SYSTEMS MODELLING IN ANIMAL PRODUCTION RESEARCH:

AN INTERACTIVE CASE STUDY

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ABSTRACT

Synthesis of improved systems of year round dairy herd feeding requires whole systems to be assembled and evaluated. In the field, only a limited number of possibilities can be examined and it is likely that there will be interaction between systems and the unique environments in which they are necessarily set. Modelling was undertaken to enlarge the possible number of syntheses and to provide a constant environment in which they could be compared.

A number of forage sources and a variety of milk production patterns were combined in a linear programming model which maximized economic or physical returns from combinations of forage supply and demand, within constraints of pasture and crop management, cow intake and forage quality.

The linear programming model was validated, firstly by exposing details of structure and output to an expert panel and secondly, by comparing model structure and output with those of several real farms.

Experiments were carried out in which cropping level, stocking rate, conservation level, cow production level and forage yield and quality were varied. Selected systems were subjected to simulated climatic variability and milkfat price variability to test the stability of preliminary conclusions.

It was shown clearly that the main thrust of the field research, feeding for higher production per cow, was likely to be both feasible and highly profitable. Most of the potential means for facilitating this were shown also to be feasible and economic, though there were limitations which had not previously been obvious.

Nitrogen fertilizer on pasture was shown to be potentially very valuable. Schedules for nitrogen use in practice would require much better definition of response patterns and the modelling lent weight to decisions regarding research in this area.

High quality, wilted, pasture silage was shown to be an essential component of systems without maize silage where high production (160 kg milkfat per year) per cow is required.

Preliminary evaluation of a summer-growing grass showed large potential benefits and supported an increase in the effort to develop such a grass for commercial use.

Several other forage crops were shown to have value. Somewhat surprising was the finding that grazing these crops was often a more profitable and productive means of utilization than conservation, despite inferior efficiencies in dry matter utilization. This was due to the higher cost of conservation allied with lower quality.

Maize silage was a particularly valuable forage source and it was shown how efforts to increase its yield or energy density, but not its protein content, would be rewarding.

It was concluded that the interaction of modelling and field research had been valuable in both development and testing of hypotheses. Suggestions are made for more formality in validation, for greater continuity in parallel modelling and for more generality in field data collection.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Applied agricultural research has a primary responsibility to solve real problems. However valuable its contributions to scientific knowledge, much earthier motives underlie its sponsorship. An abundant supply of cheap food and fibre is a basic need of all societies and a common measure of their success as organizations. Agriculture in many industrial societies has additional purpose such as generating overseas trading funds, saving imports and managing landscapes. In recent years, doubts have often been expressed about how well agricultural research has discharged its responsibility.

Two types of failure have been identified. Failure to account for adverse effects of change in farming systems has sometimes resulted in extensive soil erosion, salting, water pollution and stream silting (e.g. see McDonald 1979) as well as social injustice (Dillon 1973). This type of failure can be categorized as a failure in definition of objectives. The second type of failure is where the results of agricultural research fail to have any impact on agriculture because of irrelevancy or, more commonly, because the results exist as fragments of information which need synthesizing into a recipe which can be understood by non-scientists (Ebersohn 1976). This type of failure can also stem from inadequate objectives but it commonly occurs because of a lack of commitment by experimental scientists to synthesis of results, coupled with a lack of methodology for doing so.

An important reason for the failure to define objectives and to synthesize systems is the confusion between science and applied research. Science, that activity which adds to the body of codified knowledge, has enjoyed an exalted position since the industrial revolution. It rewards intellectual excellence and contribution to knowledge without much regard to the material benefits. But it achieves most of its success by disassembly, as attested to by the growth of such disciplines as molecular biology and particle physics. Agricultural research has been drawn inevitably in this direction since agricultural researchers generally get a fairly orthodox scientific training.

However, disassembly and specialization of research implies that at succeeding lower levels of system organization, there are many more branches of study and information than at higher levels. In this situation, synthesis of information becomes very difficult. To draw an anology from business and industrial management, where the synthesis of information is also an important activity, synthesis at the 10th level in a strictly dichotomous hierarchy would require information from $2^{10} = 1024$ sources to be consulted (Beer 1975). Similarly, specialization in particular biological disciplines insulates research from the social and economic forces from which flow the original research objectives.

Research in animal production suffers from specialization more than many branches of agricultural research since it embraces most aspects of agriculture. The traditional areas of soil science, plant nutrition, plant physiology, plant breeding and agronomy can all be identified on the plant side, each with its own subdivisions. A similar hierarchy exists on the animal side. Possibly the biggest hindrance of all to research on, rather than in, animal production systems is the dichotomy forced between plants and animals in the educational, phylogenetic and research aspects of science.

Without implying that this disciplinary research should stop, there is clearly a need for more emphasis on efforts which seek to impose relevant objectives on all levels of agricultural research and to provide the means of synthesizing fragmentary results into relevant packages. Interdisciplinary research is a notion which implies a great deal of consultation but has no meaning in an operational sense without a unifying concept.

It is the unifying concept that a systems approach seeks to provide. Although systems in agriculture and biology can be partially described by statistical measure and diagrams (e.g. Spedding 1975), a working systems approach implies the construction and manipulation of mathematical models. To be an effective part of the research process, system modelling will necessarily be an integral part of the whole research program, implying continuity and concurrence (Sturgess 1972; Morley 1977; Spedding 1976).

Although the approach is being taken up by many research groups (e.g. Wright et al. 1976; White and Morley 1977; Sibbald et al. 1979) many modelling studies reported in the literature have been conducted in isolation, spatially and temporally, from biological research programs (Anderson 1974). In addition, many have been concerned with management decisions in existing systems rather than with the synthesis and evaluation of alternative systems. One reason for these biases is that economists, more attuned to the use of mathematical models, have predominated in this activity.

Possible reasons for conservatism about the use of system models among biologically-trained scientists are several. Firstly, scientific caution (Dillon 1973) inhibits biologists from working further outside their discipline than they assume their competence can reach. Secondly, there is a reluctance to take resources away from the disciplinary areas where peer approval and institutional reward are usually sought and obtained. Thirdly, many of the enthusiastic reports of modelling in the literature have been, as indicated above, isolated from intimate knowledge of the biological systems they have modelled. Cavalier treatment by a modeller of a specialist area probably reduces the credibility of modelling, as well as modeller, as far as the specialist in that area is concerned.

This study was conceived as an attempt to apply modelling to a current animal production research program with which maximum interaction was sought.

1.2 OBJECTIVES

The general objective was to show whether systems modelling could be useful in assessing priorities in an operational animal production research program.

Within the general objective, two more specific objectives give purpose to the modelling part of the project. These were:

(a) to synthesize and evaluate alternative dairy feeding systems;

(b) to develop research priorities in the same area.

1.3 OUTLINE OF THE THESIS

Part I begins by discussing system concepts in agricultural research and development as they apply to goal definition and to conduct of applied research. Next is a consideration of research planning with emphasis on planning at the project level where the individual scientist sets his own priorities. Part I ends with a discussion of modelling in animal production research and how it might be used as a frame upon which aggregations of research projects might form a cohesive research program.

Part II deals with the background to the case study and with model development. The research program from which the case study evolved was an active one in which various aspects were at a variety of stages in the research process and whose personnel were actively seeking research priorities. Chapters 6 through 9 deal with technical components and relationships used in the model.

Part III deals with validation and use of the model and with developing experimental results as research priorities. Validation was a continuous process throughout all phases of model development and experimentation and although validation and experimentation are given separate chapters here, there remains considerable overlap. Experimental results and the identification of specific research priorities are discussed together since there are large areas of overlap. The final chapter attempts to match the results of the study with the objectives and explores the kind of developments required to make modelling an effective and integral part of applied research in animal production.

PART 1

AGRICULTURAL RESEARCH AND THE SYSTEMS APPROACH

CHAPTER TWO

SYSTEMS CONCEPTS IN AGRICULTURAL RESEARCH AND DEVELOPMENT

2.1 INTRODUCTION

Fifty years ago, agricultural research was much concerned with variety and fertilizer trials. The production system to which the trial results were to be applied was clearly perceived; indeed the experiments were often embedded within the system. Both research planning and results were clearly in context.

The subsequent fragmentation of disciplines has resulted in a distancing of the research from the context of a production system. An inevitable consequence is that experimental results often find no application in the short and medium term and in the long term run the risk of being submerged in the growing volume of experimental literature.

This chapter is concerned to show how systems concepts developed over the past two or three decades can be used in substitution for the farmers paddock of fifty years ago in giving a production system context to research planning and the integration of experimental results.

2.2 NATURE OF SYSTEM

At least since Aristotle declared that "the whole is more than the sum of its parts" there has been recognition that the functioning of some systems could not be explained by dismantling them and studying their components. In the case of biological systems, the most obvious manifestation of complex systems, a mystical principle, "vitalism", had to be invoked to explain life processes. Only in the present century has there been a realization that the forces of organization, although undoubtedly physical in their ultimate nature, are peculiar to and cannot be separated from the system in which they are embedded or from the level at which they operate (von Bertalanffy 1975).

The study of these forces has led to the development of "general system theory", which is concerned with the isomorphisms and correspondences among widely divergent systems; in other words a "system of systems" (Boulding 1956). A metalanguage of systems (Beer 1975) clearly becomes necessary to describe the common features of systems as disparate as electro-mechanical thermostats on the one hand and temperature regulation in mammals on the other.

Over the past thirty years, independent workers in a number of scientific fields have developed theories of system structure and function. Information and communication theory arose from the need to consider the transmitter, the receiver, the medium and the message in communication systems (Shannon and Weaver 1949). The role of information in systems whose primary function is not communication stimulated the development of cybernetics, with its notions of feedback and variety (Waddington 1977). On a more applied level, theories of automation and control were also developed (von Bertalanffy 1975).

All of these developments could only have resulted from a need to consider whole systems as more than an accumulation of components. Only by considering the linkages with their components could system functioning be understood. The foundation of the Society for General Systems Research gave recognition to the fact that many of these new system-orientated disciplines had a good deal of common ground; that many systems in the world will actually map onto each other after appropriate transformation (Beer 1975) in the same way as the forelegs of mammals map onto each other and onto the wings of birds with due changes of scale.

2.3 SYSTEMS IN AGRICULTURE

If the systems of General Systems Theory are characterized by complexity, interaction and feedback then agricultural production certainly qualifies as a system. Moreover, the environment is uncertain and in nearly every respect these are open systems, in the sense that they maintain and organize themselves in the face of a continuous exchange of material and information with the environment.

Agricultural products are the end result of systems designed to capture radiant energy in a useful form via photosynthesis. The multiplicity of agricultural products and the ways in which they are produced (Duckham and Masefield 1970; Spedding 1975) is one indication of how complex the process is; another is the fact that despite an efficiency of energy fixation of less than one percent (Duckham 1971), there are no real alternative methods of providing food and clothing to much of the world's population.

Acknowledging agriculture as a system may serve no useful purpose unless its place in higher order socio-economic systems and ecosystems is also recognized, since its products and side-effects, respectively, must be accommodated in these systems. The difficulties in trading internationally in many agricultural commodities serve as a significant constraint not only on methods of production - the structure of the agricultural system - but also on the choice of possible products. The importance of minimizing disturbance to the surrounding ecosystem is often well-recognized in traditional agriculture - as, for example, by New Guinea gardeners who, when clearing forest for a new garden, normally leave seed trees to facilitate forest regeneration when the garden is abandoned - but is often neglected by modern "conquering" agriculture - as, for example, by the early farmers of the Mississippi basin or the Australian mallee.

At almost any level of agriculture, from the cellular to the ecosystem, higher-order and lower-order systems can be perceived, the closest of which interact with the system being considered and the furthest of which have no effect nor are affected. A simple concept of an agricultural production system might include the components shown in figure 2.1. The simplest definition of the environment is that it is unchanged by the operation of the system; conversely the boundary includes all those components which interact with each other. Each of the components shown in figure 2.1 is properly regarded as a sub-system and further hierarchical levels of sub-systems could be postulated until the picture was very complex.

Spedding (1975) has shown how, by the use of concentric rings of variables with a central point representing the output of interest, very complex systems that are difficult to show as conventional flowcharts can be depicted. These not only ease the problem of component identification, but also facilitate the extraction of particular sub-systems, of which there may be many. A hierarchical view of systems has been outlined by Goodall (1976), who suggested that, considered in this way, many systems and sub-systems would be found to be homologous, if not identical.

2.4 SYSTEMS IN AGRICULTURAL RESEARCH AND DEVELOPMENT

Recognition that agricultural systems are complex and interacting, and incorporate feedback mechanisms, is a necessary condition for taking a systems approach to research on those systems. But it is not, on its own, a sufficient condition, nor does it specify how to go about taking a systems approach. A further condition is that a framework of theory exists, around which hypotheses are generated and tested. Without that framework, research becomes aimless, a mere quest for information in a field where knowledge is required.

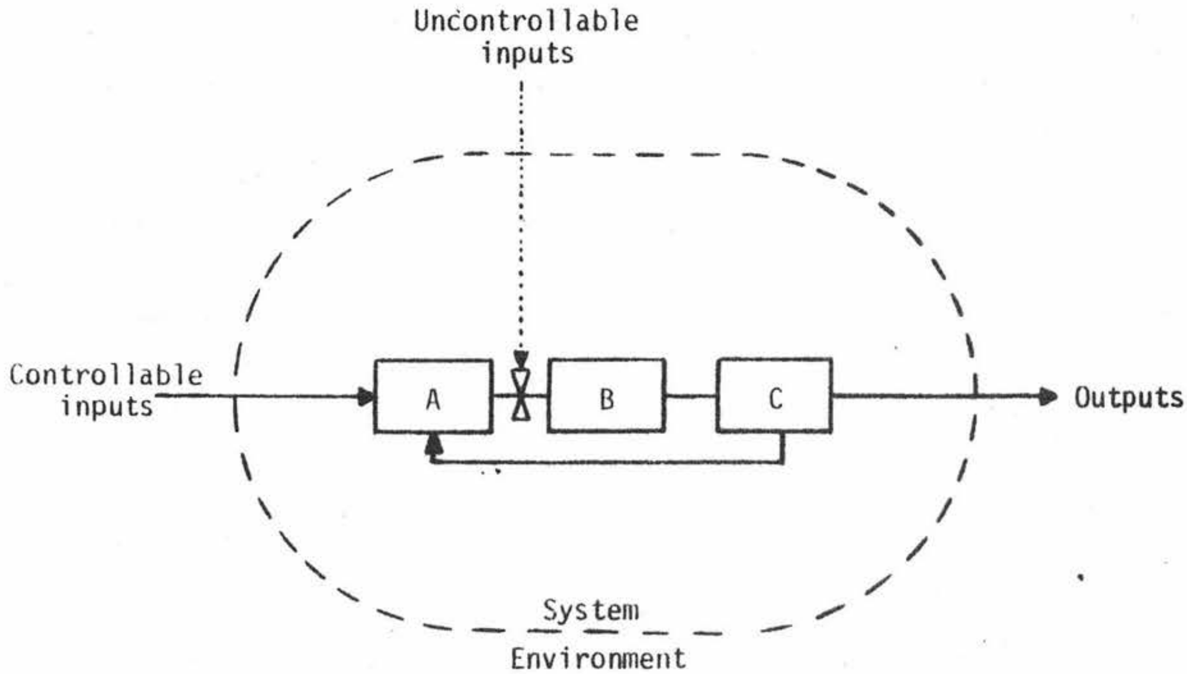

Figure 2.1 A simple system consisting of soil (A), grass (B), and cow (C). Controllable inputs such as fertilizer are distinguished from uncontrollable inputs such as solar radiation.

The development, by Mendeleyev, of the periodic table of elements is an example of a systems concept which led, inevitably, to the discovery of many new elements. Similarly, Harvey's conception of the circulation of blood as a system of pipes and pumps led him to the postulation of capillaries as logical necessities, though he never saw them.

The foundation of modern agriculture is linked with the realization, by Liebig and others in the middle of the last century, that plant growth was a system involving the soil, supplying water and minerals, the atmosphere, supplying carbon dioxide and oxygen, the sun supplying energy and the plant, supplying the biochemical pathways which integrate the material components as growth (Salmon and Hanson 1964). Liebig's "law of the minimum", a manifestation of this early systems concept of growth, served to highlight the importance of each and every part of a system.

This approach, although largely ignoring interaction and feedback as mechanisms of response, was responsible for some of the more spectacular advances in agricultural productivity, particularly in regard to modifying soil fertility by applying inorganic fertilizer. The very success of the approach in the soil fertility field led to the development of the deficiency concept and its occupancy of a central role in many perceptions of the plant-soil system. While leading to the development of viable production systems on many previously barren soils, this approach has probably hindered the development of sound theories of the functioning of the plant-soil system and left agricultural science in the position of being unable to make any quantitative extrapolation from one soil type to another (Collis-George and Davey 1960).

The "law of the minimum" and similar reductionist approaches in other aspects of agricultural science have seen much effort devoted to explaining the effect of this or that factor on plant growth and development but relatively few attempts to develop general theories of these processes which incorporate all the variables known to be involved. To judge from the pleas at the end of many scientific papers for more research into a specific field, it is implied that once all the data are collected, the functioning of a system will automatically become clear to all observers. But as Spedding (1975) points out, "subjects advance by development of theory, rather than by the accumulation of lore relating to particular experiences".

More modern system laws, such as the law of diminishing returns, and more modern concepts of system behaviour, such as hysteresis (Jeffers 1978) point up the notion that many factors may operate simultaneously and that behaviour may not be completely reversible. It is suggested, therefore, that a systems approach has value in theory development, as well as in the more visible areas of applied agricultural research, formulation of objectives, conduct of experiments and application of results.

2.4.1 OBJECTIVES IN AGRICULTURAL RESEARCH

In subsistence agriculture, where continuous or intermittent food shortages occur and human survival is threatened, there appears to be no ambiguity about the primary objective of any research. It is to increase food production. Yet, two qualifications can be imagined immediately. If current food production is already causing resource deterioration in the form of soil erosion, perhaps a first objective might be to develop systems that are stable, even if no more productive. That would at least prevent food production declining. Alternatively, a first objective might be to reduce the variability of food production from year to year, without necessarily increasing average production. That would at least prevent excessive suffering in poor seasons.

One could extend the argument to look at the possibilities of matching food shortages in one district with food surpluses in another. So, even in superficially simple agricultural systems, objectives cannot be clearly identified without first defining the system boundary.

In modern agriculture, the boundary may need to be drawn very wide to include social aspects of agricultural systems (Heady 1971) for, as forcefully suggested by Dillon (1973), narrow or irrelevant goals can bring social disaster to many engaged in the production system while producers and consumers reap the benefits of research.

Notable exceptions to the web of dependency between system boundary and objectives are perhaps the breeding of disease resistant varieties of important crop plants. Here, it is often clear that, without this effort, large sections of agriculture would fail completely.

Realization that producers, consumers, governments and scientists all may have multiple goals makes the definition of research objectives a difficult task. Dillon (1973) has argued that in purposive, hierarchical, socio-economic systems, goals should be formulated at each system level and transmitted downward, perhaps narrowing the possible courses of action but ensuring that research serves some higher-order goal. Nevertheless, it seems likely that, for high-level objectives to be more than "... platitudes which have no operational significance" (Ackoff 1962), a good deal of information, appropriately condensed and filtered (Fishel 1971), will have to flow to high-level decision makers from the operational levels.

At the operational level, formulation of objectives for applied agricultural research is likely to follow the pattern suggested by Andrew and Hildebrand (1976). First requirement is a general objective framed in a metalanguage (Beer 1975) which is meaningful to those working at a higher level of system organization. Within the general objective, it will then usually be necessary to have a number of subsidiary objectives more closely related to the hypotheses to be tested.

2.4.2. AGRICULTURAL RESEARCH AND SCIENTIFIC METHOD IN A SYSTEMS CONTEXT

The definition of progressively more specific objectives, referred to in the previous section, implies a movement towards identifying specific problems in the production system. This begins when system structure and function are observed (figure 2.2). The domain of the observations is clearly determined by system boundary (see figure 2.1), the latter having been determined by the general objectives of the research program. Spedding (1975) provides an example where the effects of stocking rate on sheep production, a sub-system in his terminology, includes wool production but excludes breed of ewe; whereas a sub-system to study the effects of lambing date includes ewe breed but excludes wool production. These boundaries, being only conceptual, cannot be absolute unless they include the whole universe, but they serve to limit the scope of observation to a manageable level without arbitrarily segmenting the world into disciplinary compartments.

In specifying problems, it has been pointed out (Andrew and Hildebrand 1976) that a researchable problem does not automatically follow from a problematical situation. But at least some of the specifications suggested for researchable problems would be more easily applied in a systems context. First, to check that problems are not hypothetical, it is necessary that theory (as embodied in the scientific literature and scientific knowledge) and practice (represented

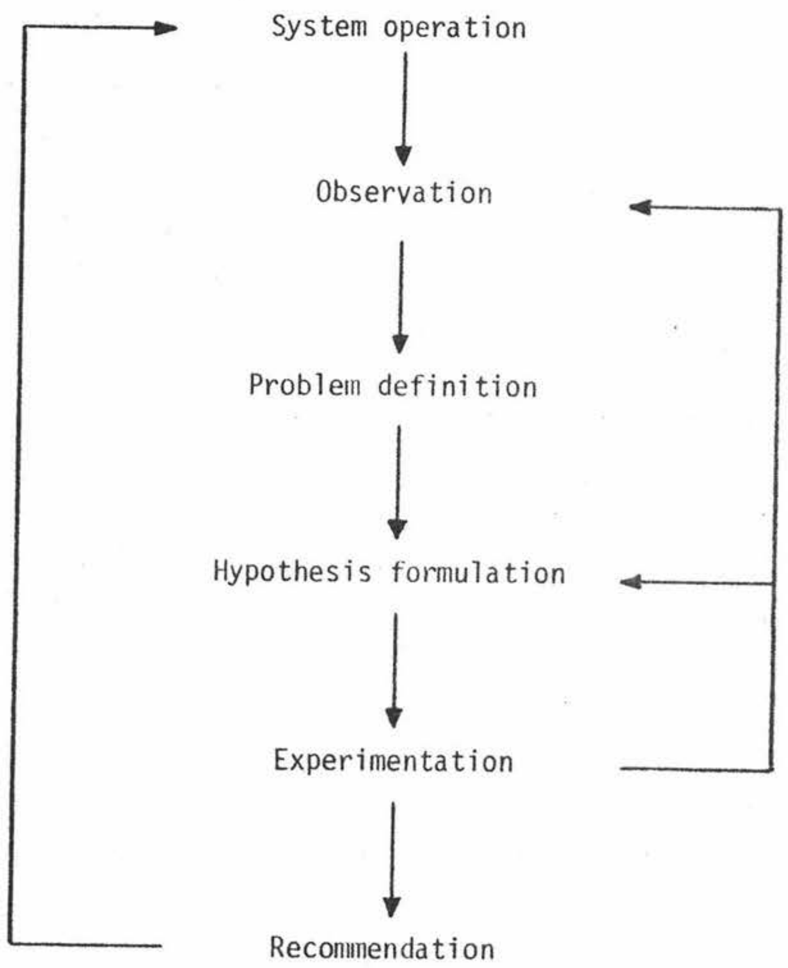

Figure 2.2 Applied agricultural research processes.

by producers and their advisers) have a common framework for interchanging views (Spedding 1975). Agreement on system boundary and structure would seem a useful approach to that communication.

Second, the scope and manageability of problems could be clearly seen in advance by reference to some agreed representation of the system, whether diagram, map or system of equations. A particular problem, for example, may only be considered researchable if there is a good chance of supporting research, identified as being necessary by reference to the whole system, being conducted. Supporting research is more likely to be carried out if those who would be involved can visualize, through some system representation, the importance of that research.

The next stage in research is customarily called hypothesis formulation (Wright 1973; Andrew and Hildebrand 1976). A good deal of conventional scientific activity is concerned with fragmenting systems down to a level where clear-cut binary questions can be posed (Waddington 1977). However, there is increasing doubt whether answers to these sorts of questions are relevant to higher-order production systems (Dillon 1973; Ebersohn 1976). Spedding and Brockington (1976) have concluded that both simple, qualitative hypotheses and complex quantified hypotheses are required in the study of agricultural systems. They note, also, that while hypotheses may be formulated Archimedes-style, in the bath, a systems approach (specifically, model-building) ought to be a better way of dealing with the complex, quantitative type of hypothesis.

A checklist of criteria which hypotheses should satisfy was given by Andrew and Hildebrand (1976) as:

(a) Hypotheses must be clearly related to the problem.

(b) They must take the form of "if ... then ..."

(c) They should be as simple as possible.

(d) They must be capable of verification or rejection.

(e) They must suggest a plan of action.

(f) They must be sufficient and efficient.

The first criterion establishes a clear link through problem definition to research objectives. Increased understanding is an insufficient objective without a statement of the purpose of understanding (Spedding and Brockington 1976). The second criterion is a check against any tendency to ask questions of the "what happens if ..." type and seeks to ensure that hypothesis testing will result in some action (i.e. be applied). The third criterion, simplicity, may have been taken too far in the past and been one of the causes of excessive disciplinary specialization (Boulding 1956). If Occam's maxim was really "Plurality must never be posited without necessity" (Skellam 1972, translated by C.W. Maughan) it might be noted that in complex systems necessity may often require plurality to give useful answers (Collis-George and Davey 1960).

The necessity for hypotheses to be capable of test has two aspects. The first is the philosophical requirement that, by definition, a hypothesis does not exist unless it can be tested (Passmore 1978). The second is the practical requirement that the reseárch must have access to sufficient resources to properly test the hypothesis. The fifth criterion is related to the previous one in that a hypothesis may be testable but if it cannot be tested in present circumstances it is really only speculation. The final criteria, sufficiency and efficiency, interact with the simplicity criterion. Sufficiency implies that the hypothesis must be as elaborate as is necessary to the problem in hand. Efficiency is that property which will result in the greatest yield of information for a given effort.

Experimentation, the next stage of research, is the testing of hypotheses. Simple hypotheses, leading to simple experiments on individual components and processes of a system, need to be justified by evidence that the part of the system studied does not interact with the rest of the system in a way that invalidates the conclusions (Morley and Spedding 1968). The more complex experiments appropriate for many aspects of agricultural research require a systematic approach to their design if they are to be feasible and relevant. A systems approach to the stages of research already discussed must largely ensure that experimentation fulfils these criteria, but three particular approaches to experimentation with agricultural systems bear some comment:

(a) Multi-factor, factorial, large-scale experiments.

These make large demands on research resources but may only be large-scale versions of the small, orthogonal experiments they replace (Ebersohn 1976). Especially in grazing systems, the desirability of comparing management systems over a range of stocking rates (Morley and Spedding 1968) makes these designs infeasible or puts too many research eggs in one experimental basket. Uniform sites, often considered as desirable for large experiments, may mean that experimental results are only relevant to a restricted set of similar sites, while the interaction of site and treatment, which may be important biologically and economically, is often ignored (McKinney et al. 1978) but is, in any case, difficult to deal with quantitatively.

(b) Evolutionary farmlets (Townsley 1973; Hutton 1973)

These represent attempts to synthesize recipes for better production systems. Hutton (1973) claimed that regression techniques could be used to determine cause and effect in these systems but in an agricultural context the method appears to be more demonstration than experiment. As originally envisaged (e.g. see Box and Draper 1969) evolutionary experimentation in industrial processes involved a continuous policy of operating part of the system slightly away from its a priori optimum. A new optimum is established when the system reacts favourably to a movement. The procedure is conducted on the actual system whose improvement is sought, not on a model (e.g. farmlet) of it, so that there exist no problems of extrapolation. Besides, responses in an agricultural production system being typically much slower than in an industrial system, they are likely to be dependent on climate. In agricultural research, therefore, evolutionary farmlets seem likely to be more useful for demonstrating system concepts than for testing hypotheses.

(c) System modelling

The next chapter discusses modelling in some detail but it is worth noting here that the construction of unambiguous models of agricultural production systems can complement physical experimentation by narrowing the range of possible treatments to a manageable but relevant set (Wright et al. 1976). Complementarity of modelling and physical experimentation implies concurrence in time, and to some extent in space, of the two activities.

Extrapolation, as with other phases of research, benefits from a systems approach in terms of generality. Many results of field experiments are soil-specific because of the interaction between treatments and soil and time-specific because of interactions with climate. In many cases, there may be no way around this problem but to repeat experiments in time and space. In all cases, the definition of system boundary and structure would help make explicit how restrictive these problems are likely to be. System modelling may be able to extrapolate the effects over a longer time sequence by sampling from historical or generated climatic sequences (e.g. see Rickert et al. 1981). That part of extrapolation which involves synthesizing information about components and processes into improved systems of production can also benefit from an approach that recognizes the importance of system linkages as well as components.

2.5 SUMMARY

This chapter has been concerned with establishing the importance of a systems approach to agricultural research. It began by considering the nature of systems in general and in agriculture, pointing to the development of a theory and language of systems which can transcend disciplinary boundaries. Next, it was postulated that systems thinking offered a formal means of giving rational context to research planning and conduct.

The next two chapters deal with the means of employing systems approaches to research planning and conduct respectively. Much of the discussion of research planning is concerned with improving the objectivity of deriving research priorities, mainly by appeal to aspects of the production system with which the research is concerned.

CHAPTER THREE

RESEARCH PRIORITIES

3.1 INTRODUCTION

Agricultural research has expanded rapidly in the past 20 years. On the one hand, disciplinary specialists have been probing ever more deeply into biological mechanisms searching for simplicity and finding complexity. On the other hand, the integrating production scientists have also come to realize the complexity of the systems they have been working with and have responded by accepting the need for more complex concepts and experiments. Both of these tendencies have expanded the range and scope of potentially researchable problems and there is an increasing need for efficiency and relevance in the mix of research projects which are undertaken (Dillon 1973; Brady 1974). The previous chapter outlined a philosophy of a systems approach to agricultural research. The purpose of this chapter is to discuss some ways of assessing research objectives in a systems context.

In the past decade or so, there has been increasing interest in and development of methods for increasing the objectivity of criteria for project evaluation. In the following sections the components of project value are identified and discussed before some methods of combining these into an index of value are outlined. These concepts and methods rely on clear definition of the production systems that are the subject of research.

3.2 THE LEVEL OF EVALUATION

Much of the literature on resource allocation to research deals with decisions at a level higher than that implied by different projects dealing with the same production system, though one of the more ambitious approaches used a single production system as a case study (Fishel 1971) and sought to present the research manager-administrator[1] with a set of ranked research priorities. It would be in the interests of individual scientists and problem-orientated groups to make use of project evaluation techniques themselves rather than have the results of higher-level evaluations forced upon them.

3.3 THE NATURE OF VALUE

The elements which determine final value of a project may be divided into benefits and costs and most of the indices of value so far developed make some comparison between these two factors. More effort has been made in developing benefit estimates than cost estimates because of the greater number of factors involved and the greater uncertainty of returns. Even for small projects, where a full analysis of benefits and costs cannot be justified (Peterson 1967), the estimation of benefits in relation to objectives can be "... the key to evaluation of research alternatives ..." (Fedkiw and Hjort 1967). Administrators at all levels, under pressure to allocate resources more efficiently, seem increasingly likely to demand from scientists more quantitative estimates of potential research benefits, whether or not formal analytical models are used to discriminate among research alternatives (Bell 1976b).

[1] Pinstrup-Andersen et al. (1974) point out that, depending on the level at which research priorities are being determined, the research manager may be the individual scientist, a team of scientists or a research director.

3.4 RESEARCH BENEFITS

The major benefit from applied agricultural research must come through the production system on which the research is carried out. But there may also be other benefits and in times when the social and opportunity costs of research are being given public prominence, it may be important to list all benefits, direct and indirect. As with benefits arising from any other kind of project, research may generate the following types of benefits (Puterbaugh 1971).

(a) Commensurable. These are a direct measure of increased efficiency of output. Expressed in money units as a resource saving and compared with research resource costs, they may be used to compare directly between projects.

(b) Incommensurable. These are measurable side benefits which may be measured in economic or physical units but are not necessarily additive to commensurable benefits. Reduced stream pollution, resulting from, say, minimum tillage cropping, is an example where the extent of the benefit may be measurable (perhaps in tons of sediment movement) but not yet amenable to economic valuation.

(c) Intangible. These benefits can be described but not measured. Increased morale in a farming community might be indexed by a decrease in the number of emigrations but cannot be directly measured and would remain an intangible benefit.

It is readily apparent that the evaluation of research benefits along these lines interacts strongly with research objectives. One of the benefits to be expected from attempts at *ex ante* evaluation of research is a much more explicit consideration of objectives.[2] Only benefits commensurable with research objectives can be used in estimates of net worth or benefit/cost ratio but, as Puterbaugh (1971) points out, incommensurable benefits may be an important decision criterion for distinguishing between projects with similar net worth or benefit/cost ratios.

The process by which research results are realized as real benefits involves a number of steps, some of which involve uncertainty and delay (see figure 3.1). The first uncertainty is that the research may not produce results which lead directly to production system benefits. The project may also have value in the sense of contributing to scientific knowledge and to scientific training (Fishel 1971) whether or not the project is "successful". The probability of a successful research outcome (P(R) in figure 3.1) would be influenced by a number of factors:

(a) The location of the project in the research-development continuum. Development of a modified tillage machine might be expected to be more certain of success than, say, development of a cold-resistant banana variety.

(b) The existence of related knowledge and theory which are necessary for success. These may be in the process of development so that probability of success will change with time.

(c) Availability of appropriate staff and resources. This type of constraint may perhaps be overcome by a higher level of spending on the same project (Fishel 1971).

[2] The contribution of a systems approach to the formulation of objectives is discussed in Chapter 2.

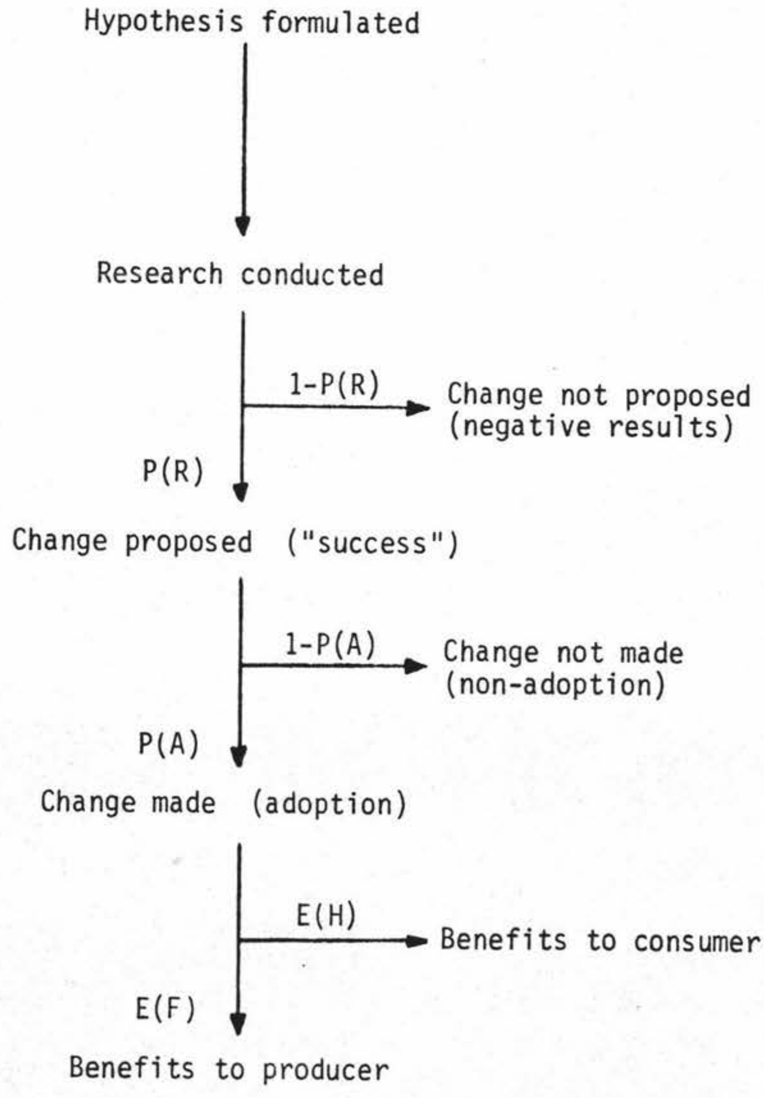

Figure 3.1 Uncertainties of research benefits.

P(R) = probability of technically successful research;

P(A) = probability of adoption;

E(H) = expected benefit to consumer;

E(F) = expected benefit to producer

The next uncertainty relates to the probability of adoption. This is analagous to the probability of commercial success (Libik 1969) in an industrial context. It may be expressed also as a pattern of adoption over time; Fishel (1971), for instance, expressed the rate of adoption with time as

$$1 - c^{t-T}$$

where T = number of years to complete the project
c = a shape parameter (Fishel used
c = 0.775 in his experiments).

The degree or probability of adoption in the long term will relate to the relevance of a finding to the production systems concerned. The time course of that adoption could well depend on whether commodity prices are affected by adoption. Auer (1973) has suggested that in cases where adoption results in a decrease in price to producers, early adoption represents an attempt to gain benefits before the price falls, while late adoption represents an attempt to minimize losses after the price falls.

An uncertainty as to the permanence and location of benefits has been raised by a number of studies. Using a simulation model in which a 10 percent increase in resource productivity and output was assumed, Auer (1973) showed that the partition of research benefits between consumer and producer depended strongly on the elasticity of demand for the commodity concerned. A similar partitioning between Canadian and United States wheat growers led Tosterud et al. (1973) to conclude that the net benefit to Canadian producers of the development, in Canada, of a new wheat variety depended strongly on price elasticity assumed. At constant prices long term benefit-cost ratios were 20.8 for Canadian growers, and 37.6 for North American growers, but at a price elasticity of 0.5, net benefits to Canadian growers were calculated to be negative.

Most of the more developed approaches to assessing research benefits estimate present value of future benefits by standard discounting techniques (Bell 1976b). Some use probability distributions as estimates of important variables in the research benefit calculation (Libik 1969; Fishel 1971; Cartwright 1972). Libik (1969) points out (as does Anderson (1976) in another context) that expected present value may be different when several distributions are combined than if single point estimates were used.

Any attempt to compare projects having different objectives would require, in addition to all the foregoing, estimates of the additive and multiplicative effects of multiple technological advances (Bayley 1971).

3.5 RESEARCH COSTS

In contrast to the usual costing of research projects in which only direct costs are estimated, most writers on the topic have stressed the need to include associated costs relating to implementation research and development and costs of disseminating the new technology (Fishel 1971; Mahlstede 1971). Further, allocation of overhead costs is necessary where indices of net research benefit are to be estimated, otherwise indices such as benefit/cost ratio and net present value appear higher than they really are.

Direct costs include all those resources which are specific to the project. These include the costs of professional and technical time, other labour, research materials, data collection and processing, new equipment and facilities and dissemination of results to other scientists (Mahlstede 1971). Overhead costs include clerical and administrative support and some part of the cost of using existing equipment and facilities. Costs of associated research and development necessary for the new technology to be implemented would be easily neglected. Salmon and Hansen (1964) point out that the implementation of hybrid maize technology was delayed by the necessity to develop seed-producing systems, the cost of which development would rightly attach to the hybrid maize research program. The final cost is that of disseminating the new knowledge to producers. This, too, could be significant part of the overall cost, particularly where a complex series of associated changes in the production system were necessary for successful implementation. New higher-yielding varieties, for instance, often need to be accompanied by improved cultural and fertilizing techniques.

It would be naive to suppose that implementation of research findings never generated adverse effects. It is more likely that they will be explicitly considered if classified as costs rather than as deductions to be made from research benefits. As with benefits, they may be commensurable, incommensurable or intangible. It is possible that incommensurable or intangible costs may preclude selection of a project. Nitrate enrichment of a water catchment containing a unique species, for instance, might be judged to be too great a risk, though no value can be put on the species at risk.

As with benefits, costs are frequently discounted back to the present. It is common experience to find also that costs are invariably higher (in real terms) than originally estimated. Tweeten (1971) presents increases on initial costs ranging from 1.2 for cargo aircraft to 4.1 - 6.4 for missiles. Lack of experience with the latter results in greater bias and variance in the increase.

3.6 INDICES OF NET ECONOMIC BENEFIT

Fishel (1971) gives three indices for comparing among research projects:

(a) Net Present Value = B - C

(b) Benefit/cost ratio = B/C

(c) Internal rate of return (R): (B - C)/R = 0

He points out that each analysis can lead to a different ordering of alternatives, depending on the ratio of initial investment to annual cash flow. It is obvious that the net present value form will favour large projects. The other two forms are dimensionless ratios in which all costs are included in the denominator.

Even if adequate procedures existed to generate this information accurately and economically, Fishel (1971) has shown that it may only be used for pre-ordering research alternatives and that administrators should and do require other information in deciding between alternatives. The other information, described by Fishel (1971) as boundary and environmental restrictions and by an administrator in the same study as technical literature review, personnel and departments involved, and cooperation expected during the research, was considered to be a vital part of the actual evaluation, as distinct from analysis, of projects.

Bayley (1971) listed four improvements required in cost-benefit analysis before they could be operationally useful:

(a) Better means of identifying beneficiaries and the way in which they benefit.

(b) Better means of identifying adverse effects.

(c) Better means of estimating the duration of beneficial and adverse effects.

(d) Better means of estimating total benefit from a combination of projects (a program).

3.7 OTHER EVALUATION METHODS

A variety of methods have been proposed, varying in their objectivity and in the scope of factors they try to encompass. Economic models have already been considered and there seems general agreement that they cannot be used for allocation, only to aid allocation (Arnon 1975; Wallace 1978). Other explicit methods are largely methods for scoring.

Scoring methods recognize explicitly that much of the information required for economic analysis can only be subjective and therefore not worthy of too much sophistication or expense in its use. However, there have been serious attempts to increase the objectivity of the criteria, as exemplified by the comparison, in table 3.1, of criteria used by USDA (Arnon 1975) and Iowa Experiment Station (Mahlstede 1971). Although criteria in the latter case are only used for ranking purposes, each criterion is potentially measurable while those in the former are used to score projects but are defined in such a way as to discourage numerical estimates and so produce less defensible evaluations.

Table 3.1 Two sets of criteria for ranking research projects

USDA (with weights) (Arnon 1975)	Iowa (Mahlstede 1971)
1. Urgency and need (10)	1. Probability of a successful outcome
2. Extent to which research meets goals of station, department or nation (9)	2. Gross benefit from adoption
3. Contribution to knowledge (9)	3. Duration of gross benefit
4. Scope and size considering area, people and units affected (8)	4. Indirect benefits
5. Benefits of research in relation to costs (7)	5. Estimated direct cost
6. Likelihood that results will not be available elsewhere (6)	6. Duration of research
7. Ease of extension and likelihood of immediate adoption (6)	7. Cost of required associated research and development
8. Feasibility of implementation and likelihood of successful completion in a reasonable time (5)	8. Probability that associated research and development will be undertaken and successful
	9. Degree and speed of adoption
	10. Cost and duration of required extension

The Iowa scheme outlined by Mahlstede (1971) is an iterative one in which the criteria are repeatedly applied to projects in relation to different overall goals, beginning with growth (a reduction in resources necessary for production of constant value output) and continuing with equity (distributive justice) and security (preservation of health and well-being of individuals and society).

