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SOIL DEGRADATION UNDER CROPPING IN THE RANGELANDS

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ABSTRACT

On the self-mulching clay soils of north western New South Wales, wheat cultivation has expanded into areas previously regarded as too dry for crop production. The current wheat system involves continuous cultivation and is not sustainable in the long-term. Physical and chemical degradation of soil under wheat production has been monitored in this environment. This degradation is of concern as more of the "rangelands" become exploited as marginal cropping lands.

INTRODUCTION

"The rangelands" have in the past been by definition grazed or ungrazed vegetation communities. A "rangeland" was not cultivated or cropped. However this definition is undergoing change. Within New South Wales and Queensland there is rangeland country, both freehold and government-controlled land, which can be cleared and cropped. Pastoralists are turning to cropping as a means of generating cash flow and, in some cases, to improve the value and/or the carrying capacity of their land (**Fig. 1**).

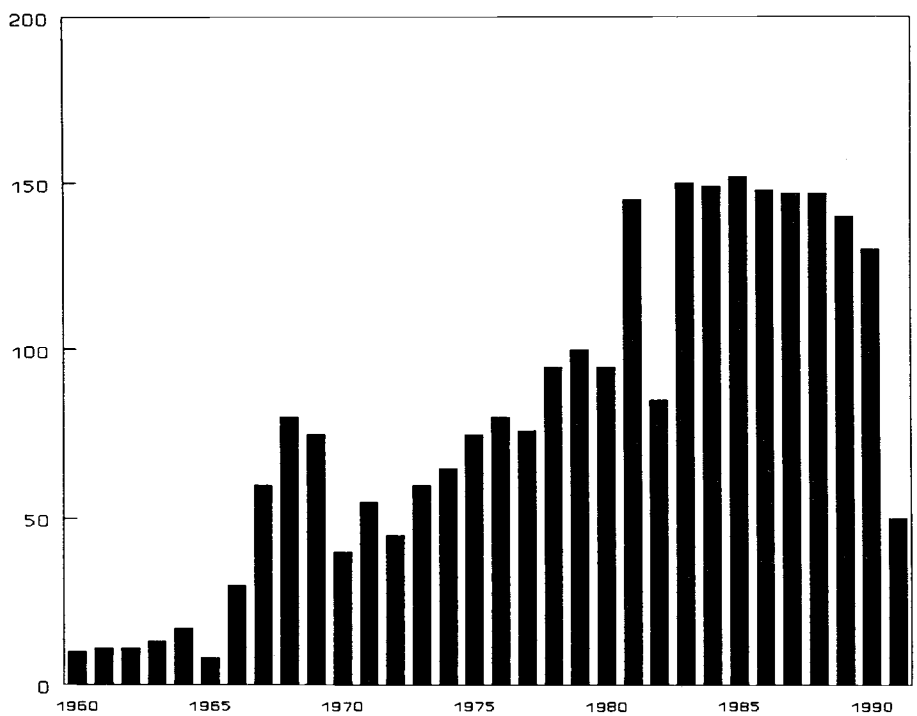

Figure 1: Area of wheat cultivation (ha*1000) for the Walgett Shire from 1960 to 1991.

The major factor affecting cropping in these regions is moisture availability. Rainfall is extremely variable. For example, the area of north-western New South Wales described in this paper, has an average annual rainfall at Walgett, centrally placed in the region, of 470mm per annum. This decreases westwards and is 60% summer dominant. The variability of rainfall dominates the reliability of wheat production and there are a number of years where crops may not be sown or, if sown, do not yield (**Fig. 2**).

