

## INTEGRATION OF CROPS AND LIVESTOCK

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Farming systems in Australia range from purely grazing enterprises through to intensively cropped farms carrying few or no livestock. .

The mixes of enterprises are by no means static (White et al. 1978). This has been illustrated by a trend towards increased crop production in traditional cropping districts and in areas where grazing has predominated from 1980 to 1986, with the reverse happening in 1987.

Farming systems that involve the rotation of crops and pasture are the norm in southern Australia. Traditionally, rotations have been practiced for reasons of soil fertility, crop hygiene, diversification of risk and the desire to produce a range of food and fibre products. There is little doubt that these reasons are still valid but, they have been modified by new financial constraints and needs.

In northern Australia, the feasibility of dryland agricultural development in the semi-arid and sub-humid tropical regions has been the subject of research for about 40 years. Until recently, when the focus has shifted to horticulture, the prevalent model envisioned has been an integrated dryland grain and beef cattle production system.

This contract acknowledges the complexity of crop and livestock integration and presents a computer model as a practical aid to account for the complexity. Various important aspects of crop and livestock integration from both southern and northern Australia are presented and many practical considerations are highlighted in the final contribution.

## MODELLING THE INTEGRATION OF CROP AND LIVESTOCK PRODUCTION

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Traditionally, economic analysis of crop-livestock farms has paid little attention to the interdependence of enterprises and has done little to account for the biological relationships of the farming system. MIDAS (Model of an Integrated **Dryland** Agricultural System) was developed to analyse the system with particular emphasis on interdependencies and biological relationships. It was developed for researchers to look at wholefarm economic implications of different research directions and for farm advisers to have a tool to analyse the **farm** systems.

## THE MODEL

MIDAS is a wholefarm mathematical programming model. It selects the profit maximising use of farm resources from about 400 variables representing alternative **ways** of running **enterprises** (e.g. fertiliser, **labour** and machinery), alternative enterprises and selling strategies. Profit maximisation is selected subject to about 200 constraints representing limited resources (areas of land of different qualities, available **labour** at peak times, finance and plant), biological relationships and logical relationships.

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MIDAS is distinguished from other mathematical programming models in its emphasis on:

- \* Enterprise interdependencies such as nitrogen fixation and other yield boosts following leguminous crops and pastures, stubble utilisation by sheep, the option of grain feeding sheep, the impact of cropping on subsequent pasture growth and the effect of pasture on subsequent crop weed control costs.
- \* Other important biological relationships such as diminishing returns to fertiliser, reduced yields for later seeding and conservational and disease limitations on stubble utilisation. Pasture and sheep nutrition parts of MIDAS specify monthly pasture and stubble growth, differences in quality between different types of stubble and different parts of stubble, the decline in quality and quantity of pasture and stubble over time and the feed-back of stocking rate on pasture growth.
- \* The model building and review process. Because of the large number of biological and other relationships, model building and review required the involvement of multi-disciplinary group of researchers, advisers, consultants and farmers. Specification of all inputs in 'user friendly' spreadsheet form has made MIDAS transparent, helping the model review process and allowing 'what if' questions to be answered easily.

In spite of its great emphasis on biological relationships, MIDAS does not represent the biology of the system in the same degree of detail as enterprise simulation models such as BREW (White et al. 1983). This is a consequence of modelling at the wholefarm rather than the enterprise level. For a more detailed description of MIDAS, see Morrison et al (1986a) and Kingwell (1987).

## RESULTS

MIDAS is seldom run simply to provide a single optimum solution but multiple runs are used for sensitivity analysis. Where a single run is used, account is taken of the shadow prices to indicate how close sub-optimal practices are to the optimum solution.

MIDAS has been used to analyse a wide range of issues, from a whole-farm perspective: for example, the value of nitrogen fixation (Pannell and Falconer 1986), development of pasture research priorities (Ewing and Pannell 1985), the value of stubble and stubble treatment (Pannell and Bennett 1987), the potential costs of skeleton weed (Pannell and Panetta 1986), the relative profitability of cropping versus livestock (Morrison et al. 1986a), the most profitable lambing time (Falconer and Morrison 1987), the value of alternative crops (Ewing et al. 1986) and the implications of seasonal variability for farm management (Morrison et al. 1986b).

