

Development of profitable milk production systems for northern Australia: an analysis of intensification of current systems

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Abstract. Milk producers in northern Australia are attempting to make rapid adjustments to production systems that enable them to compete in a newly deregulated market, although there is uncertainty about how to do this. Through industry consultation and expert review a process was developed to identify production systems that may be capable of supporting economic targets of 10% return on assets and 600,000 L milk/labour unit. A broadly based project team in terms of disciplines then used this process to identify five production systems which were each applicable to substantial numbers of current milk producers. These were modelled using whole farm economic analyses and annual feed planning, using an iterative process over an extended period, to determine the economic and physical parameters of each system when achieving the above economic targets.

All five systems achieved substantial increases in milk output from present natural resource bases, and require herd sizes from 280 to 900 cows to achieve targets. The models showed a high sensitivity to return on assets in relation to milk price, herd size and milk yield per cow, and less sensitivity to variation in input costs. It was concluded that substantial increases in milk output from farms are needed to meet economic criteria, and that the natural resource base is capable of supporting these increases. The financial risks of such increases largely relate to the difficulties in maintaining cash flow during a period of rapid capital investment and expansion. It is also accepted there are environmental risks if such rapid development takes place, though these require further quantification.

Keywords: farmers, learning, farm management education.

Introduction

Deregulation of the Australian dairy industry in northern Australia in July 2000 resulted in a 25% reduction in farm gate milk price, and the need for major changes in farm business strategies (Parker et al. 2000; Busby et al. 2002). Under the previous regulated environment, producers supplied milk to a quota which attracted a relatively high price, and much of the financial focus was on cost containment. With the removal of quota and the reduction in milk price, producers could not maintain net income from the present level of milk production, and the focus changed to the ability of farm businesses to maintain net income through rapid and relatively large increases in total milk production. This change was unacceptable to many producers, who continued to reduce costs through a minimalist approach using low input, pasture based systems of production. However the opportunities to maintain net income through this approach appear limited (Busby et al. 2002), and a small number of farms began a rapid increase in milk output.

Dairy systems in the subtropical regions of northern Australia are complex compared with those in southern Australia and New Zealand. The warm, wet summer months provide an ideal environment for high yields of generally lower quality C4 forage species as perennials, while in winter the temperatures are ideal for growing high quality temperate species as annuals, as long as irrigation is possible. In fact growth rates of irrigated ryegrass during the relatively warmer winter months in Queensland may be two to three times that achieved in Victoria (Lowe and Hamilton 1985). However, the changeover seasons of late spring and autumn are usually characterised by feed shortfalls. Autumn temperatures slow the growth of tropical species, and temperate pastures are being established. In spring, dry conditions restrict the growth of tropical pastures. The combination of tropical and temperate pastures, with conserved forages, grains and by-products, are used to supply a continuum of milk production throughout the year, as required under the quota supply arrangements (Cowan et al. 1998).

Proposals for change in production systems have focused on increasing milk output (Hoekema et al. 2000). Analyses of present production systems have shown only modest potential to reduce costs (Hoekema et al. 2000; Cowan 2000) and for the majority of milk producers there is no option but to demand an increase in milk price (Issar et al. 2003). Analyses of farms show a high potential for increased milk output, as farm paddocks were assessed as producing approximately one-third of achievable production, defined as that achieved by 10% of farms (Kerr et al. 2000), and cows and infrastructure are being used well below their potential (Cowan 2000). Busby et al. (2002) observed a linear relationship between percentage return on assets and total farm milk output. However there is considerable confusion among milk producers about the appropriate path of farm development under a regime of low milk prices and rapid adjustments in the processing and retailing environment.

The present paper describes a process of identifying viable milk production systems for northern Australia using desktop models. Milk producers were consulted in a group process and from this a range of potential production systems was identified. Biological and economic criteria were then used to prioritise five systems suited to substantial proportions of milk producers. Each of these systems was modelled to achieve target levels of economic performance and the resultant production system described. In the present analysis the assumption is made that increasing profit will improve the standard of living and lifestyle for farm families. Current research to test these hypotheses and models in practice has commenced using farmlets and the monitoring and involvement of commercial dairy enterprises.

Industry consultation to identify factors limiting dairy production in northern Australia

During 1999, six meetings were held with milk producers in regional areas of Queensland and northern New South Wales. These meetings were held to prioritise the research requirements for dairy farmers, under the auspices of the Subtropical Dairy Program. The meetings involved farmers, milk processors, agribusiness representatives and extension officers. As an initial meeting participants were asked in turn to nominate areas for research. These were listed and condensed where possible, then used in a group discussion of priorities. There was strong interest in what are the limits of a pasture-based system, both rainfed and irrigated, and whether these limits are substantially extended by incorporating crops in place of pastures. Are pasture-based production systems more or less profitable and sustainable than cropping-based systems? The amount of utilised forage grown on-farm is recognised as the key driver for retaining profitability (Bake et al. 2000). The challenge is to determine the most profitable system to increase herbage production and utilisation, and the impact on whole farm efficiency. Areas of interest that were similar in objective were integrated further, some issues that could not be physically researched on a dairy farm were deleted, and the list refined (Table 1, see Appendix). This revised list was then presented to each of the same six groups and members asked to cast their votes and rank in order of importance those topics that would have the greatest beneficial impact to dairy production. Groups consisted of approximately ten members and each member was allowed two votes. Forage system and calving pattern were selected as the priority areas requiring research, with a mean of 34 and 25% support respectively (Table 2, see Appendix). There was substantial support for investigating alternate farming methods which may enhance environmental and marketing aspects of dairy farming. One group emphasised the need to research animal breeds. A number of lower scoring areas have elements in common with forage systems, such as water use efficiency, fertiliser levels and pasture management.

