Acknowledgements

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