Another scheme involving more than one stage of evaluation was described by Gilchrist (1973). Here, there were four binding criteria which had to be satisfied before any project could move into the scoring stage of evaluation against eight independent criteria. Fishel (1971) had previously recommended some sort of screening process (he suggested the Iowa scheme) to filter out irrelevant or infeasible projects before moving into an evaluation procedure.

Cartwright (1972) has demonstrated how projects, or research activities, may be assigned scores depending on their contribution to a set of weighted objectives. MacMillan (1973) has used a similar approach to calculating economic benefits from research activities. Goal weights may be useful means of periodically updating evaluation of continuing research; changing weights to reflect changing economic circumstances and agricultural technology permits re-evaluation at any time either of these change (Arnon 1975).

Gilchrist (1973) described another scoring method which estimates potential benefits, probability of success and cost as orders of magnitude (0-5 = OM 0; 5-50 = OM 1; 50-500 = OM 2 etc.) and from these estimates expected payoff as an order of magnitude. This last estimate can be used to rank projects. Once again, the principle of trying to make numerical estimates is invoked, drawing attention to, if not necessarily resolving, the problem of quantitatively estimating benefits in relation to objectives. Gilchrist (1973) points out that if difficulty is experienced in making any of the estimates within an order of magnitude then the project objectives or planning have probably not been adequately specified. He further shows that order of magnitude estimates can compensate for the underestimation which intuition is likely to produce from dealing with very small percentages. An example given shows that a project having a 1 percent effect on 10 percent of Canadian consumers could have very large benefits in order of magnitude terms.

3.8 ALLOCATION METHODS

Possible allocation approaches will be outlined only briefly since they really belong in the province of the administrator, rather than the production system scientist.

Possible approaches seem to be of three main types:

(a) Allocating by rank until resources are exhausted;
(b) Maximizing estimated benefits by programming techniques;
(c) Minimizing discrepancies between goals and potential achievement.

Where the decisions concern incremental resource allocation to existing projects or programs, the view of Peterson (1967) that an "implicit market force" operates to allocate resources efficiently, finds support in the importance research administrators attach to the identity of the scientists proposing research (Fishel 1971 ; Gilchrist 1973). This seems to imply that the approaches outlined above would find little use in the normal type of incremental budgeting, though, as noted by Cartwright (1972), there would be value in testing the techniques to encourage explicit consideration of the many aspects of the evaluation problem. While these techniques would have more direct applicability to zero-based budgeting (Hannah 1973), the latter concept has found little support either conceptually or operationally (Puterbaugh 1971). The conceptual objections to zero-base budgeting stem from considerations of continuity of research (termed the "rhythm of research", Libik 1969); long-range planning (Mahlstede 1971); and the absence of an agreed objective in resource allocation (Hurter and Rubenstein 1971).

3.9 ESTIMATION OF RESEARCH BENEFITS

In section 3.4, some of the uncertainties of research benefit were discussed. These related to discounts to be made from potential gross benefits and it was implied that, given sufficiently clear objectives, potential benefits could be readily estimated.[3] However, experimental applications (none of the procedures seem to be operational, Cartwright 1972) of these procedures have been conducted on fairly simple production systems, for the obvious reason that the process of assigning research priorities is complex enough.

In comparison with the soybean production system studied by Mahlstede (1971) and Fishel (1971), animal production systems, especially grazing systems, are very complex in terms of the number of ways in which they can be modified (Wright 1973). Research benefits will be correspondingly harder to estimate.[4] Two approaches could ease this problem.

The first is a suggestion by Anderson (1972) that benefits be estimated for a representative farm by such means as budgeting (e.g. see Bell 1976a) or linear programming.

[3]Some procedures require only a ranking or scoring of potential benefits (e.g. Mahlstede 1971; Cartwright 1972) but even that assumes some implicit estimation of commensurable benefits.

[4]It is assumed that a subjective probability distribution with a range of zero to some maximum possible value would be of little help.

With an estimate of degree and rate of adoption, it should be possible to produce an estimate of the aggregate benefit over all farms. The second is an extension of this approach, in which a model of the farm or production system is manipulated to estimate benefits from postulated changes (Dent and Anderson 1971; Arnold and Campbell 1972; Morley 1973; Arnon 1975). This latter approach has been taken by a number of workers (Duncan 1966; Greig 1971; Trebeck 1972; Louw et al. 1976; Baars et al. 1976; Wright et al. 1976). Some, at least, have claimed that the research evaluation process has been influenced by modelling, though there is no way of proving the point.

3.10 CONCLUSION

This chapter has discussed the need for more defensible allocations of research priorities and has outlined some of the techniques being developed for more objective assessments of research benefits and costs. It dealt also with some methods of research resource allocation but recognised that research administrators will frequently have some dominating, intangible criteria upon which to base allocation.

The methods discussed here depended on some appreciation, however qualitative, of the relevant production system. However, a systems approach to the actual conduct of research requires a more explicit representation of the production system concerned. The next chapter, therefore, discusses one comprehensive means of representing a system - modelling. The discussion is restricted to agricultural production systems, in parallel with the operational part of this study.

CHAPTER FOUR

THE MODELLING PROCESS

4.1 INTRODUCTION

A systems approach to research requires the use of models for all but the simplest systems (Spedding and Brockington 1976) and for all except the very best researchers (Wright 1973). Nowhere is this more evident than in animal production systems where the boundaries of interest necessarily extend toward soil-plant interactions on the one hand and socio-economic considerations on the other. The grazing interface, in particular, has been a difficult experimental area because the diet of the grazing animal is determined partly by a complex of interrelated animal factors (e.g. N.R.C. 1971) and partly by a complex of interrelated forage factors (e.g. Morley and Spedding 1968).

Most discourses on modelling deal with only one type of model. This chapter represents an attempt to draw together those aspects of modelling common to simulation and linear programming, at least.

4.2 MODEL DEFINITION AND PURPOSE

A variety of classifications of models have been presented (Wright 1971; Innis 1975) but this discussion will primarily be concerned with mathematical models which are manipulated by computer. One classification that has direct application in any discussion of modelling animal production systems is the sequence mental, verbal, diagrammatic, mathematical.

Farmers, their advisers, and scientists in a variety of disciplines dealing with a production system all have their mental picture (model) of system structure and function. Disagreements that arise when these mental images are given verbal form (as at field days and the like) testify to the differences between the models. Differences that derive from the different boundaries that surround each group's system view are a natural expression of the different purpose each group has in manipulating or observing the system.[1] Thus a farmer would probably include variable prices in his mental model while a plant breeder developing new pasture varieties could reasonably exclude the same process. However, differences in system perception that derive from ambiguous or incorrect perceptions of reality are not usually capable of resolution by appeal to the mental models which produced them.

Progression of mental and verbal models towards diagrammatic form begins to force the resolution of ambiguities and disagreements. Diagrammatic models are usually invoked to give qualitative expression to system processes in the form of graphs, histograms, flowcharts. For example, they may distinguish between linear and asymptotic relationships, they may show that winter pasture growth is only a fraction of spring growth, they may show that pasture growth is dependent on defoliation history, as well as on current environmental conditions. One major limitation is that only two or three dimensions can normally be represented. System organization, also, has been difficult to portray diagrammatically; however developments in system representation, such as the state-variable conventions of

[1] The relationship between system boundary and purpose has been discussed in Chapter 2.

Forrester (1961) and the circular diagrams of Spedding (1975), have eased that difficulty.

Conversion of the qualitative statements of diagrammatic models into the unequivocal form of a mathematical model is the final step in describing a system in terms that can be communicated without loss of meaning or precision.

The purposes of modelling in agricultural research have been summarized as (Wright 1976):

(a) to improve understanding of how a complex system functions;
(b) to predict how a system will respond to natural or induced disturbance;
(c) to solve problems relating to manipulation of the system to achieve given ends.

Prediction and problem solving both require some understanding of system function so that the first objective can be thought to subsume the others. Yet, as Spedding and Brockington (1976) point out, total understanding is not possible and any lesser level of understanding can only be justified by reference to purpose.

In the case of applied research in animal production systems, the subject of this study, an important additional role for modelling can be proposed as the provision of a repository for information (Ebersohn 1976) from the more traditional disciplines of agronomy and animal nutrition. That such a medium is necessary can be gauged from the number of studies reported where there is almost no attempt to explain animal performance in terms of nutrient intake, on the one hand, and almost no attempt to assess the value of forages in animal production terms, on the other. The existence of a model at the animal/forage interface would impose some obligation to explain results in terms of processes as well as serving as a link between the detail of the disciplines and the generality of theory (Rountree 1977).

4.3 THE MODELLING PROCESS

The classification referred to above, mental, verbal, diagrammatic, mathematical, can be considered also as the first stage of the modelling sequence (Anderson 1974; Ebersohn 1976). A general outline of the modelling process is shown in figure 4.1 and it is proposed to discuss the process along these lines. Since a model represents a system, the discussion of section 2.4, dealing with a systems approach to agricultural research, applies equally well to modelling. Some aspects will be reiterated briefly.

4.3.1 PURPOSE AND SCOPE

As with any form of applied research the problem should be well-defined, neither trivial nor hypothetical, and should be within the scope and competence of the research unit (Andrew and Hildebrand 1976). The system boundary, within which the model will operate, is determined by the overall objectives of the research program while the scope of the model will be determined by the nature of the problem. Many writers on the subject of modelling, particularly simulation modelling, have emphasized the difficulties of, and dangers of not, clearly specifying the modelling objectives (e.g. Garfinkel et al. 1972; Anderson 1974; Charlton and Street 1975; Wright 1976). The danger is encapsulated by Dillon's (1971) Third Law of Simulation which states that "Once started, simulation of a system will continue until available funds are exhausted".

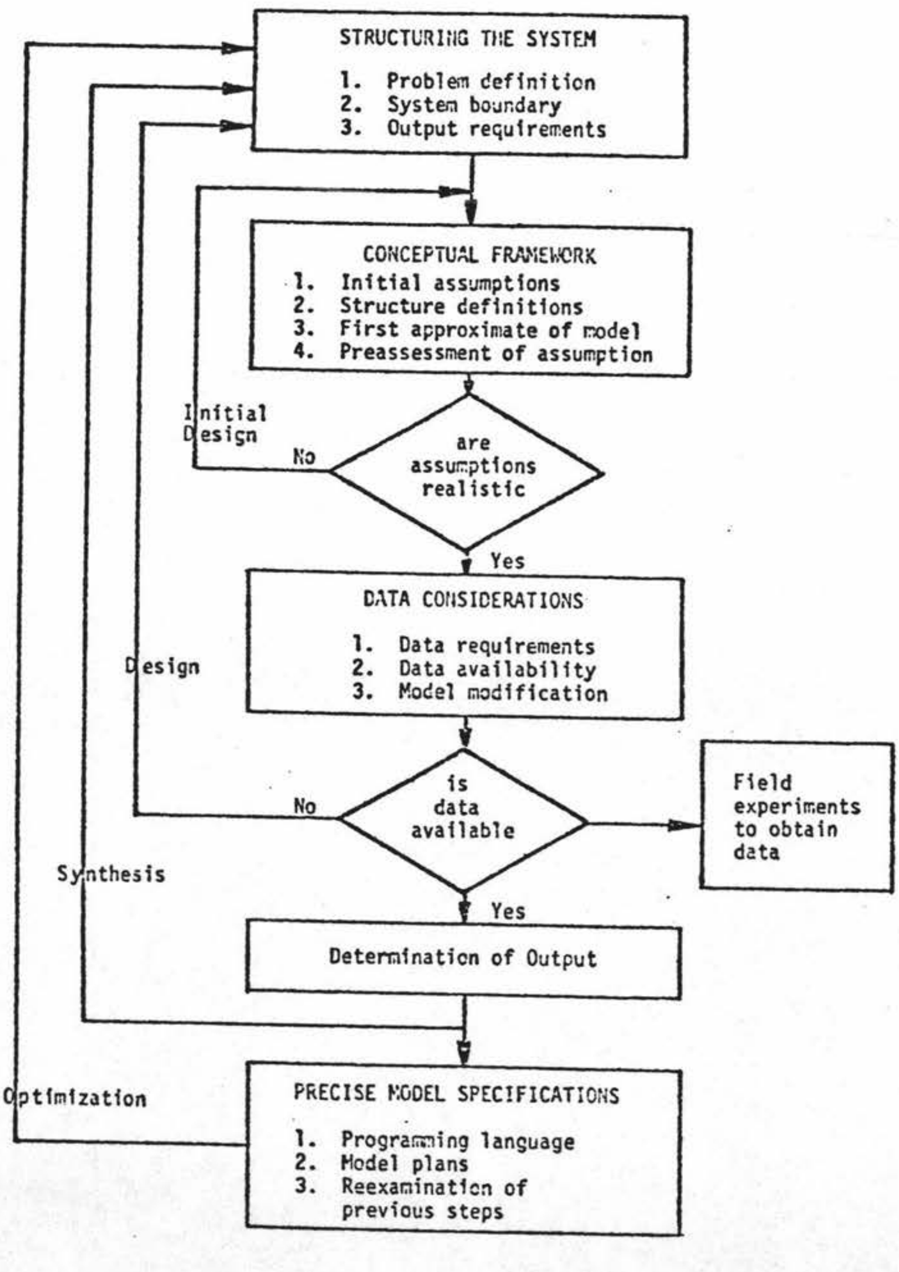

Figure 4.1 Steps of the modelling process (Baker and Curry 1976)

Recognizing the difficulty of knowing in advance all the questions that might be asked of a model (Benyon 1972), one approach to ensuring the model is used to solve problems is to fix deadlines for various stages in the modelling process, as Wright (1976) did for the end point of a modelling project.

4.3.2 MODEL FORMULATION

Some of the characteristics of models to be considered at this stage are (Anon 1973; Anderson 1974):

(a) the theory and assumption on which the model is based;
(b) the form of the model;
(c) the form of equations in which it is expressed;
(d) the stochasticity to be included;
(e) the level of resolution;
(f) the time periods to be included;
(g) the inputs and outputs required.

Since the model is really a hypothesis of system structure and function, it is probably more important that it summarizes the current state of knowledge accurately (Warner 1964; Garfinkel et al. 1972) than that it be trimmed by Occam's razor (Skellam 1972). Simplicity aids comprehension and manageability but might more properly be seen as a desirable bonus, if achieved, than as a primary objective. For bio-economic models destined for use by extension services, Charlton and Street (1975) advise restricting a model package to a single specific enterprise or problem, rather than trying to develop large complex models with greater generality. Warner (1964) points out that if the modeller is not conscientious and critical at this time, or allows preconceived notions to bias his assessment of the existing facts, his model is almost sure to lead him to false conclusions about the system. That the model may be the only coherent and comprehensive theory of the system, (e.g. see Dent 1975; Wright et al. 1976) as opposed to a collection of empirical data, may make this step doubly important.

The simplification involved in representing a real system by a mathematical model necessitates the making of assumptions about simplifications and omissions. They need to be as defensible as the structures and relationships which are included and to ensure they are explicit, Garfinkel et al. (1972) recommend they be listed as they are made.

Decisions about form of model include those about whether the model should be optimizing or not; whether the model is to be a mechanistic, process model or a collection of empirical black boxes (Wright 1971); whether the model is to be constructed on skeleton, modular, or representative farm principles (Dent 1975); whether the approach is to be hierarchical (Goodall 1976) or problem oriented (Wright 1976); and whether stochastic relationships are to be included. As pointed out by Innis (1975) and, in a more specific way, by Anderson (1976), most of the models to be found in the literature do not belong to the classifications which would provide the most realistic representations of system behaviour. These deficiencies must be due, in part, to the relative inexperience of many biologists in the modelling process but there is also the need to compromise between realism and manageability and between generality and specificity. Increased realism is achieved at the cost of increased complexity and manageability; it has been suggested (Jeffers 1978) that in hierarchical terms, a manageable model can cover only three levels of organization,[2] the level at

[2] Levels of organization are discussed in Chapter 2. An example in agriculture might be the sequence molecule, organelle, cell, leaf, tiller, sward, grazed paddock, farm, dairy cooperative, and so on.

which the problem has been defined and one level above and below. The conflict between building a model general enough to justify the costs of construction (which may be considerable - Morley 1973; Arnold and Bennett 1975) and specific enough to solve real problems, inevitable as such conflict is (Charlton and Thompson 1970), seems often to have resulted in models which have found no practical application. This reinforces the need referred to earlier, to have explicit objectives.

The inclusion of stochastic elements in a model, for which Anderson (1976) has argued powerfully, presupposes the existence of data from which the stochastic relationships may be estimated, although Anderson (1974) has suggested that it might be better to include subjective estimates than to ignore variability. Although the techniques of making these estimates and including them in some types of models are relatively well developed (Phillips 1971; Rae 1971; Bell 1976a; Wicks and Guise 1978) it may be expecting too much of novice model-builders (as most still are) to include realistic stochasticity as well as building models which adequately summarize their systems. Moreover, there is the problem, noted by Charlton and Thompson (1970), that inclusion of stochastic variables within the model (as distinct from stochastic exogenous variables like rainfall) may necessitate thousands of runs to determine response with confidence. In any case, Anderson's (1976) warnings seem to be aimed more at models which produce results for makers of economic decisions whereas many animal production models are concerned with trend prediction rather than event prediction (Innis 1975).

Two aspects of time are considered in model formulation. The first is the total duration of modelled time, which will depend on the length of the production period (often a calendar year in animal production systems) and on whether or not any model variables are stochastic (e.g. Wright (1970) found 25 years to be insufficient for distinguishing between two management policies in a sheep grazing system). The second aspect in models which deal with dynamic relationships is the number of time steps within the production period. In biological models, where most relationships are continuous, these time periods ought to be related to the time intervals between decision points but are frequently compromised by the need to restrict model size or solution times.

The form of input and output are more than trivial programming matters and need consideration during model formulation. Wright and Baars (1975), for instance, decided that to be generally useful, their pasture growth model should not require inputs of meteorological data which are only kept at a very few locations. This circumscribed the form of their model to an extent (W.G. Duncan, personal communication), but satisfied their original objectives and provided useful results (Wright et al. 1976; Wright et al. 1977). Output specifications will involve compromise between the need to restrict the mountains of output that can be produced by computer implementations of a model (Anderson 1974) and the need to monitor individual processes within the model (Wright and Dent 1969; Benyon 1972).

4.3.3 MODEL EVALUATION

Since most mathematical models are simplifications of reality and often contain more assumptions than certainties, their use as predictors requires some assessment of the accuracy of their predictions. In the case of simple models such as linear regression, predictions take the form of a confidence interval in which the predicted mean can be assumed to lie with a specified probability. The theory underpinning the use of such models to explain the data and the calculation of uncertainty is widely accepted. More complex models, implicitly or explicitly, contain many uncertainties of this sort as well as uncertainty of a less definable kind arising from ignorance of system structure and function.

In the more complex case, no adequate theory exists either to explain the data in appropriate terms[3] or to provide estimates of the accuracy of predictions. These two aspects might be considered as form and content and to some extent apply to all kinds of models (Jeffers 1978). It is proposed here to deal only with simulation and linear programming models.

4.3.3.1 MODEL FORM

The process of evaluating the form of simulation models corresponds approximately with the process customarily known as model verification (Anderson 1974). Presumably because simulation models are free-form, a large, introspective literature has developed around the evaluation process. In summary, verification is concerned with determining whether a simulation model represents reality correctly or adequately (Wright 1971), as anticipated (Anderson 1974), or reasonably (Jeffers 1978). Each case is unique as an entity

[3] One purpose of the model is to serve as a hypothesis of the system in terms appropriate to the solution of a particular problem. If adequate theory (a model) did exist, there would be no need for a new model.

although there may well be components within the model, such as stochastic generators, which are in general use. Thus, depending on the purpose of the model, and on the theoretical development of the underlying biology, verification consists of ensuring that the model mimics the system in a way that is representative of the underlying biology. Van Keulen (1976) asserts that a "black box" (Wright 1971) approach at too high a level of organization can preclude the use of the model for extrapolation.

Verification in this sense is not so much a separate stage of modelling, but a continuous iterative process involving model and sub-model formulation and testing.

In contrast to simulation models, the basic form of linear programming models, the form that permits an optimal allocation of specified resources under given conditions, is well known (Heady and Candler 1958). Doubts about the applicability of the standard formulation have given rise to a number of modifications and extensions. The unacceptability of a single-criterion, linear objective function has led to the development of sub-optimal programming (Powell and Hardaker 1969) and separable programming (e.g. Wicks and Guise 1978), the latter permitting non-linear constraints to be included (Burroughs Corp. 1975). These methods, the MOTAD formulation (Hazell 1971) and discrete stochastic programming (Rae 1971) allow the possibility of uncertainty in income due to activities to be explicitly considered in the model solution. Uncertainty in the extent to which constraints will be binding can be considered in chance-constrained programming and uncertainty in the input-output coefficients can be dealt with by a RINOCO (Wicks and Guise 1978) formulation. Intertemporal programming permits a dynamic formulation (Rae 1970).

The other aspect of linear programming model form, methods of describing activities and imposing constraints, is much more akin to the verification phase of simulation modelling. There is scope for considerable idiosyncrasy here, and as with simulation models, a responsibility on the modeller to continually ensure that the model conforms with reality in a meaningful and communicable way.

4.3.3.2 MODEL BEHAVIOUR

Evaluation of model behaviour, normally labelled validation in simulation studies, is usually defined as testing whether model output is adequate for the purpose in mind (Wright 1971; Anderson 1974). The form of the testing is usually in the form of comparison between behaviour of model and real system. In the case of descriptive models which merely summarize existing knowledge, an adequate comparison might be between the sharpened perceptions of system structure and function and the vague, ambiguous images which preceded modelling (Ebersohn 1976).

In the case of models to be used in a problem-solving role (interpolation or extrapolation) the most rigorous procedure is to compare model output and reality under identical conditions. Comparisons need to be applied to the behaviour of sub-models and processes within the model for the procedure to be effective (Benyon 1972; van Keulen 1976). As with verification, the process will commonly be iterative with validation tests being followed by reworking of parts of the model. The importance of avoiding tuning the model without correcting structural faults has been emphasized by a number of writers (e.g. Goodall 1972; van Keulen 1976; Morley 1977). Such an approach must lead to a model which may only represent the data with which it has been forced to agree (Benyon 1972).

The question of having independent data from reality with which to compare model output raises at least two issues. First, if reality, in the form of a production system, does not exist (a new crop rotation, say) or cannot be measured without disturbance (a unique ecosystem, say), then verification as outlined in section 4.3.3.1 is the best that can be done (Anderson 1974). Second, where data describing reality do exist there is a problem of ensuring its independence from the data used in model construction. Van Keulen (1976) points out the difficulty of ignoring any data which is present during model construction and the danger of circular reasoning when such data are unconsciously used in decision-making during model construction and then in validation. Finally, there are obvious advantages in testing models in near limit situations, not only to expose internal errors of specification (van Keulen 1976) but to maximize the universe in which the model might be useful (Goodall 1972).

The next question concerns the nature of the comparison between model and reality. A variety of approaches have been suggested, from qualitative analysis of extreme values, distribution shapes, cycles, convergence, number and timing of turning points (Mize and Cox 1968; Wright 1970) to goodness-of-fit tests and regression (Anderson 1974). All of these represent an attempt to be objective whereas it has been argued by many modellers of bio-economic systems that it would be as well to recognize that validity is a subjective notion (Wright 1971; Anderson 1974; Greig 1979). Statistical tests are usually designed to minimize the probability of a Type I error (rejecting the null hypothesis and the model when, in fact, both are valid) because of "significant" discrepancy whereas Greig (1979) argues that it is the Type II error (accepting the null hypothesis and the model when in fact an alternative hypothesis is true and the model is invalid) which is probably more important. He argues this on the basis that the cost of a Type I error is likely to be no more than the cost of the modelling to date, whereas the cost of a Type II error might be as large as the potential benefit expected from the modelling. Since the latter must initially have been estimated to be larger than the former (otherwise why model?), Greig (1979) argues that the best approach might be to minimize the sum of the probabilities of the two types of error, a notion also proposed for exploratory experiments in some circumstances (Balaam 1972).

Subjective comparisons of model and reality can be placed in an objective context by the use of "Turing"-type tests where unidentified sets of data are presented to one or more experienced system observers (Anderson 1974). If the model output cannot be distinguished, the test is said to be successful. Since much of the criticism of models is likely to be of a subjective nature, making formal tests of this type and reporting the participants and results would lend much credibility to any tests made by the modeller alone (Greig 1979).

4.4 THE USE OF SYSTEMS MODELLING IN AGRICULTURAL RESEARCH

Recognition of the complexity of agricultural production systems, particularly those involving grazing, has led to decreasing confidence in the traditional methods of observation, hypothesis formulation, experiment and induction (Ebersohn 1976). Expansion of the scope of the experimental method to encompass systems instead of components and processes may increase research relevance but it greatly increases the resources used by each iteration of the observation, hypothesis, experiment, induction sequence and increases the importance of making each iteration as productive as possible.

One of the most important roles for systems models is in providing an explicit conceptual base for the research process (Jeffers 1972), as noted in section 4.3.2. There is little doubt that the best researchers have always had a well-developed but mental systems model as their conceptual base (Wright 1973). However, the rapid expansion of agricultural research in mid-century saw many of these researchers promoted to administrative positions where their opportunities for communicating their concepts (never a simple process) were much restricted.

With the promotion of mission-oriented research likely to increase (Dillon 1973), the need for an interdisciplinary theoretical framework in interdisciplinary projects will increase. Despite the apparent success of modelling in such a role (e.g. Wright et al. 1976), a warning about the dangers of neglecting the more basic aspects of agricultural science has been given by Boyce and Evenson (1975), who assert that concentration on interdisciplinary projects by the U.S.D.A. commodity research programs led to a relatively unproductive period of research by that organization, though the measure of productivity was not stated.

A feature of many agricultural production system modelling studies has been the areas of ignorance that they have exposed (e.g. Wright et al. 1976; Sibbald et al. 1979) so it seems likely that for some time yet, the main result of modelling might be to send researchers back to disciplinary work, but armed with greater understanding of the framework into which their work must fit. Even when the modelling is "successful" enough to produce results at a system level, the most likely use of the results is to guide aspects of research rather than to provide producers with any directly useful information.

The literature on animal production systems modelling does provide a number of examples of models developed to provide information for use by producers and their advisers (e.g. see Anderson 1974; Charlton and Street 1975), although it is by no means clear how effective this has been. While the number of models originating from animal production research teams has also been considerable (e.g. see Seligman 1976; De Boer and Rose 1977), there must also be a good deal of unreported modelling going on that is having some effect on the research programs in which it is embedded.

As with the sketchy reporting of validation procedures and results, few of the reports of modelling give any clear indication of how the modelling has affected the research program or the producers. There is, of course, no way of defining accurately the course that research or production would have taken in the absence of modelling, but as with validation, there is a requirement for more rigour in this area.

4.5 SUMMARY

The preceding discussion has dealt with the modelling process in the sequence in which it normally occurs. First, there was consideration of model purpose and system boundary, then model formulation where questions of simplicity, stochasticity, level of resolution in time and space were discussed. Next, model evaluation and its components of verification and validation were outlined. Finally, the use of modelling in research into agricultural production systems was discussed briefly and it was noted that very few objective evaluations of its results have been attempted.

PART I CONCLUSION

Part I began by reviewing systems concepts, particularly as they apply in agriculture and in agricultural research. The application of these concepts in agricultural research was then reviewed in two parts. Firstly the setting of research priorities was discussed and it was concluded that the complexities involved, together with intangible criteria held to be important by research administrators, inhibited application of some objective methods developed recently. Next, a formal means of system representation, mathematical modelling, was discussed and it was concluded that in animal production research, although a good deal of modelling had been done, there were few indications of the effects of modelling on physical research programs.

These conclusions led to the decision to concentrate on a particular research program and to develop an interactive modelling program at a production system level rather than probe the area of setting priorities between research programs. The chosen research program and the methodology of the modelling are described in Part II.

PART II

THE CASE STUDY AND MODEL

PART II INTRODUCTION

The next five chapters deal with the setting up of a modelling project to interact with an active field research program.

Chapter 5 gives the background to the chosen field research program and outlines previous research in the same field. Chapters 6, 7 and 8 describe the animal and forage components which are potential variables in the feeding system. Chapter 9 outlines the structure of the main model, its full detail being exposed in Appendix D.

CHAPTER FIVE

INTRODUCTION TO THE CASE STUDY

5.1 INTRODUCTION

To deal with the stated objectives of studying interaction between modelling and field research in an interdisciplinary field, the first requirement is a real research program. This chapter describes briefly the feeding systems research program being undertaken by Plant Physiology Division, D.S.I.R. and outlines its advantages for concurrent modelling. Next follows a discussion of alternative forage feeding system investigations in New Zealand. Finally, conceptual aspects of the production system are discussed. These include system boundary, level of detail and intensity of technology.

5.2 CHOICE OF RESEARCH PROGRAM

Beginning in the early 1970's, Plant Physiology Division of D.S.I.R. embarked on a program of developing specialist feeding systems for Northland dairying, beef and sheep systems. Besides interest in the productive potential of alternative feeding systems, a feature shared by most studies in the field,[1] additional reasons have been advanced for this work (Taylor et al. 1974; Taylor and Hughes 1976, 1978). Among these are the supplementation of pasture at

[1] See section 5.3.

times of deficiency in quantity or quality; changing patterns of farm output to reduce processing costs; and a wish to put some of the past theoretical evaluations of forage crop systems to test.

The dairying phase of this program has been summarized by Taylor et al. (1979c). After small plot experiments gave encouraging results, four farms became involved in the development of alternative feeding systems. The authors note that because of physical and social constraints four different systems evolved on the farms. Judging from the increase in production on the test farms compared with the district average, each system has been successful in physical terms (Taylor et al. 1976b, 1977b, 1979c). To judge from continued operation of the new systems by the farmers after formal completion of the study, they must also be successful in economic terms.

However, in the experimental sense there is no control treatment and so no absolute measure of benefit. Nor can total benefits be attributed to particular components or practices, some of which may be unrelated to changes in feeding. There may, indeed, be no convenient way of doing so experimentally, since many will have effect only in combination. That is, there may be large interactions but no main effects. But any future decisions about research priorities in this field will require some estimate of the importance of each component, practice or combination.

Exploratory discussion between Plant Physiology Division and the Farm Management Department of Massey University in 1976 had revealed that the former were interested in the possibility of system modelling as a means of exploring possible future developments in dairy feeding systems. The latter were interested in the general area of system modelling as an adjunct to agricultural research and had already done some work on these lines for animal production systems (Pollard 1972; Wright et al. 1976).

Given this background, there were a number of other advantages in using this program as a case study:

(a) A degree of concurrence between modelling and field research is likely to bring benefits to the model and the modeller as well as to the field research.[2] It is suggested this advantage arises because the field research is active, data are visible and accessible and those conducting the field research are actively thinking about the systems being modelled. Alternative farm systems were being developed and monitored between 1975 and 1978. Model construction and validation spanned the period 1977-79.

(b) Plant Physiology Division is located adjacent to Massey University campus. Physical proximity of field scientists and modeller allows the possibility of more or less continuous interaction, with attendant benefits to model construction, validation and operation.

(c) Plant Physiology Division is actively engaged in computer modelling of other systems and has no institutional inhibitions about the purposes or validity of modelling.

[2] See Chapter 4.

5.3 FORAGE FEEDING SYSTEMS

Interest in alternative forage sources for feeding dairy cattle seems to stem from two sources. First is the proposition that, at least during part of the year, the main forage source of New Zealand dairying, ryegrass-white clover pasture, makes ineffective use of the resources available for growth. Representing this point of view, Mitchell (1963, 1966) has pointed to the extravagant use of water made by ryegrass at temperatures above 21°C and to the more efficient energy fixation possible by C4 carbon pathway plants. Mitchell (1970) has also pointed to the limitation of the shallow rooting of ryegrass. Kerr (1975) has shown that maize not only uses water much more efficiently than some C3 forages, but uses less water in total over summer.

A second reason for considering alternative forage sources is that the best dairy systems appear to be utilizing 90 percent or more of pasture grown, so that the scope for further gains in production or profitability lies mainly in greater forage production rather than in increased efficiency of forage utilization (Campbell et al. 1978; Scott 1978).

There has been considerable exploration of the subject, both theoretical and practical, *ex ante* and *ex post*. A brief review of these studies precedes discussion of the case study.

5.3.1 PREVIOUS EVALUATIONS OF ALTERNATIVE CATTLE FEEDING SYSTEMS

Mitchell (1966, 1969) emphasized the potential productivity of maize-based feeding systems by assuming optimum growing, harvesting, storage and feeding techniques which would maximize energy production per hectare and involve minimum losses.

Following that lead, early *ex ante* economic evaluations were concerned with a very limited number of similarly intensive systems (McLatchy 1969; Philpott et al. 1972). High crop and pasture yields were assumed but despite markedly increased production and cash surpluses, the capital requirements of these feedlotting systems were so large that they were concluded to be uneconomic at expected prices.

System design was more flexible in the study by Stephen et al. (1974). Here, several feed production, feed storage and feeding out sub-systems were specified as alternative activities in a linear programming matrix. These authors considered two yield levels which they described as "research" and "potential", both very high even when compared with research station yields (table 5.1). Although cropping and feedlotting increased profitability at higher product prices, the capital requirements were again large and the return to additional capital generally less than 10 percent (Bell 1975).

The first system to show theoretical advantages in all important economic parameters (economic farm surplus, return to capital, benefit/cost ratio) was a system described by Bell (1976a). Although much lower crop and pasture yields were assumed (table 5.1) simple feeding and storage systems for silage meant that additional capital costs were much lower than in the examples already discussed. A preliminary evaluation of this system in the field failed to show any economic advantage over an all-grass system (Campbell et al. 1978). Drought, and higher stocking rates on pasture in the cropping system than on pasture in the all-grass system, were given as two reasons for the failure of the system to match its promise. Mention was also made that maize yields fell below prior assumption and that maize silage had to be imported from outside the system. No allowance was made for the imported forage in the calculations of profitability.

Table 5.1 Forage yield assumptions of previous evaluations with some research yields (kg ha^{-1}).

		Permanent pasture	Winter ryegrass	Maize	Winter cereal
ASSUMED YIELDS					
McLatchy	(1969)	16800	7000	16800	-
Philpott et al.	(1972)	16800	15700	24700	-
Mitchell	(1974)	14700	(12100)[1]	25000	14300
Stephen et al.	(1974)[2]	18400	-	18000	11900
Bell	(1976a)	14500	8300	17300	-
MEASURED RESEARCH YIELDS (North Island)					
Lambert	(1967)	8000-11000	-	-	-
Baars	(1976b)	10200	-	-	-
Hutton & Bryant	(1976)	15000	-	-	-
Campbell et al.	(1977)	13000	-	-	-
Piggot et al.	(1978)	12800	-	-	-
McCormick	(1974)	-	-	18000-21500	-
Thom	(1977)	-	-	16600-22500	-
Kerr & Menalda	(1976)	-	7100	-	16100
Taylor et al.	(1976b)	-	4900-9400	-	13700-17000

[1] Lupins or alternative.

[2] "Research" yields; "potential" yields were up to 7000 kg ha^{-1} higher.

In the South Island too, crop grazing systems were predicted to be more profitable than all-grass systems (Stephen and McDonald 1977). As in the north, crop yields achieved on a farmlet scale did not reach the levels assumed in the initial evaluation (McDonald and Stephen 1978). A summary of economic evaluations is shown in table 5.2.

Two general conclusions emerge from this work. Firstly, unless some technical advance greatly reduces the capital costs of storing roughage feeds, cut and carry systems are likely to remain technically attractive, though uneconomic in on-farm terms. Secondly, the yields assumed for crops, while technically feasible, have not been reached consistently at paddock scale.[3]

When explanations of these shortfalls in yield have invoked unusual seasons as the reason for low yield, there has been no clear indication of whether the authors consider the originally assumed means to be too high or the originally assumed variance (if any) to be too low. In any case, comparisons of strategies to cope with variability were apparently made only by Bell (1976a) and then only between his two arbitrary systems.

5.4 GENERAL APPROACH TO THE CASE STUDY

The evaluations discussed in section 5.2 were largely concerned with discovering whether this or that system was on average more or less profitable than another. Mitchell

[3]Possible reasons for discrepancy between experimental and commercial yields are discussed in section 5.4.2.

Table 5.2 Economic evaluations of forage systems

	CONVENTIONAL ALL-GRASS SYSTEM				SYSTEMS WITH CROP			
	Cost[1] of feed DM ¢ kg^{-1}	Total capital \$ ha^{-1}	Economic surplus \$ ha^{-1}	Return to capital %	Cost[1] of feed DM ¢ kg^{-1}	Total capital \$ ha^{-1}	Economic surplus \$ ha^{-1}	Return to capital %
McCLATCHY (1969)								
Town milk	-	1559	156	10.0	2.71	2080	195	9.4
Winter beef	-	1684	58	3.5	3.62	4189	117	2.8
PHILPOTT et al. (1972)								
Factory milk	1.70	814	65	8.0	2.40	3306	119	3.6
Beef	0.70	506	14	2.7	2.07	4899	298	6.1
MITCHELL (1974)								
Dairy	3.14				2.08			
Beef	3.14				2.03			
STEPHEN et al. (1974)[2]								
Dairy grazing					1.66	1914	829	43.0
feedlot					3.57	3987	921	23.0
Beef grazing					0.80	2180	750	34.0
feedlot					2.50	5251	1001	19.0
BELL (1976a)								
Dairy	3.06	4082	387	9.5	3.09	4373	480	11.0

[1] Including all labour and interest on capital.

[2] Research level yields: milkfat prices = \$1.28 kg^{-1}; beef price = \$0.57 kg^{-1}.

(1970) has argued that profit margins can alter radically with new technology and new marketing opportunities and so should not be used to inhibit research into new possibilities but rather for "... posing the issues to be met ...". Previous evaluations have recognized this point but the comparative budgeting of a very few alternatives (McClatchy 1969; Philpott et al. 1972; Bell 1976a) can only give the most general indications of whether to proceed or not.

An approach is required that can assess the physical and economic performance of a whole range of systems under a range of physical and economic circumstances. Then, a benefit/cost approach can be used to indicate best directions rather than to draw conclusions about a whole concept. Stephen et al. (1974) took a step in this direction by constructing supply curves for two levels of technology but their model was too aggregated to draw more than the most general conclusions about research options; later their economic conclusions were questioned (Bell 1975).

Any attempt to deal with research options in any detail requires a much more flexible approach where at least the structure of the systems is not conceptually fixed or overly limited. In addition, the selection of a particular region, Northland, meant that site-specific yields had to be used. Most of the previous studies used subjective estimates of yield which often seemed to assume that each forage source was being grown in its own best environment, despite being used in combination on one farm.

5.4.1 SYSTEM STRUCTURE AND BOUNDARY

Although it is suspected that on-farm and off-farm economies interact, particularly with respect to pattern of production (Taylor and Hughes 1978), this study is almost totally concerned with on-farm systems. Apart from a wish to limit the complexity of the systems, there is very little information available about the effect on processing costs, either capital or running, of changing patterns of milk production. It may be that estimation of on-farm costs for patterns of production different from the current ones could promote a useful exchange of information between production technologists on the one hand and processors and marketers on the other. Until such a dialogue is better developed, simulated variation of product price at the farm gate is the only means of estimating the on-farm effects of changed processing economics.

Maximum flexibility of system performance requires that aggregation of components be kept to a minimum in any system model. Separation of components should also ensure minimum bias in the form of preconceived sub-systems. In Northland dairy systems, this requirement translated into separating all forage sources, even when, like Sudax and subterranean clover, they are normally considered as inseparable components of a forage sub-system (Jurlina 1978). It meant also allowing a good deal of variation in per cow performance, rather than meeting a single set of feed requirements (e.g. Stephen et al. 1974) almost certainly more suited to one system of forage production than to any others.

A further dimension of system boundary and flexibility is time. Only steady state systems were considered, although it is clear that the speed of farm development can influence long-term profitability (Bell 1976a). The primary research problem being considered here is the strategic one of identifying the directions in which a farming system might move. The more tactical problem of choosing the most economical means of changing a system is clearly subsidiary and is likely to vary with the circumstances of individual farms.

A one year production period was chosen. Because of the cyclic nature of lactation and the assumed desirability of having cows calve in a specified condition,[4] there was no need to consider cumulative effects on cows. Surplus greenfeed is assumed to decay while surplus stored feed is most simply accounted for by assigning it a monetary value.

5.4.2 LEVEL OF TECHNOLOGY[5]

In previous evaluations of alternative forage cropping systems, the use of "future" yields (an estimate of potential yield at some unspecified time in the future) with present costs and sometimes present prices has probably overstated the benefits of new systems while straining the credulity of the reader. "Future" yields seem likely to coincide with steadily worsening terms of trade for farmers (New Zealand Dairy Board 1979) so that the assumption of present yields together with present costs and prices seems less likely to bias economic predictions.

[4] See Chapter 6.

[5] Specific assumptions are detailed in Chapters 7 and 8. Only the general approach is dealt with here.

Present yields in this study are taken to mean the yields attained by good farmers using current technology. These are not necessarily the maximum yields attainable by the same farmers but are yields which integrate variation in soil fertility and crop management. In deciding which estimates of yield to use in deriving means and variances, there was still a degree of subjective judgement involved. Since most of the farmers were still learning how best to grow the forages, low yields resulting from recognized mistakes were generally excluded.

In some cases where only experimental plot yields were available, farm yields were calculated by discounting for the effects of scale and sub-optimum management. Davidson and Martin (1965) have pointed out that because experimenters are generally interested in returns to specific resources like land, their intensity of use of other resources such as labour, capital and machinery is often quite different from that of a farmer who is concerned with returns to a total package of resources. They point out that depending on the intensity of the farming systems, these differences in resource use result in differences in yield between farm and experiment.

5.4.3 COMPONENTS OF A MODEL

To give context to the description of production system components in the next three chapters it is necessary to preview here the essential elements of model structure. Section 5.4.1 implied that the major potential sources of variation in Northland dairy feeding systems lay in both feed production and cow performance. Specifically, feed production will be assumed to vary in timing, yield, quality and cost of forage available for grazing or conservation; milk production will be assumed to vary in timing of lactation start and end, and in yield during lactation, as well as in cow numbers.

5.5 SUMMARY

The case study was introduced by describing the background to the chosen field research program and outlining the particular aspects of concurrence and communication which were seen to be advantageous to interaction between field and model research. After outlining previous evaluations of forage feeding systems it was argued that only a flexible model could, with economy, evaluate a large number of alternative combinations of forage. The conceptual limits of the production system were then described. A conservative basis for technology assumptions was then proposed and finally the fundamental elements of a production system model were listed to give context to subsequent descriptions of model components and relationships.

CHAPTER SIX

DAIRY COW FEEDING

6.1 INTRODUCTION

That feeding of dairy cows must still largely be described in terms of requirements instead of production responses is partly due to the fact that lactation begins as a consequence of reproduction, not of feeding. But there is intuitive appeal in the notion that to maintain lactation the cow requires a certain amount of feed, perhaps in the sense of replacing lost nutrients. In much of western Europe and North America, the need to house cows in winter with associated high per cow overheads and running costs must have lent economic reinforcement to the requirements philosophy, by necessitating high levels of production from each cow.