Review

The output from the industry consultation phase was put to an expert review team, with the purpose of defining a process for the incorporation of the suggestions into potential farming systems. This team read the outputs of the industry consultations, and over two days developed recommendations for the development of relevant production systems. The team comprised two dairy farmers, and an academic specialist in each of farming systems research, production systems, environmental management and adult learning. The review team was commissioned in August 2000 by the joint stakeholders in the research project, Dairy Australia, Queensland Department of Primary Industries, Queensland Department of Natural Resources and Mines, and the review conducted on the 28 and 29th August 2000.

Guidelines for the review included the recommendations that any further research:

- Provides a learning platform within a systems context for farmers, extension and research professionals.
  - Ensures that water use takes pre-eminence. Water allocation could be the main variable and other aspects of the farming system developed around this.

- Takes into account the needs identified by the regional groups in relation to assessing forage systems with an increasing level of cropping, and challenge the farming, research and extension communities in regard to stocking rate and water use efficiency.

The recommendations from the review were that the farming systems should aim for high profitability, and use key resources efficiently in a way that is acknowledged as sustainable by the wider community. To support this process a target orientated approach to project development was recommended, and this should be framed in terms of farm profitability. The following goal was set as appropriate to this study:

- To achieve an annual return on assets of 10% and a labour efficiency of 600,000 L milk/labour unit.

The process of identifying production systems that may achieve this goal would be through the use of a decision tree, based on the major variables identified in industry consultation. These key variables were irrigation water availability, use of crops compared with pastures, quality or quantity of forage production, grazing or cut and carry of forage, and high or low purchase policy for off-farm concentrate feeds.

Identifying production systems

A project team was developed to follow this process through to identification of production systems capable of meeting project goals. The team comprised a leader (specialised in shed design, milking systems and herd health), a farm manager, a spreadsheet (Microsoft Excel) specialist, and specialists in the disciplines of production systems, water efficiency, environmental sustainability, farm accounting, and extension practice. Each member of the team had substantial experience in working with Queensland dairy farmers. A steering committee consisting of three dairy farmers representing south east Queensland and northern New South Wales, consultants from each the two major milk processors, and a senior Departmental Research and Extension leader was formed to oversee the process, and the project team reported to this committee each 6 months.

Using the guidelines suggested, the project team constructed a decision tree detailing the various options for milk production systems. Forty-eight potential combinations were identified, using three levels of irrigation (nil, low or high), and two of each of forage quality (low or high), type (cropping or pasture), method (grazing or harvesting), and level of purchased feed (low or high). These were separately analysed by the team, and combinations thought to presently exist or have potential to meet the goals with the resource base were identified. Combinations that did not appear possible in the environment of northern Australia, for example a high quality pasture and a low buy in of concentrates policy, were rejected. From this analysis a table of potential production systems was constructed (Table 3, see Appendix), and each scored in relation to the potential to achieve the goals and for the number of farms the system was likely to be relevant to. The inability to grow large amounts of high quality forage without irrigation, and the difficulties of grazing intensively irrigated crops, meant that some combinations were not relevant to dairy farms in northern Australia. Those systems that were applicable to a substantial number of farms were each considered feasible for development.

In considering which of these options should be closely investigated the potential impacts on environmental sustainability were also considered. The key environmental issues confronting subtropical dairy farms in Australia are soil erosion and nutrient leaching into waterways (Gramshaw and Carter 2000), and each system was assessed for the potential pollution in these ways. A particular aspect relevant to the subtropics is the need to provide shade for cows concurrently with access to pastures, and this has relevance for nutrient leaching as cows congregate under shade. The financial requirements to manage these problems were also included in subsequent economic analyses.

Of the eight combinations considered viable it was considered that option four had much in common with seven, and 10 with 14. Option 12 was not seen as viable in the future, as it is most likely that a grazing system with intensive irrigation would be used to grow high quality pasture, rather than low quality. This analysis resulted in five production systems considered relevant to a substantial proportion of dairy farms, capable of meeting economic goals and likely to be environmentally sustainable under subtropical conditions (Table 4, see Appendix). Farm 2 is similar to the majority of present production systems, and in recent years there has been a rapid decrease in the number of farms similar to farm 1. A heavy emphasis on irrigation has meant an increase in farms similar to farm 4, and there are a small number of farms developing along the lines of farm 5. Farm 3 relates to the western regions of the dairy industry, where approximately one-third of farms are located, and specialises in the use of grazed crops as a forage source.