Results illustrate the economic importance of the complementarity of cropping and livestock, and the deficiency of economic analysis which does not account for enterprise interdependencies (Morrison et al 1986a; Pannell 1987). They also indicate the potential error of a partial approach, showing, for example, that the most profitable structure for a sheep flock can be different when the wholefarm is analysed than a partial analysis of alternative structures would suggest (Falconer and Pannell 1986).

The MIDAS project has shown that it is possible to develop an **MP** model of a crop-livestock farm which accounts for enterprise interdependencies and higher level biological relationships.

**MIDAS's** use has shown it to be relevant to the Western Australian Department of **Agriculture's** research and extension programmes, providing a tool which gives wholefarm economic insight to researchers and advisers. Results indicate the economic importance of the **complementarity** of cropping and livestock enterprises.

## CROP AND LIVESTOCK INTEGRATION IN SOUTHERN AUSTRALIA

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To offset spiralling farm costs **today's** farmer must **continually** improve productivity. Hence the traditional clover/medic/crop rotation that is desirable from the viewpoint of soil fertility and diversification has been compromised for economic benefits over the last decade, resulting in a swing towards more cropping, and more recently the reverse.

Examples of the basic farming systems are:

A Traditional System:      P P P P W W O P P P P . . . .

A New System:              P P P R W L W W L W W L . . .

P = Pasture, R = Rapeseed, L = Lupins, W = Wheat, O = Oats.

## INTENSIVE (NEW) CROPPING SYSTEMS

In limited areas of Victoria (e.g. some **Wimmera farms**) and Western Australia particularly, there are **properties** where farmers sold all their livestock (often removed fences) and established **crop-crop rotations** during the 1980 s. .

The **major** problems of crop-crop systems are their effects on the soil. The need to intensify cropping must not be at the **expense** of long-term soil fertility or **indeed** crop hygiene, and therefore these relatively **new** cropping systems that **are** evolving must include grain **legumes** to maintain soil fertility, **oilseeds** and legumes to reduce the **build-up** of cereal diseases, minimum **tillage** to arrest the **breakdown** of soil structure and stubble retention to protect the soil surface. **Research** at Rutherglen Research Institute in Victoria, for example, **has** shown that wheat yields can **be at** least maintained under such **cropping** systems, whereas mono-cropping with normal cultivation resulted in **marked wheat** yield decline (Reeves et al, 1982).

The production of the grain legumes, particularly lupins and field peas, has increased markedly in recent years. Results from lupin-cereal rotations at **Esperance** in Western Australia and **Rutherglen** in Victoria have demonstrated the benefits of including a grain **legume** in the rotation, when intensive cropping is contemplated (**Poole 1983 ; Reeves 1982**).

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## LIVESTOCK INTEGRATION IN INTENSIVE CROPPING SYSTEMS

The usual situation in southern Australia is for intensive crop-crop rotations to be carried out on the better soils of a farm and for the remainder to be under pasture and grazed by stock. This has the advantage of maximizing returns from each class of land and allows flexibility in stock management of stubbles and weeds. On these farms the increased availability of grain legume products and minimum tillage machinery associated with the more intensive cropping have had beneficial effects on livestock production, in some cases more than offsetting the loss of pasture area available for grazing.

The value of grain legumes crop products and their residues (stubbles) to livestock is considerable. Lupins and field peas are the two crops that have had the most impact through the trend to more intensive cropping systems. Other legumes, such as chick peas and faba beans are now gaining attention. Comparisons in the value for sheep of a range of grain legumes, either the grain, the whole crop or the stubble have been made by Allden and Geytenbeck (1980, 1984).