After a few weeks of lactation, feeding level determines milk production between the broad limits of genetic maximum and minimum. While the requirement concept can be useful in hand feeding different amounts of concentrates to cows of different production ability, level of milk production is implied to be the independent factor, not a very useful concept to explain the response of production to given levels of feeding.

Broster (1976) has summarized the state of knowledge regarding dairy cow responses to feed intake in a model (figure 6.1) that is still largely qualitative. That is, an operational, zero-base model of milk production such as proposed by Bywater and Dent (1976) seems a way off yet. But at moderate levels of milk production there is substantial enough agreement between feed intakes of grazing dairy cows

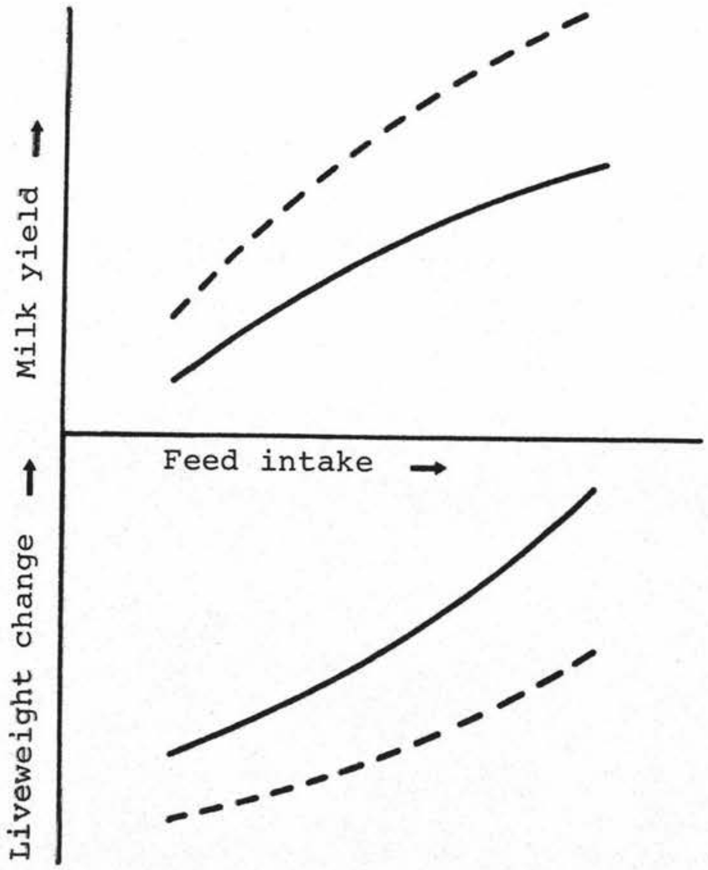

Figure 6.1 Response of milk production and liveweight gain to feed intake for high merit (---) and low merit (——) dairy cows (after Broster 1976).

and predicted requirements (Hutton 1971) to accept that within perhaps narrow limits the requirements concept will work. Taken together with some information about responses at the margin, this acceptance suggests the concept of some kind of "standard" cow whose feeding is determined according to requirements, and variations from which are described as responses. This concept is explained in detail in the next section.

The remainder of the chapter is concerned with establishing energy and protein as the two nutrients of primary importance, then with establishing the lactation cycle as an entity. Next are discussed energy requirements for various bodily functions while protein requirements are considered later as a function of total energy requirement. Then follows a discussion of appetite limits and a final section makes some comparisons between model parameters and experimental observations.

6.2 THE "STANDARD" COW AND HER DERIVATIVES

The relatively good agreement between the actual intake of grazing cows and intakes predicted from feeding standards over full and part lactations and dry periods (Hutton 1971) suggested that feeding standards could accurately specify requirements at least for a particular lactation pattern. The pattern assumed was for a Jersey-Friesian cross cow of average genetic merit grazed at fairly high grazing pressures on ryegrass-clover pastures (Scott and Smeaton 1975; M.A.F. 1976) and will be referred to as RUCOW[1] (see figure 6.2). Alone, this assumption does not permit specification of requirements

[1] Referring to Ruakura Cow since the "standard" lactation curve and liveweight pattern was based on Ruakura data.

over periods shorter than those considered by Hutton (1971). To specify requirements over shorter periods a further assumption must be made regarding any changes in requirements with time. In the absence of a series of production functions at various points throughout lactation, the simplest assumption is that, for RUCOW milk production, average requirement is constant. It is further assumed that responses to variation from RUCOW feeding level will be constant throughout lactation. Inspection of monthly requirements estimated by other workers (M.A.F. 1976; Johnstone et al. 1977; Hutton and Bryant 1976) suggests that similar assumptions have been made.

Because calving of a herd is spread over several weeks, herd requirements differ from those of an individual cow, particularly at the beginning and end of lactation. Cow requirements were converted to herd requirements for modelling purposes by assuming a rectilinear calving distribution of 75 percent calving in the first three weeks and the remaining 25 percent in the following three weeks. For each nominal lactation length, 25 percent of cows were dried off 14 days before the remaining 75 percent. The lactation lengths assumed, 183, 211, 239 and 267 days are weighted herd averages.

6.3 THE PRIME IMPORTANCE OF ENERGY AND PROTEIN

Energy is accepted as being the prime mover in the diet (Broster 1976). Because of the generally high protein content of New Zealand dairy pastures there has been no need in previous studies to consider the protein content of cows fed almost wholly on pasture. The relative feed values of other forages have generally been expressed in terms of equivalent pasture (Hutton and Bryant 1976; M.A.F. 1976), presumably on the assumption that forages of low protein content would be fed either in supplementary amounts with pasture or at a time of the lactation cycle when protein requirements are low.

In this study, all forages are seen as potential production feeds so that no such assumption is warranted. Instead, explicit representation of protein requirement by cows and protein content of feeds must be made.

Energy and protein concentration are certainly a minimum specification of feed quality. It is known that dietary proportions of volatile fatty acids can influence the efficiency of energy utilization for production (Annison 1976) and can influence the partition of dietary energy between lactation and fattening (Moe and Tyrrell 1974), but there are insufficient data from which to derive predictive relationships.

Some of the forages to be considered would be deficient in minerals and vitamins (e.g. Wilkinson and Kilkenny 1977) if fed alone but since this is unlikely to occur and cannot be predicted in advance, adequacy is assumed. If the model were to suggest diets deficient in minerals or vitamins, appropriate costs could be deducted from model gross margin. The amounts and costs would be relatively small (Hutton and Rattray 1976).

Energy is discussed throughout as metabolizable energy (ME) since this fraction represents useful energy (A.R.C. 1976; Bryant 1971). There is conflicting evidence on whether digestibility and thus ME of a feed changes with level of feed intake in the dairy cow. When observed, the effect is much more serious with rations containing higher proportions of concentrate (N.R.C. 1971) whereas this study is concerned with diets composed almost wholly of forage. Recent summaries of dairy cow requirements have recommended that no correction to ME values be made for level of intake (N.R.C. 1971; Alderman et al. 1974).

6.4 THE LACTATION CYCLE AS AN ENTITY

Milk production, body condition and food intake are interdependent aspects of dairy cow functioning. If body reserves are low at the beginning of lactation, peak milk yield will also be low (Broster 1976; Rogers et al. 1979). It follows that, relatively, a greater proportion of food goes towards replenishing reserves than towards milk production; the effect lasts throughout lactation. Thus, the potential efficiency of feed utilization for milk production is determined at the start of each lactation and a good feeding scheme will recognize calving condition as a cardinal point in the lactation cycle.

The response of milk production and liveweight change to current changes in feed supply can be described by figure 6.1. The actual quantities involved depend on peak milk yield, as discussed above, and on stage of lactation. The main point is that the liveweight response must at some stage be reconciled with a target liveweight by next calving, as proposed above.

The assumption made was to specify a range of cows with different production and liveweight patterns with a common target liveweight to be reached by the beginning of the next lactation. These patterns of production and liveweight are shown for 267 day lactations in figure 6.2. Shorter lactations are truncated versions of these. A linear recovery of liveweight to the target was assumed.

6.5 MAINTENANCE ENERGY

Although methods of determining maintenance requirements of energy vary, they seek to estimate the energy which is required for metabolic and kinetic functions. Clearly, production also involves both kinds of function, and whether

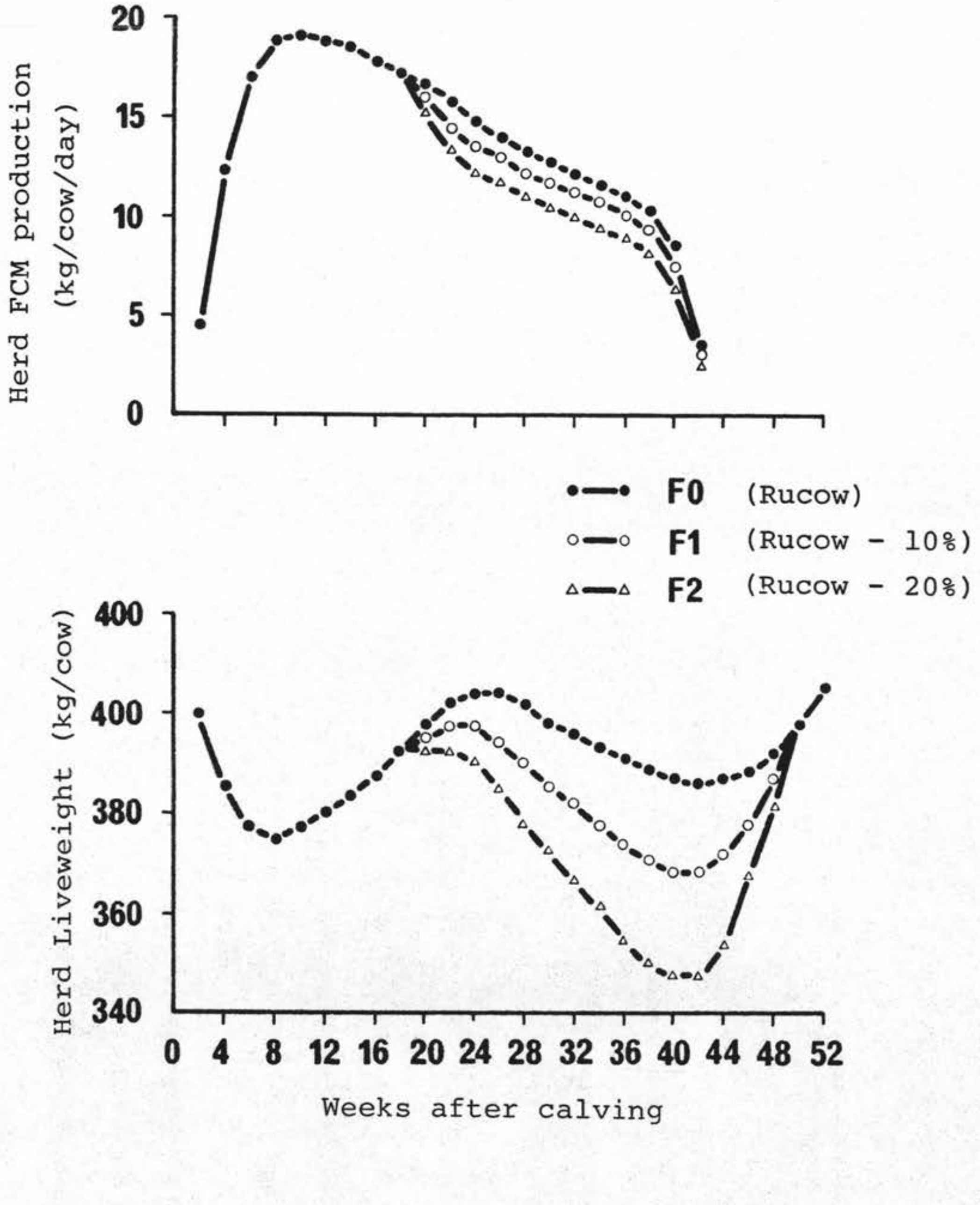

Figure 6.2 Milk production and LW patterns for three planes of nutrition.

extra energy involved in production metabolism is considered as a maintenance or production cost is irrelevant in the context of total energy requirement. Where it is relevant is in estimating the efficiency of conversion of metabolizable energy (ME) because the greater the proportion of total energy ascribed to maintenance then the more efficient production will appear to be.

There is general agreement that maintenance requirement varies with metabolic liveweight ($LW^{0.75}$) (A.R.C. 1965; N.R.C. 1971; Hutton 1971). Estimates vary from 0.41 to 0.62 MJ ME per kg $LW^{0.75}$ per day but more recent work was consulted to decide on values of 0.42 and 0.50 MJ ME per kg $LW^{0.75}$ per day for non-lactating and lactating cows respectively (Moe and Tyrell 1974; van Es 1976).

These estimates are for stalled, thermoneutral cattle so to this was added an allowance for activity. Suggested additions have been 4.0 MJ ME per day (A.R.C. 1965; Hutton 1971) or an additional 10 percent (Joyce et al. 1975). The maintenance requirements were therefore increased to 0.46 MJ and 0.55 MJ per kg $LW^{0.75}$ respectively.

Energy requirements for increased basal metabolism due to pregnancy are usually aggregated with those for foetal growth and increasing cow condition (N.R.C. 1971; Hutton 1971). Because of the need to treat liveweight change separately in this study, the energy requirements for each of these three functions was separately calculated. Energy requirements for increased basal metabolism were calculated from the following regression, calculated from data of Flatt et al. (1969).

$$Mp = 0.00166t - 0.304 \quad (r^2 = 0.76^{***})$$

where Mp = additional maintenance energy required from day 184 to day 281 of pregnancy (MJ ME per kg $LW^{0.75}$)

and t = day of pregnancy (days from conception).

6.6 ENERGY REQUIREMENTS FOR FOETAL GROWTH

The requirements for growth of foetus and accompanying tissues is relatively small, but since the growth of these tissues is exponential (N.R.C. 1971), the timing of the requirement may be important. Any energy deficiency in late pregnancy would presumably have to be met by mobilization of body reserves since it can be assumed that reproduction would have high priority at that stage.

Combining the data of Hutton and Bryant (1976) on weight of uterine contents with the energy content of reproductive tissue given by Hutton (1971) and assuming an efficiency of conversion of ME of 25 percent (van Es 1976) the requirements shown in table 6.1 were calculated.

Table 6.1 Energy requirements for foetal growth of a Jersey x Friesian cow

Fortnights before calving	Weight of reproductive tissues at mid-fortnight (kg)	Daily pregnancy energy (MJ ME)
10	9	)
9	11	)
8	14	) 6.5
7	17	)
6	21	)
5	25	6.6
4	30	7.5
3	36	9.0
2	42	10.8
1	48	14.4

6.7 ENERGY REQUIREMENTS FOR LIVEWEIGHT CHANGE

Liveweight gain during lactation is relatively efficient in energy terms. Assuming the efficiency is 60 percent (van Es 1976) the metabolizable energy requirement for liveweight gain depends on the value assumed for energy content of tissue gain. Assuming a higher fat/protein ratio than implied by Hutton's (1971) estimate of tissue net energy content (14.6 MJ per kg), a value of 20 MJ per kg is assumed (van Es 1972; Alderman et al. 1974), making the requirement for gain 33.3 MJ ME per kg.

During the dry period, all liveweight gained by RUCOW is assumed to be foetal and reproductive tissue, for which separate allowances are made[2]. Cows which have been underfed during lactation however, must regain body condition during the dry period. Since it is clear that efficiency of tissue gain is lower in dry than in lactating cows (A.R.C. 1965; N.R.C. 1971) it was assumed that efficiency of conversion of ME for liveweight gain fell linearly from 50 percent 12 weeks before calving to 30 percent 2 weeks before calving. Thus ME requirement increases from 40 MJ to 67 MJ per kg liveweight gain.

This falling efficiency is assumed to be related to stage of pregnancy and so any liveweight regained earlier than 12 weeks before calving by cows having shorter lactations is assumed also to require 40 MJ ME per kg.

The energy sparing effect of falling liveweight has been ignored on two grounds. First, the effect in late lactation is very small. Second, in the first few weeks after calving, the large loss in liveweight is assumed to be the unavoidable minimum and that the liveweight profile assumed was that of cows being fed *ad libitum*, rather than to calculated requirements.

[2] See section 6.6.

6.8 LACTATION ENERGY

An efficiency of conversion of ME for milk production (k_1) consistent with the maintenance requirements already discussed is around 60 percent (van Es 1976). Taking the energy content of milk (Tyrrell and Reid 1965) as

$$NE_1 = 0.3858\ MF + 0.2054\ SNF - 0.2356$$

where NE_1 = net energy in milk in MJ kg^{-1}

MF = percent milkfat

SNF = percent solids not fat

the net energy content of FCM at 8.9 percent SNF, is 3.14 MJ kg^{-1}. At a k_1 of 60 percent, ME requirement is therefore 5.23 MJ per kg FCM. To this basic requirement was added five percent to allow for additional inefficiencies in forage use. Among these are the effects of high protein content (Morgan 1972) as well as unexplained inefficiencies in silage utilization for milk production (Bryant and Donnelly 1974; Hutton and Rattray 1976; Bryant 1978). This brought the FCM ME requirement to 5.5 MJ kg^{-1}, the average requirement assumed for the milk production of RUCOW, throughout lactation.

Following Alderman et al. (1974) the efficiency of ME for milk production was assumed to be unaffected by energy concentration of feed. The latter is not expected to vary widely since concentrate will not be a routine component of rations.

6.9 NON-STANDARD LACTATIONS

Three feeding levels other than that specified for RUCOW were defined. These were 10 percent lower (L10), 20 percent lower (L20) and 12 percent higher (H12). The first two were defined as having total ME intakes uniformly 10 or 20 percent lower than RUCOW from week 18 of lactation to drying off.

Earlier underfeeding was not considered because of the importance of early lactation in setting efficiencies for the remainder of lactation (Broster 1976).

H12 was specified as a series of fortnightly options throughout lactation rather than as a single pattern.[3] The maximum increase assumed for any period was related to stage of lactation and corresponds approximately with appetite limits.

These feeding patterns were chosen to cover the range of production levels found on seasonal supply dairy farms (see table 6.2).

Table 6.2 Lactation patterns and milkfat production per lactation (kg)

Lactation length (days)	Plane of nutrition		
	Standard	-10%	-20%
267	161[1]	155	148
239	150	145	139
211	137	133	129
183	124	121	117

[1] The so-called "standard" cow (RUCOW).

Assumed responses to these changes in feeding level were derived from Broster's (1976) summary of short-term responses: a change in ME intake of 17 MJ results in a change in milk yield of 1.4 kg FCM and a change in rate of LW change of 0.15 kg per day.

[3] This was done on the simplifying assumption that liveweight change would be unaffected, an assumption justified only by the infrequency of levels of feeding higher than RUCOW.

Responses assumed for L10 and H12 were changes of 0.083 kg FCM and 0.0088 kg LW change per day for each MJ change in ME intake, as above. For feeding level L20, the response between 10 and 20 percent change in feeding was assumed to be 0.091 kg FCM and 0.0076 kg LW change per MJ change in ME intake, a 10 percent higher milk response but a linear total response in net energy. No change in maintenance energy requirement is considered warranted for loss of what is probably mainly storage fat.

To enable comparison between RUCOW and estimates by other workers these responses need to be expressed in terms of requirements. In these terms feeding 10 percent above or below RUCOW standards requires 12 MJ ME per kg FCM of which 3.6 MJ is unavoidably partitioned to LW change (LW change may be either LW gain or reduction in the rate of LW loss - a contribution to maintenance) giving a net requirement for additional milk production of 8.4 MJ ME. Requirements in the 80-90 percent feeding increment are 11 MJ ME per kg FCM of which 2.8 MJ is partitioned to LW change, giving a net requirement for additional milk of 8.2 MJ ME.

An example of a production function for milk and liveweight is shown in figure 6.3, where the linearity of the joint response can be seen. Calculated over the whole year, the milk production function would be much less linear, due to the penalties associated with regaining depleted body condition during late pregnancy.

6.10 PROTEIN REQUIREMENTS

It has been assumed that energy is the dominant factor in determining productivity. Minimum protein requirements are specified in recognition that some of the forage sources to be included in the model are deficient in protein and would require supplementing with high protein forages or with meatmeal.

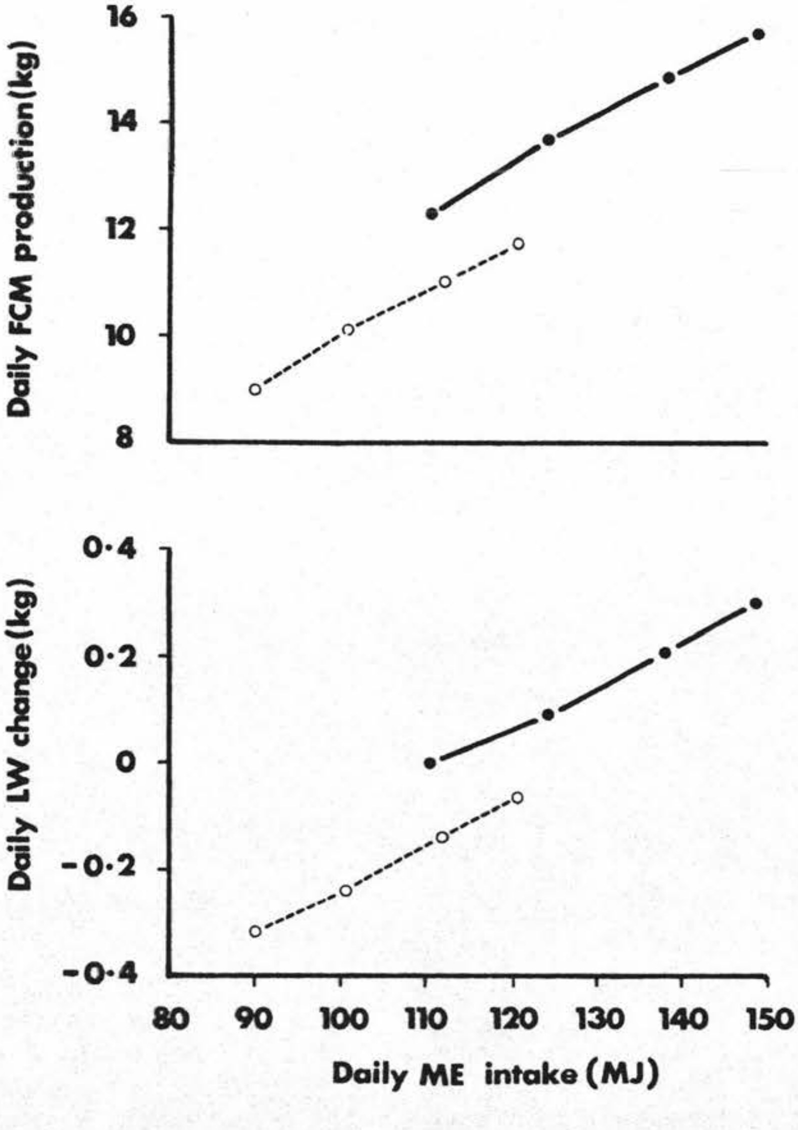

Figure 6.3 Milk production and liveweight change function 23 weeks (——) and 35 weeks (---) after calving

Any move toward extensive use of high protein supplements (including non-protein nitrogen) would require a more sophisticated approach such as that suggested by Satter and Roffler (1975).

The derivation of protein requirements generally follows the scheme of Preston (1972). Using a maintenance requirement of 1.6 g digestible crude protein (DCP) per kg $LW^{0.75}$, suggested by Preston (1972) and accepted by Satter and Roffler (1975), and a lactation requirement of 56 g DCP per kg FCM (Broster 1972; Lewis and Annison 1974) produces a requirement curve where on the x axis, energy intake expressed as a multiple of maintenance can be exchanged for level of production and on the y axis, protein requirement per unit energy can be exchanged for absolute protein requirement (figure 6.4). Thus allowances can be made for liveweight gain and pregnancy as well as lactation.

One problem with forages differing widely in protein content is that their protein digestibilities will also differ. Figure 6.5 compares estimates of protein digestibility given by Glover et al. (1957) with values for some forages from the N.R.C. (1971) tables. The former authors have shown that the same relationship applies to mixed feeds so that the digestibility of a mixture of forages of different protein contents will not be the same as a weighted mean of their digestibilities. Preston's (1972) suggestion was to convert animal requirements to crude protein and this has been done by assuming a feed energy content of 10.5 MJ ME per kg.

Thus in weeks 29 and 30 of a standard lactation, total energy requirement is 2.42 times maintenance. From figure 6.4 is read off a protein requirement of 7.15 g DCP per MJ ME which, with 10.5 MJ ME per kg DM, equates to a DCP concentration in the dry matter of 7.5%. From figure 6.5, crude protein required is 12.3% and this converts to 11.71 g CP per MJ ME

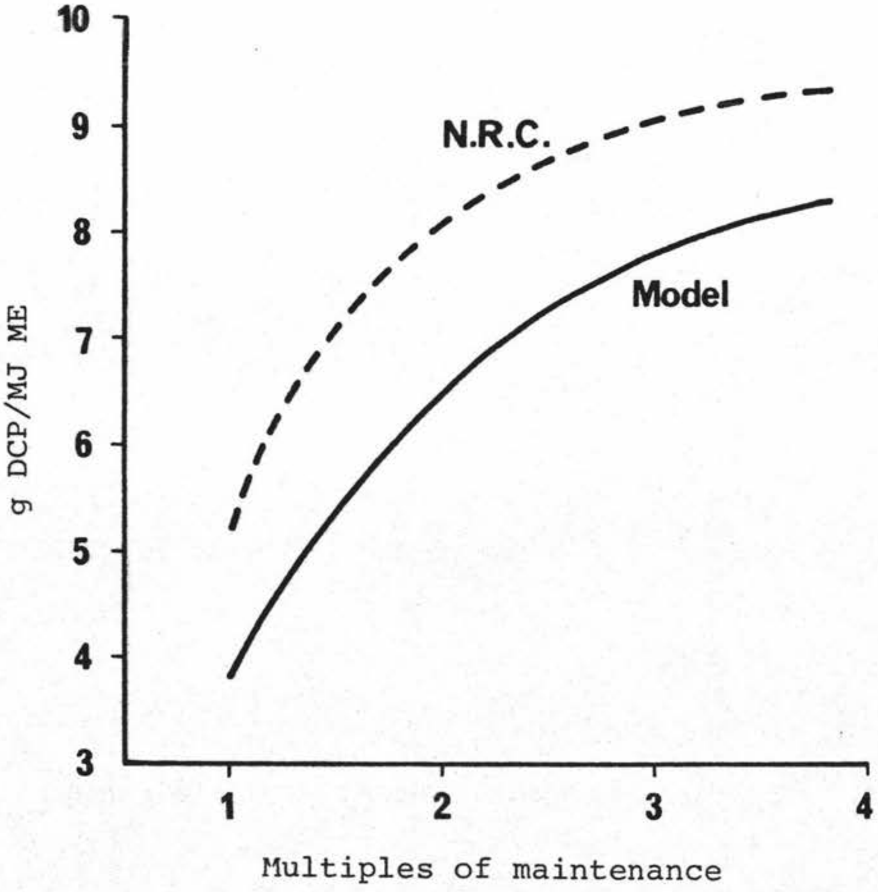

Figure 6.4 Digestible crude protein requirements related to level of production.

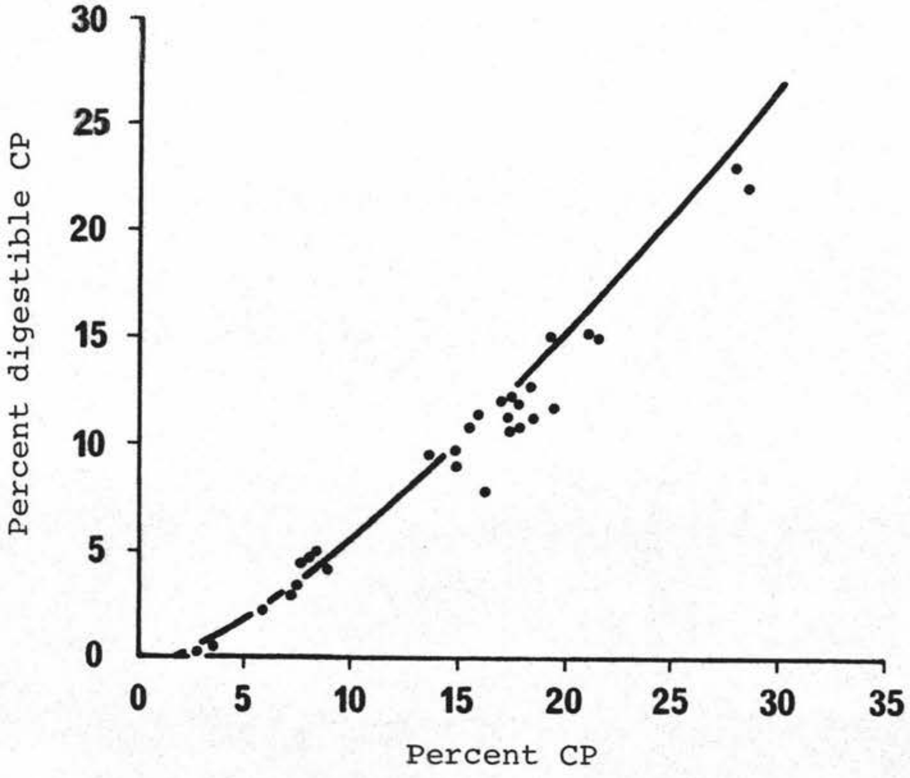

Figure 6.5 Apparent digestibility of crude protein. Points are NRC (1971) values for maize, lucerne, red clover, wheat and birdsfoot trefoil. Line represents DP = CP (0.7 log CP - 15). (Glover _et al_ 1957).

and a daily requirement of 1393 g crude protein. In practice, a curve giving the requirement of CP per MJ ME for any multiple of maintenance was constructed and used.

On the assumption that protein is most likely to be limiting in summer and autumn the energy content of 10.5 MJ per kg DM was chosen as an average value for summer forage and silage.

At a forage energy content of 10.5 MJ ME per kg DM, dietary crude protein levels for the RUCOW vary between 8.3 percent at maintenance to 13.7 percent at lactation peak. These estimates may be compared with N.R.C. (1971) estimates of 8.5 percent for maintenance and 14 percent for milk production of less than 20 kg per day. Satter and Roffler (1975), after calculating the metabolizable protein content of various feeds, estimate crude protein requirements of high producing cows as 16.5 percent early in lactation, falling to 10 percent in late lactation.

The latter authors suggest that while non-protein nitrogen can be used extensively as a protein supplement to bring rations up to a crude protein content of about 12.5 percent, only true protein is useful to raise crude protein levels to the higher levels required in the first third of lactation.

6.11 DRY MATTER INTAKE

Despite the existence of simple formulas like

$$DMI = 0.025\ LW + 0.1\ Y$$

where DMI is dry matter intake and Y is milk yield per day (Bines 1976), the control of dry matter intake in most likely a closed-loop system with feedback control mechanisms, and so, much more complex than the formula just given (Monteiro 1972). If dietary characteristics also influence voluntary intake despite dry matter digestibility being greater than 65-67 percent (Conrad et al. 1964; Bryant and Donnelly 1974) then the prediction of intake limits on variable diets becomes extremely complex.

Experimental estimates of voluntary intake are specific to the cows concerned and normally take no account of cow body condition or of dietary characteristics (e.g. Hutton 1963). Moreover, the data available are intake achieved rather than potential intake.

The simplified approach taken here is to assume that intake limit is a function of bodyweight alone and is not affected by food source. There is enough experimental evidence to indicate that for forages of greater than 65 percent digestibility, substitution of other forages for pasture does not necessarily result in a decrease in voluntary intake (e.g. Bryant and Donnelly 1974; Hutton and Douglas 1975).

It was assumed that the higher published peak intakes represented limits to forage intake. Accordingly, expressed as a percentage of bodyweight, dry matter intake limit is taken to increase from 2.5 during the dry period to 4.0 after peak lactation and then to fall until the end of lactation (Hutton 1963, 1971; Hutton and Bryant 1976; M.A.F. 1976). The pattern assumed is shown in figure 6.6.

6.12 SUMMARY OF ME REQUIREMENTS

<u>Maintenance</u> = $\alpha W^{0.75}$

α = 0.42 MJ (non-lactating)

α = 0.50 MJ (lactating)

<u>plus</u> 10% for grazing activity to give

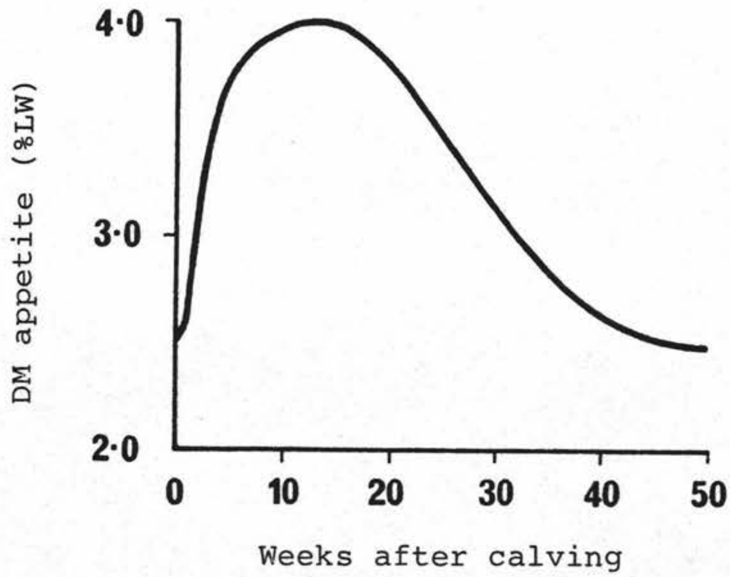

Figure 6.6 Assumed DM appetite limits

α = 0.46 MJ (non-lactating)

α = 0.55 MJ (lactating)

plus (0.00166 t - 0.304) MJ from day 184-281 of pregnancy (where t = days from conception).

Lactation

(a) "Standard" cow (100% relative feeding)
5.5 MJ per kg FCM at all stages of lactation. This is a net requirement. Liveweight change has separate requirements.

(b) Marginal requirements

90-112% relative feeding
12.0 MJ per kg FCM change of which 3.6 MJ is actually partitioned to LW change (8.4 MJ net).

80-90% relative feeding
11.0 MJ per kg FCM change of which 2.8 MJ is actually for LW change (8.2 MJ net).

Liveweight gain

(a) During lactation
33.3 MJ kg^{-1}

(b) Dry period
40 MJ kg^{-1} up to 12 weeks before calving thereafter (72.4 - 2.7 w) MJ kg^{-1} where w = weeks before calving.

Growth of foetus etc.

Increasing from 6.5 MJ ME per day 20 weeks before calving to 14.4 MJ ME per day in the week before calving (a total of 1130 MJ).

6.13 SUMMARY OF DCP REQUIREMENTS

Maintenance

1.6 g per kg ($W^{0.75}$)

Lactation or equivalent energy demand

56 g per kg FCM

6.14 COMPARISON OF MODEL COW WITH OBSERVED COWS

Brought together in table 6.3 are comparisons of aggregated requirements between model assumptions and independent[4] data derived from experiments. Where possible, ranges have been compared with ranges but in some instances, only "standard" cows are compared. Where necessary, figures are expressed per unit of liveweight or production to allow comparison between cows of different breeds or liveweights.

Generally, model assumptions fall within the limits of experimental observations although there is scope for compensating errors to exist in model aggregates. In particular, the assumptions of constant requirements for lactation and LW gain of RUCOW and constant rates of response throughout lactation are hard to justify except on the grounds of lack of data.

[4] M.A.F. (1976) data not experimental and probably not completely independent.

Table 6.3 Comparison of model requirements and responses with independent calculations and experimental observations[1]

	Model	Observed	Reference
Lactation efficiency (270 days)	9.07	9.19	(1)
(MJ ME per kg FCM)		8.71	(2)
(milk energy/total ME intake - %)	34.6	34.5	(1)
		36.1	(2)
Dry period ME (MJ per kg $LW^{0.75}$)	0.66	0.80	(1)
		0.74	(3)
		0.63	(2)
Annual efficiency	28.5-23.8	25.0	(1)
(kg DMI per kg MF)		31.4-25.5	(4)
		20.0	(3)
		22.5	(2)
		23.6-20.0	(5)
		18.5	(6)
LW gain efficiency in dry period (kg DM per kg LW)	5.8-4.5	5.0	(3)
Milk response to feeding	12.0-8.2	12.6-8.6	(4)
(mid-late lactation		7.9-4.7	(7)
MJ ME per kg FCM)		24.6-10.2	(8)
		28.0-15.9	(9)
Efficiency of milk + LW response to feeding in mid-late lactation ((NE in milk + NE in LWG)/ME intake) (%)	38-44	49-123[2]	(7)
		38-41	(9)

[1] Where not given, pasture ME assumed as 11.0 MJ per kg except in summer when 10.5 MJ assumed; LW gain and FCM assumed to contain 20 MJ and 3.14 MJ NE per kg respectively.

[2] High variance in LW estimates.

References:
(1) Hutton (1971)
(2) M.A.F. (1976)
(3) Hutton and Bryant (1976)
(4) Hutton (1974)
(5) Campbell et al. (1977)
(6) Campbell et al. (1978)
(7) Bryant and Donnelly (1974)
(8) Hutton and Douglas (1975)
(9) Bryant (1978)

CHAPTER SEVEN

THE PASTURE COMPONENT

7.1 INTRODUCTION

In the context of this study, pasture refers to permanent pasture, as normally grazed by dairy cows in New Zealand. This is a mixture of perennial grasses and clover, varying in detailed composition from site to site and from time to time. Other forages, whether permanent or not, grazed or not, are discussed as crops in the next chapter. This chapter deals with the assumptions made regarding conventional pasture in the linear programming model, including the use of a simulation model to generate several years pasture growth data.

The diversity of soil types (Gradwell 1971) and associated pasture in Northland meant that some "representative" pasture type had to be assumed. Although paspalum (*Paspalum dilatatum*) and kikuyu (*Pennisetum clandestinum*) can be dominant in Northland pastures, most dairy pastures are dominated by perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). Paspalum is generally decreasing in abundance, probably as a result of increasing stocking rates and black beetle (*Heteronychus arator*) damage (Percival 1977). Kikuyu is being actively eradicated from dairy farms because of its slow winter and spring growth (Lambert 1967) and its low digestibility in comparison with ryegrass. A "representative" pasture is assumed also to be growing under conditions of moderate soil moisture or soil fertility.

7.2 PASTURE GROWTH

When the study began, there was no detailed information about ryegrass-clover pasture production in Northland. Kikuyu-dominant swards had been studied at Kaitaia, Dargaville and Whangarei (M.B. O'Connor, personal communication) while published data concerned paspalum-dominant pastures at Dargaville on heavy clay soil (Baars 1976a) or was aggregated into seasonal totals (Lambert 1967).

Initially, the only feasible approach was to consider synthesising pasture growth by modelling. A simulation model of ryegrass-clover pasture growth developed by Wright and Baars (1975) as part of a beef production model (Wright et al. 1976) was the only such model readily accessible at the time so much effort was made to adapt it to Northland conditions.

7.2.1 ADAPTATION OF SIMULATION MODEL

The simulation model uses a set of quadratic functions to define potential growth rate at the mid-point of each month. These curves describe potential growth rate as a function of current dry-matter yield and can be taken to imply the relationships between radiation receipt, leaf area and potential growth rate. Linear interpolation between month mid-points provides functions to calculate potential growth rate each day. Potential growth rate is then modified by a correction factor to account for the difference between daily and long-term average temperature. Growth may be further reduced if soil moisture availability limits potential evapotranspiration.

Differences in radiation receipt between Northland and the region for which the potential growth functions were originally developed prompted the first adjustments, shown in table 7.1. Mid-points of Northland months were assigned the listed original function or mean of two original functions. These changes had only minor effects on potential growth rate, as shown in figure 7.1.

Table 7.1 Adjustments for radiation differences

Month	Wright and Baars (1975) relationship used
July	July-August
August	August
September	September
October	September-October
November	November
December	December
January	January-February
February	February-March
March	March
April	March-April
May	April-May
June	May

The second adjustment was for temperature. The original model modifies daily potential growth rate according to the difference between actual and average temperature. Since average temperatures in Northland are higher than in the environment for which the original model was developed, the temperature functions of the original model were used to make permanent increases in the potential growth rates between May and October. These changes resulted in increases in potential growth rate of between 6 kg ha^{-1} day^{-1} in June and 23 kg ha^{-1} day^{-1} in October (see figure 7.1). In summer and early autumn, potential growth rate in the original model was negatively

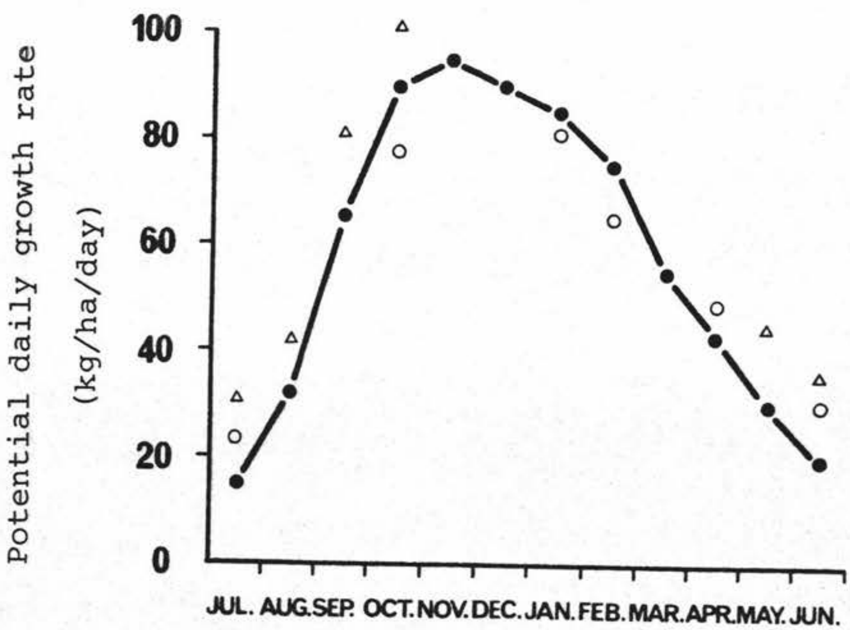

Figure 7.1 Potential growth rates of original model (solid circles); original rates adjusted for radiation (open circles); and adjusted rates modified for temperature (open triangles)

correlated with daily maximum temperature but this relationship was omitted from the Northland model. Reference to the data of Brougham (1959) and Brougham and Glenday (1969) indicated that while ryegrass responded in this way, white clover growth rate was increased by increasing temperature.

In the operational phase of the model, temperature effects operate on potential growth rate in an analagous way. Between mid-April and mid-November each degree difference between daily and average mean temperature causes a ten percent change in growth rate. During the rest of the year, daily temperature has no effect.