Specifying the production systems

An economic spreadsheet model was developed which enabled the farm description, land and water inputs, human resources, herd and stock sales, production, fertiliser and grazing inputs, purchased feed, and financing to be input as separate sheets and then linked to an overall analysis sheet. This model was initiated using inputs from five farms similar to each of the five farms proposed in Table 4 (see Appendix). Mean inputs were identified from the Queensland dairy farm accounting scheme (Bake et al. 2001), as were those costs not directly linked to the changes in inputs, such as shed costs. The project team worked through an iterative process of using the model to alter investments in this farm, assess the feasibility and sustainability, and identify cost areas requiring further investigation. This process was done through three-hour meetings each week, with appropriate work between, over a period of six months. The project team examined the sensitivity of the models by varying inputs and testing a range of scenarios. Inputs that had a high level of sensitivity included milk price, cow numbers, milk yield/cow, level of supplementary feeding and amount of conserved fodder. Conservative values were assigned to each of these variables in the presented scenarios. Throughout this process the objective was to specify the farm investment necessary to return a 10% return on assets and 600,000 L milk/labour unit. Scenarios that were thought to be realistic by the team and most closely achieved these goals were then put forward to the steering group for consideration.

In each farm model annual inputs of feed were matched with annual requirements. As an added check on the feasibility of each farm, monthly assessments of feed inputs were calculated and also matched with monthly requirements. These assessments were based on locally generated growth rates for crops and pastures (N. Gobius unpublished), nutrient contents of home grown and purchased feeds (RUMNUT 1998; CAMDAIRY 1996 feed libraries for Queensland), and nutrient requirements of cows (NRC 2001). Rates of utilisation of these feeds and response of milk production to supplement inputs were taken from local experience (Cowan et al. 1993; Fulkerson et al. 1993; Kaiser et al. 1993; N. Gobius unpublished) and locally developed knowledge incorporated in decision software (Kerr et al. 1999a and b).

Farm description

The feedbase of the selected production systems represents a cross section of the Queensland dairy industry, and was the governing factor in determining the location of these systems. For instance, the full feedlot farm 5 with an intensive system of crop production and total confinement of cows required low rainfall and humidity to minimise animal heat stress and nutrient runoff, and had to be in a cropping area and close to large stores of grain (Table 5, see Appendix). The high quality pasture farm 4 was located in the mild climate of the coast where rainfall is relatively high (>800 mm/annum). The conditions are favourable for the growth and persistence of high quality temperate perennial pastures that make up the greater proportion of the feedbase. The high quality crop farm 3 requires a large proportion of the farm to be arable land and greater than 600 mm/annum rainfall. The location of the limited-irrigation farm 2 and rainfed farm 1 are less restrictive, needing only annual rainfall greater than 800 mm for the production of rainfed pastures and forage crops. In general, pasture-based farms are located in coastal areas and crop-based farms from 100 to 300 km inland of these. There are substantial limitations in confining cows, and in the agronomy, conservation of, and nutrient management of crops, in the humid coastal environment (Ashwood et al. 1993).

Total stock for each farm ranged from 280 for farm 1, 360 for farms 2, 3 and 4, and 900 for the feedlot farm 5 (Table 5, see Appendix). Stocking rate (head/ha) and milk yield (litres of milk/cow) varied from 1.4 and 7,300 for farm 3 to 3.9 and 9,650 for farm 5. The number of labour units and litres of milk production/labour unit ranged from 3.1 and 584,000 for farm 1 to 9.4 and 797,000 for farm 5. Compared to current industry averages, relatively high stocking rates and milk production per cow were essential in achieving the economic goals.

The calving pattern for each farm was determined by the type of feed system and milk sales contract agreement with the milk processor. For example, farm 5 would supply a constant level of high quality forage using a total mixed ration, enabling an all year calving pattern (Table 5, see Appendix). Annual milk production for this farm was in excess of 7 million litres and monthly output was constant. The milk processor offers a price incentive compared to the other farms (Table 7, see Appendix). Farm 4 produces the bulk of its forage during the cool winter/spring seasons, and to take advantage of this high quality forage and a premium milk price normally offered at this time of year, 65% of the herd calves during autumn. Similarly, farm 3 calves 70% of its herd during autumn. Farm 2 calves equal number during two periods, in May/June and

November/December, to take advantage of the growth rates for the temperate and tropical herbages that make up the feed base for this system. The rainfed farm 1 was limited to calving predominantly in spring just prior to the tropical pasture and forage crop growing season. Because much of the milk is produced during summer and the monthly milk yield is more influenced by rainfall than in other farms, the milk price received by this farm is relatively low (Table 7, see Appendix). Milk price thus reflects the proportion of milk produced during winter, and the continuity and volume of supply.

Farm 3 has the largest allocation of land with 260 ha, 220 of which is fully cultivated (Table 6, see Appendix). This reflects the lower value of rainfed farms away from the coast. Farm 5 is also in this region, but has a high proportion (90%) of the farm irrigated. Farm 4 has the least amount of area with 120 ha, but with 90% of the farm irrigated. Farms 2 and 3 have relatively small areas of irrigation (20 and 10% respectively), the situation most often occurring on farms in Queensland (Kerr et al. 1996). Each ha of irrigable land was allocated 6 ML of water annually. The composition of pastures and crops on each farm varied markedly, from tropical grass pastures and forage oats for farm 1, annual ryegrass and tropical grasses for farm 2, annual and perennial temperate pastures and summer forages for farm 4, and temperate and tropical forage crops for farm 5. Farm 3 has the most complex feed mixture, with annual and perennial ryegrass, lucerne, oats, forage sorghum and lablab. All farms have high inputs of fertilizer, and received the equivalent of 3 t DM/cow/year of complementary feeds.