Lupins have attracted the majority of research interest of the grain legumes. There is good evidence that lupin grain is an excellent feed for both sheep and cattle in a wide range of situations. Lupin stubbles are a particularly valuable feed for grazing sheep; Increases in lambing percentage of over 20% have been consistently recorded at Rutherglen for ewes mated on lupin stubble, compared with similar ewes mated on dry, annual pasture (Roberts and Kenney, pers. comm.).

Other benefits of lupins on livestock production include:- improved wool growth of sheep, faster growth rates of lambs and young cattle, better survival of drought-fed livestock, improved milk production in sheep and cattle (Smith and Kenney 1987).

Direct-drilling has reinforced the move toward crop intensification with its consequent reduction in total pasture area. Within this overall change in the area for grazing, direct-drilling results in an increased period when grazing is available. Heavy grazing with sheep prior to direct drilling is used to reduce the quantity of dry matter remaining in the paddocks so that it does not restrict the growth of the crop seedlings. This must be regarded as a potential conflict with the grazing enterprise because such heavy grazing may result in considerable weight loss of sheep and corresponding adverse effects on wool production.

## TRADITIONAL CROP-PASTURE SYSTEMS

Legume-based pastures in rotation generally increase soil nitrogen concentration, soil fertility and improve soil structure. In southern Australia this has directly contributed to two other soil problems that are threatening the stability of the ley farming areas, namely soil acidity and secondary soil salinity - the latter often as a result of waterlogging.

## LIVESTOCK INTEGRATION IN TRADITIONAL CROP/PASTURES SYSTEMS

Cannon (1974) showed that in comparison with land used for wool production alone, a system of dual land use involving wheat production as well, imposed a penalty on wool production and, at high stocking rates, a risk of animals falling to critically low liveweights. In other words, the availability of wheat stubbles for grazing during the summer did not

compensate for the reduced availability of grazing during the winter months. As previously discussed, where grain legume stubbles are available, this situation has changed somewhat.

The performance of both sheep and cattle grazing cereal stubbles depends mainly on the availability of spilt grain and green weeds in the stubble. Sheep are able to select far more intensively than cattle for these more nutritious components (Mulholland et al, 1977).

It should be possible, with skilled management, to sustain a ley-farming system indefinitely. The choice of enterprise mix is more likely to be made on economic grounds rather than on biological constraints. Dann et al. (1977) suggested improvements to the integration of crops and livestock through the winter grazing of cereals, and Reeves and Roseby (1982) also highlighted cropping techniques that are conducive to better animal production.

#### PASTURE SYSTEMS WHERE CROPPING IS BEING INTRODUCED

The expansion of cropping into traditional grazing areas - either high rainfall (650 mm) zones or the very low rainfall (350 mm) pastoral zones - has occurred during the last decade due to depressed returns from sheep, beef and dairy production.

Winter waterlogging is the greatest single barrier to increased crop production in the high rainfall areas (HRA); solutions to this have involved the selection of paddocks for cropping that have good natural drainage, often associated with a fairly significant slope. The cropping of this type of land poses the potential for serious erosion and it is already clear that conventional cultivation systems cannot safely be used. Summer crops have also been considered, but are generally restricted by spring frosts and lack of summer rain.

The other threat to soil fertility arising from an increase of cropping in the HRA is a compounding of the soil acidity problem. Many of the high rainfall zones in southern Australia have naturally acid soils. Indeed in much of southern New South Wales and in Victoria; pH (measured in water) can be as low as 4.0, yet despite this sub. clover persists. Recent research at Rutherglen has indicated that the survival of sub. clover on these soils is often associated with the buffering effects of the surface organic matter.

#### PROSPECTS FOR CROP-LIVESTOCK INTEGRATION IN NORTHERN AUSTRALIA

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##### BACKGROUND

In northern Australia, the most severe production constraint in the existing beef industry is the long dry season which reduces the productivity of all animal classes. The poor quality of natural forage at this time militates against the adoption of simple management, options such as weaning or preferential class feeding, and this further reduces efficiency. Research aimed at alleviating this dry season problem using pasture legumes has been successful in the semi-arid regions, typified by Katherine (Northern Territory), but unsuccessful in areas with sufficient moisture in the dry

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season to cause spoilage of the high quality dry leaf litter. Although in all cases increased cattle production on these pastures in the wet season occurs, the economics of this improvement are generally unfavourable.