The other major change to the original model concerned the effects of nitrogen deficiency, thought to be greater in Northland than elsewhere (Piggot et al. 1978) due possibly to the effects of recurrent summer drought on clover persistence. Nitrogen was assumed to be a rate-limiting factor and nitrogen deficiency was assumed to be important at growth rates above 50 kg ha^{-1} day^{-1}. An arbitrary function was defined which would discount by 20 percent growth rates of 100 kg ha^{-1} day^{-1} and provide linear interpolation down to 50 kg ha^{-1} day^{-1} .

Using weather data for 1975-77, the results shown in figure 7.2 were obtained. These were discussed with a number of people familiar with Northland pastures and there was general agreement that the pattern was reasonably typical of Northland pasture growth. There were no prospects of better validation so the model was run for 16 years of historical weather data from Kaitaia Aerodrome. The resulting average growth rate in each fortnight is shown in figure 7.3. With no prospect of detailed validation against field data there was no justification for simulating a longer sequence of years.

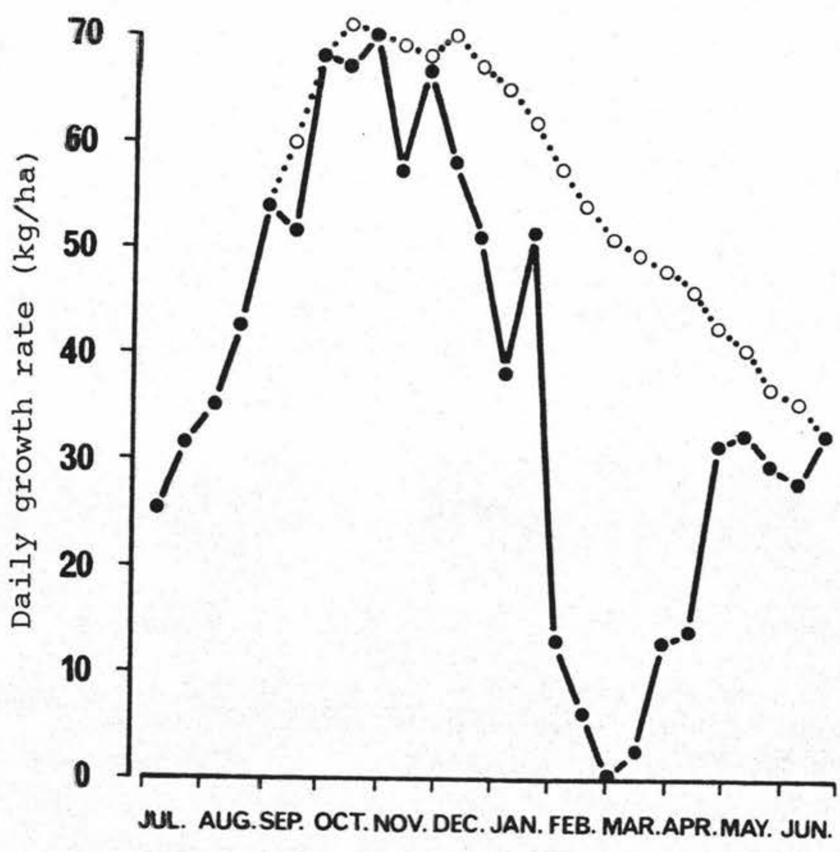

Figure 7.2 Simulated dryland (——) and irrigated (...) pasture growth rates 1975-77.

7.2.2 OTHER ESTIMATES OF PASTURE GROWTH

By late 1978 more information about Northland pasture growth rates was available. Ten years measurement of the growth of a ryegrass-clover pasture at South Kaipara was reported by Piggot et al. (1978). Pasture growth at four sites around Kaitaia was measured by Taylor et al. (1979c), and T.S. Clarkson (personal communication) was measuring pasture growth at two sites near Whangarei. Also, L.J. Davies (personal communication) kindly provided data from an experiment comparing ryegrass with some tropical grasses at Kaitaia. All these estimates had much lower late autumn, winter, and early spring growth rates than the simulation model (see table 7.2 and figure 7.3). South Kaipara spring growth rates rose more slowly in spring than the Kaitaia simulation or Hamilton measurements (Baars 1976b), due possibly to greater nitrogen deficiency in Northland (Piggot et al. 1978); excessive soil moisture seems an unlikely cause on such a well-drained soil, although it probably limits spring pasture growth on many Northland soils (A.O. Taylor, personal communication).

7.2.3 FINAL GROWTH PATTERN ASSUMED

Data of Taylor et al. (1979c), Clarkson (personal communication) and L.J. Davies (personal communication) relate to a limited number of years so they were finally used to decide, for each period, whether to accept simulation or South Kaipara growth rates. South Kaipara means were accepted for periods 1-12 (July 1 - December 15) and periods 23-26 (May 5 - June 30) and simulation means for periods 13-22 (December 16 - May 4). However, growth rates for periods 22, 23 and 24 were discounted by 0.5, 0.25 and 0.125 respectively to account for the residual effects of drought on pasture productive capacity. This gave an average growth rate over

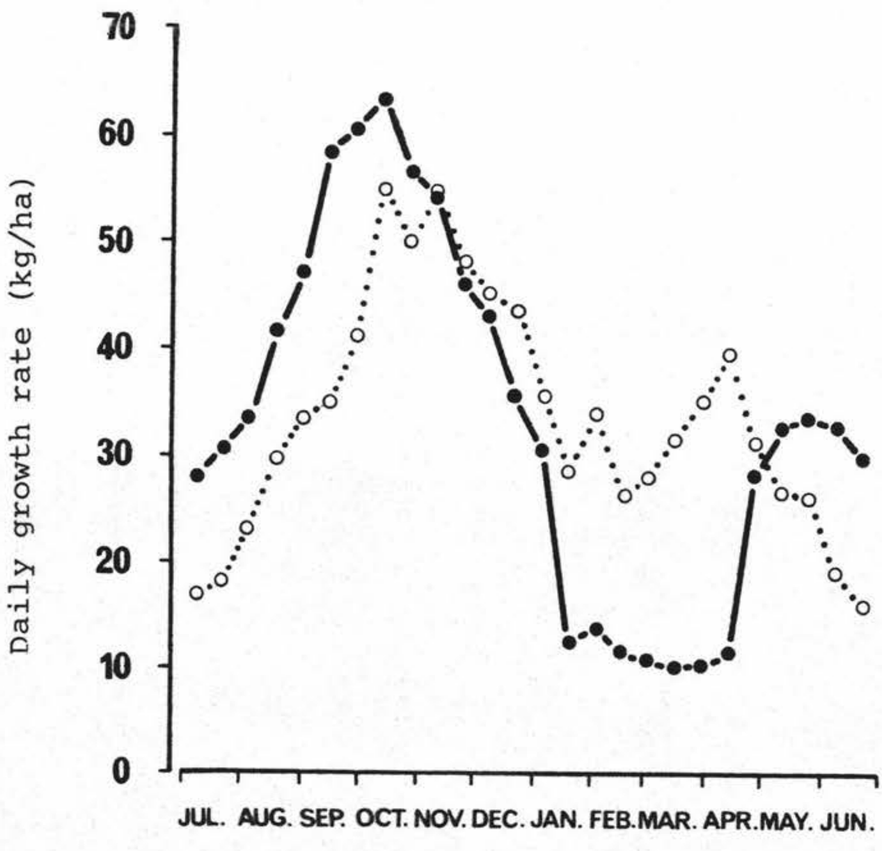

Figure 7.3 Average pasture growth rates at Kaitaia (——, simulated) and at South Kaipara (..., Piggot et al. 1978)

Table 7.2 Pasture growth estimates

Period no.	Starting date	Simulated Kaitaia 1962-78	S.Kaipara 1964-74	Kaitaia 1977-78	Whangarei 1978-79	Kaitaia 1976-78	ASSUMED Mean	S.D.
1	Jul 1	28	17	18	11	18	17.0	1.8
2	15	30	18			19	18.3	1.7
3	29	34	23			27	23.1	2.4
4	Aug 12	41	30	17	26	27	29.5	2.4
5	26	47	34			27	33.5	3.2
6	Sep 9	58	35		34	31	34.8	2.3
7	23	60	41	43		44	41.1	3.7
8	Oct 7	64	55		27	44	45.0	5.8
9	21	56	50	49		40	49.8	12.0
10	Nov 4	54	55			49	54.7	19.1
11	18	46	48	48	21	56	47.8	19.9
12	Dec 2	43	45			56	45.4	18.7
13	16	36	43	24		28	35.6	21.8
14	30	31	35		12	28	30.5	20.8
15	Jan 13	12	28	13		28	12.5	10.5
16	27	14	34		25	23	13.8	14.6
17	Feb 10	12	26			23	11.5	14.5
18	24	11	28	7		24	10.8	14.0
19	Mar 10	10	32			27	10.1	9.3
20	24	10	35		N/A	13	10.5	10.1
21	Apr 7	11	40	13		13	11.4	6.2
22	21	28	31		28	19	14.0	4.9
23	May 5	33	26	18		19	19.9	5.0
24	19	34	26			19	22.6	5.5
25	Jun 2	33	19		10	19	19.1	4.6
26	16	30	16			19	15.9	2.1
Annual yield		12785	12760	9780		10627	9500	

the three periods of 18.8 kg ha^{-1} day^{-1}, a figure almost identical with the results of Davies and of Taylor (see table 7.2). The final assumed growth rate is shown in the last column of table 7.2.

A feature of the simulations was the markedly skew distribution of growth rates over summer. Between January and April, modal growth rate was less than 10 kg^{-1} day^{-1} yet the highest growth rates usually exceeded 40 kg^{-1} day^{-1}. There is some doubt whether these high rates are realistic. Much of the rainfall at this time of the year is in the form of high intensity storms and would, in practice, largely be lost as runoff before the profile was recharged.

7.3 PASTURE MANAGEMENT AND UTILIZATION

The treatment of pasture management in the model is relatively simple. Unlike the studies of McRae (1976) and Pollard (1972) the details of pasture management are not at issue here. While there may be small gains to be made from better pasture management than occurs in this model or on Northland farms, the reliability of pasture growth data does not justify any attempt at specifying detailed management options.

The basic assumption is that pasture grown in any period can be grazed in that period with 90 percent efficiency. Any assumptions about the level of utilization of standing pasture are implicit in the pasture growth data sources. It is not possible to specify the pasture presentation yields (before or after grazing) which led to the growth pattern assumed. In the case of the growth data taken from Piggot et al. (1978), no presentation yields are available. In the case of the simulation model, the growth rates were averaged over 16 years and over three replicates whose grazing cycles were 10 days out of phase. No averages for presentation yields were computed but yield before grazing ranged from about 2500 kg DM ha^{-1} in autumn and spring to about 1000 kg DM ha^{-1} in January-February. Stubble after grazing ranged between 800 and 1000 kg DM ha^{-1}.

Pasture grown but not grazed may be saved into the next fortnightly period. For most of the year this is assumed to involve no losses or that whatever losses occur are compensated by an increase in growth rate resulting from average standing pasture yields being closer to those giving optimal potential growth. During summer, slow growth and high temperature desiccation are assumed to result in dry matter losses of 10 percent in periods 15 and 19; of 20 percent in periods 16 and 18; and of 30 percent in period 17. Pasture management is assumed continuous by allowing carryover from the last period to the first.

Pasture energy content is taken directly from estimates made by Wright (personal communication) and his Ruakura colleagues for use with the simulation model described by them. Crude protein content is an amalgamation of the measurements made by Taylor et al. (1976a, 1977b, 1979c).

7.4 NITROGEN FERTILIZER ON PASTURE

Nitrogen fertilizer has potential for changing the pattern of pasture growth as well as its total quantity. Responses to nitrogen depend on the interaction of environment and pasture management (Ball 1970) so that the limited field data available are likely to be time and site specific. What is required is a more general scheme for predicting responses.

During (1967) suggested average dry matter responses of 13 kg per kg nitrogen in the cooler parts of the North Island and 20 kg in northern areas. While data can be selected which may or may not support these suggestions, there are enough observations of responses in excess of 20 kg per kg nitrogen (see, for example Ball et al. 1976, Ball 1970, Sherlock and O'Connor 1973) to allow the assumption that given appropriate conditions, these responses can be obtained. As far as timing is concerned, Sherlock and O'Connor (1973) could show no difference in efficiency of response to nitrogen applied at any time between April and early September, only in the time over which the response is spread.

Because of these uncertainties and the unknown effects of continuous nitrogen application, total annual nitrogen was limited to 150 kg ha^{-1} in three applications. Responses of 20 kg dry matter per kg nitrogen are assumed, recoverable over 8 weeks in late autumn (periods 22-25) and late winter (periods 4-7) and over 6 weeks in spring (periods 7-9). Any application of nitrogen is at 50 kg ha^{-1} and although only 3 application times (periods 4, 7 and 22) are specified, by defining the responses as occurring over several periods, it is possible to imply times of application and availability of responses as shown in table 7.3. If extra herbage grown contains 2.5 percent nitrogen, recovery in the tops of 50 percent of applied nitrogen is assumed. Twenty-five percent of the extra herbage is assumed to be below defoliation height. The remainder is aggregated with pasture growth in the ordinary way.

Table 7.3 Implied timing of nitrogen application and response

Specified application period[1]	Specified response periods	Implied application period
4	4	1
	5	2
	6	3
	7	4
7	7	5
	8	6
	9	7
22	22	19
	23	20
	24	21
	25	22

[1] See table 7.2 for actual dates.

7.5 PASTURE SILAGE

Many of the assumptions made about pasture silage are quite arbitrary since there was no information from field monitoring of any silage making in Northland, let alone wilted, fine-chop silage making as assumed here.

Pasture is shut up for 6 weeks before cutting for silage. During that time and for the next 2 weeks no growth is available for grazing. For the next 2 weeks (weeks 9 and 10 from shutting up) only half the normal growth is assumed to take place. Shutting up may commence in periods 7, 8 or 9 (September 23, October 7 or October 21). Yield of silage is not directly related to pasture growth since different defoliation levels are assumed. The two early cuts are assumed to yield 3.5 t DM ha^{-1} fed out, the late cut 3.0 t ha^{-1}. With assumed dry matter losses of 12 percent in storage and 5 percent in feeding out, paddock yields of 4.2 t and 3.6 t ha^{-1} are implied.

In practice, greater yields may be achieved by delaying harvest, but only at the expense of silage quality. Since one of the objectives of wilted fine-chop silage is to produce a high quality feed suitable for production rations, high quality silage was the only kind specified. Thus all pasture silage was assumed to have a M.E. concentration of 9.5 MJ kg^{-1} and a crude protein content of 14 percent.

Silage costs were divided into production costs, (those incurred on a per unit area basis), and storage and feeding costs, (those incurred on a per unit weight basis).

7.6 PASTURE HAY

The mechanics of conserving pasture as hay were the same as for silage except that pastures were shut up in periods 8 and 10 and were not available for grazing again until 12 weeks had passed. As with silage, yields are arbitrary. Higher growth rates while pasture is locked up, different defoliation levels, and haymaking losses account for differences between pasture withheld from grazing and yield of hay. While regrowth is delayed in the same way as after silage is harvested, the later timing of haymaking means that there can be no build up of pasture to carry into January and February.

Metabolizable energy content is assumed to be 8.4 MJ per kg DM and crude protein content 12 percent. This implies good quality hay (M.A.F. 1976), a notion again incompatible with delaying harvest to promote higher yields.

Costs are divided in the same manner as for silage but are based on the farmer doing most of his haymaking rather than contracting as with silage. Thus hay was slightly cheaper per unit dry matter or per unit energy, though if costed in the same way as pasture silage would cost more.

7.7 SUMMARY

This chapter has outlined the assumptions made about pasture growth and utilization. It began by showing how a simulation model developed for another region was adapted for Northland. Next, the process of combining simulation model output with other estimates of pasture growth to derive a synthetic growth pattern was discussed. Then the assumed simple scheme of pasture grazing management was described. Next, it was argued that the influence of nitrogen fertilizer on pasture growth and utilization was so uncertain that substantial restrictions were necessary on its timing and quantity. Finally, assumptions regarding the conservation of pasture as silage or hay were given.

CHAPTER EIGHT

THE CROP COMPONENT

8.1 INTRODUCTION

For purposes of discussion crops are here defined as forage sources other than the conventional pasture dealt with in the previous chapter. Specifically included are perennial swards (of species other than perennial ryegrass and white clover) whose main use will be as grazing.

The range of crops considered is limited to those either in commercial use or which have been tested experimentally in Northland or in a similar environment. The subjective nature of the prior decisions leading to this situation are recognized though there is at present, no remedy. In the present circumstances, a crop may be considered as a potential forage source on two criteria. Firstly, it may be envisaged filling a conceptual role in a particular kind of system, e.g. winter legumes as a means of reducing fertilizer nitrogen inputs (Taylor and Hughes 1976). Secondly, it may simply have high potential yields but no obvious role in an animal production system, e.g. winter cereals which give yields up to 20 t ha^{-1} harvested in November-December (Kerr and Menalda 1976).

8.2 CROP MANAGEMENT

The yield advantages of crops over pasture can only be realized where crops are well managed. In particular, time of sowing and harvest have been shown to greatly influence yield of annuals (Menalda and Kerr 1973; Kerr and Menalda 1976; Taylor et al. 1976b). If double cropping systems, as envisaged in this study, are to succeed there is little latitude for altering sowing dates, though harvesting time is flexible up to a limit. Only one optimal sowing time is assumed for each crop.

This assumption is made on the basis that different patterns of forage availability can be got from different crops or different harvesting times, rather than from sequential planting times as used by Stephen and McDonald (1978). A theoretical example is provided by Taylor and Hughes (1978) where, in the final year of a maize and cereal sequence, an early maturing wheat is substituted for oats so as to allow establishment of red clover in early October.

Other aspects of management, though unspecified, are implicit in the yields and costs given. That is, assumed yields are below experimental means but assume a certain adequate standard of management together with the costs thereby incurred.[1]

Efficient harvesting, storage and feeding of silage (and hay) is assumed. Harvesting losses are assumed to be already accounted for in the yield data. Assumed losses in storage (12 percent) and feeding (5 percent) result in a total loss of 16.4 percent of dry matter yield for all conserved forages.

Changes in nutritive value during the conservation process may result in losses of nutrients additional to those lost physically in the dry matter. For instance, the

[1] Assumptions about level of technology are discussed more fully in section 5.4.2.

reduction of ME content from about 11.0 MJ kg^{-1} in fresh pasture to 8.4 MJ kg^{-1} in pasture hay, when added to the 16.4 percent loss in dry matter results in a total ME loss of 36 percent.

8.3 CROP NUTRITIVE VALUE

In many cases, there was no direct information about crop quality in Northland or in New Zealand. Recourse was often made to overseas data (e.g. N.A.S. 1971; A.R.C. 1976) which for conserved forages was reasonable enough. However, feeding trials and proximate analyses which provide such data presumably refer to whole plants and will usually underestimate the nutritive value of a crop which is selectively grazed. Some allowance was usually made for the effects of selective grazing on the assumption that cows will select for higher digestibility.

8.4 MAIZE (*Zea mays*)

Maize has been a key component of most alternative forage feeding systems considered for New Zealand. It is widely used as a forage crop in western Europe and the U.S.A. (Taylor 1975). Its putative advantages have been summarized by Kerr (1975) as:

(a) potential yield twice that of pasture;
(b) less affected by drought than pasture;
(c) conserved as silage, it reduces the correlation between season and farm output.

Although there is limited information on maize yields in Northland, substantial data are available for other areas. Mean yield at maturity was therefore calculated by taking the mean Waikato grain yield for the years 1970-71 to 1974-75[2] and converting to silage dry matter yield by multiplying by 1.7 (Kerr 1975). Yields of earlier years were not considered because of the novelty of the crop at that time. The generally declining yields of years after 1974-75 were not included in the calculation. It is suspected that they were due to low temperature in November and December (McCormick, personal communication). The relationship can be described by the equation

$$y = 0.0154x + 1.88 \ (r^2 = 0.79^{***})$$

where y = grain yield at 15% moisture (t ha^{-1})
x = accumulated degree days above 10°C in November and December.

Generally higher temperatures in Northland, it is assumed here, would result in more stable yields. The final silage yield (harvested) assumed was 14.3 t ha^{-1}.

The possibility of earlier grazing of maize required estimates of yield prior to maturity. The growth curve synthesized from data of Menalda and Kerr (1973), Thom (1977) and Ridler (personal communication) is shown in figure 8.1. Utilization by grazing was assumed to fall linearly from 90 percent at a dry matter yield of 3.5 t ha^{-1} (early January) to 65 percent at a dry matter yield of 14.3 t ha^{-1} (mid-March) although limited field experience suggests no such simple relationship (B. Ridler, personal communication; K. Jagusch, unpublished data).

Assumed metabolizable energy and crude protein contents of maize consumed by cows are shown in figure 8.1. The

[2] Data supplied by S.J. McCormick

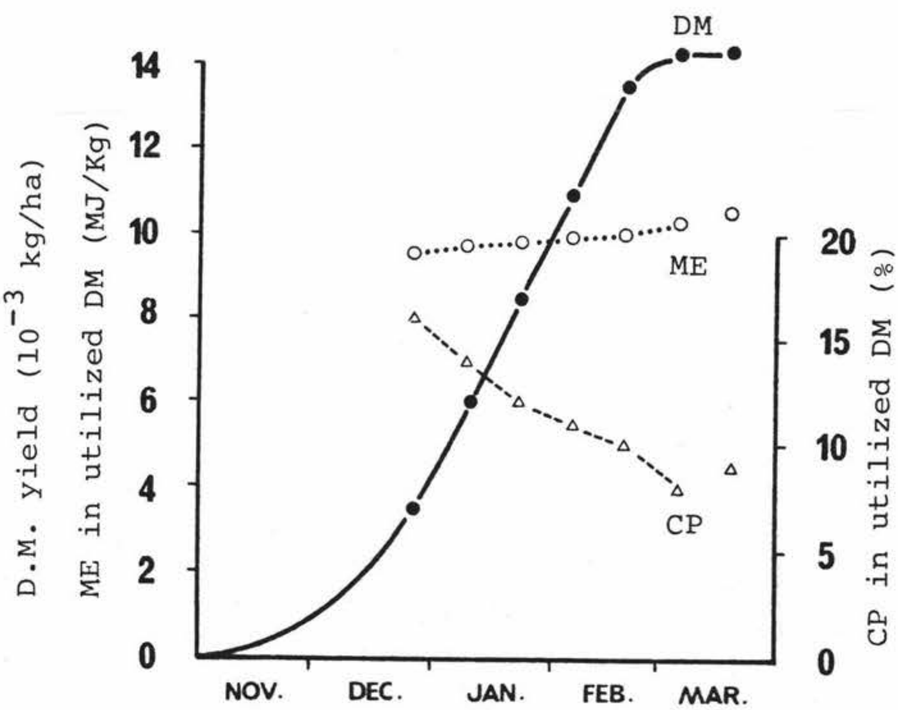

Figure 8.1 *Maize:* assumed growth pattern and nutritive value of greenfeed (joined points) and silage.

former was inferred from data of N.A.S. (1971), the latter from data of Hanway (1962) who showed that, prior to silking, nitrogen accumulates faster in maize than dry matter. Silage nutritive value is taken from Wilkinson and Kilkenny (1977) who suggest that crude protein content can be increased cheaply, if necessary, by adding urea.

Maize silage is assumed to be made from mature maize with a grain content around 50 percent of the dry matter and with a mean dry matter content of 30-35 percent.

8.5 HYBRID GRAZING SORGHUM (*Sorghum bicolor* x *S. sudanense*)

Two factors favour the use of a sorghum such as cv. Sudax SX6 in Northland. First is its relative drought resistance (Gerlach and Cottier 1974; Taylor et al. 1974) compared with ryegrass-clover pasture. Second is its characteristic of regrowing after defoliation (Chu and Tillman 1976) thus extending its useful grazing season over a longer period than a non-regrowing crop such as maize.

Cut twice or three times, Sudax in Northland yields around 10000 kg ha^{-1} DM (Jurlina 1978) compared with 9400-9700 kg ha^{-1} in the Waikato (Gerlach and Cottier 1974). Although much higher yields can be obtained from a single later harvest, a total DM yield of 10000 kg ha^{-1} was assumed in this study. Strip grazing can be used to obtain a smooth pattern of dry matter availability over summer (Jurlina 1978) though some quality variation is assumed as the crop becomes more mature. Table 8.1 suggests three grazing patterns which have been aggregated to give the feed availability pattern in table 8.2. Although there may be circumstances in which a different pattern of feed availability might be desirable, the influence of maturity on digestibility, dry matter utilization and regrowth potential (A.O. Taylor, personal communication) and on hydrogen cyanide toxicity (Hunt and

Taylor 1976) effectively limits grazing management options with Sudax.

The quality assumptions of table 8.2 are drawn from N.A.S. (1971) data on Sudan grass together with some crude protein measurements made in Northland (Hunt et al. 1979; Taylor, unpublished data).

Table 8.1 Sudax: three assumed grazing patterns

Period no.	Grazing no.	Yield on offer kg ha^{-1}			Utilization %
15	1	3500			90
16	1		4500		80
17	1			5000	65
18	2	4000			85
19	2		4500		85
20	2			3000	85
21	3	2000			80
22	3		2000	1000	80
Total		9500	11000	9000	

Table 8.2 Sudax: assumed pattern of availability of DM, ME and CP when grazed as in table 8.1.

Period no.	Utilizable DM (kg ha^{-1})	ME content (MJ kg^{-1})	CP content (%)
15	1070	10.7	14
16	1220	9.5	12
17	1100	9.4	10
18	1150	10.5	13
19	1290	10.5	13
20	860	10.5	13
21	540	10.3	12
22	410	10.3	12
Total	7640	10.2	12

8.6 WINTER CEREALS

Winter cereals, particularly oats, have been seen as useful forage sources which can be grown between successive maize crops and can be grazed or ensiled (Eagles and Taylor 1976; Kerr and Menalda 1976). Only in the last few years have specialist forage varieties been sought and evaluated (Taylor et al. 1976b; Eagles et al. 1979).

The growth curve assumed for oats was that of Florida 501 grown at Kaitaia (Taylor et al. 1976b). The pattern of growth is similar to that given by Kerr and Menalda (1976) and Eagles et al. (1979) except that rapid growth commences earlier in Northland than in areas further south. These experimental means were discounted by 28.5 percent to give the paddock scale yields shown in figure 8.2. The discount factor was calculated from the ratio of average farm maize yields[3] to average experimental maize yields in the Waikato. This ratio was used on the assumption that yields of crops grown on the same scale and for the same purpose would differ between farm and experiment by the same proportion (Davidson and Martin 1965). The ratio used was 14.3/20 = 0.715 where the numerator is the average maize silage yield assumed in section 8.4 and the denominator is an average recent experimental yield (Thom 1977).

Oats regrowth is significant only if harvested before stem elongation begins, when primary yield is so low that the pattern of feed availability is scarcely changed (Taylor et al. 1976b). Therefore all oats is assumed to be harvested only once. Utilization by grazing cows is assumed to fall

[3] See section 8.4.

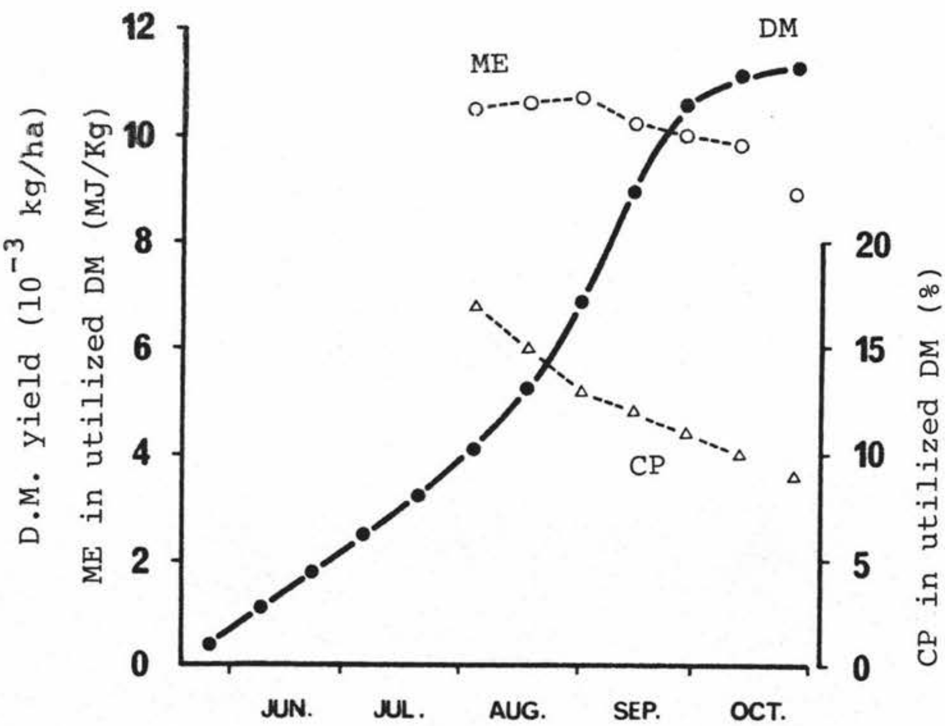

Figure 8.2 *Winter cereal:* assumed growth pattern and nutritive value of greenfeed (joined points) and silage.

from 85 percent in early August to 60 percent in mid-October.

Crude protein levels were taken from data of Taylor et al. (1976b) while ME contents were inferred from N.A.S. (1971) supplemented by data of Eagles et al. (1979). The nutritive values shown in figure 8.2 for grazed oats are higher than those suggested by some unpublished analyses. However, the latter often refer to whole plant analyses (e.g. Eagles et al. 1979) whereas a fair degree of selective grazing (presumably resulting in higher quality intake) is implied by the utilization quotients given above.

Earlier maturing cereals for silage may be required as part of certain rotations.[4] Karamu wheat was used as a representative, although more specialized early-maturing forage cereals may become available in time. Using yield data from Taylor et al. (1976b) and discounting by 28.5 percent as for oats, a silage yield of 7.94 t ha^{-1} was assumed. ME and CP contents were assumed to be identical to those of oats.

8.7 WINTER CEREAL-RYEGRASS MIXTURE

For grazing purposes, a mixture of rapidly-growing cereal and an annual ryegrass (*Lolium multiflorum*) which establishes more slowly but remains vegetative longer might combine the best features of both (Taylor et al. 1979c).

No growth data for such a mixture were available so a growth pattern was synthesized from data of Taylor et al. (1976b). For periods 01 through 04 mixture growth rate was assumed to be the mean of oats and Tama growth rates. It was

[4] An example is given in section 8.2.

assumed that a first grazing would be complete by then to allow good ryegrass growth/regrowth. In periods 05 through 08 mixture growth was assumed to be represented by Tama growth. A three-period moving average of these growth rates was used as the final smoothed growth pattern and 75 percent of the growth was assumed available for grazing[5] (see table 8.3). Two defoliations by strip grazing are implied. ME content of grazed DM was assumed to be 10.5 MJ kg^{-1} throughout with a CP content falling from 17 percent in periods 01 through 03, to 15 percent in periods 04 and 05, to 14 percent in periods 06 through 09.

Table 8.3 Cereal/Tama: assumed pattern of growth and DM availability for grazing (kg ha^{-1})

Period	Oats growth	Tama growth/ regrowth	Mean	Moving average (MA)	Utilizable DM (0.75 MA)
01	950	600	780	780	580
02	1100	600	850	850	640
03	1250	600	920	920	690
04	1500	600	1050	820	620
05	all	600	600	670	500
06	first	600	600	580	440
07	grazings	530	530	560	420
08	complete	460	460	480	360
09		460	460	460	345

[5] The reasoning is similar to that for pasture growth in Chapter 7.

8.8 TURNIPS (*Brassica rapa*)

Although not considered to have a permanent place in dairying systems where pasture silage can be made (Jurlina 1978), turnips were included because of their high quality (A.R.C. 1976) and because they are relatively simple and cheap to grow (R.A. Brown, personal communication).

On the basis of a few yield estimates made on Northland turnip crops (Taylor et al. 1976a, 1977b, 1979c), a utilizable DM estimate of 4.5 t ha^{-1} was assumed to be available by period 13 (late December). This was assumed available for grazing between periods 13 and 19 with no change in yield. ME content of grazed DM was assumed to rise linearly from 11.8 MJ kg^{-1} in period 13 to 13.0 MJ kg^{-1} in period 19 as the top/root ratio decreased (N.A.S. 1971; A.R.C. 1976). Crude protein content was assumed constant at 10 percent (Taylor et al. 1976a, 1977b, 1979c).

8.9 RED CLOVER (*Trifolium pratense*)

In the context of dairy forage systems, red clover has been considered as a ley legume adapted to a wider range of soils than lucerne (Taylor and Hughes 1976). However, being relatively deep-rooted and drought-resistant it may have other roles in areas with dry summers.

Based on yield measurements made in Northland (Taylor et al. 1976a, 1977b, 1979c) and at Palmerston North (Anderson 1973), growth rates assumed for a three year stand of a diploid cultivar such as Turoa are shown in figure 8.3. The lower yields assumed for year 3 reflect declining vigour of the stand (Fergus and Hollowell 1960; Taylor et al. 1977b). Forage produced in October of year 3 is assumed to be volunteer white clover (Taylor et al. 1977b) and the discontinuity of

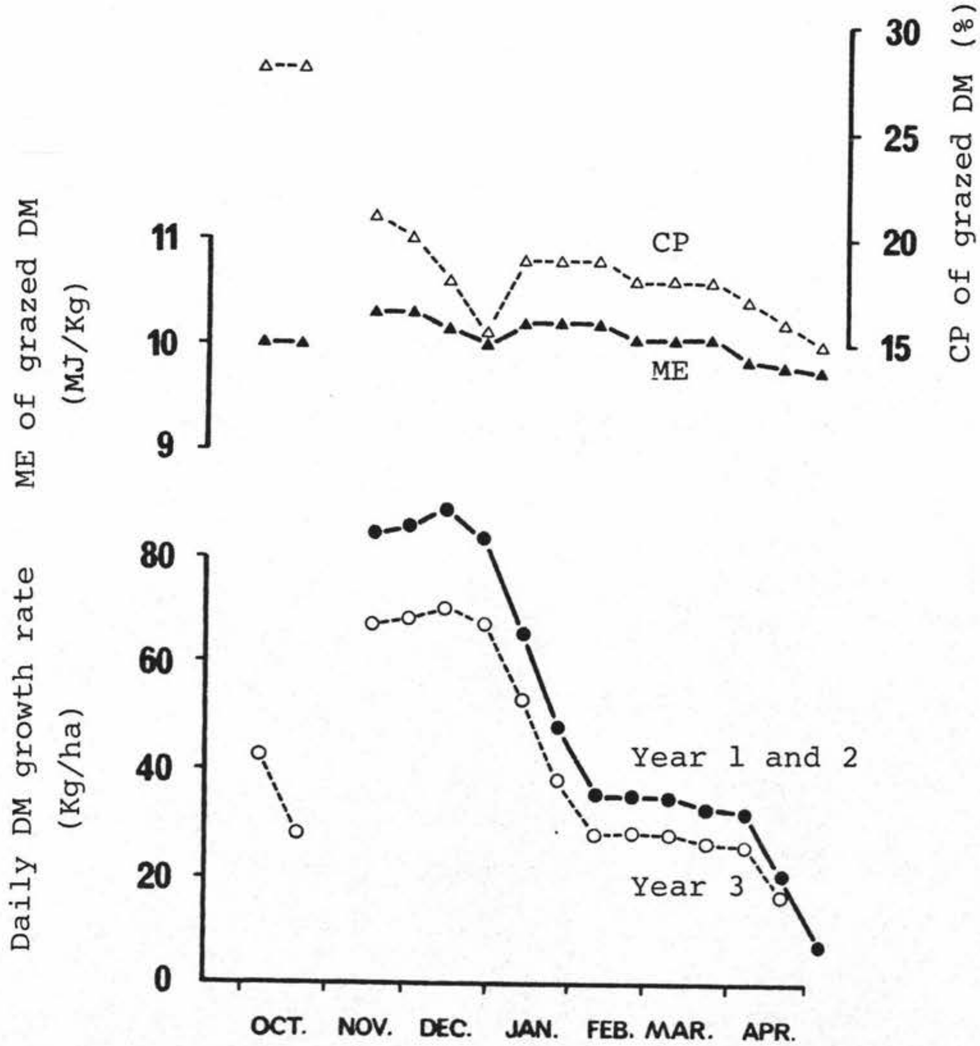

Figure 8.3 Red clover: assumed growth patterns and nutritive value.

the lines in figure 8.3 indicates a hiatus in forage production during late October and early November. Utilization of growth was assumed to be 90 percent.

Nutritive value assumptions in figure 8.3 reflect an assumed pattern of rotational grazing which produces forage of varying maturity and nutritive value (N.A.S. 1971; Taylor et al. 1976a, 1977b).

It was assumed that surplus red clover could be conserved as hay in January or February after shutting paddocks up for six weeks. Hay yields assumed were 3.23 t ha^{-1} and 2.35 t ha^{-1} in January and February respectively assuming total DM losses of 19 percent between harvest and intake. Hay quality was assumed to be relatively high at 9.5 MJ kg^{-1} and 15 percent CP (N.A.S. 1971).

8.10 SUBTERRANEAN CLOVER (*Trifolium subterraneum*)

Widely used as a forage legume in Australia both in leys and in more permanent pastures, subterranean clover is adapted and useful in some pastoral situations in New Zealand (Levy 1970). As a dairy forage, it has been seen mainly as a naturally regenerating cool season legume in association with Sudax (Taylor et al. 1976a; Jurlina 1978).

Paddock yields are inferred from data of Jurlina (1978) and Taylor et al. (1979a, 1979b). Three patterns of grazing were specified:

(a) grazing in period 07 (yield of 3 t ha^{-1}) and again in period 10 (3 t ha^{-1});

(b) grazing in period 08 (4 t ha^{-1}) and again in period 10 (1 t ha^{-1});

(c) grazing in period 09 (4.5 t ha^{-1}) with no further grazing.

At assumed utilizations in the four periods of 90 percent, 80 percent, 70 percent (first grazings) and 85 percent (second grazings) a total of 4.82 t ha^{-1} of utilizable DM is produced from a paddock yield of 5.17 t ha^{-1}.

Metabolizable energy content was assumed to be lower than the data of Taylor et al. (1977a) suggested because it is likely that an earlier maturing cultivar than Woogenellup will regenerate more reliably (Taylor et al. 1977a). Crude protein content is similarly discounted from data of Taylor et al. (1977a). Table 8.4 shows assumed yields and nutritive value.

Table 8.4 Subterranean clover: assumed pattern of forage availability and nutritive value

Period	Utilizable DM (kg ha^{-1})	ME in grazed DM (MJ kg^{-1})	CP in grazed DM (%)
07	1040	10.0	20
08	1240	10.2	20
09	1220	10.0	20
10	1320	10.2	20

8.11 NON-REGENERATING WINTER LEGUME

Non-regenerating but higher yielding annual legumes may also have a role in dairy feeding systems (Taylor and Hughes 1976). Examples which have shown some field promise are burr medic (*Medicago polymorpha*) and serradella (*Ornithopus sativus*). Without specifying any particular species or cultivar the assumptions shown in table 8.5 were made. These imply a total yield of 10 t ha^{-1} in one cut

(Taylor et al. 1979b, 1979c). The quality assumptions reflect the fact that these legumes mature rapidly when vegetative growth is completed (Taylor et al. 1979a). Field experience has shown that the utilization assumed here is probably too optimistic (see Taylor et al. 1979a).

Table 8.5 Non-regenerating winter legume: assumed pattern of forage yield, utilization and nutritive value

Period	Standing DM (kg/⅓ ha)	Grazing utilization (%)	Utilizable DM (kg/⅓ ha)	ME in DM ($MJ\ kg^{-1}$)	CP in DM (%)
07	2800	0.85	2380	9.1	0.16
08	3300	0.80	2640	9.1	0.16
09	3900	0.75	2925	9.1	0.16
Total ha^{-1}	10000		7945		

8.12 PERENNIAL SUMMER GROWING GRASS

A perennial summer forage could combine the advantages of greenfeed maize and sorghum in providing feed in summer and early autumn with the simplicity and low cost of conventional pasture. *Paspalum dilatatum* did fulfil such a role in Northland as a normal component of pastures. Its recent disappearance from many Northland pastures (Percival 1977) is a matter of some concern (R.A. Brown, personal communication; Taylor et al. 1979a) and there has been some effort to find a replacement (Taylor et al. 1976c, 1976d, 1976e). Although a forage of this type has not yet been proven under grazing, a tetraploid form of *Hemarthria altissima* has shown that the environment is capable of sustaining such a forage. It was decided to carry out some preliminary modelling with such a hypothetical forage.

Unpublished data of L.J. Davies from a three year experiment was used to construct a growth curve. For the warm season between December 16 and April 20, growth rate was assumed as the mean of three years data. For the rest of the year, when the sward was composed largely of temperate grasses such as *Poa* spp., experimental growth rates were adjusted by calibrating them with assumed ryegrass-clover growth rates. This was done by comparing ryegrass-clover rates from the experiment and from the final assumptions of Chapter 7 and whenever experimental growth rates were higher than assumed growth rates, the ratio of the latter to the former was used to adjust *H. altissima* growth rates. The final pattern assumed is shown in figure 8.4. It was assumed that 80 percent of growth would be available for grazing throughout the year. While this is 10 percent lower than the utilization assumed for ryegrass-clover, it is by no means clear that *H. altissima* could be grazed in any conventional sense (Taylor, personal communication).