Although farm 5 has the greatest accumulated value in assets of $3.3 m and a relatively low equity, return on assets was high at 20.3% and return on equity at 36% (Table 7, see Appendix). Of the grazing farms, the relatively low land value of farm 3 resulted in a high return on assets, and the low milk price received by farm 1 make it difficult to attain the 10% return on assets. Though less for farm 1, all farms have a relatively high capital input in addition to land, water and stock. A sensitivity analyses of return on assets showed that the factors having the most impact for anticipated ranges in value were milk price, stocking rate, and production per cow.

As a cross check on the feasibility of production systems 1 to 4 through the year, the monthly feed supply was compared with animal requirements. Pasture and forage crop production was calculated for each month and compared with requirements calculated from NRC (2001) (Figure 1, see Appendix). Farm 1 has a large deficit of forage growth during winter and early spring, while farm 2 experienced a shorter feed deficit in late autumn. Farm 3 experienced a modest deficit throughout winter and spring, while farm 4 showed a similar deficit throughout summer and autumn. Each production system has a surplus of forage growth for 4 to 6 months of the year. A combination of fodder conservation within the production system and purchase of fodder (farms 1 and 2) are used to supply forage during periods of deficit.

Discussion

Each production system was assessed as capable of a large increase in productivity compared with present industry averages. The systems modelled had a similar resource base to current averages, and supported up to a three-fold increase in productivity. Stocking rates on irrigated and rainfed pastures of Queensland dairy farms are in the order of 5 and 0.5 cows/ha respectively, and milk output 7,000 and 2,000 kg/ha respectively (Kerr et al., 2000). Milk output over the whole farm area was in the order of 4,000 L/ha/year. Forage to grain ratio in the diet varies from 90:10 to 40:60, with an average of 60:40 (Kerr et al. 1996). This ratio is similar to that modelled in the current scenarios, demonstrating that increases in productivity have not been achieved by a relative increase in the grain and byproduct inputs, but through increases in forage productivity. The increased forage yields supported up to 4 cows/ha. Kerr et al. (2000) also concluded that the average dairy farm was producing approximately one-third of the yield considered achievable based on the top 10 percentile of farmers. The potential for high forage output on sub-tropical farms is well documented (Colman 1971; Lowe and Hamilton 1985). The predicted increase in yield and utilisation of pastures and crops on farms enabled proportionate increases in inputs of complementary feeds such as grains and byproducts and cow numbers.

In our analyses we were unable to demonstrate acceptable levels of profitability on farms with current levels of production. The median level of milk output on current farms is approximately 750,000 L/year, and at this level our models were unable to achieve return on assets levels above 3 to 4 %. This is a reflection of the complex and labour intensive nature of current production systems. Farm 2 is most common in practice (Moss and Lowe 1993), and this system requires a high input of labour to maintain year-round production from a mixture of temperate and tropical forages (Cowan et al. 2003). Analyses of farm accounting data have shown that the potential to cut costs on these farms is insufficient to enable large gains in profitability (Busby et al. 2002). On average, farms could save $11,000 per annum by achieving cost efficiencies equivalent to the top 10 percentile of farms, and this has only limited impact on return on assets. Consequently the models have demonstrated a need to almost triple milk output to enable the required level of profitability to be achieved. Ashwood et al. (1993) predicted a need for substantial increases in milk output from northern Australian dairy farms to maintain economic viability. This is consistent with many other primary industries and with dairy farm experience in other regions. For example in Victoria, where the industry has effectively been deregulated for many years, herd sizes have grown to double those in Queensland (Fulkerson and Doyle 1999). An even more rapid increase in herd size has occurred in New Zealand. The effect of deregulation of the Queensland and New South Wales dairy industries has been to expose them to the same economic forces that farmers in Victoria and New Zealand have been responding to continually for 30 years. The regulated marketing system isolated Queensland and New South Wales farmers from these forces until the year 2000, and now rapid adjustments are needed if these farms are to compete successfully.

The benefits of involving farmers in research to encourage industry engagement and learning for scientists and farmers has been well documented (Paine et al. 2002; Oenema et al. 2001). In this project farmer involvement was through the initial industry consultations, and membership of the review team and steering committee. Both the SRT groups and the steering committee emphasized the need for the modelled systems to be profitable, and strongly endorsed our target-based approach to modelling. Feeding systems and seasonal calving pattern were selected by the regional groups as areas of research that would have the greatest impact on profitability, and the review process added the focus on water use efficiency in the desktop modelling. The steering committee assessed the farm system scenarios developed by the project team, and proposed adjustments to best achieve the project's objectives. The process has resulted in strong industry interest in current research to test the proposed scenarios in practice (Andrews et al. 2003).

The rapid adjustment and increased intensification of the business each increase risks for dairy farmers. The achievement of rapid increases in milk output requires a substantial increase in debt levels and the harnessing of additional management skills. The level of equity remains relatively high, at least in the grazing systems, and the major economic risk is probably associated with maintaining the cash flow projected during the expansion phase, and this in turn is dependent on the management skills of the farmer and the quality of advice available. These skills have been developed in a regulated market environment, where production was required to be consistent in each month of the year and increased cash flow was obtained through government legislated price increases in line with consumer price increases each quarter. As a consequence of this experience, many farmers do not feel confident of making such changes and have exited the industry or remain unsure of future plans (Todd et al. 2003). Those who have accepted the challenge are now dealing with the risk associated with rapid intensification. Brockington et al. (1992), using modelling techniques to assess changes to small scale production milk systems in east Brazil, demonstrated a period of risk after substantial change, which was usually followed by a new, more stable equilibrium. The scenarios proposed in the current paper require large quantities of purchased feed and stocking rates at a level where any restriction in forage growth results in further purchases of hay or silage. This has been clearly demonstrated during the recent drought in Australia. Farm production of forage was substantially reduced, and the cost of purchased fodder and grain increased by 170 and 100% respectively. This has resulted in negative cash flow on almost all those farms making rapid increases in productivity, and demonstrates some of the risks associated with rapid expansion.