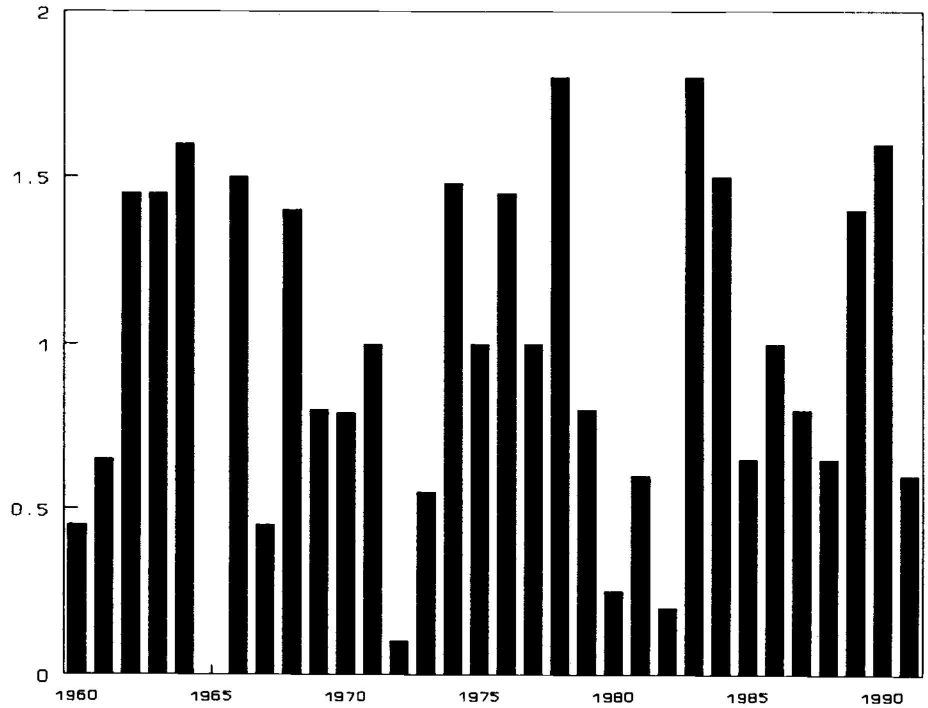

Figure 2: Mean grain yield (t/ha) for the Walgett Shire from 1960 to 1991.

The rapid expansion of wheat cropping into these low rainfall areas of Australia in the last few decades has been of concern to farmers, government agencies and the community as a whole. Cropping has expanded into areas previously considered too dry for crop production. Community bodies in Australia have become aware of the importance of soil conservation and the difficulties of preserving soils in these marginal environments. The problems that have been faced by this type of exploitive farming system on the Canadian prairies and the Great Plains of the United States are documented. As there, the expansion of dryland farming in the Australian rangelands has preceded the development of a stable farming system.

In the rangelands of north western New South Wales, the wheat farming system that has developed consists of a continuous monoculture of wheat. It does not include the use of fallowing, rotation with grain legumes or pasture, or the use of fertilisers, and is not sustainable in the long term. This system has already led to serious soil degradation problems (Chan *et al.*, 1988). These in turn have led to a decline in grain yield and protein. This decline in soil chemical and physical fertility was an inevitable consequence of the system. Soil examinations carried out in the Walgett Shire have proven the fundamental assumption: the existing cropping system is degrading the soil resource.

In this region, the increase in the cropping area has also meant increasing pressure being placed on the remaining pasture lands to maintain stock numbers. This increase in grazing pressure in combination, with a number of years of autumn rainfall rather than summer-dominant rainfall, has led to a decrease in the perennial grass component of these rangelands, and an increase in the annual component. There has been an invasion of annual species such as barley grass (*Hordeum* sp.), wild rape and turnip (*Brassica* sp.) and annual phalaris (*Phalaris paradoxa*). This means that while there is a bulk of feed from these species in autumn, winter and spring, there is virtually only burr from the naturalised medics (*Medicago polymorpha*, *Medicago minima* and *Medicago laciniata*) and some vine weeds, such as yellow vine (*Caltrop* sp.) and cow vine (*Ipomoea lonchophylla*) available for stock in summer. Hence carrying capacity of the land fluctuates rapidly, self-induced summer droughts are common, and there is no stability within the grazing system.

This wheat farming area in north-western New South Wales is situated on the heavy, self-mulching (Grant and Blackmore, 1991), grey clay soils of the river flood plains. These soils are inherently fertile with naturally high levels of nitrogen and phosphorus (around 30 ppm), and a pH of 7 and higher. In the past these areas have been natural grassland communities, with Mitchell grass (*Astrebla* sp) and Queensland Bluegrass (*Dichanthium sericeum*) associations in the north, and windmill grass (*Choris* sp) communities in the south. Because much of these areas were naturally treeless, it has been economic to clear and cultivate them. The Shire of Walgett, which has wheat production situated on this landtype, produces between 95,000 and 200,000 tonnes of wheat a year (**Figure 1**). Traditionally this wheat has had a high protein content. However the combination of soil physical degradation, soil nutrient decline and weed and disease build-up has seen a decline in both grain yield and protein.

RESULTS OF SOIL EXAMINATIONS AT WALGETT

Self-mulching soils under continuous cropping near Walgett were monitored for soil changes, and compared with natural pasture soils that had never been cropped.

Examining soil chemical fertility demonstrated substantial declines in organic carbon in cultivated soils when compared with adjacent natural pasture soils. The largest differences were found in the 0 to 0.1 metre layer. Organic carbon levels of cultivated soils were only 58-67% of the corresponding pasture soils. The results suggest that most of this loss occurred in the first six to eight years of cultivation. However there can be substantial declines in organic carbon after just one year of cultivation (Bowman and Chan, 1991).

Soil organic matter plays a key role in maintenance of soil fertility. It is the primary source of nutrient elements, such as nitrogen, phosphorus and sulphur. Organic matter also helps maintain a good friable soil structure by binding soil aggregates. Evidence from south east Queensland (Dalal, 1982) indicates that depletion of organic matter is significantly retarded by reducing the number of cultivation operations.

Extractable phosphorus levels were also significantly lower in cultivated soils at Walgett, the lowest being in paddocks under the longest periods of cultivation. This same response has been found on the brigalow, belah and coolabah soils of south-east Queensland, where the original levels of bicarbonate-extractable phosphorus were reduced to half their level in less than 20 years.