Metabolizable energy content was assumed to be a constant 10.5 MJ kg^{-1} throughout the summer period December 16 to April 20. The only known estimate of digestibility, 71.4 percent, was an *in vitro* measurement from a single harvest (Taylor et al. 1976e). During the cool season, metabolizable energy was assumed to be the same as ryegrass-clover. Crude protein in the warm period was calculated by taking the ratio of *H. altissima* crude protein content in March (Taylor et al. 1976e) to ryegrass-clover crude protein at the same time and applying this to ryegrass-clover crude protein content throughout the period. The ratio used was 0.675. In the cool season a ratio of 0.84 was assumed arbitrarily. Nutritive value assumptions are shown in figure 8.4

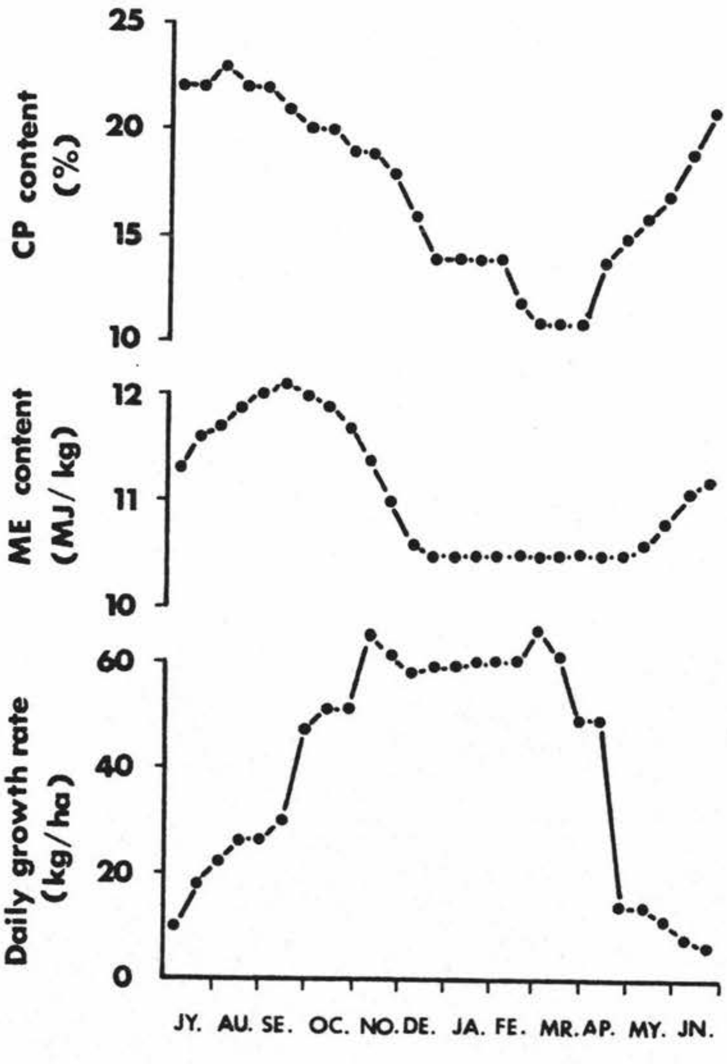

Figure 8.4 *Hemarthria altissima*: assumed growth pattern and nutritive value

The experiments from which these data were drawn were conducted on well-drained sites which were fertilized with 200 kg N per ha each summer. Any comparison with ryegrass-clover pasture would need to recognize the extra nitrogen as a factor in the environment.

8.13 SUMMARY

The chapter began by distinguishing between crops with perceived roles in feeding systems and those with no obvious role but high potential yield. In specifying these crops as model components, however, no such distinction was made because it was one of the purposes of this study to investigate possible roles of the latter type of crop. It was then pointed out that assumed crop management was constrained in certain respects to permit double cropping and to ensure efficient harvesting and storage of conserved feed. Detailed assumptions regarding various crops make up the bulk of the chapter.

CHAPTER NINE

THE DAIRY SYSTEM MODEL

9.1 INTRODUCTION

Chapter five dealt with the choice of research program and the general attitude taken toward the production system. The next three chapters outlined the relationships assumed to describe the operation of the system. This chapter is intended to describe how the whole system was represented as a mathematical model.

9.2 TYPE OF MODEL

System management (control)may be defined as those operations necessary to make a system work and presupposes the existence of a particular system. Proposing new forms of system organization is the preserve of system design (planning). It is axiomatic that the two functions interact. Comparisons between system designs, the essence of this study, must take account of management, either by qualifying the performance of each system with a statement of the management to which it was subjected or by ensuring that management of each system reaches some specified standard.

One such standard is "optimal", meaning that management, as well as system design, is such that a stated objective is at a maximum value. Linear programming models are optimizing in this sense. Heuristic models can be manipulated so that an objective function approaches (though in a complex model probably never reaches) an optimum, but with a large number of control points, as in a dairying system, approaching an optimum could be quite cumbersome. Furthermore, there will usually be no means of ensuring that an optimum has been reached.

Thus, the major benefit seen in using a linear programming model is that comparisons between systems are not confounded with differences in system management. The major drawback is likely to be the lack of flexibility in altering relationships within the model as the study progresses.

9.3 MODEL STRUCTURE

The crux of the problem is to find the optimum combination of lactation patterns, feed production technologies, and feeding plans for a given objective function, set of constraints and set of assumptions. Feed production may vary in the following characteristics:

(a) timing of land occupation;
(b) timing, yield and quality of forage available for grazing or conservation;
(c) cost of growing, storage and feeding.

Milk production may vary in terms of:

(a) timing of start of lactation (calving);
(b) timing of end of lactation (drying off);
(c) level of milk production within lactation.

The interaction of these variables in the production of output is considered to comprise a sufficient model for the purpose given above. Remaining sections of this chapter deal with the objective function and various sections of the model.

One remaining feature common to most parts of the model is the size of the time periods which comprise the production cycle discussed in Chapter five. As in most modelling studies the decision about the length of individual time periods is somewhat arbitrary, usually a compromise between simplicity and speed of computation on the one hand, and reality and flexibility on the other. Whereas with crop and pasture growth models, 24 hour periods are a natural expression of the fact that photosynthesis begins anew each morning, ruminant animals, inherently and in the way they are managed, smooth out daily fluctuations in feed production. Thus, unless daily feeding management is under close study there seems every reason for using longer time periods in feeding models.

In a planning model, the length of time periods, between which are located decision points, ought to relate to the timing of decision points in real-life planning of similar systems. Feed budgeting is commonly done on a monthly basis (Bell 1976a; Hutton and Bryant 1976; M.A.F. 1976; Johnstone et al. 1977). Where only pasture is involved and growth rates and forage quality form a continuous pattern through the year, such a level of resolution is probably adequate for both predictive and interpretative purposes, providing pasture defoliation management is not at issue (Pollard 1972; McRae 1976). However, shorter periods seem necessary to adequately specify the discontinuous availability and rapidly changing quality of some forage crops. The final choice was to specify a year as 26 periods each of 14 days. Because lactation was generally expected to begin in late winter-early spring, a model year was assumed to start on July 1. The periods and their starting dates are listed in Appendix A.

In a single year model, the real-life process of carrying stored feed over from one production cycle to the next must be simulated by permitting stored forage to be fed out in the model before it is produced in calendar terms. Such an artifice assumes that forage fed before production has been produced in the previous cycle and that an equivalent quantity is carried over into the next production cycle.

In the following sections, crop and pasture yields refer in all cases to utilizable dry matter. Utilization of forage is specified in such a way that the losses associated with grazing or conservation can be regarded as fixed, so that degree of utilization does not enter the model as a variable. The values given in the tables are not necessarily those actually used in the model though they are of the correct order of magnitude.

9.3.1 PASTURE PRODUCTION AND UTILIZATION

A schematic outline of the pasture portion of the matrix is shown in figure 9.1. Pasture production (PSPR) is specified as 26 separate activities for two reasons. The first is that, for some purposes, pasture area may not be constant, pasture being taken out of production to plant other crops and coming back into production as new pasture develops. The second reason is to enable pasture saving to be limited to one time period.

Land rows (LAND) constrain area of pasture, crop and fallow to be less than a specified area (50 ha in this case). PLAB rows constrain the area of saved pasture to be no more than the area of pasture already present. To make a completely general pasture saving scheme able to handle changing pasture area requires the PLBB rows which constrain the area of pasture in period t to be at least as great as the area saved from period t-1.[1] In circumstances where pasture and crop are not permitted to rotate, the normal assumption in this study, an extra set of rows (PLAND) constrain pasture area in all periods to be equal.

[1] A scheme suggested by A.F. McRae to prevent saved pasture being ploughed.

		PSPR t-1	PSPR t	PSPR t+1 ...	PSSV t-1	PSSV t	PSSV t+1 ...	PSFG t-1	PSFG t	PSFG t+1 ...	PSGP t ...	PSGFG t-1	PSGFG t	PSGFG t+1 ...	PSN t ...
$LAND_{t-1}$	50≥	1													
$LAND_t$	50≥		1												
$LAND_{t+1}$	50≥			1											
$PSNLIM_t$	0≥		-1												1
$PLAB_{t-1}$	0≥	-1			1										
$PLAB_t$	0≥		-1			1									
$PLAB_{t+1}$	0≥			-1			1								
$PLBB_{t-1}$	0≥	-1													
$PLBB_t$	0≥		-1		1										
$PLBB_{t+1}$	0≥			-1		1									
$PSDM_{t-1}$	0≥	-300			300			1			300				
$PSDM_t$	0≥		-400		-300	400			1		400				-200
$PSDM_{t+1}$	0≥			-500		-360	500			1	500				-400
PSGDM	0≥										-3000	1	1	1	
$COWDM_{t-1}$	0≤							-1				-1			
$COWDM_t$	0≤								-1				-1		
$COWDM_{t+1}$	0≤									-1				-1	
$COWME_{t-1}$	0=							-10.5				-9.5			
$COWME_t$	0=								-10.1				-9.5		
$COWME_{t+1}$	0=									-9.8				-0.5	
$COWCP_{t-1}$	0≥							-0.20				-0.14			
$COWCP_t$	0≥								-0.18				-0.14		
$COWCP_{t+1}$	0≥									-0.17				-0.14	
MARGIN		-35									-80	-0.01	-0.01	-0.01	-30

Figure 9.1 The Pasture Matrix

Pasture dry matter rows (PSDM) constrain the utilization of pasture produced by the PSPR activities for saving (PSSV), grazing (PSFG) or pasture silage production (PSGP). The PSGDM row constrains the total quantity of pasture silage fed out in various periods (PSGFG) to be not greater than the total produced by the PSGP activities.

Pasture grazing (PSFG) activities transfer pasture dry matter, with its time-specific contents of metabolizable energy and crude protein, to the cow feeding rows that are common to all feeds. Pasture silage feeding activities (PSGFG) transfer silage dry matter, with its constant nutritive value, to each of the 26 time periods.

Pasture nitrogen activities (PSN) add to the supply of pasture in the PSDM rows, thus assuming that the utilizable pasture so produced is identical in quality with pasture produced in the normal way (PSPR). The pasture area fertilized with nitrogen is limited to the amount of pasture present at that time by PSNLIM rows. To be completely general, these area constraints would need to be extended to as many periods as the nitrogen response is spread over.

The objective function normally employed, MARGIN, shows how costs are divided between pasture growth, conservation, and feeding out. This allows silage to be carried over without incurring feeding out costs.

9.3.2 CROP PRODUCTION AND UTILIZATION

Crops were dealt with in one of three ways. Those that are normally repeatedly grazed, such as red clover or Sudax, are represented as single activities with vectors of dry matter production. An example in figure 9.2 is CAPR which does not occupy land or produce dry matter (in the CADM rows)

		...	CAPR	...	CBPR t-1	CBPR t	CBPR t+1	...	CCSGPR t-1	...	CAFG t	CAFG t+1	...	CBFG t-1	CBFG t	CBFG t+1	...	CSGFG t-1	CSGFG t	CSGFG t+1	...
$LAND_{t-1}$	50≥				1	1	1		1												
$LAND_t$	50≥		1			1	1		1												
$LAND_{t+1}$	50≥		1				1														
⋮																					
$CADM_t$	0≥		-300								1										
$CADM_{t+1}$	0≥		-350									1									
⋮																					
$CBDM_{t-1}$	0≥				-600									1							
$CBDM_t$	0≥					-800									1						
$CBDM_{t+1}$	0≥						-900									1					
⋮																					
CCSGDM	0≥								-5000									1	1	1	
⋮																					
$COWDM_{t-1}$	0≤													-1				-1			
$COWDM_t$	0≤										-1				-1				-1		
$COWDM_{t+1}$	0≤											-1				-1				-1	
⋮																					
$COWME_{t-1}$	0=													-11				-10			
$COWME_t$	0=										-10				-10				-10		
$COWME_{t+1}$	0=											-0				-9				-10	
⋮																					
$COWCP_{t-1}$	0≥													-0.20				-0.1			
$COWCP_t$	0≥										-0.2				-0.15				-0.1		
$COWCP_{t+1}$	0≥											-0.1				-0.12				-0.1	
⋮																					
MARGIN			-100		-120	-120	-120		-350									-0.01	-0.01	-0.01	

Figure 9.2 The Crop Matrix

over the full year. Crops where grazing is destructive, such as greenfeed maize, are represented by as many activities as there are possible grazing times. Thus in figure 9.2, CBPR represents the same crop occupying land until grazing, later grazings resulting in higher yields (in the CBDM rows). Crop grazing activities (CAFG and CBFG) are specified in a manner analagous to pasture feeding. The third type is a silage crop (e.g. CCSGPR in figure 9.2), where production (CCSGPR in figure 9.2) is represented by a vector of land use and a single final yield (in row CCSGDM), and where feeding out is specified identically with pasture silage.

All costs of grazing crops are allocated to the production activity (in row MARGIN) while costs of silage crops are divided in the same manner as for pasture silage.

9.3.3 PURCHASED CONCENTRATES

Meatmeal or complete meal were specified simply, as shown in figure 9.3. The purchasing activity (CONBUY) was specified in kg of concentrate supplying dry matter to a specific row (CONDM) at a given cost per kg ($0.15 in the example). Concentrate feeding (CONFG) was specified in the same manner as was silage feeding except that no cost is assumed.

9.3.4 MILK PRODUCTION

Variations in pattern of system milk production were facilitated by specifying, for each of three calving dates, 12 lactation patterns[2] as separate activities (see figure 9.4),

[2] Specified in Chapter 6.

		...	CONBUY	...	$CONFG_t$	$CONFG_{t+1}$	...
⋮							
CONDM	$0 \geq$		-1		1	1	
⋮							
$COWDM_t$	$0 \leq$				-1		
$COWDM_{t+1}$	$0 \leq$					-1	
⋮							
$COWME_t$	$0 =$				-12		
$COWME_{t+1}$	$0 =$					-12	
⋮							
$COWCP_t$	$0 \geq$				-0.14		
$COWCP_{t+1}$	$0 \geq$					-0.14	
⋮							
MARGIN			-0.15				

Figure 9.3 The purchased feed matrix

		...	AP267FØ	AP267F1	AP267F2	...	AP183F2	...	JY239F1	...	AU183F0	AU183F1	AU183F2	...	XMF t	XMF t+1	...	SELLMF
⋮																		
$COWDM_t$	0≤		136	136	136		136		156		173	173	173		12			
$COWDM_{t+1}$	0≤		138	138	138		138		149		164	164	164			14		
⋮																		
$COWME_t$	0=		770	1120	1430		770		1410		690	690	690		125			
$COWME_{t+1}$	0=		820	1070	1320		820		1130		680	680	680			146		
⋮																		
$COWCP_t$	0≥		8	13	18		8		17		5	5	5		1.5			
$COWCP_{t+1}$	0≥		9	12	16		9		12		5	5	5			1.7		
⋮																		
MILKFAT	0≥		-161	-155	-148		-117		-145		-124	-121	-117		-0.10	-0.11		1
⋮																		
MARGIN																		1.6
BOUNDS															≤1800	≤1900		

Figure 9.4 The cow requirement matrix

each representing a notional cow. The three calving dates were July 1, August 1 and April 1.[3] In addition, to permit higher than "standard" milk production and mid-late lactation increases in production in above average conditions, a number of activities (XMF) were defined which were not intended to represent a cow, but the requirements of one cow for a specified increase in milkfat production. The size of the increase was limited according to the stage of lactation (see figure 6.2) and the limit to activity (XMF) level was the number of cows in the average-season plan.

Specifying each lactation pattern (implying an associated liveweight pattern) as a separate vector of feed requirements satisfies the requirement of Chapter 6 to have a mechanism which ensures lost bodyweight is regained following "underfeeding". It also enables the specification of shortened lactations, each with a different pattern of liveweight change in the early part of the dry period.

Each notional cow has a set of metabolizable energy requirements which must be met in the COWME rows. This establishes unequivocally the prime role of energy in determining voluntary intake. If both energy and protein are specified only as minimum requirements then either could determine voluntary intake by causing an increase in dry matter intake (and an excess intake of the other) when present in a feed at low concentrations. An increase in dry matter intake (and possibly feeding an "excess" of energy) resulting from low protein concentrations, a possible solution in such a scheme, would be contrary to the generally accepted notion that low feed protein actually depresses intake.

[3] With calving distributions as in Chapter 6.

Minimum crude protein requirements of each notional cow are specified in the COWCP rows as kg crude protein. Similarly, voluntary intake limits are specified in COWDM rows to ensure that energy and protein requirements are met within the limits of cow appetite. Total milkfat production of each notional cow was specified in the MILKFAT row from which a selling activity (SELLMF) sells milkfat by contributing the only positive value to the objective function (MARGIN).

9.3.5 OBJECTIVE FUNCTION

Total gross margin, the function normally to be maximized, is defined as gross return from milkfat sales less all variable feed costs. The latter included all expenses directly attributable to feed production[4] but excluded such infrastructure expenses as are not normally attributed to particular areas or practices. Examples of such overheads are fencing, water supply, repairs and maintenance of plant and equipment, labour, rates and electricity. The model incorporates no constraints on capital or labour supply so that most operations additional to those on conventional all-grass farms were assumed to be contracted out, and are costed on this basis. Storage and feeding out of silage cannot be costed in this way so were dealt with by including depreciation and interest on additional capital as part of the variable cost of silage at the point of feeding out.

9.3.6 MISCELLANEOUS ROWS

For a variety of purposes, output interpretation and parametric analysis among them, a number of rows with no time dimension were defined. These were normally non-computational rows.

[4] Detailed in Appendix B.

Total maize (MAIZE) and total winter cereal (CER) rows calculated the total area of these respective forages. Four cash flow (CASH) rows aggregated the cash requirements of the forage production program for each of four seasons. A capital row (CAPITAL) aggregated the total capital requirements of the plan and calving time rows (APCOWS, JYCOWS, AUCOWS) aggregated all cows calving in each of April, July and August. Total cows (COWS) and total silage area (SIL) aggregated their respective activities.

PART III

RESULTS OF MODELLING

CHAPTER TEN

MODEL EVALUATION

10.1 INTRODUCTION

This chapter is concerned with model behaviour under a variety of conditions. Chapters 6 through 9 dealt with the relationships assumed for the model and can be seen as analagous to the process of verification. Evaluation of whole-model behaviour, as considered here, is analagous to the process of validation.[1]

Model development involved a good deal of inter-disciplinary consultation but initially was largely a one way process of obtaining information from specialists to use in model construction. Nevertheless, the model was run many times during this process as a means of preliminary validation. Most of the checks at this stage were merely to see if performance parameters were rational and that model logic was as intended. When these criteria were met basic model development was considered complete.

Evaluation, although in practice a continuous process, is discussed here in two stages. The first deals with the presentation of some early results for Northland to a panel of experts, Here, emphasis was placed on evaluating model behaviour in near-limit situations. The second stage deals

[1] Verification and validation processes are discussed in Chapter 4.

with later testing and evaluation, some of it in conjunction with extension and research personnel in Northland and Manawatu and at Ruakura.

10.2 VALIDATION PROCEDURES

Validity of the model was pre-defined as acceptance of the model for its defined purpose. That is, providing the model appeared to represent reality (in a logical sense) in those aspects under study, the model was considered valid if it produced output acceptable to experienced observers. However, system behaviour consists of more than the value of the objective function, particularly since gross margin (the objective function normally employed here) is neither an absolute quantity, nor is it as familiar a measure to biological scientists as more physical ones like dry matter yield and milkfat production. Thus, validation was taken to include many aspects of a solution:- feed production combinations, dry matter production, feed surpluses, potential feed deficits,[2] feeding patterns, stocking rates, calving patterns, lactation patterns and cash and capital requirements. In this respect, the model used here differed considerably from those of Pollard (1972) and McRae (1976) where the majority of activities described a grazing sequence which was frequently arbitrary[3] and was conceded to be difficult to interpret in practical terms.

With a variety of criteria available for validation and in view of the difficulties in establishing a rational

[2] The model does not permit real feed deficits but meal feeding and feed row shadow prices indicate where within-system feed is most expensive.

[3] In linear programming terms, there was no unique solution.

significance level for statistical comparisons (Grieg 1979) it was decided to concentrate on subjective validation by independent experts. Much of the reviewing and validation involved only one consultant at a time but on one occasion before the main experimental program began, the model and its output were presented to a meeting at which all the main consultants were present. This occasion is described in some detail to illustrate the validation-reviewing process and to provide some independent evidence of model validity.

10.3 EARLY RESULTS FROM NORTHLAND MODEL

Panel members were given an up to date summary of progress in advance of the meeting. This document also proposed three main areas for discussion: model validity, system stability and component value. These are considered separately below. The panel comprised seven people,[4] combining expertise in crop and grassland agronomy, dairy cow nutrition and management, process and system modelling, economics and farm management. All had been in some contact with the study from its early stages.

10.3.1 BASIC MODEL

With only the basic set of constraints[5] operating, the optimal feeding plan (figure 10.1) was quite complex and some associated feed production activities were in novel combinations.

[4] Identified in Appendix C.

[5] Described in Chapter 9.

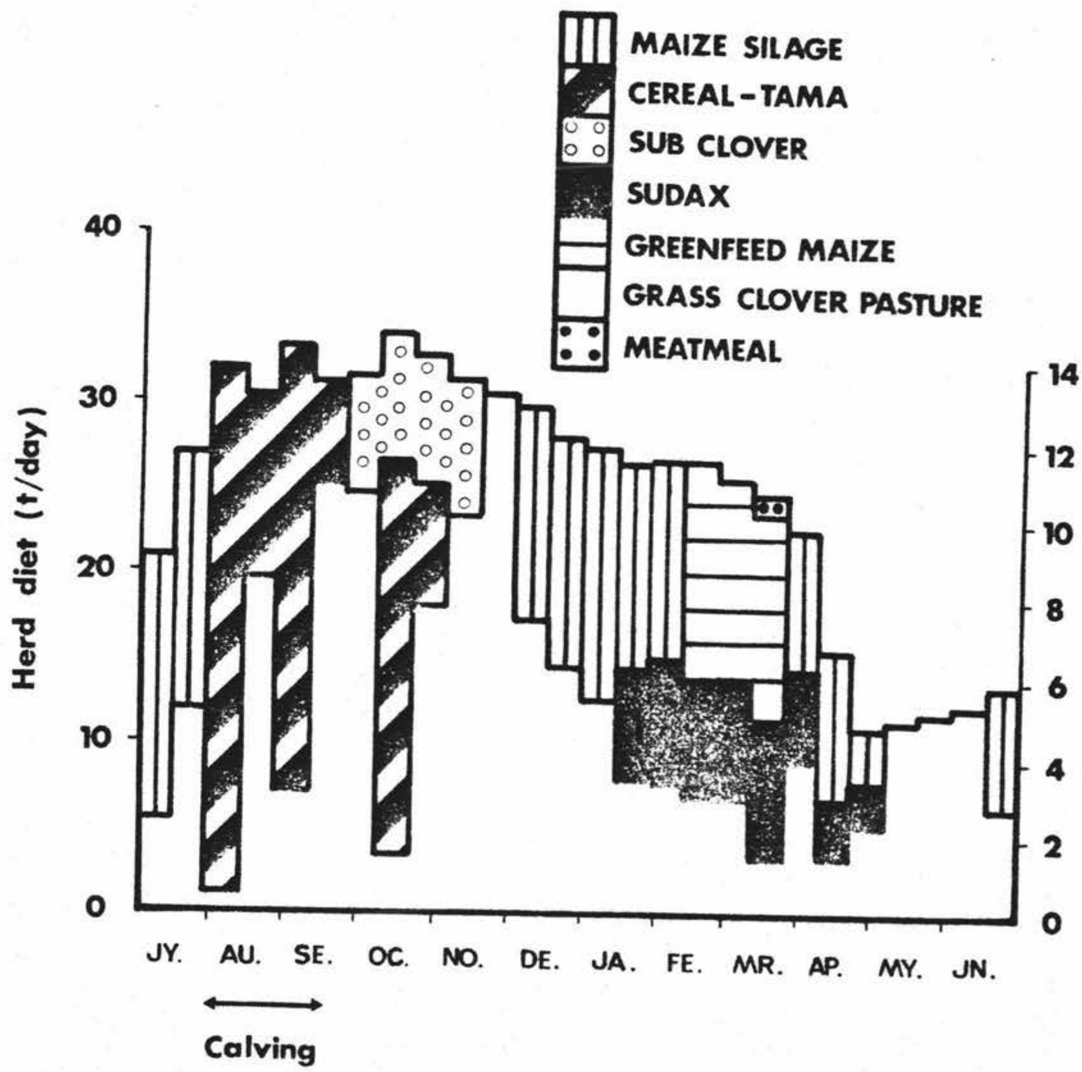

Figure 10.1 Optimal feeding plan of basic, unconstrained model

However, it illustrated what was to become a common pattern. Considering ryegrass-clover pasture as the basic forage source, the gross pattern of feed supply was altered to the feed demand pattern of high-producing cows by three means; by application of nitrogen to pasture whenever possible (August-September and April-May), by the growing of greenfeed crops whenever possible (August-November, January-May) and by the use of maize silage to fill remaining gaps.

Some details of farm organization are listed in the last column of table 10.1 where it can be seen that half the farm area was devoted to cropping, a situation unlikely to be encountered in current practice. Feed conservation, while substantially greater than average practice, nevertheless represented less than 20 percent of total feed utilized.

10.3.2 CONSTRAINED CROPPING LEVELS

In order for validation to proceed from more familiar starting points a series of plans beginning from all-grass systems and progressing through increasing levels of cropping were examined. In addition to the basic constraints, each plan was constrained to have a certain minimum area of conventional pasture but was otherwise unrestricted.

Table 10.1 shows that the main effects of permitting increased cropping were increases in total forage yield, stocking rate, total milkfat production and gross margin, and a replacement of pasture silage by crop silage. None of these plans suggested model rejection though the all-grass plan had higher-producing cows than Northland averages (N.Z.D.B. 1979), indicating that, to represent an average existing Northland farm, the model would need to be constrained still further.

Table 10.1 The effect of cropping level on system structure and performance (50 ha)

Maximum crop area (% of farm)		0	10	20	33	50[1]
Summer GF	(ha)	-	3	5	10	15
Winter GF	(ha)	-	2	8	15	25
Pasture silage	(t)	79	29	3	4	1
Crop silage	(t)	-	52	69	92	121
DM grown per ha	(t)	11.6	12.5	13.3	14.7	15.9
Cows milked	(no.)	130	137	144	156	165
Milkfat per ha	(kg)	414	442	460	500	530
Gross margin per ha	($)	514	555	580	606	621

[1] Optimum cropping level

10.3.3 COMPARISON WITH REAL FARMS

Since the opportunity to evaluate the model before a panel of experts was likely to occur only once, the scope of evaluation was widened by attempting to have the model generate optimal plans for three of the real farms monitored and described by Taylor et al. (1979c). While the model was never intended to be used in this mode, it was considered that there could be value in having the model represent something more tangible than a "representative" Northland farm.

The model was constrained to permit only those crops already grown successfully on each farm and allowance was made for replacements and non-dairy stock run. Apart from limiting calving to July and August no other modifications were made to the model. A major difficulty in comparing model predictions with real farm performance is in assigning a relative value to pasture on the various soil-topographic associations of a heterogeneous farm. The least heterogeneous, and the only one where most of the pasture was of the type assumed in the model, was the Brown farm so this farm was compared in more detail with the model.

A summary of all farms is given in table 10.2 where all entries refer to a 50 effective ha farm to facilitate comparisons between farms as well as within farms. In the Jurlina and Milich systems the model grew more crop and conserved more silage than the farms and also fed cows better. In the Brown system, model and farm conserved equivalent total silage but different proportions of maize and pasture. In other respects Brown model and farm were in good agreement (see figures 10.2 and 10.3).

Table 10.2 Comparisons[1] of farm and model plans and performances

		BROWN		JURLINA		MILICH	
		FARM	MODEL	FARM	MODEL	FARM	MODEL
GF maize	(ha)	1	2	-	-	-	-
Sudax-sub clover	(ha)	-	-	5	11	-	-
Pasture silage	(t)	38	14	23	28	47	64
Maize silage	(t)	70	88	-	-	-	-
Cows milked	(no.)	126	133	79	105	84	120
Days in milk		251	252	265	250	245	243
Milkfat per cow	(kg)	163	159	146	158	148	156
Milkfat per ha	(kg)	409	424	232	332	250	374
Adjusted MF per ha[2]	(kg)	428		349		376	

[1] All comparisons assume a 50 ha farm.

[2] See text.

Before any comparisons of farms and model had been made, farmers were asked to make a subjective estimate of the value of pasture (relative to the best pasture in the district, as assumed in the model) on each soil-topographic association of their farm. Two farmers were very precise about this and

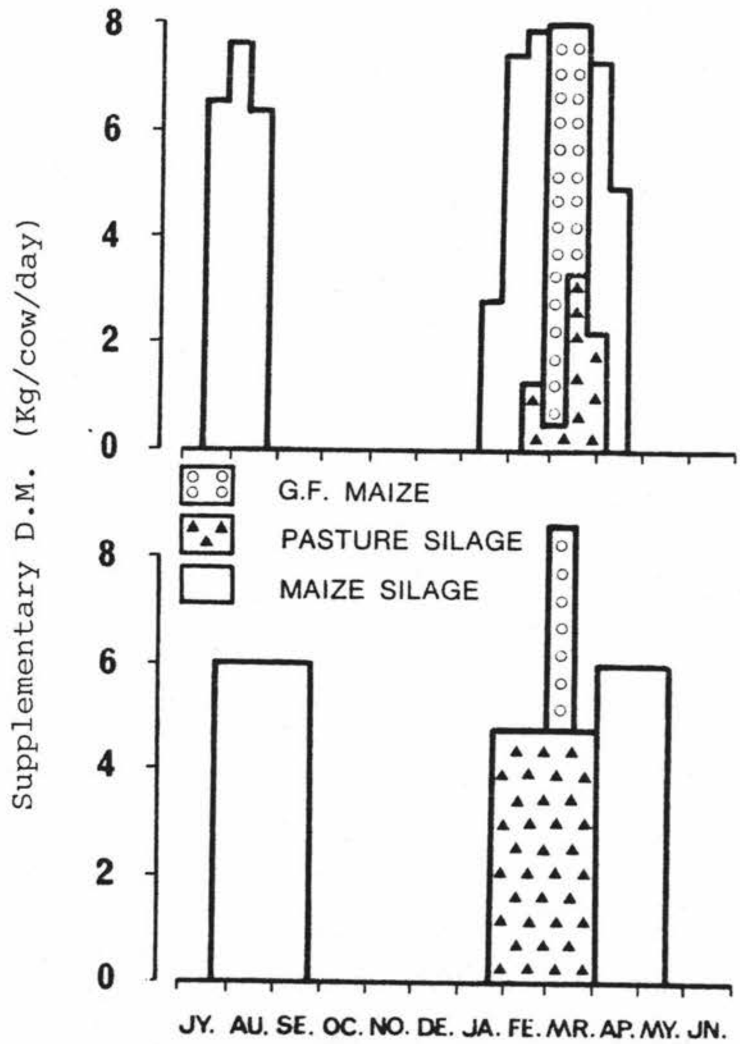

Figure 10.2 Supplementary feeding by Brown (lower) and Model (upper).

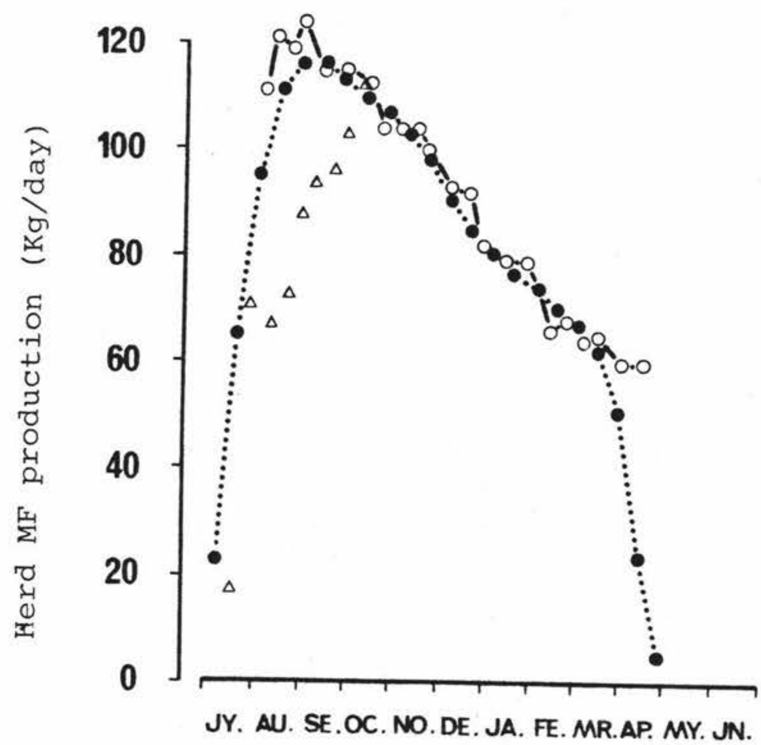

Figure 10.3 Production patterns of Brown farm (open triangles 1976-77, open circles 1977-78) and model (solid circles)

it was possible to derive an overall rating of farm pasture in relation to model pasture. The third farm was given the same rating as the farm most like it topographically. Correcting milkfat per ha production using these ratings gave the estimate given in the last line of table 10.2. These adjusted estimates appeared to add to the evidence for model acceptance.

10.3.4 HIGH MILKFAT PRODUCTION

The consequences of increasing milkfat production beyond an optimal level are outlined in table 10.3. These plans were generated by specifying a minimum level of milkfat production and then maximizing gross margin. An apparent maximum cropping level of 60 percent corresponded with the simultaneous operation of quality constraints in several periods of the year. Beyond this level of milkfat production, energy supplements were necessary and gross margin fell sharply.

Table 10.3 The structure and performance of higher producing systems (50 ha)

Milkfat (kg ha^{-1})		530	560	600	638[1]
Crop area (% of farm)		50	56	61	60
Summer GF	(ha)	15	14	12	2
Winter GF	(ha)	25	27	30	22
Pasture silage	(t)	1	9	20	24
Crop silage	(t)	121	168	237	399
DM grown per ha	(t)	15.9	17.1	18.4	19.3
Cows milked	(no.)	165	173	186	198
Gross margin per ha	($)	621	619	613	571

[1] Maximum milkfat production from a self-contained system.

At the maximum production level shown in table 10.3, protein density of the diet was limiting at all times except during May and June. This is a consequence of high levels of low-protein crop silage.

None of these results indicated the model should be rejected.

10.3.5 LOW MILKFAT PRICES

With decreasing milkfat price, the model exhibited the insensitivity around the optimum characteristic of bio-economic systems (Jardine 1975). For instance, despite a 25 percent decrease in milkfat price, the savings from reorganization of the farm plan amounted to less than 2 percent of the gross margin (see table 10.4), whereas with a 50 percent decrease in milkfat price, savings amounted to 23 percent of gross margin.

Table 10.4 Effects of lower milkfat price on system performance

	Milkfat price ($ kg^{-1})			
	1.60	1.20	0.80	0.40
Pasture silage (kg cow^{-1})	0	0	62	133
Crop silage (kg cow^{-1})	732	480	96	0
Cows milked (no.)	165	153	128	114
Milkfat (kg ha^{-1})	530	494	413	367
Gross margin ($ ha^{-1})	621	416	243	86
Gross margin without re-optimization ($ ha^{-1})	621	409	197	-15

The other effects of lower milkfat price, less conservation (particularly of crop) and a generally less intensive operation, were in accord with previous analyses (e.g. Stephen et al. 1974).

10.3.6 PANEL REACTION

There was general agreement amongst the panel with the overall pattern of model assumptions and behaviour although it was recognized that, in the limited time available, there was no possibility of making many details of the model transparent to panel members. Some specific reactions were as follows:

(a) The panel showed some surprise at the consistent role of grazing crops but had no specific objection to this aspect of model output. Since the role of grazing crop and the effects of level of conservation are not well-explored areas, there was little experience to draw on for validation of these aspects. This is an almost inevitable situation where the model being used to synthesize alternative systems produces novel results.

(b) There was concern that the assumed maximum level of milkfat production per cow may have been too low to allow maximum expression of cropping and conservation benefits.

Within undetermined limits, it would be more efficient, in terms of feed requirements (see table 6.3), to increase productivity per cow. However, despite observations of Friesian cows producing 200 kg MF or more on all-forage diets (A.M. Bryant, personal communication; Scott 1978) there were no experimental bases, comparable to those used in calculating the requirements of a "standard" cow producing 161 kg MF, on which to calculate feed conversion efficiency, and thus feed requirements, of such cows.

The general conclusion was that although higher producing cows might conceivably suit forage crop systems better than the lower producing cows assumed optimal for all-grass systems, there was insufficient information to justify the routine inclusion of high producing cows in the planning model.

(c) Information presented to the panel did not clarify the possible model relationships between stocking rate, feed availability patterns and forage yield.

This aspect of the early model results may have actually reduced the credibility of the model in the eyes of the panel. It was to an extent unavoidable in that when many aspects of an optimal system change simultaneously with a change in one or more constraints, there is no simple cause and effect relationship which can be unambiguously identified. The only clear effect was that, once milkfat per cow reached the specified maximum, feed supply and stocking rate increased together.

The conclusion drawn from this section of the discussion was that there was a need for a detailed explanation of the interaction between stocking rate and system structures as it affected optimal farm plans.

(d) The panel raised the possibility that the forage supply options included in the model would predetermine the kinds of systems the model could predict as useful. In particular, the broad pattern of feed deficiency on Northland dairy farms, long known, may have resulted in a biased selection of forages for field study and for model construction.

The argument applies more to the selection of forage sources for field research than to the alternatives specified in the model. These latter, within the very broad limits of data availability, were not restricted in any conscious way. In fact, the range of alternatives was deliberately expanded by including crops which were being actively discouraged (e.g. turnips) and by including alternative end uses (e.g. grazing of oats, a crop seen mainly as a silage source).

10.4 LATER RESULTS WITH NORTHLAND, RUAKURA AND MANAWATU VERSIONS

These later evaluations were carried out over a period of some months. The process was iterative, evaluation normally being followed by some experimentation. The results of such experiments were often used in evaluating the model for particular roles, though the experiments did not necessarily have that purpose.

10.4.1 FURTHER EVALUATION OF NORTHLAND VERSION

A synopsis of the foregoing results, together with some later results, were presented to meetings of advisory and research people at Whangarei and advisory people and farmers at Kaitaia. The main additional result was a plan representing an all-grass, no-nitrogen, low conservation system, a system commonly found in practice. This plan was taken from a series where conservation was parametrically constrained and represents a point where further reduction in conservation would result in a combination of pasture surpluses and meal feeding. Some details of this plan are:

Silage fed cow	(kg)	97
Meal fed per cow	(kg)	67
Stocking rate	(cows per ha)	2.53
Lactation length	(days)	195
Milkfat per cow	(kg)	128
Gross margin per ha	($)	450

The main feature of this plan that caused comment was the stocking rate. Average Northland stocking rate over the period 1973-74 to 1976-77 was only 1.28 cows per effective ha. This was ascribed to the general heterogeneity of Northland pastures, many of them on poorly drained soils or on light sandy soils, whereas the model assumes homogeneous pastures.

In other respects, the model conformed with the perceptions of the observers. In addition, neither lactation length nor plane of nutrition nor milkfat per cow reached their minimum values under fairly severe constraints and it was concluded that no arbitrary limits were likely to limit the adaptability of the model system.

10.4.2 EVALUATION OF A RUAKURA VERSION

Results of modelling were discussed with a small group of Ruakura dairy nutrition research people. In addition to the foregoing results another dimension was added to the evaluation by including a plan for an all-grass, no-nitrogen system based on Ruakura pasture growth data. These latter were taken from unpublished data of A. Wright and are shown in figure 10.4. Nutritive value assumptions were unchanged from those used in the Northland model. With calving limited to July and August the resulting plan had the following features:

Forage grown per ha	(t)	15.4
Silage fed per cow	(kg)	280
Stocking rate	(cows per ha)	3.5
Lactation length	(days)	266
Milkfat per cow	(kg)	160
Milkfat per ha	(kg)	561
Gross margin per ha	($)	834

Milkfat production per ha corresponds well with observations made over the past ten years at Ruakura (Hutton and Bryant 1976; Campbell et al. 1977), but is achieved at a lower stocking rate and higher production per cow. To achieve this higher production, 80 percent of the silage is fed in late lactation, whereas the systems described by Hutton and Bryant (1976) and Campbell et al. (1977), and commercial systems, tend to feed conserved feed in winter to increase cow body condition. The difference was concluded to be due to the wilted silage in the model being of high enough quality to be fed as part of a production diet and thus to prevent large losses in cow body condition during summer and autumn.

10.4.3 EVALUATION OF A MANAWATU VERSION

Using local pasture growth rates, B.J. Ridler (personal communication) has found that the model predicted milkfat production of two farms closely enough to warrant using the model as a basis for preliminary investigation of alternative calving times.

10.4.4 UNSOLICITED EVALUATION

Interest was expressed in using the model to investigate

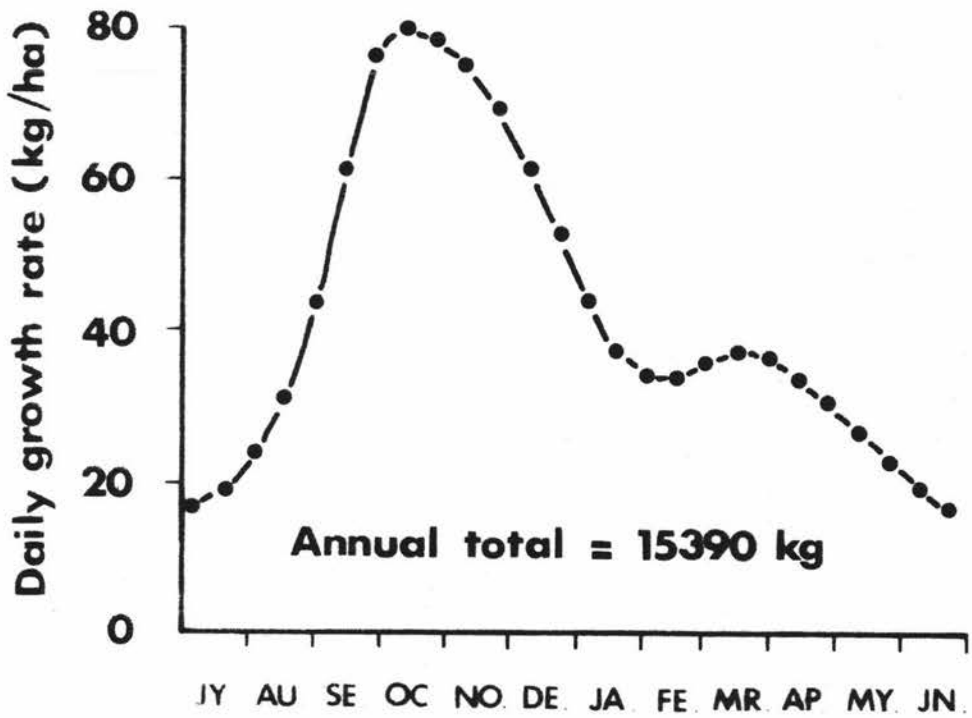

Figure 10.4 Assumed growth pattern of pasture at Ruakura

the consequences of altering calving time[6] (A.M. Bryant and K.L. McMillan, personal communication) and in using the model as the production module of a dairy industry model (K. Hall, personal communication). Such interest followed some exposure to model results and was interpreted as additional evidence that the model could be useful.

10.5 SUMMARY

The linear programming model was evaluated in two stages. In the first, a preliminary set of results was presented to a panel of experts. These results concentrated on model behaviour in near-limit situations and on comparisons of model and real farm structure and production. The second stage was a continuing interaction between model output and research and extension personnel in Northland and Manawatu and at Ruakura.