Trebling milk output of current farms, through the rapid increase in stock numbers and intensive irrigation and fertilizer inputs to pasture and crop, has the potential to increase the amount of nutrient runoff and leaching. For instance, the modelled limited-irrigation farm 2 is calculated to have 300 kg N/ha brought in from off farm via urea fertilizer and complementary feeding, compared to 100 kg N/ha with the high quality crop farm 3 (Table 6, see Appendix). The additional costs associated with the management of increased nutrient loads, from feeds, fertilizer and animal waste, is being considered in our current physical research.

All systems, including those based on high proportions of irrigated pasture, required high inputs of grains and/or byproducts to meet the objective of 10% return on assets using existing costs of production and price paid for milk. This was counterintuitive to many members of the development team, who felt that maximising pasture inputs and minimising purchased feed inputs would result in high profit. However sensitivity analyses on the models showed that return on assets was most responsive to milk price, milk yield per cow, cow numbers and labour costs. Milk price was not under the control of the production system. Cow numbers were determined by the quantity of forage grown, and the model in effect maximised the cow numbers for the amount of forage grown. Given this, increases in milk output per cow had a direct effect in reducing labour, overhead and debt costs per litre of milk, and these effects were directly reflected in return on assets. Changes in milk yield have a multiple effect on cost, whereas changes in input costs such as grain do not and the model was relatively insensitive to 50% variation in grain price. Changes of up to 50% had only minor effects on return on assets. However, as noted above, real changes during the drought have been much larger than this and contributed to negative cash flow. Extreme changes in input costs therefore do reduce profitability, but within the normal range of prices the model shows that profitability is increased by a combination of high inputs of feed in association with high stocking rates.

In the initial consultation with industry, seasonal calving was rated as a high priority for investigation, on the basis that this may reduce costs. Such a move is not favoured by the fresh milk processors, as the industry is based on a continuous supply of fresh milk. The economic modelling of the present production systems has demonstrated that calving pattern is a consequence of the production system adopted, and allows some understanding of the choice between a production system based on a market contract and one based on the natural resource base. In the regulated market system a similar market contract, a minimum daily quota, was set for all farmers and costs were incurred in developing a feed base to ensure this output. In the deregulated environment farmers have choice of market contract, and there is the opportunity to select one that enables a production system driven by the natural resource base. The milk output pattern from farm 1 is highly dependent on the seasonal pasture growth pattern. The present models reflect the range of systems feasible under northern Australian conditions. They share the principle of optimising forage production and utilisation from the natural resource base, and complementing this with purchased concentrates, but milk supply patterns differ markedly. In general it is likely that a more consistent supply pattern will attract a milk price premium, but the natural resource base will set limits on the extent to which a farmer is able to attract this premium. Many farmers may feel limited to one of the options present in this paper.

The testing of these desktop models in practice is the subject of current research, where the ecological and sociological impacts of trebling production are being compared.

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References

Andrews RJ, Busby GJ, Callow MN, Chataway RG, Cowan RT, Todd H, Walker RG, and Waters WA 2003, 'Sustainable dairy farm systems for profit', *Australian Farming Systems Conference,* Toowoomba, Queensland.

Ashwood A, Kerr D, Chataway R and Cowan T 1993, 'Northern dairy feedbase 2001. 5. 'Integrated dairy farming systems for northern Australia', *Tropical Grasslands,* 27 (3), 212-228.

Bake G, Busby G, Hetherington G and Itzstein R 2000, *'New century new dairy industry: 1998-99 South-east Queensland production costs and returns'*, Queensland Department of Primary Industries, Information series, QI00005.

Bake G, Busby G, Hetherington G, Itzstein R and Thorburn L 2001, '*Dairy deregulation one year on: Queensland financial and production trends 2001'*, Queensland Department of Primary Industries, Information series, QI02009.

Brockington NR. Veil JM and Zoccal R 1992, 'Herd dynamics and management strategies for small scale milk production systems in southeast Brazil', *Agricultural Systems* 39, 201-225.

Busby G, Hetherington G and Itzstein R 2002, *'Building a better dairy business: QDAS financial and production trends 2002',* Queensland Department of Primary Industries, Information series, QI03005.

Colman RL 1971, 'Quantity of pasture and forage crops for dairy production in the tropical regions of Australia', *Tropical Grasslands* 5, 181-194.

Cowan RT, Moss RJ and Kerr DV 1993, 'Northern dairy feedbase 2001. 2. Summer feeding systems', *Tropical Grasslands* 27 (3), 150-161.

Cowan RT, Moss RJ, Goodwin PG and Fulkerson WJ 1998, 'Efficiency in feeding systems for subtropical dairy production', *Proceedings of the 1st Australian Society of Animal Production* 22, 125-128.