The absence of a grain industry is due largely to (1) low returns from cropping due to high costs of production and marketing in this remote region and (2) high weather-related risks of low yields. These risks include unfavourable planting conditions or delay of land preparation and planting due to soil being either too wet or too dry, water stress during growth, and high costs of soil conservation structures adequate for this climatic zone.

#### RESEARCH PROGRAM

In 1977, a program of research was designed at Katherine to test a system of crop-livestock integration that seemed to offer synergistic alleviation of several of the above constraints (McCown et al. 1985). The main features are (a) self regenerating annual legume pastures of 1-2 years duration grown in rotation with maize or sorghum, (b) cattle grazing native pasture during the green season and then legume ley pastures plus crop stover during the dry season, and (c) crops planted directly into killed pastures. The major questions were: how much would animal production benefit; how much nitrogen does the legume ley contribute to the crop; does rotation with a non-leguminous crop reduce the grass invasion of the legume pastures; accepting the universal finding that no-tillage/mulch is very effective in soil conservation, what crop yield penalties might result?

#### RESULTS

Answers come from a number of separate studies including a 4 year grazing experiment in which steers grazing native pasture during the dry season lost 180 g/day while those grazing legume leys and crop stover gained 450 g/day (McCown et al 1986). This growth rate is considerably less than that possible from standover forage sorghum or winter cereals from areas with cooler climate and better soils in Central Queensland (Clewett et al. 1985). Although wet season compensatory gains often erode advantages gained by a dryseason input, there was an annual benefit of 30 kg for those steers grazing the legume ley and crop stover.

In general, 1-2 year legume leys contribute 40-80 kg/ha N to a subsequent maize crop (between one and two thirds of fertilizer requirement). Contributions to a second crop were about halved.

Grasses increased in the legume leys (which were ungrazed in the wet season) so that they comprised 5% of the dry matter in the first year and about 40% in the second, indicating that two years may be a maximum where there is no deliberate attempt to control grasses during the wet season.

Maize yields were generally, 20% higher with no-till than with conventional tillage, mainly due to improved crop stands.

#### THE FUTURE

, While it is clear that several important constraints are alleviated by this combination of practices, chances are slight that such a system can be profitable in the foreseeable future. Input costs have been reduced but are still high and, although some of the adverse environmental effects have been modified by better crop husbandry, they still pose a serious threat to economic viability.

At present an integrated crop-livestock enterprise appears to be technically feasible, particularly from the livestock viewpoint where the major limitation to animal growth, i.e., the poor quality of the native vegetation during the dry season, is able to be overcome. As an investment in a possible future period with more favourable economic circumstances, research on key issues of cropping in this climatic zone is continuing. These are: - analysis and management of climatic risk, the efficacy of natural mulches in improving crop environment and more efficient use of the legume N in cropping systems.

## A PRACTICAL APPROACH TO CROP-LIVESTOCK INTEGRATION

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Profitable integration of crop and livestock enterprises is an exciting objective for farmers in southern Australia. A lack of combined animal and crop husbandry skills, a fluctuating climate and unpredictable commodity prices make this objective a major management challenge.

### SOCIAL CONSTRAINTS

It is extremely rare to meet a farmer who has the skill to reach full potential in all enterprises on the farm. On mixed farms, particularly family farms, different family members pursue excellence in managing crops or livestock. This is purely a social problem but in fact can be a serious constraint to the profitable integration of both. Family members may compete against each other to better their enterprise rather than considering the 'good' of the farm.