Defining validity as acceptance of the model for its defined purpose, the model was judged to be adequate for its purpose. There were also indications that it might be accepted for use for other purposes in other dairying regions.

[6]Some preliminary work has been completed and published (Taylor and Miller 1979).

CHAPTER 11

EXPERIMENTATION

11.1 INTRODUCTION

Having concluded that the model was valid for the purpose of synthesizing optimal forage feeding systems for a variety of circumstances, the next step was to fulfil that purpose under as many relevant circumstances as possible.

Two types of experiment were conducted. The first was where specific, agronomic-type questions were raised. This included such aspects as the effect of cropping level and conservation level on productivity and profitability, the possible role of a summer-growing grass, and the sensitivity of forage systems to variation in forage yield. The second type sought to test some of the earlier conclusions under varying climatic and economic environments.

Slight modifications to the model mean that comparisons between results of this chapter and chapter 10 are not valid. Modifications to some feed production costs, winter cereal yields and quality, and bloat prevention costs associated with red clover resulted in the values given in chapter 8 and Appendix B.

11.2 EFFECTS OF CROPPING LEVEL

Preliminary experiments had shown[1] that there were large differences in physical productivity between systems

[1] See sections 10.3.2 and 10.3.4

with differing cropping levels though the economic differences were somewhat smaller. Since economic circumstances may change considerably during the course of a medium-long term field research program there was interest in estimating the physical limitations of various classes of forage system. It was intended also that benchmarks be developed, against which the productivity and profitability of simplified systems could be compared.

The basic experimental design was a factorial combination of cropping levels and stocking rates. Cropping level was either unconstrained (CROPOPT) or fixed at either zero (CROPO), 20 percent (CROP 20) or 40 percent (CROP 40) of farm area. The unconstrained level was included to give a reference optimal system at each stocking rate while the three fixed-level systems were chosen to represent the range of feasible cropping levels.

Stocking rate, the most important variable influencing milkfat production (Campbell et al. 1977), was used as a means of manipulating milkfat production in the model. For each of the four systems, stocking rate was varied from a level below which land or forage was unused up to a level where energy supplement was purchased.

Figure 11.1 shows that increasing cropping level resulted in systems that were able to adapt to a wider range of stocking rates. With the initial economic assumptions, stocking rates above 2.2 cows per hectare would require some cropping and above 3.2 cows per hectare would require more than 20 percent of the farm area to be devoted to cropping. The arrows of figure 11.1 indicate where energy supplements were necessary to sustain further increases in production. These points are almost independent of economic assumptions since they resulted from the operation of quality and quantity constraints in the diet. In that sense they indicate the upper limit of production from self-contained systems. With higher

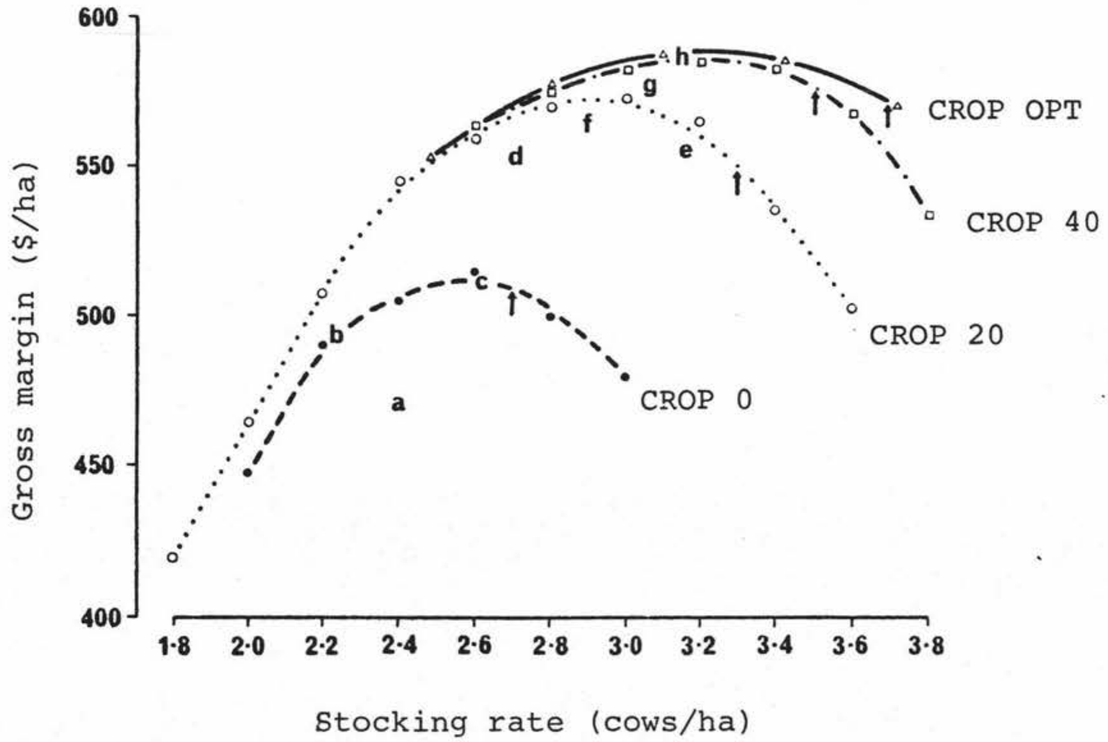

Figure 11.1 Effects of stocking rate on gross margin at four cropping levels. Arrows indicate the stocking rate at which meal feeding commenced. Letters refer to the systems of section 11.8

meal cost, stocking rate could be further increased without meal feeding but only at the expense of milkfat production per cow.

Table 11.1 Effects of stocking rate on feed production activities

Stocking rate ($cows\ ha^{-1}$)	Pasture nitrogen[1] ($kg\ ha^{-1}$)	Greenfeed crops Summer (ha)	Greenfeed crops Winter (ha)	Crop silage Summer (ha)	Crop silage Winter (ha)	Pasture Silage (ha)
			CROP0			
2.00	0	-	-	-	-	12.0
2.20	0	-	-	-	-	13.5
2.40	48	-	-	-	-	17.8
2.60	104	-	-	-	-	22.3
2.80	118	-	-	-	-	18.4
			CROP20			
2.00	0	10.0	0	0	0	0.4
2.20	0	10.0	1.5	0	0	3.4
2.40	8	10.0	9.8	0	0	5.1
2.60	42	8.2	7.3	1.8	1.7	3.6
2.80	65	6.4	6.2	3.6	3.8	0
3.20	148	3.7	2.1	6.3	7.9	0
3.40	150	1.4	3.7	8.6	6.3	0
			CROP40			
2.46	3	17.2	19.1	0.5	0	6.2
2.60	33	18.8	20.0	1.2	0	3.4
2.80	57	15.2	20.0	4.8	0	1.7
3.00	93	12.8	18.2	7.2	1.8	1.3
3.20	120	8.9	17.5	11.1	2.5	0
3.40	150	7.8	11.9	12.2	8.1	0
3.60	150	4.1	11.4	15.9	8.6	0
			CROPOPT			
2.22	0	5.8	0.6	0	0	4.2
2.48	11	13.3	11.7	1.2	0	1.7
2.80	79	23.2	18.0	4.1	0	0
3.11	143	22.5	22.9	10.7	0.4	0
3.42	150	16.4	24.1	16.9	2.9	0
3.73	150	7.6	18.2	20.2	10.8	0

[1] An index of N use on pasture = total N used/total pasture area. N could be applied only at 50 $kg\ ha^{-1}$ at three times of the year. Maximum possible is 150 $kg\ ha^{-1}$.

Table 11.2 Effects of stocking rate on supplementary feeding and milkfat production

Stocking rate (cows ha^{-1})	Silage fed per cow Crop (kg)	Silage fed per cow Pasture (kg)	Milkfat production per cow (kg)	Milkfat production per ha (kg)
		CROP0		
2.00	-	425	159	318
2.20	-	430	158	348
2.40	-	520	158	380
2.60	-	600	159	413
2.80	-	445	155	434
		CROP20		
2.00	0	15	161	322
2.20	0	100	161	354
2.40	0	150	161	386
2.60	277	98	161	419
2.80	536	39	161	451
3.00	693	0	161	483
3.20	875	0	155	497
3.40	900	0	156	531
		CROP40		
2.46	49	176	161	396
2.60	108	92	161	419
2.80	407	38	161	451
3.00	660	30	161	483
3.20	955	0	161	515
3.40	1238	0	161	547
3.60	1448	0	160	576
		CROPOPT		
2.22	0	137	158	350
2.48	113	45	161	400
2.80	346	0	161	450
3.11	845	0	161	500
3.42	1320	0	161	550
3.73	1760	0	161	600

The changes in structure and production which produced these economic results are summarized in tables 11.1 and 11.2. Taking CROPOPT first, since it is the least constrained system, the changes with increasing stocking rate are:

(a) Increased use of pasture nitrogen, firstly in spring and, as stocking rate increases further, in autumn also.

(b) Greenfeed crops increased at first but then decreased as silage crops increased. Between stocking rates of 3.1 and 3.7, total crop area was relatively constant.

(c) Pasture silage was significant only at the lowest stocking rates and was rapidly replaced by crop silage as stocking rate increased.

(d) Milkfat production per hectare was closely related to stocking rate, since milkfat per cow was relatively constant.

Patterns of change as stocking rate changed were similar in the CROP 40 system except that, because of the fixed cropping level, there was more cropping at the lowest stocking rate, 2.46 cows per hectare, than in CROPOPT at a similar stocking rate.

In the CROP 20 system, summer greenfeed crops apparently replaced pasture silage at stocking rates below 2.4 cows per hectare as there was considerable fallowing of winter-spring crop land.

In the all-grass system, CROPO, where the possibilities for coping with higher stocking rates were fewest, pasture nitrogen usage increased with increasing stocking rate, although the maximum level was not used. Pasture silage, on the other hand, increased to 2.6 cows per hectare and then decreased as meal feeding increased.

Overall, this experiment led to the following conclusions:

(a) Increased cropping (and conservation) enabled increases in forage yield, stocking rate and milkfat production substantially beyond those possible in all-grass systems. Table 11.3 shows that potential forage yield was almost doubled moving from an all-grass to an all-crop system.

(b) Greater use of pasture nitrogen could be made in cropping systems than in all-grass systems. Autumn application of nitrogen was of only limited use in an all-grass system because of the dominating importance of feed deficiencies in summer and early autumn.[2]

(c) Only in all-grass systems is pasture silage an important component. Besides pasture nitrogen, it was the principal means in an all-grass system of adjusting the match between forage supply and demand. However, it simply transfers feed from a time of high demand (around peak lactation) to a time of even higher demand (midsummer drought) so that opportunity costs can only be high.

(d) In physical terms alone, the amount of crop grown for conservation was limited by the quality of crop silage. Thus, in an unconstrained system, total forage yield at maximum stocking rate was only 77 percent of potential (see table 11.3) whereas in systems with constrained cropping levels, relative forage yield was more than 95 percent of potential. Both energy density and protein concentration were limiting in a number of time periods.

[2] Discussed in more detail in Chapter 12.

(e) The first increment of cropping resulted in the largest increase in system flexibility. Maximum stocking rates increased by 0.6 cows per hectare, maximum milkfat production increased by almost 100 kg per hectare and optimum gross margin by $55.00 per hectare. Only at stocking rates above 3 cows per hectare was there any advantage in having more than 20 percent cropping.

(f) In economic terms, each system produced almost optimal (95 percent) gross margin at stocking rates and dry matter yields well below those resulting in optimal gross margin (see table 11.3). This is important in operational terms where sub-optimal management or variable environment could reduce forage yield, and in planning terms where assumptions made in the planning may not be matched by reality.

Table 11.3 Dry matter yield and stocking rate at some selected points for four cropping levels

	CROPO	CROP20	CROP40	CROPOPT
Maximum possible DM yield (t ha^{-1})	12.5	14.8	17.2	24.3
Relative yield at maximum stocking rate[1]	96	100	98	77
Relative yield at optimal GM (%)	93	95	93	63
Relative yield at 95% optimal GM (%)	76	75	75	50
Stocking rate at optimal GM (cows ha^{-1})	2.6	3.0	3.2	3.2
Relative stocking rate at 95% optimal GM (%)	85	80	81	78

[1] That stocking rate above which dairy meal is fed as an energy source.

11.3 LEVEL OF CONSERVATION AND SUPPLEMENTARY FEEDING

Feed conservation has several conceptual roles in dairy feeding systems:

(a) To alleviate expected feed deficits by transferring feed from a period of relative surplus.

(b) To maximize yield of nutrients per hectare by harvesting at a specified time and by avoiding the losses associated with grazing.

(c) To disconnect milk production pattern (and patterns of other downstream processes) from a highly seasonal and uncertain pasture supply.

The importance of the first role was examined by varying conservation in an all-grass system in which the only other possible adjustments were in cow numbers, meal feeding, plane of cow nutrition, lactation length and consequent level of milkfat production. Pasture nitrogen was excluded to simplify interpretation since its timing as well as its quantity was a variable in the model.[3]

Results of this experiment are summarized in table 11.4 and figure 11.2.

In table 11.4, marginal pasture DM values are an index of relative pasture scarcity. They are in fact shadow prices (marginal value products) of pasture dry matter reconciliation rows and represent the gross value to the plan if an extra unit of pasture could be made available at that time without reducing resources at other times.[4] While the model structure

[3] Effects of pasture nitrogen are discussed in section 11.4.

[4] More accurately, the shadow prices represent the quantity dZ/dp where Z = gross margin of plan and p = pasture DM available in the period.

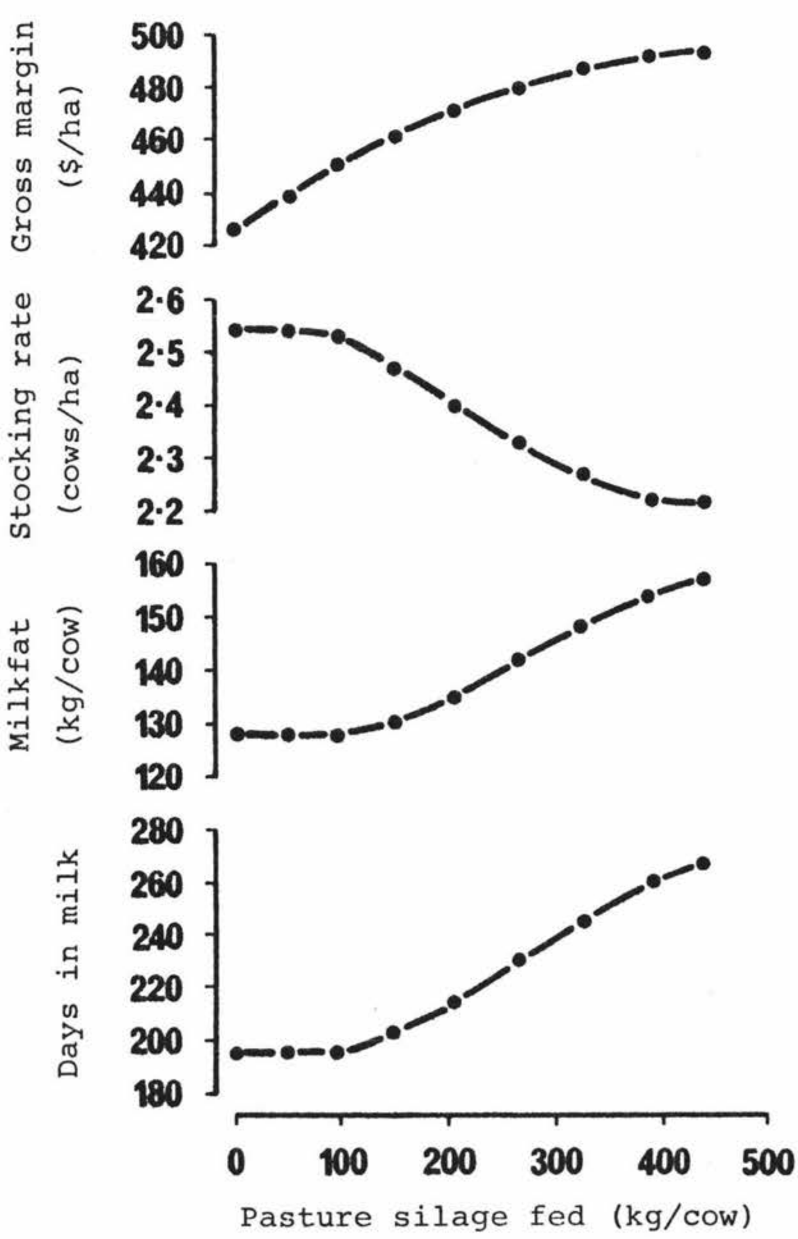

Figure 11.2 Effects of limiting conservation in an all-grass system.

does not permit real shortfalls in feed supply, McRae (1976) has shown the validity of treating these values as indices of relative scarcity by using them to iteratively adjust the match between feed supply and demand and so progress to higher "optima".

At levels of silage feeding below 50 kg per cow, there was considerable meal feeding despite the presence of surplus pasture (see table 11.4). Where more conservation was permitted, such surplus could be transferred into summer and early autumn and displace the meal fed during feed deficits at that time. Below 100 kg silage per cow, this substitution was the mechanism responsible for increased gross margin, since there were no changes in cow numbers or productivity (see figure 11.2).

As conservation increased above 100 kg silage per cow, a decreasing number of better-fed cows was able to maintain and increase total milkfat production, while gross margin increased throughout. However, the increase in total milkfat (see table 11.4) was quite modest since only the timing of forage supply, not its total quantity, was changing significantly.

A general effect seen in table 11.4 is an increase in the differences between marginal pasture values in each season as conservation decreases. This serves simply to indicate the increasingly poor match between supply and demand with decreasing conservation. Adjustments made to minimize the mismatching were increases in stocking rate and shorter lactations. This results in increasing feed scarcity in July and August and a consequent shift towards August calving.

Table 11.4 Some effects of level of conservation on calving date, potential feed deficits and meal feeding in an all-grass system. Numbers in brackets show tonnes of surplus pasture and the season in which they occurred.

Percent of grass area conserved	Silage fed ($kg\ cow^{-1}$)	Median calving date	Mean marginal pasture DM value ($c\ kg^{-1}$)				Meal fed ($kg\ cow^{-1}$)	Milkfat Production ($kg\ ha^{-1}$)
			May-Jun[1]	Jul-Sep	Oct-Dec	Jan-Apr		
0	0	AUG 4	1.8	10.8	0.7(13)	12.2	148	323
4	49	AUG 4	1.8	10.8	0.7(6)	12.2	108	323
8	97	AUG 4	1.4	10.5	0.9	12.2	67	323
12	150	AUG 2	1.4	10.1	1.3	12.2	24	322
16	207	JUL 30	2.1	9.2	2.0	12.0	0	324
20	265	JUL 28	2.2	8.4	2.6	12.0	0	331
24	326	JUL 25	1.4	7.9	4.0	10.6	0	338
28	390	JUL 22	1.5	7.7	4.3	10.3	0	343
32	441	JUL 19	1.3	7.7	5.7	8.4	0	346

[1] Seasonal periods correspond approximately with dry period, and early, mid and late lactation respectively.

However, one of the more important results has, so far, been only implied. It is that all conserved feed, and meal, is fed in February and March. The only interpretation possible is that supplements are used to extend lactation and can do so economically by bridging a relatively short feed deficit between the end of vigorous pasture growth in early summer and the beginning of rapid autumn growth.

Important conclusions from this experiment are:

(a) Milkfat production per hectare in all-grass systems can be largely maintained at low levels of conservation by increasing stocking rate and decreasing lactation length, as recommended by Ruakura workers (Campbell et al. 1977; Scott 1978). However, for the assumptions used here regarding Northland pasture, there was a considerable economic advantage in feeding cows for higher production.

(b) While conservation used solely to produce extra milkfat through increasing level of production or by extending lactation length may be a doubtful economic proposition (Scott and Smeaton 1975; Bryant 1978), its value may be enhanced by using it to maintain lactation between two periods of adequate pasture growth.

With 20 percent or more cropping, there was, as already indicated in the previous section, sufficiently good match between forage supply and demand to enable the maximum assumed milkfat per cow using only small quantities (less than 100 kg per cow) of conserved feed. Thus, the effects of conservation in cropping systems must be primarily those involved in the second role of conservation mentioned above, maximizing forage yields and minimizing utilization losses.

Although no specific experimentation was conducted on this point, table 11.5 shows changes in forage yield, conservation level and efficiency of forage utilization in the CROP 40 system as stocking rate was changed in the experiment already described. This table clearly shows that while forage grown increased by 40 percent and conservation of forage grown increased from 5 to 30 percent, there was no change in overall efficiency of dry matter utilization. This was achieved in the model by grazing crops at a stage of maturity when grazing losses were at their lowest and nutritive values at their highest. In turn, this was achieved by growing a mix of crops with differing maturity times. For example, at a stocking rate of 3.4 cows per ha a total of 11.9 ha of winter greenfeed consisted of 4.4 ha cereal/Tama, 4.4 ha sub clover and 3.1 ha winter legume. In practice, serial plantings of particular forage might fulfil the same function.

Table 11.5 Influence of stocking rate on forage production, level of conservation and efficiency of forage utilization with a fixed 40 percent of the farm area cropped.

Stocking rate (cows ha^{-1})	DM grown (kg ha^{-1})	DM conserved (%)	DM/MF (kg)
2.46	11794	5	29.8
2.60	12515	5	29.9
2.80	13476	12	29.9
3.00	14466	17	30.0
3.20	15452	24	30.0
3.40	16534	30	30.2

Results with the other cropping systems were very similar. The conclusion that conservation will result in maximal forage yields without necessarily lower utilization losses than grazing must be qualified by recognition of the importance in model solutions of maize silage. Maize is one of the few crops which maintains high digestibility at maturity[5] and so can combine high yield with high nutritive value. Generalizing with respect to other crops, high yields approaching maturity are associated with poor utilization in the case of grazing or with low nutritive value in the case of conservation.

11.4 PASTURE NITROGEN

The effects of nitrogen fertilizer on pasture growth are not well known for dairy pastures; the effects on milk production and profitability in whole systems have only been guessed at. This study provides an opportunity to estimate the latter.

The effects of pasture nitrogen in facilitating a different pattern of feed supply is confounded with stocking rate, increases in which result in a greater potential mis-match of supply and demand. Thus, in the comparison between all-grass systems with and without pasture nitrogen (see table 11.6), there is only a very slight increase in milkfat production per cow but an 18 percent increase in stocking rate. However, an additional 30 t of pasture silage in the latter system is made economic by strategic pasture nitrogen.

[5] Defined as the presence of black-layer development on kernels (Menalda and Kerr 1973).

Table 11.6 Comparison of structure and performance of an all-grass system with and without pasture nitrogen.

		Without N	With N
Pasture N	(ha)		
August		-	50
September		-	50
April		-	5
Pasture silage	(t)	49	79
Total DM	(kg ha^{-1})	9500	11590
Stocking rate	(cows ha^{-1})	2.22	2.60
Milkfat per cow	(kg)	157	159
Milkfat per ha	(kg)	349	414
Gross margin	($)	493	514

Another means of indicating where additional pasture nitrogen might improve system performance is to calculate what response or what price would make nitrogen economic. The breakeven responses shown in figure 11.3 are calculated from:

$$\frac{Px}{MVPy}\ \frac{1}{0.75}$$

where Px is the price per unit of nitrogen
MVPy is the shadow price of pasture dry matter
and it is assumed, as before, that only
75 percent of the response can be utilized.

To preserve clarity only three systems are shown in the figure but the curves for all cropping systems follow the Sudax one shown quite closely. Calculations for different nitrogen prices would only be valid if it could be assumed that no other prices, especially that of milkfat, changed. The pattern is similar for all systems with breakeven responses of around 10 kg DM per kg N in mid winter, late summer and

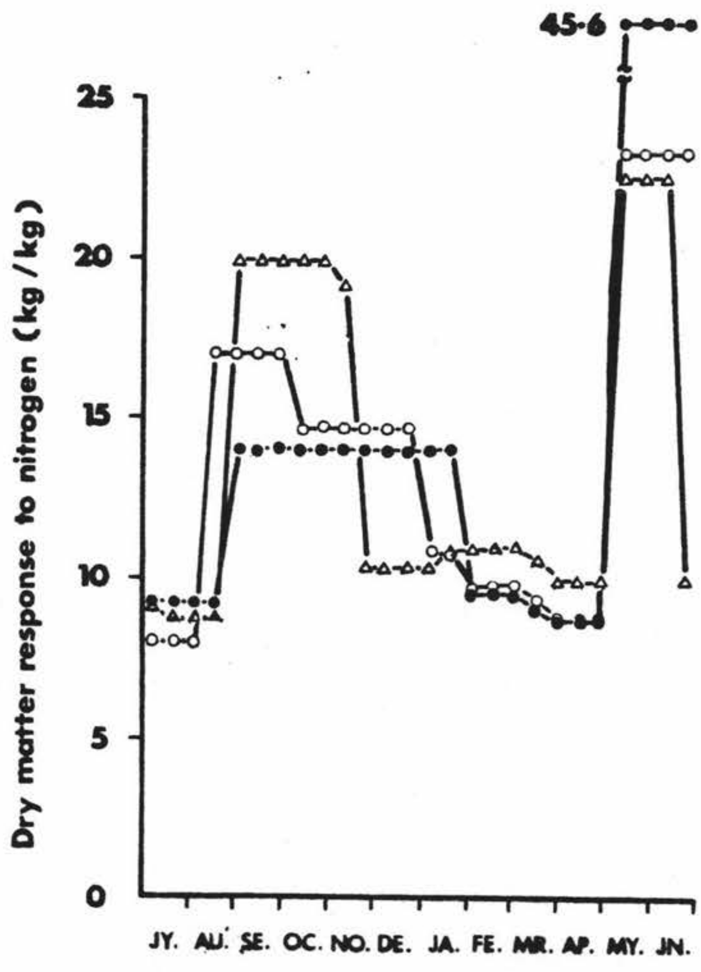

Figure 11.3 Responses necessary to make pasture nitrogen economic at a nitrogen price of $0.60kg^{-1} (Solid circles all-grass without N; open circles, all grass with N; open triangles, 20% of farm area in Sudax-subclover).

and early autumn but higher responses in spring, late autumn and early winter.

It is not possible to predict, for any particular assumed responses and system, how much nitrogen would be used or what its effects would be. But the consistency between systems in the quantity of nitrogen used, especially in spring, suggests that nitrogen has an important role to play in both changing pattern of feed supply and in increasing yields generally.

11.5 POTENTIAL OF A SUMMER-GROWING GRASS

As mentioned in chapter 8, the sub-tropical grass *Hemarthria altissima* was being considered as a potential forage source for Northland. Although a good way off being proven as a practical proposition, indications of its potential value to production and profitability when integrated into a dairy feeding system were considered desirable as a basis for continuing agronomic research.

A system having *H. altissima* as a forage source (HEMARTH) but otherwise with the same constraints as CROPOPT is compared with that system and an all-grass system (CROPO) in table 11.7. In this comparison, each system is at its optimal stocking rate. The large difference in productivity between CROPO and HEMARTH was due primarily to the much higher assumed yield of *H. altissima* compared with conventional pasture, together with the presence of maize silage. The resulting 36 percent increase in total forage yield was reflected in increases of more than 30 percent in stocking rate and milkfat production and a 21 percent increase in gross margin.

Table 11.7 Comparison of a system containing *Hemarthria altissima* (HEMARTH) with an all-grass system (CROPO) and an unconstrained cropping system (CROPOPT), each at its optimal stocking rate.

		CROPOPT	HEMARTH	CROPO
Conventional pasture	(ha)	20.1	1.3	50.0
Hemarthria	(ha)	-	37.6	-
Summer greenfeed	(ha)	18.9	0	-
Silage maize	(ha)	11.0	11.1	-
Winter greenfeed	(ha)	29.1	11.1	-
Total forage DM	(kg ha^{-1})	15420	15789	11593
Stocking rate	(cows ha^{-1})	3.14	3.40	2.60
Milkfat production	(kg ha^{-1})	506	548	414
Gross margin	(\$ ha^{-1})	586	623	514

However, when compared with the unconstrained cropping system (CROPOPT), HEMARTH had very similar forage yields although there were substantial differences in stocking rate, milkfat production and profitability. This was clearly the result of *H. altissima* replacing all the summer greenfeed and more than half of the winter greenfeed, giving generally higher quality forage at lower cost.

This result, together with the presence of *H. altissima* in many plans derived during model development and validation, confirms that efforts to find new summer growing grasses for Northland (Taylor et al. 1976c) could be very rewarding. It shows also how the benefits of any particular pattern of forage availability added to any chosen base system could be estimated.

11.6 EFFECTS OF CHANGES IN FORAGE YIELD AND QUALITY

A common goal of physiological and agronomic research is to increase crop yield or quality. The sensitivity of a Northland dairy system to changes in yield and quality of forage was examined using maize. Greenfeed maize, a relatively minor forage source in the systems so far discussed, was excluded so that there could be no direct effect on distribution of forage yield and quality through the year, only on total quantity.

Two experiments were carried out. In both, maize yield in a 30 percent cropping system was varied parametrically from 14.3 to 20.3 t per ha. In the first experiment, there were three metabolizable energy densities (10.0, 10.5, 11.0 MJ per kg) at each yield level. In the second there were three crude protein concentrations (5.0, 7.5, 10.0 percent) at each yield level.

Analyses of variance, shown in tables 11.8 and 11.9 indicate large effects of yield, smaller effects of nutritive value, and very little interaction. The mean effects of yield variation on productivity and profitability are summarized in figure 11.4. Increasing responses up to 16.7 t per ha were associated with increasing areas of maize in the respective optimal plans. The extra maize area resulted from displacement of greenfeed Sudax and to a lesser extent, silage oats.

Table 11.8 Analysis of variance of gross margin per ha as affected by DM yield and ME concentration of maize silage.

Source of variation	Degrees of freedom	Mean square
Yield	5	2708
ME	2	794
Yield x ME	10	13

Table 11.9 Analysis of variance of gross margin per ha as affected by DM yield and crude protein concentration of maize silage

Source of variation	Degrees of freedom	Mean square
Yield	5	2622
CP	2	436
Yield x CP	10	41

Average system response in the linear interval between 16.7 t ha^{-1} and 20.3 t ha^{-1} was 5.07¢ per kg yield increase. As indicated by the lower rate of response at maize yields below 16.7 t ha^{-1} (see figure 11.4) the rate of response of the whole system to yield change must depend on the proportion of total area in maize.

The responses to changing maize yield estimated in this experiment are very close to those predicted by the solution shadow prices of maize silage dry matter, as shown by the comparison in table 11.10. The diminishing returns of table 11.10 translate into increasing returns in figure 11.4 because of the increasing optimal area of silage maize up to a maize yield of 16.7 t ha^{-1}.

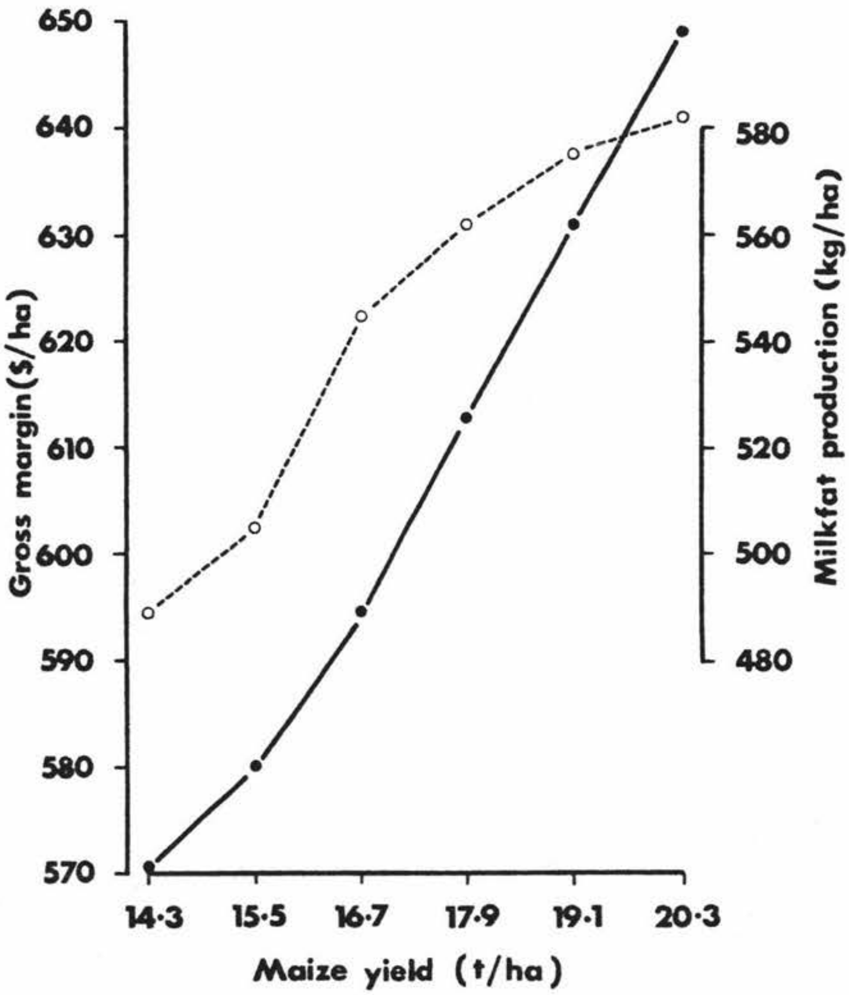

Figure 11.4 Effect of maize yield variation on gross margin (——) and on milkfat production (---)

Table 11.10 Predicted and observed response to increases in silage maize yield (c per kg yield increase).

Maize yield	Predicted marginal value	Observed marginal value
14.3	5.64	(5.43)[1]
15.5	5.42	(5.24)
16.7	5.10	5.09
17.9	5.08	5.07
19.1	5.07	5.06
20.3	5.04	-

[1] Values in brackets are estimated from mean area of maize between two plans.

Diminishing response in milkfat production with increasing yield (see figure 11.4) above 16.7 t per ha was associated with a diminishing rate of increase in total forage grown as increasing areas of lower-yielding forages such as sub clover were grown to supplement diet quality.

The close agreement between predicted and observed (through model manipulation) responses to maize yield increase (in table 11.10) suggests that, where other forage sources are being used at near-optimum levels, their shadow prices may be used as an indication of potential system response to yield increase. Such predictions are discussed in chapter 12.

The effect of a change in energy concentration is almost identical with the effect of a change in energy yield resulting from a change in dry matter yield. Taking the top three curves of figure 11.5 to represent the maximum rate of response to increasing energy density, the mean response is 0.608 c MJ^{-1}, compared with a response of 0.578 c MJ^{-1} when energy yield was increased by increasing silage dry matter yield. The similarity of these responses indicates that metabolizable energy yield, where ME density is greater than 10 MJ kg^{-1}, is a reasonable basis for comparison of forages, providing they are fitted into an appropriate system, a conclusion also reached when comparing responses to yield change in pasture and maize (Miller 1980).

Maximum responses to changes in crude protein content were 10.5 - 12.2 c kg^{-1} crude protein, a good deal less than the cost of protein supplements. Protein supplement was used at rates up to 37 kg cow^{-1} but the extra protein supplement fed with maize silage of low protein content was less than half of the difference in system protein resulting from differences in maize silage protein content (see table 11.11). Larger quantities of sub clover, smaller quantities of cereal silage and adjustments in timing of various forages were the other main mechanisms of maintaining protein intake.

Table 11.11 Differences in crude protein supplementation expressed as a percentage of the difference in crude protein contained in maize silage.

Maize yield	Maize crude protein interval (percent)	
(t ha^{-1})	10.0-7.5	7.5-5.0
17.9	37	12
19.1	39	36
20.3	35	44

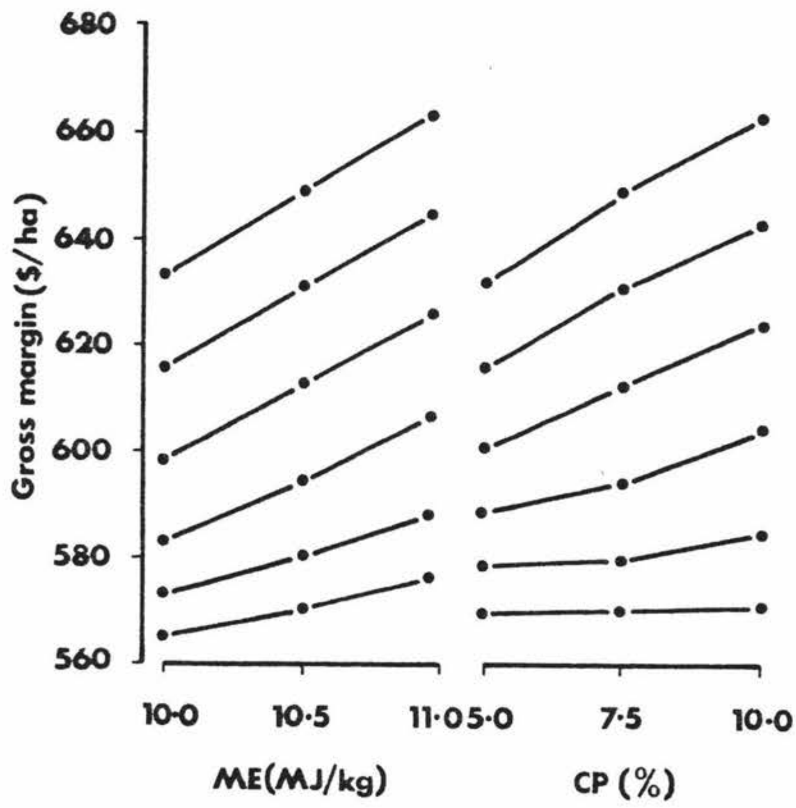

Figure 11.5 Effects of metabolizable energy and crude protein concentration of maize silage on gross margin at six yield levels. Yield levels are those of figure 11.4 and increase from bottom to top.

There is no way of comparing directly the responses to crude protein changes with the responses to change in yield or energy density. However, on a density basis, variation of ± 50 percent in crude protein had effects similar to that produced by variation of ± 5 percent in energy density. It must be concluded that, in a relative sense, energy is by far the most important aspect of diet and that the conclusions reached about maize would apply to other forages in a similar way.

11.7 EFFECTS OF HIGHER PRODUCING COWS

Possible understatement of the benefits of forage cropping and conservation through limiting cows to a maximum annual 161 kg milkfat[6] was assessed by including cows with a potential of 190 kg milkfat and with feed requirements extrapolated from those described in chapter 6. With respect to feed production possibilities the model had no constraints additional to those described in chapter 9.

Details of the resulting plan were:

Stocking rate	3.0 cows ha^{-1}
Proportion of farm cropped	57 percent
Forage grown	15.4 t ha^{-1}
Silage fed	950 kg cow^{-1}
Days in milk	267 days
Milkfat per cow	176 kg
Milkfat per ha	520 kg
Gross margin per ha	$596

During the 42 weeks of lactation, dietary energy density was limiting for 12 weeks, dietary protein density for 8 weeks

[6] Foreshadowed in section 10.3.6.

and both for a further 4 weeks. Energy density was within 0.25 MJ ME per kg of being limiting for a further 8 weeks. Since half these limitations occurred in early lactation when appetite is high, and since all forage options were available, it must be concluded that this level of cow productivity is close to the economic limit with the voluntary intake limits assumed. The increase in gross margin associated with these higher producing cows was only $9.94 per ha. The economic response to allowing higher per cow production in an all-grass system could, because of less restrictive quality limitations, possibly be higher than this if there were no other effects. Practically, decreasing efficiency of pasture utilization brought about by lower grazing pressure would likely nullify any such extra response (Hutton 1971).

11.8 EFFECTS OF CLIMATIC VARIABILITY

All the results so far refer to an assumed average year. It is necessary, in a study of this type, to expand the domain of the results (or to falsify the initial results) by subjecting the systems in question to deliberate disturbance. Variations in economic assumptions are dealt with in a subsequent section. This section is concerned with the effects of seasonal variability on system performance. There is no intention of finding, for particular kinds of systems, a plan which maximizes expected value under uncertainty, although there are some fairly elaborate linear programming formulations designed for the purpose (Hazell 1971; Rae 1971; Wicks and Guise 1978). What is required is a comparison between selected systems in their reaction to seasonal variability. This was achieved by running eight selected systems through nine arbitrary seasons.

11.8.1 DEFINITION OF SIMPLIFIED SYSTEMS

The results of the stocking rate x cropping level experiments suggested that, at least for assumed average conditions, a number of cropping levels, conservation levels and stocking rates had to be considered. Systems designed to represent a variety of combinations could have been chosen from among the optimal plans generated in the stocking rate x cropping level experiments. They would have been not only arbitrary but also unnecessarily complex. Some may even have been agronomically and logistically infeasible by implying such anomalies as legume - legume rotations and conservation of three different silages.

A more subjective selection of systems, to include some which were under evaluation in the field, was made by taking three levels of cropping, 0, 20 and 40 percent and specifying at least two levels of conservation systems in each. In all-grass systems, level of nitrogen usage was an additional major factor which could be used for subdivision. Eight systems were finally specified:

(a) GRASSA An all-grass, no nitrogen system in which conservation was limited to that necessary to obviate any requirement to purchase feed. This system is typical of many existing dairy farms and represents the kind of system often recommended for North Island dairying districts (Hutton and Bryant 1976; Campbell et al. 1977; Scott 1978).

(b) GRASSB An all-grass, no nitrogen system with an optimal level of conservation. This is meant to represent the limit of the previous system without introducing any new technology.

(c) GRASSN An all-grass system with optimal nitrogen use and conservation. It represents the first step into relatively unorthodox technology. Because nitrogen application is limited to 50 kg ha^{-1} at only three times of the year, the system by no means represents the limits of pasture production.

(d) SUDAX A system with 20 percent of farm area in a Sudax-subterranean clover rotation. Agronomically the rotation seems to be viable and it has been successfully integrated into a dairy feeding system (Jurlina 1978). It is relatively unsophisticated in its requirements for additional machinery and skills. Pasture silage is the only conservation possible.

(e) MZCER A system with 20 percent of farm area in a maize-oats rotation and all crop conserved. It should achieve maximum utilization of all forage grown and maximum yields from forage crops but would demand quite sophisticated farming techniques.

(f) MZRCLOV A system where at any time, 20 percent of farm area is in red clover and 20 percent in a maize-cereal rotation. The two areas would alternate with each other every three years to maximize agronomic benefits from the legume ley (Taylor and Hughes 1976). To avoid the small quantities of cereal silage produced in preliminary experiments with this system, cereal could only be grazed in the final specification.

(g) MZSDX This system was an attempt to simplify the optimal but complex cropping plan (CROPOPT) generated in the stocking rate x cropping level experiments. Sudax-sub clover was specified on 20 percent of the farm and maize-cereal on another 20 percent. Again, winter cereal could only be grazed.

(h) FREE With no constraints other than those of the basic model this "system" provided, in most situations, a benchmark against which the performance of sub-optimal systems could be compared. In some experiments, its capacity for adjustment was limited, for reasons detailed in the appropriate place.