Cowan RT 2000, 'Trends in feeding systems for dairy production in the subtropics of Australia', *South African Society of Animal Science Congress*, Kwazulu-Natal, 223-235.

Cowan RT, Amenu B, Issar G, Todd H, Martin M, Hoekema M and MacLachlan BP, 2003, 'Developing competitive milk production systems in the subtropics', *Proceedings 1st Australian Farming Systems Conference*, Toowoomba, Queensland.

Fulkerson WJ, Lowe KF, Ayres JF and Launders T 1993, 'Northern dairy feedbase 2001. 3. Winter pastures and crops', *Tropical Grasslands* 27 (3), 162-179.

Fulkerson WJ and Doyle P 2001, *'The Australian Dairy Industry'*, the State of Victoria, Department of Natural Resources and Environment, ISBN 0731147650, pp. 56.

Gramshaw D and Carter D 2000, 'Dairying "Better 'n Better". Resource management practices: sustainability from cow to catchment', *Proceedings of the Australasian Association of Animal Production – Australian Society of Animal Production satellite conference, "Profitable dairy production in the tropics"*, University of Queensland, Gatton, pp. 17-24.

Hoekema M, Jelbart M, Clark D and Worsley A 2000, 'Future farming systems – options for a deregulated market', *Final report to the Dairy Research and Development Corporation*, August 2000.

Issar G, Cowan RT and Wegener M 2003, 'Success strategies being implemented in fresh milk supply chains', *Proceedings of the 14th International Farm Management Congress*, Perth, 528-537.

Jones BB, Kellaway RC and Lean IJ 1996, 'CAMDAIRY 1996, development of the Camdairy nutritional management model', *Proceedings of the Australian Society of Animal Production* 21, 270-273.

Kaiser AG. Havilah EJ, Chopping GD and Walker RG 1993, 'Northern dairy feedbase 2001. 4. Feeding systems during winter and spring', *Tropical Grasslands* 27 (3), 180-211.

Kerr D, Davison T, Hetherington G, Lake M and Murray A 1996, *'Queensland dairy farm survey 1994-5'*, Summary Report, (QI96115, DPI Brisbane).

Kerr DV Cowan RT and Chaseling J 1999, '*DAIRYPRO* - A knowledge based decision support system for strategic planning on sub-tropical dairy farms - I. system description', *Agricultural Systems* 59 (3), 245-55.

Kerr DV, Chaseling J, Chopping GD and Cowan RT 1999, '*DAIRYPRO* - A knowledge based decision support system for strategic planning on sub-tropical dairy farms – II', *Validation Agricultural Systems* 59 (3), 257-66.

Kerr DV, Pepper PM and Cowan RT 2000, 'Estimates of achievable milk production on subtropical dairy farms in Queensland', *Australian Journal of Experimental Agriculture* 40 (6), 805-811.

Lowe KF and Hamilton BA 1985, 'Dairy pastures in the Australia tropics and sub-tropics', *Proceedings third Australian conference on tropical pastures*, Rockhampton, (eds. Murtagh. M.G.J. and Jones, R.M.), Tropical Grassland Society of Australia, Occasional Publication number 3.

Moss RJ.and Lowe KF 1993, 'Development of irrigated forage systems for dairying in subtropical Australia', *Proceedings of the 17th International Grasslands Congress,* Hamilton NZ/Rockhampton, Australia, 1191-1193.

National Research Council 2001, *'Nutrient requirements of dairy cattle',* National Research Council, 6th revised edition, National Academy Press, Washington, DC.

Oenema J, Koskamp GJ and Galama PJ 2001, 'Guiding commercial pilot farms to bridge the gap between experimental and commercial dairy farms; the project Cows and Opportunities', *Netherlands Journal of Agricultural Science* 49 (2-3), 277-296.

Paine M, Weatherly J, Crawford A and Champion S 2002, 'Farmlets as learning platforms: a national approach to farming systems research, development and extension in the Australian dairy sector', *Proceedings of the Fifth IFSA European Symposium*, Florence, Italy, pp 729 – 738.

Parker A, Woodford K and Woods E 2000, 'Deregulation and restructuring in the Queensland dairy industry', *University of Queensland, School of Natural and Rural Systems Management, Occasional* Paper 7(2), 28.

RUMNUT 1998, *'RUMNUT Dairy version 4'*, copyright AT Chamberlain 1998.

Todd HL, Cowan RT and Paine MS 2003, 'Sustainable dairy farm systems for profit - social implications of intensification of family dairy farms', *Proceedings 1st Australian Farming Systems Conference*, Toowoomba, Queensland

Appendix

Table 1 (see Appendix). Areas selected as suited to dairy farm research and submitted to the six regional industry groups for priority setting

Option	Research areas
Forage systems	Compare grazed pasture/grazed cropping/harvested cropping; stocking rates, fertiliser inputs levels, (seasonal calving), rainfed *vs.* irrigation, supplementation levels of minerals and concentrates. Improvement and management of grasses, native, naturalised and improved e.g. prairie (*Bromus unioloides*), Queensland blue grass (*Dichanthium sericeum*), combinations, alternatives to cultivation. Litres per cow in relation to capital and labour. Heifer rearing systems. Cost benefit of milking 2 or 3 times/d.
Calving pattern	Seasonal/batch/continuous calving, to minimise production costs, take advantage of milk price incentives.
Fertiliser levels	Optimum rates, most efficient crops.
Sustainable farming systems	Antibiotic *vs.* no antibiotic, mineral *vs.* alternate fertilisers (especially Ca), organic *vs.* inorganic farming, tillage methods, legume *vs.* N fertilised systems.
Breeds	Breed comparisons.
Water use efficiency	Rainfed *vs.* irrigation, irrigation systems, irrigation techniques, rainfed water efficiency.
Pasture management	Heifers on grass, clover ratios in ryegrass, leaf stage and grazing.
Recycling of nutrient	Particularly when no access to irrigation, methods.