### FARM PLANNING, "NO TWO PADDOCKS ARE THE SAME!"

The management policy for the farm must be based on the **capability** of each paddock. Managers have been **slow** to adopt a farming model which will allow each paddock to develop its true potential. Only paddocks with good fertility and soil structure should be committed to long term cropping rotations and even then managers must adopt husbandry to avoid soil degradation and improve fertility. Paddocks with difficult soils, subject to waterlogging should be converted into hard working perennial pastures - and stay that way. With good management, pastures of **Phalaris** and sub-clover can be highly productive over many years. Some re-fencing is leading to more successful integration of crop and livestock.

### NEW TECHNOLOGY

Adoption of new technology in crop production has had a definite **"spin-off"** into the livestock enterprise. A wide range of crop herbicides are now being used for pasture manipulation, renovation and establishment. The adoption of **direct** drilling is now spilling over into **pasture** improvement providing more robust system%. In some circumstances direct drill **pasture**-establishment is the only recommended system. Improved returns from wool will hasten the adoption of these systems and lead to better livestock productivity.

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Animal nutrition practices are being reviewed by many farmers and feed mixtures of grain legumes with cereals will pave the way for improved profitability from meat and wool.

### ECONOMICS

An integrated farming system has many economic advantages, the most important being income stability. This stems from having a range of commodities to sell at varying times of the year. Insulation against violent fluctuations within a market segment which can be caused by drought or a collapse of the commodity price. Cash flow is more even with crop incomes early in the calendar year and livestock income mainly in the second half. Other benefits include a sharing of farm plant, buildings and a more even utilisation of farm **labour**.

#### Benefits of livestock to the cropping enterprise

- \* A long pasture phase improves nitrogen status
- \* Soil structure can be enhanced during pasture phases
- \* Grazed crop residues are ideally suited to minimum **tillage** and direct drilling
- \* Rotation of crops and pastures conducive to breaking some pest and disease cycles

#### Benefits of cropping to the livestock enterprise

- \* Economic provision of fodder reserves such as oats, lupins and triticale. Hand feeding these grains will improve **the utilisation** of low nutritive value stubbles
- \* Grazing long seasoned cereal varieties can help **fill** in the winter feed **gap**
- \* Cropping in a pasture improvement program can help fill in the winter feed gap
- \* Value of lupin stubbles in lifting lambing percentages
- \* The cropping phase provides '**clean**' paddocks for grazing/minimising a build up of internal parasites

### THE MODEL ~~INTEGRATED~~ PROPERTY

#### . Land Utilisation.

- a) Perennial pastures in areas unsuitable for cropping. They are hard **working**, ideal for haymaking and drought tolerant.
- b) Clover leys which can be cropped from time to time. They build up a nitrogen reserve and provide a balance **in** pasture budgeting.
- c) Intensive cropping area on fertile, well structured soils.

#### Enterprise Selection - Livestock

- a) A Merino self replacing Merino ewe enterprise which utilises crop, residues and home made fodder to improve **lamb** and **wool** production.
- b) A Merino **wether** flock which works in concert with the cropping and pasture manipulation programs.

#### Enterprise Selection - Crops

- a) A **simple** range of crops does not dilute management effort or represent financial risk.

- b) Rotations which include cereals, rape and grain legumes. The rotation mix should be designed to minimise disease risks, improve fertility of the cropping area and provide fodder reserves and crop residues for the livestock enterprise.

## CONCLUSIONS

T.G. REEVES\*

There are still many areas of crop-livestock integration unresearched and unresolved. Very little work has been done on multi-enterprise farming systems research. That which has been carried out is often based on computer simulation of results from single enterprise research. Factors on integrated farms which need further immediate attention include:

- \* Optimum paddock sizes for crop-livestock integration (White et al. 1978)
- \* Better stubble utilization (e.g. Mulholland et al. 1976)
- \* Grazing of cereals
- \* Economics of various farming systems
- \* Relationships between pasture legume productivity and crop-livestock performance.

The majority of mixed farms are producing less than their true potential. Managers will have to work harder at the integration of crop and livestock enterprises as well as adopting the correct husbandry to maximise wholefarm profitability.

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