To justify use of these systems it was first necessary to calculate their sub-optimality with respect to the un-simplified systems[7] having the same cropping level. Except for GRASSA, a system designed to be significantly sub-optimal, all simplified systems had gross margins within $20.00 per ha of the maximum gross margin for their respective cropping levels (see figure 11.1). In the case of GRASSA the difference was $45.00 per ha. Other features of these simplified systems are shown in tables 11.12 and 11.13.

Table 11.12 Structure of representative systems in an average year.

	Pasture	Greenfed crops Summer	Greenfed crops Winter	Crop silage Summer	Crop silage Winter	Pasture silage	Pasture N[1]
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(kg ha^{-1})
GRASSA	(50)[2]	-	-	-	-	(6)	-
GRASSB	(50)	-	-	-	-	14	-
GRASSN	(50)	-	-	-	-	23	105
SUDAX	(40)	(10)	(10)	-	-	16	112
MZCER	(40)	-	-	(10)	(10)	0	125
MZRCLOV	(30)	15	(20)	5	-	0	120
MZSDX	(30)	12	(20)	8	-	2	133
FREE	20	19	29	11	1	0	144

[1] See footnote to table 11.1

[2] Numbers in brackets were fixed in advance.

[7] Discussed in sections 11.2 and 11.3.

Table 11.13 Performance of representative systems in an average year

	DM grown	Stocking rate	Milkfat production		Gross margin	Variance of feed supply[1]
	(kg ha^{-1})	(cows ha^{-1})	(kg cow^{-1})	(kg ha^{-1})	(\$ ha^{-1})	
GRASSA	9500	2.40	135	324	471	27.5
GRASSB	9500	2.22	157	349	493	8.1
GRASSN	11590	2.60	159	414	514	7.9
SUDAX	12590	2.70	161	436	552	5.8
MZCER	14390	3.16	161	501	555	1.1
MZRCLOV	13790	2.90	161	466	564	3.3
MZSDX	14660	3.06	161	491	578	4.5
FREE	15420	3.14	161	506	586	2.8

[1] An index of difficulty in matching feed supply and demand. Calculated as the variance of marginal value product for dry matter in each fortnight. See text for full details.

In table 11.13, variance of feed supply is given to demonstrate the difference between systems in feed scarcity through the year. The reasoning behind this index requires some explanation. A linear programming solution tableau provides information concerning the scarcity of resources. It may indicate that the resource is not scarce at all by having a surplus or it may give a "shadow price" for the resource, indicating the marginal value product of an increase in resource supply.[8] In the present mode, the scarcity of feed nutrients is expressed in the surpluses and shadow prices of the 26 metabolizable energy rows, 26 crude protein rows and 26 dry matter appetite rows. Since neither appetite restrictions nor crude protein are normally limiting it is proposed that the metabolizable energy rows be used as an index of feed scarcity. In order that the shadow prices of these rows can be compared with the costs of providing supplements, the values are converted to a dry matter equivalent, assuming a "standard" forage ME concentration (M/D) of 11.0 MJ kg^{-1}. However, where crude protein is also limiting, the shadow price of crude protein can similarly be converted to a dry matter equivalent. This is done by assuming that any useful protein supplement would need to contain 20 percent crude protein. Where both protein and energy are scarce the highest of the two shadow prices so calculated is taken to represent feed scarcity. Crude protein and appetite limitations, where indicated, mean that the shadow prices given according to the above scheme are valid only for diets of the same or better quality.

[8] Strictly, in a maximization problem, the shadow price is the decrease in value of the objective function for a marginal decrease in resource supply.

11.8.2 DEFINITION OF SEASONAL VARIABILITY

Seasonal variability, expressed for the purpose of this model as variation in yield of pasture and crop, could be defined in several ways. One is to subject the model to a sequence of historical years. Historical yields, while real within the limits of measurement error, imply a considerable data base and would require a considerable number of years to establish a pattern of response. These data are not available.

Random sampling from defined yield distributions would be difficult when many of the forage yields would be correlated with each other and would show autocorrelation with time. As with sampling historical years, a large number of years would need to be simulated to derive stable means and there would be little opportunity to analyse the effects of individual seasons.

A third possibility is to choose the extreme seasons of interest and specify yields for those seasons. An example might be to take the driest summer-autumn on record, take yields recorded or estimated for that season and assume that system reaction to this circumstance characterizes its stability or lack thereof.

The approach adopted here was to specify a number of arbitrary seasons, defining yield in each according to some assumed distribution. Such an approach recognizes that yields are variable because of climatic variation but that equally, because of limited observation, there is great uncertainty as to the actual means, variances and correlations. For many of the forages considered here there were less than ten estimates of yield, more than one often having been made in a single year.

It was first necessary to define the seasons. Subjective assessments of the merits of seasons made by people with experience of Northland made frequent mention of spring, summer and early autumn. To simplify interpretation it was decided to define variability only for that part of the year between October 7 and April 20 and assume constant average conditions in the remainder of the year. Some justification of this decision is to be found in the results of simulating 16 years of pasture growth at Kaitaia. Standard deviations were 2-10 kg ha^{-1} day^{-1} between May and September while the range was 8-22 kg ha^{-1} day^{-1} during the period assumed variable. However, it was also clear from the results of these simulations that variation in late spring - early summer growth was largely due to temperature variations while that in late summer - early autumn was mainly due to variations in soil moisture status. An arbitrary division was therefore made at January 12-13 giving two variable seasons, each 14 weeks long. Because the sources of variation differ in kind there was reason to suppose that the seasons were independent; no significant correlation was found between the sums of 16 years pasture growth in the two seasons. Therefore, allowing for the possibility in each season of above average, below average, and average conditions provided for a total of nine different kinds of years.

Next, in was necessary to define above and below average seasons in probability terms. This was done by taking a standard normal probability curve, cutting off 2.5 percent in each tail and dividing the remaining area into three equal parts (see figure 11.6) and assuming seasons would occur in each area with equal probability. Each area was represented by the point of median probability, the point dividing each area into two halves of equal probability (see figure 11.6). Thus, the points chosen to represent above average (G), average (M) and below average (B) seasons are ($\bar{x}$ + 0.903 S.D.), $\bar{x}$, and ($\bar{x}$ - 0.903 S.D.) respectively, where $\bar{x}$ = mean and S.D. = standard deviation.

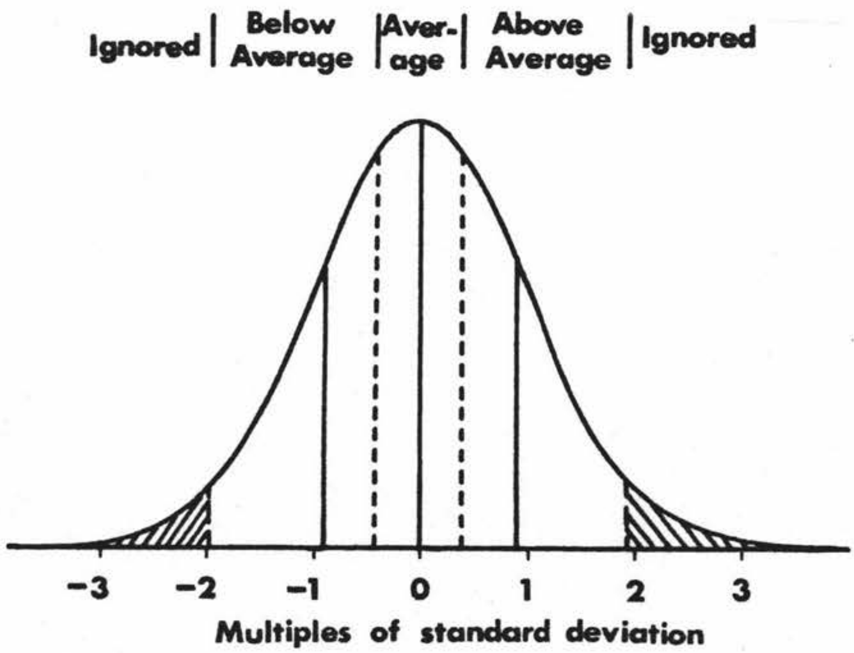

Figure 11.6 Areas of equal probability of a standard normal probability distribution with 2.5 percent cut off in each tail. Solid vertical lines halve each area.

Defining forage yields corresponding to these points was a two-stage process. First, the standard deviation of yield of each crop was estimated from yields of all site-year combinations available. For the purposes of this estimation, the justification for regarding between-site and between-year variation as equivalent lies in the wide variation between sites in moisture retention capacity of soils and in rainfall pattern over short distances (Gradwell 1971; Taylor personal communication). Pasture yield variability was estimated from data of Piggot et al. (1978) for the October 7 - January 12 period (hereafter labelled "summer" in this context) and from the simulation results for the January 13 - April 20 period (hereafter "autumn"). These sources had originally been used for pasture growth means in the two periods. The resulting coefficients of variation were 27 percent in "summer" and 54 percent in "autumn". These estimates referred to total pasture yield in each 14 week period.

Secondly, this total variability was apportioned among the seven fortnights of each period in proportion to the standard deviation calculated for each fortnight. By so doing it was assumed that a particular season type, say, below average, would be uniformly so throughout 14 weeks. The pasture growth patterns so assumed are shown in figure 11.7.

The standard deviations calculated for crops in some cases combine variability from each of the variable seasons, so it was necessary to apportion it between them. This was accomplished by assuming that "autumn" variability was twice that of "summer" variability, as calculated for pasture. In the cases when one type of "autumn" followed a different type of "summer" it was necessary to apply the estimates of variability to net growth so that the final yield of, say, greenfeed maize in an average "autumn" depended on whether the preceding "summer" had been average or above or below average . The final variability assumed for all important forage

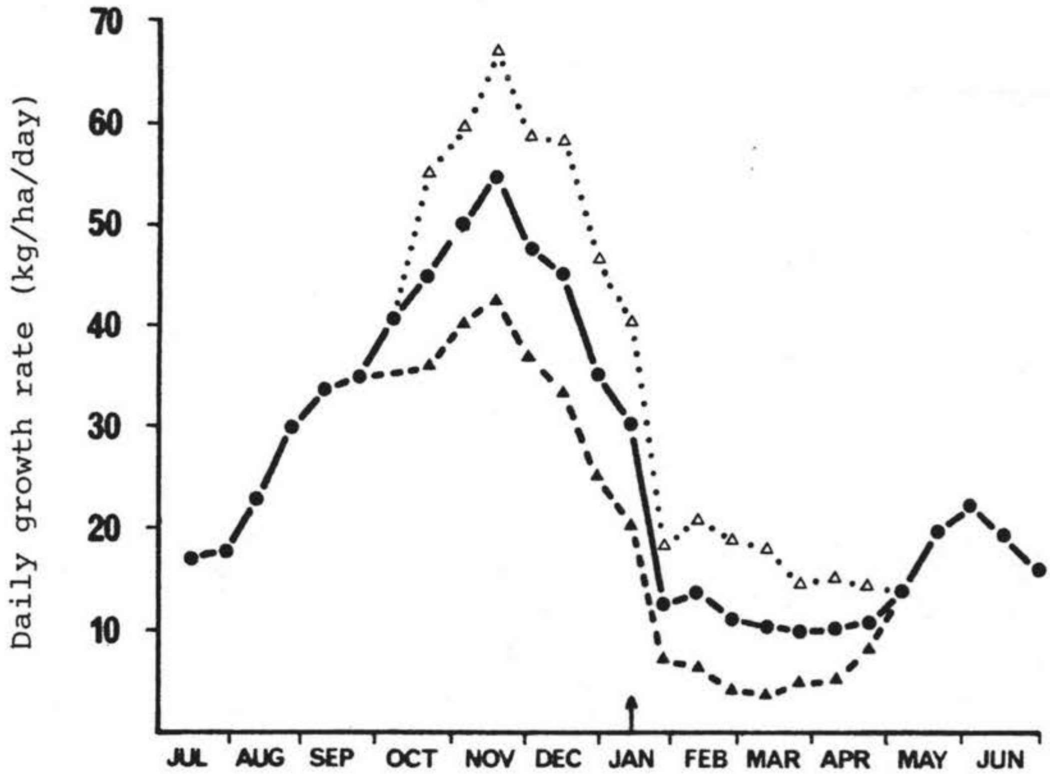

Figure 11.7 Assumed seasonal variation in pasture growth (mean——, above average ..., below average ---). Division into "summer" and "autumn" shown by arrow.

sources is shown in table 11.14. It is important to note that any comparison between forages is really a comparison between forage-environment combinations. There is, for instance, no deliberate implication that red clover is more resistant to drought than maize; it may well have been grown on better-watered sites.

Table 11.14 Assumed variability of forage yields in Northland

	Coefficients of Variation (%)		
	"Summer"	"Autumn"	Total
Pasture	27	54	-
Greenfeed maize	14	27	25
Sudax	12	23	19
Winter cereals	27	-	-
Red clover	12	24	20
Winter legumes	27	-	-

For this set of experiments, yield of silage maize is assumed constant. In model solutions the bulk of maize silage is fed before the current maize silage crop is harvested, implying carryover from the previous year. Since maize yields between consecutive summers are likely to be independent in practice, there was no theoretical basis for varying carried-over maize silage in response to current season.[9]

The nine seasonal combinations are referenced as BB, BM, BG, MB, MM, MG, GB, GM, GG where the first letter of each pair refers to "summer", the second to "autumn", B refers to below-average, M to average and G to above-average.

[9] However, see section 11.9 where the effects of independently varying silage maize yield are estimated.

11.8.3 THE LINEAR PROGRAMMING MODEL AS AN OPTIMIZING SIMULATOR

As already envisaged, the experimental plan called for a scheme which would optimize feed allocation in a relatively fixed system. Selection of a range of representative systems has already been dealt with[10] but the only fixed aspect of these was their cropping areas.

In practice, many other aspects of a farm plan are fixed, or at least constrained within limits, in advance of seasonal variation. Cow numbers and calving times are to a large extent determined at the beginning of the (July to June) year; spring nitrogen must be applied to pasture before there are any indications of late spring-early summer feed deficits; pasture silage must be made before the extent of these feed deficits are known but after seasonal variation has begun. Specific limits are detailed in table 11.15. Here it may be noted that cow numbers, calving times and spring pasture nitrogen, activities all requiring decision before seasonal variation is assumed to begin, were fixed at their optimal values for average conditions. Pasture silage was fixed at its average-season optimal level for average "summers" but was allowed to exceed this value in above-average "summers". In below-average "summers", pasture conservation was limited to half optimal level so that the model could not conserve surpluses for silage in anticipation of feed deficits later in the summer or in the autumn. The last line of table 11.15 refers to an assumption that in good seasons maize originally destined for silage may be fed off as greenfeed; conversely

[10] In section 11.8.1

this constraint prevents poor autumns from being anticipated. The other modification for these experiments was provision for higher production per cow so that the system could respond to above average conditions with fixed cow numbers. Because higher production per cow, as specified here, is very profitable, the possibility was permitted only in above-average seasons.

Table 11.15 Additional constraints for seasonal variability experiments.

	Type of "Summer"		
	above average	average	below average
July calving cows	= M	= M	= M
August calving cows	= M	= M	= M
Spring pasture N	= M	= M	= M
Pasture silage	⩾ M	= M	⩽ 0.5M
Area silage maize/ Total maize area	⩽ M	⩽ M	⩽ M

M represents the activity value in the optimal plan for an average season.

A somewhat arbitrary division has been made between feeding activities and those activities concerned with feed production and cow nutrient requirements. All the foregoing limitations apply to feed production and cow requirements and numbers and, as in previous experimentation with the model, no explicit constraints at all were imposed on the manner in which forage is apportioned to cows through the year.

This is entirely consistent with early decisions[11] to compare systems at an "optimum" level of management, though it clearly permits a degree of foreknowledge not usually granted in true simulators. The limiting values are those resulting from optimal solutions in average seasons and are shown in table 11.16. The only seasonal constraints on FREE were stocking rate, calving time and maximum silage maize area. Total crop area, spring pasture nitrogen and crop silage, activities limited in various ways in all other plans, were not limited in any season for the FREE plan.

Table 11.16 Average-season values (M) of constraints added for seasonal variability experiments.

	Crop area (%)	Stocking Rate (cows ha^{-1})	Median calving date	Spring pasture nitrogen (kg ha^{-1})	Pasture silage (kg cow^{-1})	Crop silage (kg cow^{-1})
GRASSA	0	2.40	JUL 30	0	175	-
GRASSB	0	2.22	JUL 20	0	440	-
GRASSN	0	2.60	AUG 2	100	615	-
SUDAX	20	2.70	AUG 9	96	420	-
MZCER	20	3.16	AUG 2	100	0	1270
MZRCLOV	40	2.90	JUL 22	100	0	420
MZSDX	40	3.06	JUL 17	93	45	600
FREE	NL	3.14	AUG 1	NL	0	NL

NL = no limits except a maximum 22% of farm area in silage maize.

[11] Detailed in chapters 9 and 10.

11.8.4 RESULTS OF SEASONAL VARIATION

Over the full range of specified seasons, gross margin varied by up to 30 percent above and below average. Generally, there was a larger response to below-average than to above-average seasons, so that mean performance over all seasons (these are the means referred to subsequently in this section) was usually lower than performance in an average season. This was partly due to the limited potential for increased production per cow, but largely due to the curvilinearity of the milk production function, as shown by the fact that milk production never fell to its lowest possible level of 117 kg per cow (see table 11.20). The range of gross margins for each system are shown in table 11.17. All minimum gross margins occurred in a year when both "summer" and "autumn" were below-average and all maximums occurred in a year when both "summer" and "autumn" were above-average. The rankings of the three parameters of table 11.17 were almost identical with the ranking of gross margin in an average season. The major exceptions concerned MZCER which was less variable than all other systems except FREE.

Table 11.17 Mean and extreme values of gross margin ($ ha^{-1}) in nine seasons.

	GRASSA	GRASSB	GRASSN	SUDAX	MZCER	MZRCLOV	MZSDX	FREE
Average season	471	493	514	552	555	564	578	586
Minimum	308	339	382	381	431	422	429	501
Mean	452	481	509	544	555	560	574	604
Maximum	579	590	619	662	657	664	689	714
S.D.	79	77	80	88	71	74	82	66

S.D. = standard deviation

An analysis of variance of gross margin for the 7 system x 9 season combinations is summarized in table 11.18. Interactions had relatively minor effects in contrast to seasons and to systems. As far as systems are concerned, the absence of interaction implies that systems with higher mean gross margin dominate those with lower gross margin. That is, whatever season two systems were compared in, their gross margin ranking would remain unchanged. Nevertheless, for the purposes of this study, it is pertinent to look at the responses of individual systems to seasonal variation. These are depicted in figure 11.8 where there are indications that the all-grass, no-nitrogen systems (GRASSA and GRASSB) performed relatively poorly in good "summers" and in poor "autumns". The former characteristic is a consequence of the inflexibility of these systems in utilizing surplus pasture in October-November and May-June. In other systems, a combination of strategic nitrogen, conservation and cropping permitted full use of forage grown. Poor "autumns", on the other hand, resulted in intensive meal feeding in GRASSA and GRASSB because in these systems, cows are already underfed in average conditions and thus have limited flexibility to be fed at a still lower plane of nutrition.

Table 11.18 Analysis of variance of gross margin as affected by systems and seasons.

Source of variation	Degrees of freedom		Mean square
System	6		18606
Season	8		
summer		2	149283
autumn		2	41198
summer x autumn		4	984
System x Season	48		
system x summer		12	246
system x autumn		12	249
system x summer x autumn		24	63

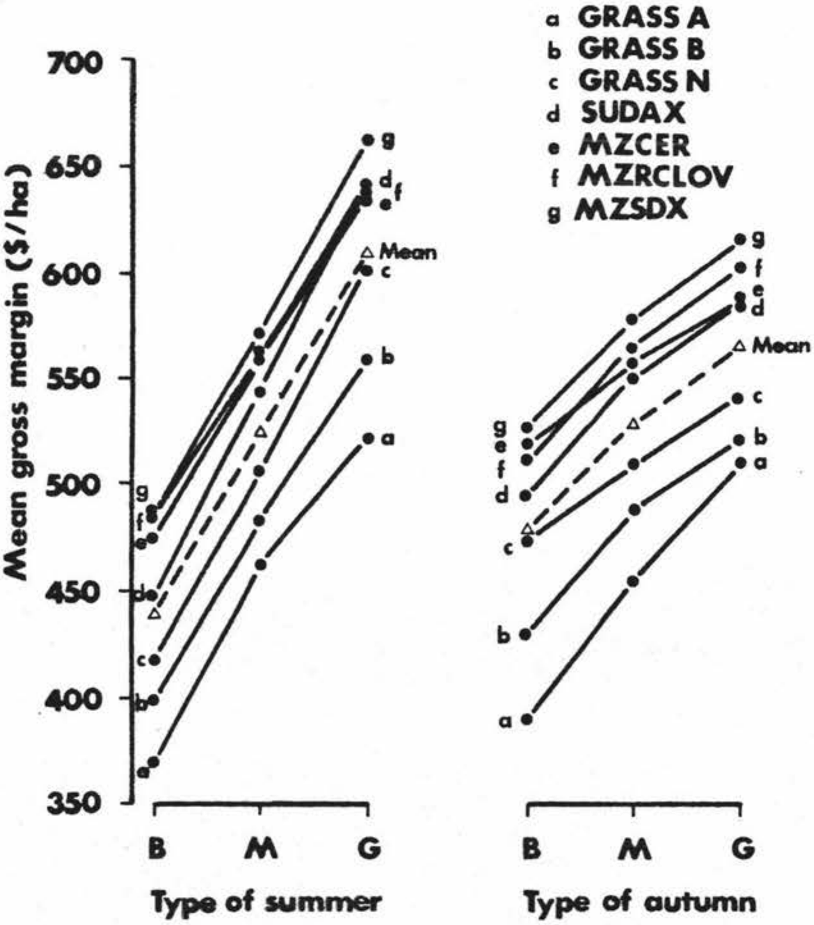

Figure 11.8 System responses to seasonal variation

The other main feature of figure 11.8 is that average "summer" responses were larger than "autumn" responses. But when related to the actual variation in forage yield, a procedure analagous to making the length of the x-axis of figure 11.8 proportional to the range in forage yield, there was almost no difference. Mean "summer" response was 9.2 c change in gross margin per kg change in total forage yield and mean "autumn" response was 9.6 c kg^{-1}.

In order to relate the response in gross margin to all seasonal variation in forage yield, least squares estimates of the response of each system over all nine seasons were calculated and are shown in table 11.19 along with average and extreme forage yields. The regression coefficients show that increasing responses accompany increasing cropping and conservation. The high value for MZCER was associated with normal variability of gross margin, with the possible exception of poor "autumns" (see figure 11.8), but with a lower than average dry matter variability. The high conservation apparently permitted efficient reorganization of feeding according to seasonal circumstances.

Table 11.19 Total forage dry matter, and mean response of gross margin to season by seven systems.

	Total forage DM grown				Least squares GM/DM
	BB	MM	GG	S.D.	
		(kg ha^{-1})			(c kg^{-1})
GRASSA	7890	9500	11110	970	7.46
GRASSB	7890	9500	11110	970	7.81
GRASSN	9890	11590	13110	960	8.20
SUDAX	10630	12590	14270	1030	8.43
MZCER	13420	14390	15220	540	13.05
MZRCLOV	12770	13790	14750	710	9.60
MZSDX	13240	14650	15810	840	9.56

Other physical aspects of system performance in variable seasons are summarized in table 11.20. The relative similarity among fixed systems in the extent of variation of milkfat production and lactation length disguises an important difference between systems. This is that the first four systems were not self contained, all requiring substantial amounts of meal to maintain lactation in poor seasons. Meal feeding at the levels indicated in table 11.20 was an optimum economic level. Minimum levels of meal consistent with model physical constraints would result in lower levels of milkfat production in the first four systems, together with lower gross margins as a result of having to recoup large cow bodyweight losses.

The main feed production adjustments made in variable seasons are shown in tables 11.21 and 11.22. The only unrealistic adjustments amongst all these were the large increases in pasture silage areas of the MZRCLOV and MZSDX systems in GB seasons. Here, it could be argued that the increase was only made in the knowledge of an impending feed shortage in late summer and autumn. However, that it was a genuine pasture surplus is indicated by the observations that no meal was fed in that season and that milkfat per cow in that season was less than 3 kg below that in the GM and GG seasons.

In non-maize systems, the main feed production adjustment was in the area of pasture topdressed with nitrogen in autumn (table 11.21). It is possible that if higher levels of production per cow were assumed, there could be greater adjustments in these systems, perhaps in the quantity of pasture silage conserved. In the two all-grass systems, not detailed in table 11.21, there was only one possible adjustment besides those already discussed. That was the area of pasture conserved as silage. In both GRASSA and GRASSB, maximum silage was conserved in all below-average "summers" while minimum silage was conserved in above-average "summers".

Table 11.20 Summary of system performance in variable seasons.

		GRASSA	GRASSB	GRASSN	SUDAX	MZCER	MZRCLOV	MZSDX	FREE
MF yield (kg ha^{-1})	Mean	334	344	408	429	509	469	487	526
	S.D.	30	42	50	49	42	42	49	24
	Minimum	301	288	337	320	435	386	397	506
	Maximum	393	405	468	488	562	528	546	559
MF prodn (kg cow^{-1})	Mean	139	155	158	159	161	162	159	168
	S.D.	13	19	18	18	13	15	16	8
	Minimum	126	130	130	131	138	133	130	161
	Maximum	164	183	180	181	178	179	178	178
Lactation length (days)	Mean	213	243	250	253	262	261	252	267
	S.D.	15	22	19	19	11	13	20	0
	Minimum	199	210	213	215	234	228	208	267
	Maximum	240	267	267	267	267	267	267	267
Maximum meal fed (kg cow^{-1})		371	223	130	153	5	10	0	0

S.D. = standard deviation

Table 11.21 Feed production adjustments for variable seasons - systems without maize.

		Autumn pasture nitrogen (ha)	Pasture silage Area (ha)	Pasture silage Quantity (t)
GRASSN				
	BB	0	11.4	30
	BM	1	11.4	30
	BG	21	11.4	30
	MB	16	22.7	79
	MM	5	22.7	79
	MG	0	22.7	79
	GB	8	25.3	110
	GM	0	22.7	90
	GG	0	22.7	90
SUDAX				
	BB	12	8.1	21
	GM	24	8.1	21
	BG	22	8.1	21
	MG	26	16.1	56
	MM	13	16.1	56
	MG	0	16.1	56
	GB	16	17.9	78
	GM	0	16.1	69
	GG	0	16.1	66

Table 11.22 Feed production adjustments for variable seasons - systems with maize.

	Autumn pasture N (ha)	Pasture silage area (ha)	Maize area Greenfeed (ha)	Maize area Silage (ha)
MZRCLOV				
BB	30	0	4.9	5.1
BM	30	0	4.9	5.1
BG	28	0	4.9	5.1
MB	29	0	4.9	5.1
MM	12	0	4.9	5.1
MG	12	0	7.1	2.9
GB	21	12.0	4.9	5.1
GM	12	1.6	5.4	4.6
GG	0	1.6	6.7	3.3
MZSDX				
BB	11	0	2.3	7.7
BM	11	0	2.3	7.7
BG	11	0	2.3	7.7
MB	11	2.0	2.3	7.7
MM	7	2.0	2.3	7.7
MG	7	2.0	4.5	5.5
GB	11	8.0	2.3	7.7
GM	7	4.0	4.0	6.0
GG	0	4.0	5.7	4.3
FREE				
BB	27	0	9.6	11.0
BM	24	0	7.4	11.0
BG	22	0	6.1	11.0
MB	21	0	7.7	11.0
MM	18	0	4.8	11.0
MG	20	0	1.7	8.4
GB	24	4.8	7.7	11.0
GM	19	4.6	3.6	8.9
GG	9	2.1	0.7	5.6

In systems with maize, the additional potential adjustment was to divert maize from silage to greenfeed on the assumption that maize silage already in storage and not required could be carried over for a further year. In both MZRCLOV and MZSDX systems, substantial diversion of maize to greenfeed occurred only in MG, GM or GG seasons, that is in an above-average "autumn" following an average "summer" or where above-average "summers" were followed by average or better "autumns".

Adjustments made by the less constrained FREE system serve to indicate what kind of strategies and structure minimize decreases in production and income even though the adjustments themselves might be unrealistic in a practical system. The major adjustment in feed production concerns cereal silage which increased from a nominal 6 t in an average season through 35-45 t in MB, BM and BG seasons to 90 t in a BB season. The extra cereal replaced sub clover and Sudax. Feed quality was maintained partly through increased use of meatmeal but mainly through a larger area of pasture, all of which was grazed. This latter result is somewhat surprising in that, of all forage sources, pasture yields are the most variable in "autumn" and at least as variable as any other in "summer". The stability offered by this structure of pasture with crop silage is even more pronounced than tables 11.17 and 11.20 suggest. Lower variability in production and gross margin is largely the result of better performance in below-average seasons whereas reaction to above-average seasons was similar to that of other systems.

The main purpose of this set of experiments was to test earlier conclusions under different climatic conditions. It is apparent that in both physical and financial performance, rankings of the systems were unchanged. This finding adds strength to earlier conclusions regarding the roles of pasture nitrogen, cropping, conservation, summer-growing grass, and higher yielding forage.

Two other conclusions are important. Firstly, it was shown that increasing cropping and conservation and pasture nitrogen reduces the effects of poor seasons. Secondly, greater use of crop silage to combat poor seasons requires greater use of higher quality forage, pasture in this case, to offset lower crop silage quality.

11.9 EFFECTS OF CONSERVATION ON DAMPING SEASONAL VARIABILITY

In the main experiment dealing with seasonal variation, the yield of silage maize was assumed not to vary with season. It was reasoned that since most of the maize silage fed in a variety of systems was fed before March 30, when maize is assumed to be harvested for silage, the silage must derive from a crop in the previous year. However, variation in yield of silage maize, even if independent of current seasonal conditions, may be expected to result in a greater variability of forage supply than previously assumed. An estimate of the contribution of silage maize yield variability would be useful on two counts. Firstly, it should provide an assessment of the degree to which the main experiment on climatic variability misrepresented a more realistic situation. Second, it should provide an estimate of the value of disconnecting, to some extent, feed supply from current seasonal conditions.

In each of the nine plans derived for MZCER in section 11.7, therefore, maize silage yields of 9.015 and 14.885 t per ha[12] were substituted for the previously assumed yield of 11.95 t per ha. Possible adjustments in these re-optimizations were limited to the same extent as in the previous section. In the

[12] Computed as for greenfeed maize in section 11.8.2.

case of MZCER, these comprised autumn pasture nitrogen, meal feeding, lactation length, plane of nutrition and forage allocation to cows. This gave a total of 27 solutions, enabling two main comparisons:

(a) Between the mean of 9 solutions with constant maize yield and the mean of 27 solutions with independently varying maize yield. This estimates the extent to which the previous assumption of constant yield under-estimates the variability of this system.

(b) Between the mean of 27 solutions with independently varying maize yield and the mean of 9 of these solutions where maize yield varies with other forage yields as if the maize was being grown in the current season. This comparison estimates the extent to which variability is damped by storage of conserved feed from one season to an independent, subsequent season.

Some details of the physical adjustments made are shown in table 11.23. As in the previous section, most of the feed production adjustments were relatively minor and variation in forage yields was accommodated through changes in feeding pattern and consequently milkfat production. No pasture silage was made in any of the 27 solutions and the only forage detail not shown in table 11.23 is the occurrence of surplus cereal silage (up to 33 t) in some of the above-average seasons with high maize yield.

The two comparisons referred to above are summarized in table 11.24 and figure 11.9. The first comparison indicates that assuming constant yield resulted in only slight over-estimation of mean gross margin and mean milkfat production (table 11.24). Under-estimation of variation was only slightly greater and would amount to a difference of only $500.00 in net income of a 50 ha farm at a probability of one year in ten. These small differences are taken as justification for the decision not to vary silage maize yield in other systems.

It has to be recognized that maize silage in the MZCER system formed only about 20 percent of the total feed supply and that these simplifying assumptions could perhaps not be applied where the feed in question comprised a larger part of total feed supply.

Table 11.23 Adjustments made in the MZCER systems for variable seasons.

Maize Yield ($t\ ha^{-1}$)		Dairy meal (t)	Autumn pasture N (ha)	Days in milk	Milkfat production ($kg\ cow^{-1}$)
	BB	20.8	40	228	134
9.015	MM	0	40	262	151
	GG	0	29	267	175
	BB	0.7	40	234	138
11.95	MM	0	20	267	161
	GG	0	0	267	177
	BB	0	40	267	151
14.885	MM	0	20	267	161
	GG	0	0	267	178

Table 11.24 Effects of seasonal variation on variability of MZCER performance with maize yield constant, varying with current season, and varying independently.

		Maize Yield		
		Constant (n=9)	Varying independently (n=27)	Varying with current season (n=9)
Gross margin ($\$$ ha^{-1})	Mean	555	550	547
	S.D.	71	75	85
	Low (P=0.1)	464	454	438
	High (P=0.1)	646	646	656
Milkfat (kg ha^{-1})	Mean	509	506	504
	S.D.	42	42	45
	Low (P=0.1)	455	450	446
	High (P=0.1)	563	564	562
Milkfat (kg cow^{-1})	Mean	161	160	160
	S.D.	13	13	14
Total forage DM (kg ha^{-1})	Mean	14380	14380	14480
	S.D.	722	660	817

S.D. = standard deviation

The second comparison indicates that storage of feed from one year to the next had only minor effects on mean gross margin and milkfat production but a greater influence on reducing variability of gross margin, if not variability of production (table 11.24). Figure 11.9 shows that the reduction of variability was manifested primarily in autumn, reflecting the fact that, in these systems, maize silage was largely fed at that time. If the difference in slope of the response to variable autumns is taken as a measure of the damping effect

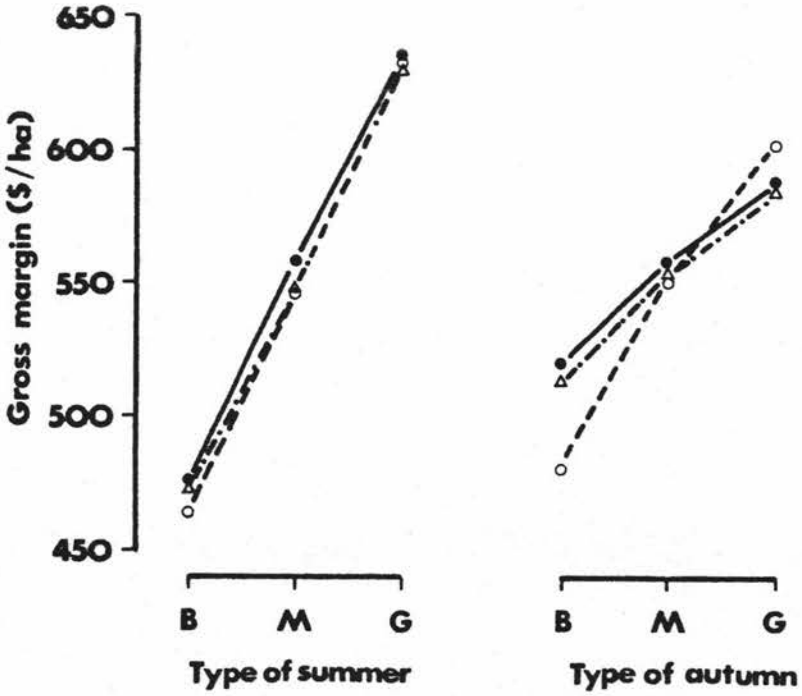

Figure 11.9 Responses of MZCER system to seasonal variation, assuming contant maize yield (——), and maize yield varying with current season (---) or independently (-.-)

of feed storage from year to year, the average effect was 1.6 c kg^{-1}, or, on a 50 ha farm, about $1000.00. Again, were maize silage a larger component of the total diet, the effect would be magnified to some extent.

11.10 EFFECTS OF CHANGE IN COST/PRICE RATIO

The objectives of subjecting systems to different economic conditions are twofold, as in the previous two sections.

(a) To test the robustness of earlier conclusions about agronomic-type questions.

(b) To indicate the types of system which best withstand adverse economic conditions. There is no intention here of deriving detailed optimal plans for an uncertain future.

As a first step, an unconstrained system was reoptimized for a range of milkfat prices. Comparisons of profitability between the reoptimized plan and the original plan under the new economic conditions gave an estimate of the benefits of reoptimizing. Because of the flexibility of an unconstrained system, such an estimate is a maximum since the potential adjustments are unlimited. If the benefits of reoptimization under these circumstances are small, then there is scarcely any need to reoptimize more constrained systems when economic circumstances change.

In table 11.25, it is clear that although changes in milkfat price result in large changes in gross margin, the effects of reoptimizing are small except at the very extremes of price change. In absolute terms, the effects are smaller at low milkfat prices than at high ones. These results were taken to justify the next step of recalculating, without reoptimization, gross margins of a range of systems at lower milkfat prices.

Table 11.25 Effects of milkfat price on gross margin on an unconstrained system with and without reoptimization.

Milkfat price ($ kg⁻)	Gross margin of $1.60 plan ($ ha⁻)	Gross margin of reoptimized plan ($ ha⁻)	Difference ($ ha⁻)	(%)
1.00	280	303	23	8
1.20	381	390	9	2
1.40	482	487	5	1
1.60	583	583	-	-
1.80	684	693	9	1
2.00	785	812	27	3
2.20	886	931	45	5

Table 11.26 shows the recalculated gross margins, together with economic farm surplus. In both these calculations, gross margin and milkfat production at $1.60 are the means of the nine seasons of section 11.7. Economic farm surplus (EFS) is defined here as

EFS = GR-CFE-CDE-MA where

GR = gross revenue from milkfat sales,

CFE = cash feed expenses,

CDE = other cash and depreciation expenses; assumed here as $14091 for a 50 ha farm,

MA = manager's allowance of $6240,

and is the effective return to capital.

Decreasing milkfat price had the largest effect on higher-producing systems so that one effect was to compress profitability differences, both absolute and relative, between systems (table 11.26). A second effect was to render four systems unprofitable (negative EFS) at a 20 percent lower milkfat price and all systems unprofitable at a 40 percent lower milkfat price (table 11.26). Changes in rank were the third effect. Almost no rank changes resulted from a 20 percent change but at the lowest milkfat price there were wholesale changes in rank resulting in SUDAX having the smallest losses and MZCER the largest.

Although this last result suggests that under economic stress grazing systems perform better than conservation systems, both MZSDX and MZRCLOV, systems incorporating considerable conservation, were almost as effective as SUDAX at low milkfat prices (table 11.26). Averaged over the full range of prices, MZSDX was the top ranking system.

Table 11.26 Effects of milkfat price on economic performance of a 50 ha farm.

	GROSS MARGIN ($ ha^{-1})			ECONOMIC SURPLUS ($)		
MF price	$1.60	$1.28	$0.96	$1.60	$1.28	$0.96
GRASSA	452	346	240	2290	-2374	-7718
GRASSB	481	372	263	3778	-1718	-7222
GRASSN	509	379	249	5180	-1259	-7787
SUDAX	544	407	270	6904	73	-6791
MZCER	555	387	219	7681	-387	-8531
MZRCLOV	560	410	260	8114	312	-7192
MZSDX	574	418	262	8858	811	-6981

Together with the consistently low ranking of all-grass systems, this result suggested that a combined crop-grass system incorporating moderate conservation might be the most resilient in the face of worsening economic conditions. Support for this suggestion was found by examining the physical aspects of the unconstrained system previously reoptimized for a range of milkfat prices. The resulting farm plans are outlined in figure 11.10 and their physical and economic performance summarized in table 11.27.

Table 11.27 Effects of milkfat price on optimal physical characteristics of an unconstrained system.

Milkfat Price ($ ka^{-1})	Pasture[1] nitrogen (kg ha^{-1})	Forage DM (kg ha^{-1})	Stocking rate (cows ha^{-1})	Milkfat (kg ha^{-1})	Gross margin ($ ha^{-1})
1.00	75	13140	2.73	439	303
1.20	85	13560	2.81	453	390
1.40	115	14540	2.96	477	487
1.60	150	15570	3.14	505	583
1.80	150	16370	3.32	534	693
2.00	150	18230	3.64	586	812
2.20	150	18540	3.69	595	931

[1] See table 11.1 for an explanation of the units.

The main features of the farm plans were the relatively constant total crop and pasture area and the increase in crop silage area with increasing milkfat price. As with the seasonal variability experiments, pasture fulfilled two separate roles, one as a cheap energy source, the other as a cheap, high quality supplement to silage. The former was relatively more important under adverse economic conditions and the latter under favourable conditions.

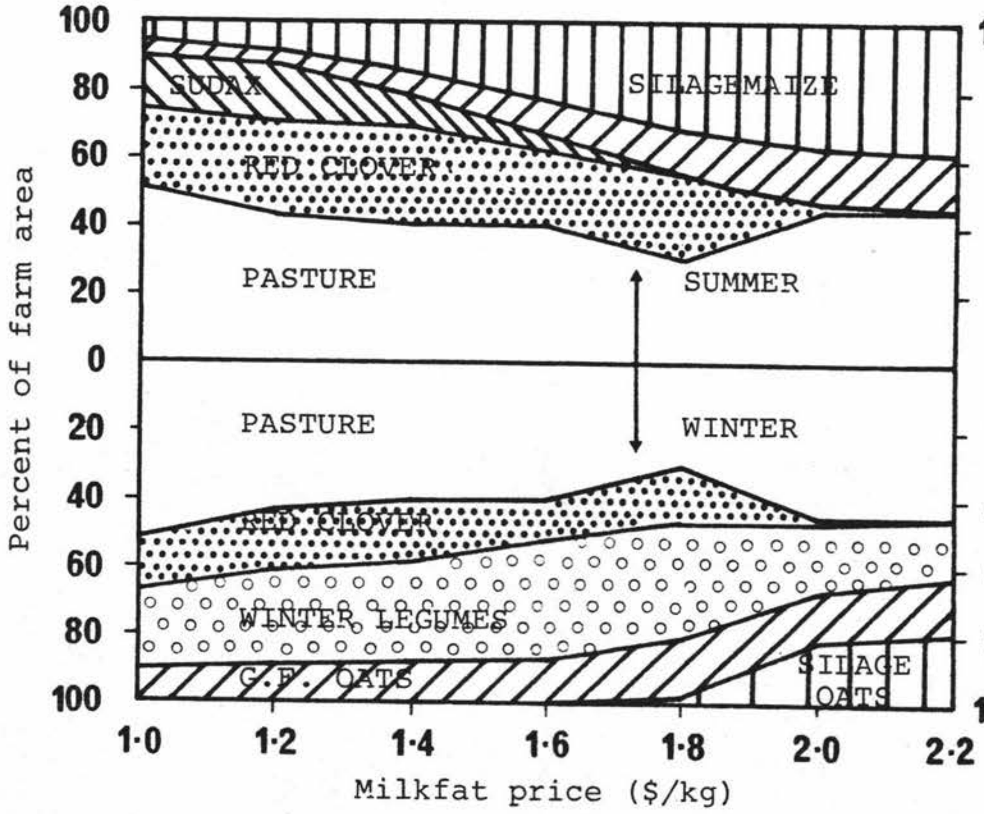

Figure 11.10 Effects of milkfat price variation on optimal system structure.