Figure 1. The adequacy of forage growth to meet forage requirement in each month for the (◇) rainfed farm 1, (O) limited irrigation farm 2, (X) high quality crop farm 3 and (+) high quality pasture farm 4 (Table 6, see Appendix)

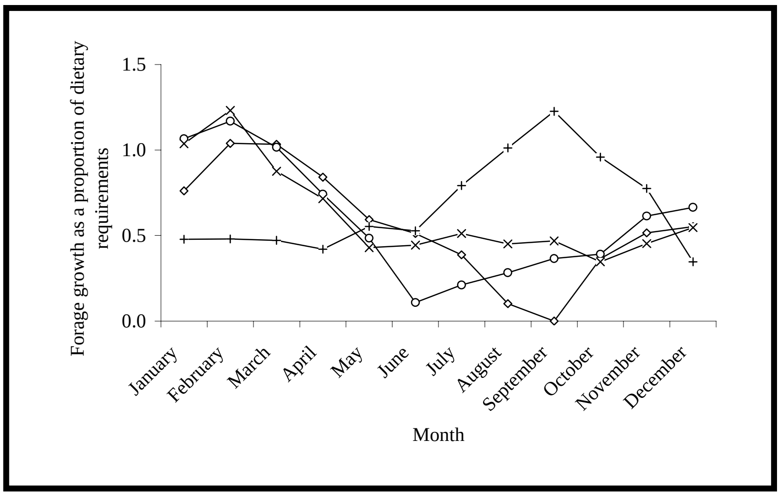

Table 2. The allocation of votes to determine the level of importance a range of research areas for each regional industry group

Option	Research area	SRT group	Votes within group (%)	Mean
1	Forage systems	**South Burnett**	38	
		Rockhampton	57	
		Urunga	26	
		South East Queensland	42	
		Darling Downs	42	
				34
2	Calving pattern	South Burnett	19	
		Rockhampton	10	
		Urunga	31	
		South East Queensland	21	
		Darling Downs	21	
		Casino	40	
				25
3	Sustainable farming systems	South Burnett	23	
		Rockhampton	28	
		Urunga	7	
		South East Queensland	26	
		Darling Downs	26	
				18
4	Fertiliser levels	South Burnett	10	
		Urunga	26	
		Casino	27	
				10
5	Water use efficiency	South Burnett	10	
		South East Queensland	11	
		Darling Downs	11	
				5
6	Breeds	Rockhampton	5	
		Casino	33	
				6
7	Recycling nutrients	Urunga	5	
				1
8	Pasture management	Urunga	5	
				1

Table 3. Potential milk production systems for northern Australia based on the resources available, their relevance to present farm numbers, and potential to achieve economic goals

Option	Water allocation	Crop type	Quality	Harvest method	Buy in policy	Relevance (number of farms)	Goal achievable
1	Nil	Pasture	Low	Grazed	High	200	
2	Nil	Crop	High	Grazed	High		
3	Nil	Crop	High	Harvested	High		
4	Nil	Crop	Low	Harvested	High	200	(Combine with 7)
5	Low	Pasture	Low	Grazed	High	1,000	
6	Low	Pasture	High	Grazed	High		
7	Low	Crop	Low	Harvested	High	200	
8	Low	Crop	High	Grazed	High		
9	High	Pasture	High	Grazed	Low	300	
10	High	Crop	High	Harvested	High		(Combine with 14)
11	High	Crop	High	Grazed	Low		
12	High	Pasture	Low	Grazed	Low	700	
13	High	Crop	High	Grazed	High		
14	High	Crop	Low	Harvested	High	200	
15	High	Pasture	Low	Grazed	High		

Table 4. The five production systems identified as relevant, potentially sustainable and able to meet economic goals

Farm	Option from Table 3	Level of irrigation	Forage source	Grain feeding strategy
1	Option 1	Nil (Rainfed)	Perennial tropical grass (grazed)	Heavy grain feeding (perhaps 3 tonnes per cow) and some purchased haylage or silage
2	A combination of options 5 and 6	Limited (<1 ML/ha)*	As for 1, and ryegrass/clover (grazed)	Flexible level of grain and forage supplementation
3	A combination of options 4, 7 and 8	Limited (<1 ML/ha)*	High quality crops (oats, lablab, lucerne) (grazed)	Heavy supplementation with grain and home grown silage
4	A combination of options 9 and 12	High level (>6 ML/ha)	Ryegrass, rye clover irrigated summer feed (clover or lucerne)	Low concentrate feeding, minimum silage and hay
5	A combination of options 10 and 14	High level (>6 ML/ha)	Maize silage, lucerne, barley silage or green chop (feedlot)	Heavy grain feeding

Table 5. Regional location characteristics, herd size and production of five production systems achieving economic goals