The reduction in phosphorus at Walgett may also be partly due to the increase in pH of these soils. Continuous cultivation has increased the pH from around neutral (7) to alkaline (7.5 to 8.5). Such increases in pH may lead problems in future cereal crops, such as zinc deficiencies.

Total nitrogen levels also declined significantly under cultivation at Walgett. Soil nitrogen decrease follows a similar pattern to that of soil organic matter. By increasing the decomposition of organic matter, cultivation stimulates the release of mineral nitrogen, which is used by crops. Many of the older cultivated soils have now reached a stage where organic matter has declined to a level where inadequate nitrogen is mineralised for crop needs. Thus these soils may now require the input of nitrogen from other sources for optimum cereal production. The farmer can add fertiliser nitrogen to compensate for the inadequate nitrogen release. Alternatively he can maintain the supply of nitrogen-rich decomposable organic matter in the soil through a legume crop.

Soil physical measurements at Walgett demonstrated that natural pasture soils have a higher structural stability than adjacent cultivated soils as measured by aggregate stability tests. Soil pits also revealed the presence of a compacted layer at 20cm to 30cm (Bellotti, 1987). The presence of this compacted layer was attributed to cultivation when the subsoil was moist and plastic, although the top soil was dry.

The marked loss of organic matter resulting from increasing periods of cultivation is accompanied by significant increases in bulk density. Results showed that at the same water content, the soil under pasture had a higher air-filled porosity and higher oxygen flux density than the soils that had been cropped. Oxygen flux density (Hodgson and MacLeod, 1989) could be 1.5 to 2.5 times higher for pasture soils than cropped soils (Bowman and Chan, 1991). This indicates that poorer subsoil structure exists in the cropped soils.

Soil biology is also being affected. Carbon dioxide is produced by microbial metabolism and is therefore an indicator of microbial activity in the soil. Carbon dioxide production by natural pasture soils was greater than for adjacent cultivated soils (Bellotti, 1987). Microbial activity in all the cultivated soils is carbon and nitrogen-limited. The implications of reduced biological activity on cereal crops is uncertain, and requires further investigation.

POSSIBLE SOLUTIONS TO THE PROBLEM

There are a number of possible ways to prevent this soil degradation from worsening. The introduction of a long fallow into the cropping system would improve soil moisture storage and decrease reliance on follow-up rain for crop yields. By retaining stubble cover, some of the soil stability problems could be minimised, as soil erosion would be reduced. The addition of organic matter from the stubble would assist build-up of soil fertility and reduce surface crusting. Deep ripping could be used to break plough pans.

The use of a crop rotation with either grain legumes or other break crops would decrease disease build-up and help bring weed burdens under control. A grain legume or green manure crop would also add vital soil nitrogen, as would the use of fertilisers. A perennial grass/annual medic pasture in rotation with the crops would add both organic matter and nitrogen to the soil. As well, the deep-rooted perennial pasture grasses would cause an increase in channels for water and air movement, and assist in breaking down compaction layers (Litter, 1984).

However, all these options are reliant on rainfall. The erratic pattern of rainfall in this environment means that fertiliser applications can often be wasted, and break crops are not successful. There are also major pasture establishment problems because of rainfall variability, which coupled with the self-mulching nature of the soils, often leds to establishment failure of small-seeded pasture species. Thus, transfer of the traditional crop/pasture rotation technology from southern Australia to this region is not successful. Pasture species are available that will persist in this environment but the establishment of these species is, and will continue to be, risky.

Despite the risk associated with all these strategies, there is an increasing awareness of the need to use them. In the past three to four years in the Walgett Shire, there has been an increase in the use of grain legume crops, and an increase in interest in available pasture species and their associated establishment technology.

CONCLUSIONS

The time frame in which these changes have occurred in the soils of the rangelands has not been clearly determined. Experimental work at Walgett demonstrated that one year of cropping on an area of previously natural pasture significantly reduced the organic carbon in the 0 to 0.5 metre layer within 12 months by 20 to 25% (Bowman and Chan, 1991). One season of cropping also significantly reduced the stability of these heavy clay soils. These effects are dramatic and occur rapidly.

The documented soil degradation is of concern to the region's farmers. This is a prime hard wheat growing area. Returns to producers come from the production of high protein wheat. With decreasing soil nitrogen, the protein levels of wheat are also falling. This means lower returns to growers, and reduced investment in the cropping system overall.

The farmers of the region are only too aware of the problems they face. However their desire to crop areas of the rangelands continues. There are now options available to these farmers to decrease the pressure they are placing on the soil resource, and the majority are aware of these options. Cropping in the rangelands will continue, and even increase, but cropping in future must not use the exploitive systems of the past. The years of large yields from this area are probably finished. In the future landholders will have to be good managers of the soil. They will have to work within the limits of these difficult environments to produce returns from cropping, while increasing the long term stability of the cropping system.

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