Variable		Rainfed	Limited irrigation	High irrigation: High quality crop	High irrigation: High quality pasture	High irrigation: Feedlot
	Farm	1	2	3	4	5
Rainfall (mm/annum)		>800	>800	600-800	800-950	<600

Humidity	High	High	Low	High	Low
Temperature (°C) (maximum/minimum)					
January	32/19	32/19	29/18	32/19	32/18
July	24/11	24/11	18/4	24/11	22/6
Topography	Undulating	Undulating	Flat	Undulating	Flat
Maximum distance from coast (km)	100	80	200	50	400
Frost (number/year)	10	25	25	10	25
Total head*	280	360	360	360	900
Stocking rate (head/ha)	1.9	2.8	1.4	3	3.9
Milk production (L/cow)	7,040	6,560	7,300	7,100	9,650
Total litres (ML)	1.82	2.18	2.25	2.36	7.45
Labour units	3.1	3.5	4	4	9.4
Labour efficiency (L '000 /labour unit)	584	623	563	590	797
Calving pattern Autumn	0	50	70	65	Through out
(% cows) Spring	100	50	30	35	the year
Heifers purchased/year	56	80	72	80	300
Lactation length (days)	300	300	320	300	360

* Cows milked per year

Table 6. Physical description of models

Variable	Rainfed	Limited irrigation	High irrigation: High quality crop	High irrigation: High quality pasture	High irrigation: Feedlot
Farm	**1**	**2**	**3**	**4**	**5**
Area (ha)	150	130	260	120	230
Potentially cultivated (ha)	30	26	220	110	210
Undulating (ha)	100	80	20	0	0
Not suitable for cultivation (ha)	20	84	40	10	20
Irrigable (ha)	0	26	25	110	210
Irrigation (ML)	0	156	150	660	1,260
Irrigated annual ryegrass+summer crop(ha)	0	26	10	45	0
Irrigated lucerne (ha)	0	0	15	25	120
Perennial temperate pasture (ha)	0	0	0	40	0
Oats (ha)	30	0	110	0	0
Lucerne/grass (rainfed) (ha)	0	0	5	0	0
Forage sorghum (ha)	0	0	55	0	0
Summer legume (rainfed)	0	0	25	0	0
Maize/barley forage crops (ha)	0	0	0	0	90
Tropical grass (ha)	100	84	0	0	0
Naturalised species	20	20	40	10	20
Urea (t/year)	46	78	50	44	80
Superphosphate (t/year)	13	30	12	30	15
Muriate of potash (t/year)	13	15	12	15	15

Intake (kg DM/cow/day)					
Complementary feeds					
Molasses	2	0	2.1	1.5	2.2
Grain (sorghum, barely, wheat	4.7	6.4	4.7	4.1	4.7
Cotton seed meal	1.9	1.1	0.9	0. 5	1.8
Mineral pre-mix	0.03	0.06	0.06	0.06	0.1
Whole cotton seed	0.72	0.54	0.54	0.54	0.58
Medium quality hay (purchased)	2.9	2.9	3	0	0
Lucerne hay (purchased)	0	0	0	3.5	0
Complementary total	12.3	11.0	11.3	10.2	9.4
Grazing					
Annual ryegrass	0	2.1	1	3.4	0
Oats	1	0	3.4	0	0
Lablab	0	0.8	0.5	1.5	0
Perennial temperate pasture	0	0	0	3.9	0
Lucerne	0	0	1.2	0	0
Lucerne + grass	0	0	0.2	0	0
Tropical grass	4.2	3	0	0	0
Silage					
Maize silage	0	0	0	0	5
Lucerne silage	0	0	0	0	5
Barley silage	0	0	0	0	2
Forage sorghum	0	0	1.5	0	0
Forage total	5.2	5.9	7.8	8.8	12
Total	17.5	16.9	19.1	19	21.4

Table 7. Financial parameters for five production systems achieving economic goals

Variable	Rainfed	Limited Irrigation	High irrigation: High quality crop	High irrigation: High quality pasture	High irrigation: Feedlot
Farm	**1**	**2**	**3**	**4**	**5**
Assets ($ '000)					
Land/water	557	521	530	935	920
Plant/equipment	149	377	459	469	1,574
Stock	252	324	324	324	810
Total	958	1,222	1,313	1,728	3,304
Return on assets (%)	7.5	9.3	14.7	12.1	20.3
Return on equity (%)	7.4	9.4	17.3	12.7	36.2
Liabilities ($ '000)	82	288	402	278	1,927
Equity ($ '000)	876	935	912	1,451	1,377
Milk price (c/L)	30	32	33	33	34
Sales ($ '000/year)					
Milk	546	698	744	779	2,532
Stock	34	66	60	73	235
Total	580	764	804	852	2,768
Variable costs ($ '000/year)					
Feed related	237	292	253	225	949
Herd	24	26	23	28	97
Shed	16	17	18	17	52
Cartage/levies	36	44	45	47	149
Repairs/maintenance	14	55	45	71	112
Other variable	17	7	23	24	79
Heifer purchases	44	64	58	64	240
Variable total	391	505	464	475	1,678
Interest/leases	7	26	36	25	173
Administration/overheads	20	16	14	14	30
Permanent labour	30	60	75	60	210
Fixed total	57	102	125	99	413
Depreciation	7	19	23	23	79
Management allowance	60	50	35	70	100
Total costs	515	676	646	668	2,280