Results in table 11.27 show that there were considerable changes in physical aspects of production as milkfat price varied. As milkfat price increased, extra forage was produced, to be consumed by more, fully-fed cows. Thus, even though it was shown above that reoptimization had only minor effects on profitability, there are considerable production benefits to be gained from changes in system structure as economic conditions improve. The corollary is that the economic incentives to make such changes are very small under the present assumptions.

11.11 SUMMARY

Earlier sections of this chapter sought to test the effects on Northland dairy feeding systems of some alternative forage sources. Among these were pasture nitrogen, conventional forage crops, grazed and conserved, as well as less orthodox possibilities such a sub-tropical grass. All were shown to have value in particular circumstances.

These preliminary conclusions were confirmed and extended under economic and climatic conditions different from those initially assumed. It remains to place these conclusions in the context of field research options and priorities, the subject of the next, concluding chapter.

CHAPTER TWELVE

IMPLICATIONS FOR RESEARCH AND GENERAL CONCLUSIONS

12.1 INTRODUCTION

The previous chapter dealt with specific experiments and their results. Although a good many research alternatives were implied there, it remains to draw them together here as an integrated statement. In addition, both convention and the fact that the study was solicited and supported by a physical research organization require an evaluation of modelling as an active adjunct to field research.

12.2 SYNTHESIS AND EVALUATION OF ALTERNATIVE DAIRY FEEDING SYSTEMS

One objective of the study was to do this synthesis and evaluation through modelling. This section outlines the objectives of the Northland dairy forage feeding system project as they existed at the beginning of the study and indicates how they have been modified, subtracted from and added to during the modelling project. The objectives of the field program are taken mainly from Taylor et al. (1979c) and from discussions with those involved.

12.2.1 FEEDING FOR HIGHER PRODUCTION

Low production per cow in Northland was ascribed to poor feeding on the basis of observed cow condition. A major field research priority was to derive some input-output relationships describing the response by cows to various systems of improved feeding.

Modelling had two roles to play here. First, it was possible to show the relative importance of feed deficiencies at various times, assuming certain feed supplies and feed demand patterns. An illustration of the seasonal pattern of relative feed scarcity for three systems is given in figure 12.1. All systems have periods of relative feed abundance in spring and late autumn while GRASSA and SUDAX have a period of relative scarcity in summer or autumn. There is an interesting contrast between GRASSA and MZCER in that while the former gives a very poor match between cow demands and feed supplies compared with the latter, it has no quality problems. MZCER on the other hand has limiting crude protein from January 13 to April 20 and limiting energy density from January 13 to April 6. During this period the MZCER plan includes a high level of crop silage feeding.

Figure 12.1 shows clearly that an all-grass, low conservation system (GRASSA) did not cope well with the feed demand pattern of the lactating cows even though the lactations were 53 days shorter than the 267 days of other feed supply systems. High shadow prices of feed during February through April indicate where feed is most limiting and where attempts to improve feeding might start. The same curve suggests the gains from any alleviation of feed scarcity during this summer-autumn period might be quite limited because of similar scarcities in July-August (see figure 12.1). However, when this change was modelled, as for instance by changing the feed supply pattern to that of GRASSB with its much higher pasture silage potential, the optimum number of cows decreased as production per cow increased, so that the relative scarcity of winter compared with summer feed did not increase.

The consistency of this kind of result throughout the modelling study reinforced the conclusion that under most circumstances, summer feed supplies remained the most important limitation to system productivity and profitability.

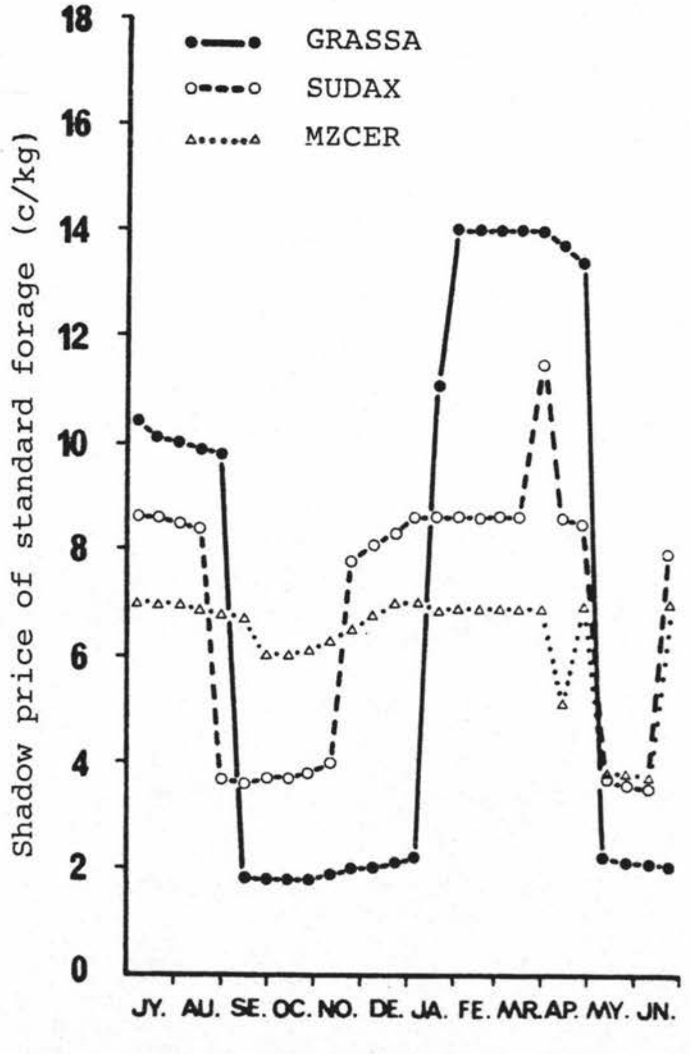

Figure 12.1 Pattern of relative feed scarcity in three systems.

The second role of modelling higher production per cow was to indicate the physical and economic effects of various strategies aimed at permitting higher production. It was clearly shown that almost all strategies were successful. Increasing pasture silage alone resulted in an extra 22 kg MF per cow and, despite a lower stocking rate, an extra 25 kg MF per ha. Addition of pasture nitrogen to this all-grass system resulted in an economic increase in stocking rate while milkfat per cow increased slightly. Grazing crops and conserved crops, either alone or in combination, produced further economic increases in stocking rate.

Because the model was able to consider the whole 12 month production period at once, evaluation of the effects of improving seasonal feed supply was much more comprehensive than otherwise possible. An instance of such integration was in the level of conservation experiment and in seasonal variability experiments where meal and silage were frequently fed in late lactation. Such a policy would be uneconomic were it not for the other mechanisms, included in the model, of firstly, maintaining cow condition and avoiding the penalties associated with regaining that condition during the dry period and secondly, bridging a feed deficit between two periods of relative plenty.

12.2.2 EFFECTS OF PASTURE NITROGEN ON SYSTEM PERFORMANCE

Comparatively simple budgeting can be used to demonstrate that nitrogen on pasture is likely to be economic under some circumstances. Assuming a pasture dry matter requirement of 25 kg per kg milkfat, a milkfat price of $1.60 per kg (as in this study) and a utilizable pasture dry matter response of 15 kg per kg N, a breakeven cost of N is $0.96 per kg. However, such calculations have very limited validity despite the reasonable nature of the assumptions. Responses of pasture to nitrogen, and of milkfat production to pasture, change seasonally depending on climatic environment, stage of lactation and grazing pressure. Pollard (1972) used a linear programming model to cope with some of these changes and was able to show a variety of pasture-based farm plans for the Manawatu that could use nitrogen economically.

The present study extended the analysis to cope with the effects of plane of nutrition on cow liveweight and the effects of other, interacting forage sources. Furthermore, the results have been expressed not only as farm plans but also in terms of breakeven responses. It was shown that pasture nitrogen, particularly when applied in late winter and late summer, could be used extensively to increase stocking rates and milkfat production. This was shown to be true for a variety of systems, nitrogen usage on pasture actually increasing as forage cropping increased. When these conclusions were tested over a range of seasonal conditions and a range of milkfat prices it was shown that although late summer pasture nitrogen usage was somewhat sensitive to climatic and economic conditions, late winter usage was very consistent.

Since the agronomic assumptions regarding pasture nitrogen were fairly arbitrary and could only be justified for very limited periods of the year, it is clearly important to define nitrogen response functions for pasture. Such functions would ideally include climatic and edaphic conditions as well as the physiological state of the pasture and its capacity for growth.

A major field study to define pasture responses to nitrogen in Northland was begun by Plant Physiology Division of DSIR in 1979 as a first step in defining these functions. An ideal future would see information from these field experiments being progressively incorporated in a model such as the present one. That could be done either by specifying a complete matrix of responses related to pasture stage and time of year, as in Pollard's (1972) study, or by iterative optimization following definition of response functions for periods of the year when feed is scarcest, as in McRae (1976).

12.2.3 EFFECTS OF WILTED, FINE-CHOP PASTURE SILAGE

Silage has commonly been used in New Zealand dairying as an alternative maintenance forage to hay. It has mostly been made from mature pasture of low digestibility and chopped and ensiled fairly casually. The result has been material of poor quality resulting in low intake and poor responses. It was argued (Taylor et al. 1979c) that with minimal intervention in existing management systems, it would be possible on most Northland dairy farms to make high quality pasture silage. Instead of a maintenance forage, it was postulated, this material could be used in mid-late lactation as a production feed. This was seen as a particularly important option for farms where, because of soil limitations, cropping would not be feasible.

By the time of this study, field testing had already shown the validity of the general argument. Nevertheless, the modelling work was able to explore the interactions between pasture nitrogen and pasture silage, on the one hand, and between pasture silage and forage crops, on the other.

Pasture silage was shown to be an essential part of all-grass systems for high production per cow. Although pasture nitrogen was apparently not essential for this level of per cow production, it was shown that its use could enable an extra 30 t of pasture silage to be made with a consequent 17 percent increase in stocking rate.

The interaction between pasture silage and forage cropping was completely dominated by maize silage. Where maize silage was available, all plans used it to the almost total exclusion of pasture silage, presumably a reflection, in part, of the much higher yield of maize silage.

12.2.4 POTENTIAL OF A SUMMER-GROWING PASTURE GRASS

The search for a sub-tropical pasture grass arose originally from the notion that in many parts of New Zealand a plant with a C_4 carbon fixation pathway would likely make better use of soil moisture during summer than the traditional C_3 plants (Mitchell 1966; Kerr 1975). The concept was originally applied to forage crops such as maize and sorghum but was later extended to more orthodox pasture grasses (Taylor et al. 1976c, 1976d, 1976e), partly as a response to the disappearance of paspalum from most Northland pastures.

Modelling showed clearly that a summer-growing grass could have large effects on productivity and profitability. This result lent considerable weight to a decision to pursue more actively the evaluation of summer growing grasses.

This process of preliminary data collection followed by modelling to help evaluate the results was a useful illustration of the benefits of interaction between modelling and field research. Favourable results justify the collection of more detailed data and more detailed modelling could again evaluate the results.

12.2.5 EFFECTS OF FORAGE CROPS

Forage cropping was originally seen as a means of increasing total forage yield above the apparent ceiling set by ryegrass - white clover pasture (Mitchell 1963, 1966). Mitchell (1969, 1970) proposed a combination of double cropping and heavy use of nitrogen fertilizer as a means of greatly increasing milk and beef production.

This concept was modified by Taylor et al. (1979c) to incorporate as a principal objective the improvement of seasonal patterns of feed supply. It was envisaged also that, in contrast to some of the earlier proposals for cropping-only systems, forage cropping in Northland would be integrated with grazed pasture and grazed crops.

Modelling showed that a variety of systems incorporating forage cropping could give substantially higher milkfat production and profitability than all-grass systems, a finding that paralleled the development of three different successful systems in the field (Taylor et al. 1979c).

Grazing crops were shown to have a consistent role in cropping systems, despite lower than maximum yields of utilizable nutrients. This was a result of the high costs associated with conservation, costs only justified substantially by maize, with its high yield and its high nutritive value at maturity.

The maximum extent of forage crop used appeared to be limited more by dietary quality constraints than by economic factors. Because pasture was by far the most economical high-quality supplement to silage, cropping never exceeded about 65 percent of farm area, though as a fraction of diet, forage crops reached 75 percent.

Both energy density and protein density of forage crops were limiting. The future may see cheaper or more effective protein supplements in the form of fishmeal but it is difficult to imagine an energy-rich supplement which would not have more economical uses in more direct application to human food. That being the case, the only means of increasing cropping above the limits mentioned above would be to forego some production per cow. In the present economic context that would not be a profitable alternative.

The importance of maize silage has previously been referred to. Modelling systems with maize silage has shown that, more so than other crop forages, it can enable much greater flexibility in feed supply pattern. This is so because its relatively high energy density enables it to be fed at almost any stage of lactation.

On the other hand, it was shown that storing 20 percent of total feed supply from one season to another had very minor effects on either mean or variability of production and profitability compared with using feed in the same season in which it has grown.

For a forage of such potential importance as maize silage, it is important to define those characteristics which make it valuable to the system, thereby giving agronomic research a focus within the chosen crop. Study of model reaction to changes in assumptions about maize yield, energy density and protein content made clear the importance of the first two characteristics and the relative unimportance of protein content. It was shown that the effects of the first two were relatively similar when expressed on a metabolizable energy basis so that the decision about which aspect to tackle in research becomes based on the potential variability in each characteristic and the chances of influencing those characteristics by genotype selection or by environmental modification.

The role of legume crops deserves particular mention because of their potential role as nitrogen fixers for succeeding gramineous crops. Several systems incorporated a legume in rotation with maize, sorghum and cereals. Their selection as potential forage sources clearly involves some a priori assumptions that legumes would be useful both as dietary protein sources, and for their nitrogen-fixing capacity. This study has concerned itself with the former, to the complete exclusion of the latter. In estimating costs of forages no allowance was made for the nitrogen contribution of the legumes, so that legumes may be more valuable than the solutions indicate. To assist evaluation of legume nitrogen contribution, it could be useful to estimate the penalties associated with forcing a legume into a system. This was done only with red clover where the legume was forced into an otherwise optimal system to the extent of 18 percent of farm area. The cost was \$328 or \$37.04 per ha of red clover. At a nitrogen value of \$0.60 kg^{-1} the red clover would need to contribute the equivalent of 62 kg N ha^{-1} yr^{-1} to make its presence economic.

Regardless of their potential value, several rotations predicted here, and elsewhere, are not fully tested, either for feasibility, or for cost. Doubts regarding feasibility are mainly in the area of timeliness of planting and harvesting in double cropping sequences; they are likely to be resolved only by the development of adequate direct drilling technology - a problem of research and development.

12.3 MANAGEMENT LIMITATIONS OF PROPOSED SYSTEMS

Many of the structural changes discussed up to now imply changes in management. These changes have been assumed to be feasible and effective but the validity of that assumption for the more important changes requires some discussion.

12.3.1 CROP MANAGEMENT

It has been assumed throughout this study that crops and pasture did not rotate with each other. The limited areas on typical Northland dairy farms that are suitable for cropping forced this assumption, despite the probability that rotating crops (gramineous ones at least) with pasture would be the safest way to preserve soil structure and fertility (Taylor and Hughes 1976). Some of the systems in this study have cropping programs which are by no means proven.

12.3.2 GRAZING MANAGEMENT

One of the effects of cropping and conservation is that, to the extent that land is taken out of the grazing area, so stocking rates on the remaining grazing area are increased. The effect is magnified when, as a consequence of an increase in total forage yield, total stock numbers are also increased. Stocking rate estimates in table 12.1 show that there is a twofold to fourfold increase in maximum stocking rates between all-grass and forage cropping systems. In modelling such a situation, it is usual to assume, as have Pollard (1972) and Wright et al. (1976), that conserved feeds are fed before grazing commences or that stock are held off the grazing area for an appropriate time. Both those assumptions have been made here so that stock are assumed to commence grazing with only sufficient appetite or sufficient time to graze their greenfeed ration.

Table 12.1 Maximum stocking rates on grazed forage (cows ha^{-1})

	Jul-Sep	Oct-Dec	Jan-Apr	May-Jun
GRASSA	2.73	2.73	2.40	2.40
GRASSB	2.22	3.09	2.22	2.22
GRASSN	2.60	4.17	2.60	2.60
SUDAX	3.38	3.38	2.70	3.38
MZCER	3.95	3.95	3.95	3.95
MZRCLOV	3.73	4.14	3.62	4.83
MZSDX	5.10	5.10	3.82	5.10
FREE	7.83	4.97	4.97	7.83

In reality, very high stocking rates may present novel problems of grazing management, especially on pasture, where, for both agronomic and animal husbandry reasons, a specified residual yield after grazing is desired (Brougham 1970; M.A.F. 1976). Clearly, these potential problems ought to be expressed as grazing pressure in the sense that units of appetite (measured as liveweight or some function of liveweight) per unit of forage (measured as dry matter or energy) is an index of pressure that is not specific to a particular stocking rate or forage yield. At very high animal densities, there may also be social effects on grazing behaviour. It may be concluded that any development of systems incorporating a significant level of cropping will require development of management techniques to minimize untoward effects of high stock densities on limited grazing areas.

12.4 RESEARCH PRIORITIES

An objective of this study was to develop research priorities for the field research program. One means of beginning this process is to calculate system benefits from increases in forage yield and rank forage sources accordingly. Using this approach, it was concluded that short term returns would be greatest if research was concentrated on grazing forages, particularly perennial pasture-type forages (Miller 1980).

However, as indicated in that discussion, potential benefits would in many cases be reduced by weighting the estimated benefits by the area potentially suitable for the forage. Many other weighting procedures could be applied, some objective, some intangible, some within the boundaries of the systems modelled, some outside. In addition, there are possible research avenues which do not seek to increase forage yield. Many of the considerations of this type which would be necessary in priority allocation are clearly the province of those who will be conducting the research and would be outside the competence of an external modeller.

Nevertheless, some generalized priorities can be stated without too much presumption:

12.4.1 PASTURE GROWTH

There is a clear need for more information regarding seasonal patterns of pasture growth and the limitations involved. Perennial pasture occupies a central place in existing systems and in any alternative systems considered in this study. The main reasons for this are low cost and high quality. It is therefore essential, when synthesizing new systems in the future, that patterns of growth and quality are well defined. These patterns need to be defined as functions of environment and management, rather than as averages across unknown variations of both. Environmental variation should encompass soil factors like drainage and nutrient supply as well as the more usual climatic variations between years and sites.

Comprehensive description of growth and quality patterns would also provide a better basis for design of conservation and nitrogen application strategies, both shown here to have potential value.

12.4.2 ALTERNATIVE PASTURE SPECIES

The potentially high value of moisture-efficient, summer-growing forages alluded to in chapter 5 have been confirmed in this study. *Hemarthria altissima*, Sudax and maize were each important components of higher-producing systems. As well as low cost, pasture types of forage have the particular merit, not specified in the modelling, that they involve the least disruption to present management systems on dairy farms. Further, the introduction and development of new genetic material can lead to improvements in farming which require few other new inputs to sustain them. The species evaluation work which has led to the selection of *H. altissima* and *Setaria sphacelata* should therefore be maintained or expanded.

12.4.3 HIGH ENERGY CROPS

Crops with high DM yields and with energy densities greater than about 9.5 MJ ME kg^{-1} in the forage as fed featured prominently in modelled systems. Increases in energy yield through increase in either DM yield or energy density have been shown here to be of equivalent and high value. An important priority is to make these crops, particularly silage maize, more reliably productive because, although high yields are known to be possible, variability of yield appears to be high. Developing better silage maize varieties, in particular, need not be very expensive since a good deal of improved genetic material must become available from large breeding programs in Europe and North America.

Two further considerations apply to this type of crop. Firstly, they will require high levels of soil nitrogen which may have to be met, in part at least, by rotating legumes. Secondly, regular double cropping will require adequate minimum tillage technology. An integrated research and development program involving engineers and agronomists will be required to develop such technology.

12.5 EVALUATION OF THE MODELLING PROCESS

It is difficult to imagine an objective means of estimating the effects of an exercise such as has been attempted here. On the one hand, there is no parallel but "untreated" research program for comparison. On the other hand, the stated attitudes of those involved need bear no relationship to the actual effect, however objectively the attitudes are assessed. Wright et al. (1976) noted similar difficulties. All that can be done here is to note some of the symptoms of success and some aspects of the approach which have not been well-developed in the literature.

12.5.1 SOME POTENTIAL ROLES

Progress in defining those aspects of technology which might repay research have been discussed already. Whether modelling is the most efficient means of this kind of system analysis cannot be decided here. Where it was efficient was as a means of assembling knowledge from diverse disciplines and sources into a coherent representation of a dairy forage feeding system. As with most other modelling studies, the assembly process revealed areas of ignorance. Some of these areas are more important than others but it is the more general conclusions that are outlined here.

(a) Despite the imprecision with which many biological events can be predicted in the short term, modelling at a level of organization and detail somewhat coarser than specialists would like has illuminated aspects of system behaviour which are not generally amenable to intuition or practical desk calculation.

(b) A possible corollary of identifying sensitive areas is that these areas should perhaps, themselves, be modelled to refine the focus of technological research. In contrast to physical experimentation, model experimentation offers a completely controllable environment where variability, instead of being blanketed out by experimental designs which seek to provide very simplified models of reality, can be progressively assigned to explicit aspects of system and sub-system structure and function.

(c) Modelling agricultural systems at any particular level of organization or detail illustrates the need for better models at lower levels of organization. These needs are probably also apparent to those who do no modelling, but without a coherent context, such as a system model, the only rational response is to call for more research in general terms, a call that implies exponential increases in research activity.

12.5.2 LIMITATIONS AND ADVANTAGES OF THE APPROACH

Again, concern here is with general aspects of the approach rather than with technical details of the modelling. Several aspects can be noted:

(a) Concurrence of the study with a functioning, well-defined research program had a number of features worth outlining. Firstly, a well-defined research program facilitated the development of a model with well-defined objectives and boundaries, a factor argued in chapter 4 to be important. Secondly, whatever information was available was readily accessible and could usually be checked against raw data and memory, no trivial matter according to Wright and Baars (1975). One disadvantage is that some experiments will always be incomplete, tempting the modeller to wait for more information. Thirdly, validation procedures can appeal to a variety of people associated with the research program. Their current involvement in the program is likely to maximize their power and motivation of critical evaluation of the model.

(b) The fact that the modeller was an outsider to the research program and to the particular research organization had advantages and disadvantages. The disadvantage of ignorance and unfamiliarity with the production system was countered, to some extent, by the neutrality of the modeller. This found expression in the modelling as a reluctance to aggregate parts of the system which could be validly left separate and a reluctance to impose subjective constraints based on ill-defined notions of aggregate behaviour. Perhaps the chief disadvantages lie in the lack of continuity and the difficulty of an outsider becoming really involved in developing research priorities. For this reason, modelling as an aid to research planning would probably best originate from within a research group.

(c) The time involved in interdisciplinary cooperation and continuous interaction between model, modeller and real research program was a real limitation. Despite the speed with which experiments can be conducted on a mathematical model, the real time involved in model development, testing, evaluation, experimental planning, and result interpretation, much of it iterative, limited the modelling process. In particular, the development of formal Turing-type tests for validation purposes, a procedure that ought to become standard practice, would have required more time to be spent on the validation phase of the modelling. In addition, development of quantitative research priorities beyond the level attempted here would certainly have required more extensive experimentation with the model.

The extensive time required for this kind of interaction between modelling and research program has been noted also by Wright et al. (1976) but often has not been explicitly considered where the modelling has been isolated from the research program in space or time.

(d) Many of the agronomic data for Northland were collected from a very limited number of sites in only a few seasons. Many measurements had been made under only one system of management and at only one or a very few times during crop growth and development. The uncertainty deriving from these limitations would be relieved by data collection with extrapolation more in mind.

One means of guiding the collection of more generally useful data would be to use some kind of model as a framework (McPherson et al. 1979). But there are two other kinds of hedges against information being too specific.

Firstly, although measurements ought properly to be concentrated on what are likely to be key areas in the present and near-future context of use, some measurements ought to be made in areas which conceivably could have future importance. An example is a silage crop, where most measurements will be concentrated around assumed optimum harvest time. There may be circumstances of season where the parameters of an unconventional end-use would be more easily estimated if some estimates of crop yield and quality were made at intervals during the vegetative stage of growth.

Secondly, a more general hedge would be a better understanding of crop growth and development as influenced by edaphic and climatic circumstances. This is not to say that every variety trial ought to attempt to explain differences in dynamic terms but that fewer field experiments ought to be conducted and they ought to include more measurements of both environmental factors and crop growth and development (e.g. see Collis-George and Davey 1960), especially with the variety of multivariate analyses now widely available (e.g. Kendall 1975). An example from the Northland work is the study of crop growth curves from serial plantings (Taylor et al. 1976b). Such understanding would ease the difficulty of extrapolating forage performance in space and time.

12.6 CONCLUSION

This study has taken place on a number of different levels. At the top of the hierarchy was the research system which, it was postulated, could be influenced beneficially by systems modelling. Next were the animal production systems, the subject of the case study research program, which, it was postulated, could be notionally manipulated by means of a mathematical model. At a lower level still were the biological systems which comprised the animal production system and which, it was postulated, could be described mathematically. Finally, there was an information system, informal though it may be, which, it was postulated, could provide the concepts and numbers of the biological system.

Each postulate has been satisfied sufficiently to influence the research system at the top of the hierarchy (Taylor et al. 1979c). It has proved possible and beneficial to synthesize and evaluate alternative dairy feeding systems, the first objective of this study. The second objective, development of research priorities, has been less well fulfilled because the modeller was external to the research program. However, the process of interaction between a field research program and a modelling program has been a valuable one. It would be more valuable still if taken up on a continuing basis by any cross-disciplinary research program.

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APPENDIX A: MODEL TIME PERIODS

Period number	Starting date
1	July 1
2	15
3	29
4	August 12
5	26
6	September 9
7	23
8	October 7
9	21
10	November 4
11	18
12	December 2
13	16
14	30
15	January 13
16	27
17	February 10
18	24
19	March 10
20	24
21	April 7
22	21
23	May 5
24	19
25	June 2
26	16

APPENDIX B: ECONOMIC ASSUMPTIONS

1. Permanent pasture (Bell 1976a)

	($/ha)
Fertilizer 0.5t/ha	30.50
Oversowing $35/10 years	3.50
Weed control $5/5years	1.00
Total variable costs	35.00

2. Pasture silage production (Bell 1976a; A.C. Innes, unpublished)

	($/ha)
Harvesting	45.00
Stacking $8.33/t	
Total variable costs for 4.2t/ha	80.00
for 3.6 t/ha	75.00

3. Silage storage and feeding (Bell 1976a; Taylor et al. 1979c; Wallace 1978)

	($/t)
Cover	0.70
Feeding (labour and tractor)	4.00
Bunker capital	
depreciation 5% of $10.00	0.50
interest 10% of $10.00	1.00
Wagon	
depreciation 10% of $11.70	1.17
interest 10% of $11.70	1.17
Total variable costs	8.54

4. Silage maize production (MAF 1977)

	($/ha)
Cultivation	50
Seed	30
Fertilizer	100
Planting	20
Insecticide	30
Herbicide	30
Harvesting	130
Total variable costs into bunker	390

5. Greenfeed maize (K.I. Lowe, B.J. Ridler; personal communication)

	($/ha)
Cultivation	40
Seed	30
Fertilizer	32
Planting	11
Insecticide	20
Total variable costs	133

6. Sudax (Taylor et al. 1979c)

	($/ha)
Total variable costs	133

7. Winter cereals and mixtures (MAF 1977)

	($/ha)
Cultivation and planting	53
Seed	36
Fertilizer	21
Pesticide	15
Total variable growing costs	125
Harvesting and stacking silage	127
Total variable costs into bunker	252

8. Red clover (\$/ha)
(MAF 1977)

Year 1:	
Seed	21
Cultivation and planting	52
Fertilizer	35
Year 2 and 3:	
Fertilizer	35
Total variable growing costs/3 years	178

Bloat Control:

1500 grazing half days @ \$0.40
in the following pattern.

Period	Cost (\$/ha)
08	1.10
09	0.74
11	6.83
12	6.94
13	7.19
14	6.78
15	5.36
16	3.93
17	2.90
18	2.90
19	2.83
20	2.64
21	2.57
22	1.68
23	5.57
Total	60.00

Harvesting, storing and feeding hay	(\$/ha)
January	129
February	94

9. Winter legume

	($/ha)
Cultivation and drilling	25
Seed	25
Total variable costs	50

10. Turnips

	($/ha)
Cultivation and planting	45
Seed	8
Fertilizer	37
Total variable costs	90

11. Concentrates

	($/kg)
MAF (1977)	
Meat meal	0.30
Complete dairy meal	0.15

APPENDIX C: EVALUATION PANEL

Dr A.M. Bryant,	Ruakura Agricultural Research Centre.
Dr T.R.O. Field,	Grasslands Division, D.S.I.R. Palmerston North.
Dr J.P. Kerr,	Plant Physiology Division, D.S.I.R. Palmerston North.
Mr B.J. Ridler,	Department of Agricultural Economics and Farm Management, Massey University.
Dr A.O. Taylor,	Plant Physiology Division, D.S.I.R. Palmerston North. Now at Whangarei.
Prof. R.J. Townsley,	Department of Agricultural Economics and Farm Management, Massey University.
Dr A. Wright,	Department of Agricultural Economics and Farm Management, Massey University.

APPENDIX D

```
B6700/7700 TEMPO                                                        F
VERSION: 26.600.000

BCDDUT        TIME--PROCESSOR =        0.01    ELAPSED =               (

NAME               FREEDATA
ROWS
 L   LAND01
 L   LAND02
 L   LAND03
 L   LAND04
 L   LAND05
 L   LAND06
 L   LAND07
 L   LAND08
 L   LAND09
 L   LAND10
 L   LAND11
 L   LAND12
 L   LAND13
 L   LAND14
 L   LAND15
 L   LAND16
 L   LAND17
 L   LAND18
 L   LAND19
 L   LAND20
 L   LAND21
 L   LAND22
 L   LAND23
 L   LAND24
 L   LAND25
 L   LAND26
 E   PLD0102
 E   PLD0203
 E   PLD0304
 E   PLD0405
 E   PLD0506
 E   PLD0607
 E   PLD0708
 E   PLD0809
 E   PLD0910
 E   PLD1011
 E   PLD1112
 E   PLD1213
 E   PLD1314
 E   PLD1415
 E   PLD1516
 E   PLD1617
 E   PLD1718
 E   PLD1819
 E   PLD1920
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NOTES

1. The matrix listed here is an example only. It may not correspond in every detail with the generalized description given in Chapter 9.

2. Explanatory material relating to the matrix can be found in "Matrix details of a Forage Systems Research Model", Technical Discussion Paper No 17, Department of Agricultural Economics and Farm Management, Massey University. The paper is available upon request.

MAS

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VERSION: 28.600.000

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L  PLD2021
L  PLD2122
L  PLD2223
L  PLD2324
L  PLD2425
L  PLD2526
L  PSN04LIM
L  PSN07LIM
L  PSN22LIM
L  RCA/B
L  RCB/C
L  LAV07
L  LUS07
L  LAV10
L  LUS10
L  LAV22
L  LUS22
L  LAV23
L  LUS23
L  PLA/B01
L  PLA/B02
L  PLA/B03
L  PLA/B04
L  PLA/B05
L  PLA/B06
L  PLA/B07
L  PLA/B08
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L  PLA/B13
L  PLA/B14
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L  PLB/B03
L  PLB/B04
L  PLB/B05
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L    PLB/B08
L    PLB/B09
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L    PLB/B11
L    PLB/B12
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L    PLB/B24
L    PLB/B25
L    PLB/B26
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L    PSDM25
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L    GFMDM16
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VERSION: 28.600.000

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L   OADM06
L   OADM07
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L   CIDM06
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L   CIDM08
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L   SXDM16
L   SXDM17
L   SXDM18
L   SXDM19
L   SXDM20
L   SXDM21
L   SXDM22
L   TORDM
L   RCDM11
L   RCDM12
L   RCDM13
L   RCDM14
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L   RCDM09
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L   SCDM08
L   SCDM09
L   SCDM10
L   WLDM07
L   WLDM08
L   WLDM09
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FREE

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L   PSGDM
L   MZSGDM
L   DASGDM
L   KOSGDM
L   RCHAYDM
L   MMDM
G   CUWDM01
G   CUWDM02
G   CUWDM03
G   CUWDM04
G   CUWDM05
G   CUWDM06
G   CUWDM07
G   CUWDM08
G   CUWDM09
G   CUWDM10
G   CUWDM11
G   CUWDM12
G   CUWDM13
G   CUWDM14
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G   CUWDM16
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G   CUWDM24
G   CUWDM25
G   CUWDM26
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L   CUWME05
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L   CUWME08
L   CUWME09
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L   CUWME11
L   CUWME12
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L   CUWME18
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B6700/7700 TEMPO   FREE
VERSION: 28.600.000

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 L   COWME20
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 L   COWME22
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 L   COWME26
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 L   COWCP17
 L   COWCP18
 L   COWCP19
 L   COWCP20
 L   COWCP21
 L   COWCP22
 L   COWCP23
 L   COWCP24
 L   COWCP25
 L   COWCP26
 L   MILKFAT
 N   MARGIN
 L   MEALDM
 N   CASHWI
 N   CASHSP
 N   CASHSU
 N   CASHAU
 N   CAPITAL
 N   APCOWS
 E   JYCOWS
 E   AUCOWS
 N   COWS
 E   SIL
COLUMNS
     PSPR01      LAND01        1.00000   PLA/B01      -1.00000
     PSPR01      PLB/B01      -1.00000   PSDM01     -214.00000
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PSPR01	PLD0102	-1.00000	MARGIN	-35.00000
PSPR01	PLD0203	-1.00000	PLD0304	-1.00000
PSPR01	PLD0405	-1.00000	PLD0506	-1.00000
PSPR01	PLD0607	-1.00000	PLD0708	-1.00000
PSPR01	PLD0809	-1.00000	PLD0910	-1.00000
PSPR01	PLD1011	-1.00000	PLD1112	-1.00000
PSPR01	PLD1213	-1.00000	PLD1314	-1.00000
PSPR01	PLD1415	-1.00000	PLD1516	-1.00000
PSPR01	PLD1617	-1.00000	PLD1718	-1.00000
PSPR01	PLD1819	-1.00000	PLD1920	-1.00000
PSPR01	PLD2021	-1.00000	PLD2122	-1.00000
PSPR01	PLD2223	-1.00000	PLD2324	-1.00000
PSPR01	PLD2425	-1.00000	PLD2526	-1.00000
PSPR01	CASHAU	30.00000		
PSPR02	LAND02	1.00000	PLA/B02	-1.00000
PSPR02	PLB/B02	-1.00000	PSDM02	-230.00000
PSPR02	PLD0102	1.00000		
PSPR03	LAND03	1.00000	PLA/B03	-1.00000
PSPR03	PLB/B03	-1.00000	PSDM03	-291.00000
PSPR03	PLD0203	1.00000		
PSPR04	LAND04	1.00000	PLA/B04	-1.00000
PSPR04	PLB/B04	-1.00000	PSDM04	-372.00000
PSPR04	PLD0304	1.00000	PSN04LIM	-1.00000
PSPR05	LAND05	1.00000	PLA/B05	-1.00000
PSPR05	PLB/B05	-1.00000	PSDM05	-422.00000
PSPR05	PLD0405	1.00000		
PSPR06	LAND06	1.00000	PLA/B06	-1.00000
PSPR06	PLB/B06	-1.00000	PSDM06	-438.00000
PSPR06	PLD0506	1.00000		
PSPR07	LAND07	1.00000	PLA/B07	-1.00000
PSPR07	PLB/B07	-1.00000	PSDM07	-518.00000
PSPR07	PLD0607	1.00000	PSN07LIM	-1.00000
PSPR08	LAND08	1.00000	PLA/B08	-1.00000
PSPR08	PLB/B08	-1.00000	PSDM08	-572.00000
PSPR08	PLD0708	1.00000		
PSPR09	LAND09	1.00000	PLA/B09	-1.00000
PSPR09	PLB/B09	-1.00000	PSDM09	-627.00000
PSPR09	PLD0809	1.00000		
PSPR10	LAND10	1.00000	PLA/B10	-1.00000
PSPR10	PLB/B10	-1.00000	PSDM10	-689.00000
PSPR10	PLD0910	1.00000		
PSPR11	LAND11	1.00000	PLA/B11	-1.00000
PSPR11	PLB/B11	-1.00000	PSDM11	-602.00000
PSPR11	PLD1011	1.00000		
PSPR12	LAND12	1.00000	PLA/B12	-1.00000
PSPR12	PLB/B12	-1.00000	PSDM12	-572.00000
PSPR12	PLD1112	1.00000		
PSPR13	LAND13	1.00000	PLA/B13	-1.00000
PSPR13	PLB/B13	-1.00000	PSDM13	-448.00000
PSPR13	PLD1213	1.00000		

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PSFR14	LAND14	1.00000	PLA/B14	-1.00000
PSFR14	PLB/B14	-1.00000	PSDM14	-384.00000
PSFR14	PLD1314	1.00000		
PSFR15	LAND15	1.00000	PLA/B15	-1.00000
PSFR15	PLB/B15	-1.00000	PSDM15	-157.50000
PSFR15	PLD1415	1.00000		
PSFR16	LAND16	1.00000	PLA/B16	-1.00000
PSFR16	PLB/B16	-1.00000	PSDM16	-174.60000
PSFR16	PLD1516	1.00000		
PSFR17	LAND17	1.00000	PLA/B17	-1.00000
PSFR17	PLB/B17	-1.00000	PSDM17	-144.90000
PSFR17	PLD1617	1.00000		
PSFR18	LAND18	1.00000	PLA/B18	-1.00000
PSFR18	PLB/B18	-1.00000	PSDM18	-135.90000
PSFR18	PLD1718	1.00000		
PSFR19	LAND19	1.00000	PLA/B19	-1.00000
PSFR19	PLB/B19	-1.00000	PSDM19	-127.80000
PSFR19	PLD1819	1.00000		
PSFR20	LAND20	1.00000	PLA/B20	-1.00000
PSFR20	PLB/B20	-1.00000	PSDM20	-132.30000
PSFR20	PLD1920	1.00000		
PSFR21	LAND21	1.00000	PLA/B21	-1.00000
PSFR21	PLB/B21	-1.00000	PSDM21	-143.00000
PSFR21	PLD2021	1.00000		
PSFR22	LAND22	1.00000	PLA/B22	-1.00000
PSFR22	PLB/B22	-1.00000	PSDM22	-176.00000
PSFR22	PLD2122	1.00000	PSN22LIM	-1.00000
PSFR23	LAND23	1.00000	PLA/B23	-1.00000
PSFR23	PLB/B23	-1.00000	PSDM23	-251.00000
PSFR23	PLD2223	1.00000		
PSFR24	LAND24	1.00000	PLA/B24	-1.00000
PSFR24	PLB/B24	-1.00000	PSDM24	-284.00000
PSFR24	PLD2324	1.00000		
PSFR25	LAND25	1.00000	PLA/B25	-1.00000
PSFR25	PLB/B25	-1.00000	PSDM25	-240.00000
PSFR25	PLD2425	1.00000		
PSFR26	LAND26	1.00000	PLA/B26	-1.00000
PSFR26	PLB/B26	-1.00000	PSDM26	-201.00000
PSFR26	PLD2526	1.00000		
PSN04	PSDM04	-75.00000	PSDM05	-225.00000
PSN04	PSDM06	-225.00000	PSDM07	-225.00000
PSN04	MARGIN	-30.00000	PSN04LIM	1.00000
PSN04	CASHWI	30.00000		
PSN07	PSDM07	-150.00000	PSDM08	-300.00000
PSN07	PSDM09	-300.00000	MARGIN	-30.00000
PSN07	PSN07LIM	1.00000	CASHSP	30.00000
PSN22	PSDM22	-75.00000	PSDM23	-225.00000
PSN22	PSDM24	-225.00000	PSDM25	-225.00000
PSN22	MARGIN	-30.00000	PSN22LIM	1.00000
PSN22	CASHAU	30.00000		

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MZSGPR	LAND10	1.00000	LAND11	1.00000
MZSGPR	LAND12	1.00000	LAND13	1.00000
MZSGPR	LAND14	1.00000	LAND15	1.00000
MZSGPR	LAND16	1.00000	LAND17	1.00000
MZSGPR	LAND18	1.00000	LAND19	1.00000
MZSGPR	LAND20	1.00000	LUS10	1.00000
MZSGPR	LAV22	-1.00000	MZSGDM	-11950.00000
MZSGPR	MARGIN	-390.00000	CASHSP	190.00000
MZSGPR	CASHAU	140.00000	CAPITAL	120.00000
GFMPR14	LAND10	1.00000	LAND11	1.00000
GFMPR14	LAND12	1.00000	LAND13	1.00000
GFMPR14	LAND14	1.00000	LUS10	1.00000
GFMPR14	LAV22	-1.00000	GFMDM14	-3150.00000
GFMPR14	MARGIN	-133.00000	CASHSP	80.00000
GFMPR15	LAND10	1.00000	LAND11	1.00000
GFMPR15	LAND12	1.00000	LAND13	1.00000
GFMPR15	LAND14	1.00000	LAND15	1.00000
GFMPR15	LUS10	1.00000	LAV22	-1.00000
GFMPR15	GFMDM15	-5100.00000	MARGIN	-133.00000
GFMPR15	CASHSP	80.00000		
GFMPR16	LAND10	1.00000	LAND11	1.00000
GFMPR16	LAND12	1.00000	LAND13	1.00000
GFMPR16	LAND14	1.00000	LAND15	1.00000
GFMPR16	LAND16	1.00000	LUS10	1.00000
GFMPR16	LAV22	-1.00000	GFMDM16	-6800.00000
GFMPR16	MARGIN	-133.00000	CASHSP	80.00000
GFMPR17	LAND10	1.00000	LAND11	1.00000
GFMPR17	LAND12	1.00000	LAND13	1.00000
GFMPR17	LAND14	1.00000	LAND15	1.00000
GFMPR17	LAND16	1.00000	LAND17	1.00000
GFMPR17	LUS10	1.00000	LAV22	-1.00000
GFMPR17	GFMDM17	-8250.00000	MARGIN	-133.00000
GFMPR17	CASHSP	80.00000		
GFMPR18	LAND10	1.00000	LAND11	1.00000
GFMPR18	LAND12	1.00000	LAND13	1.00000
GFMPR18	LAND14	1.00000	LAND15	1.00000
GFMPR18	LAND16	1.00000	LAND17	1.00000
GFMPR18	LAND18	1.00000	LUS10	1.00000
GFMPR18	LAV22	-1.00000	GFMDM18	-9450.00000
GFMPR18	MARGIN	-133.00000	CASHSP	80.00000
GFMPR19	LAND10	1.00000	LAND11	1.00000
GFMPR19	LAND12	1.00000	LAND13	1.00000
GFMPR19	LAND14	1.00000	LAND15	1.00000
GFMPR19	LAND16	1.00000	LAND17	1.00000
GFMPR19	LAND18	1.00000	LAND19	1.00000
GFMPR19	LUS10	1.00000	LAV22	-1.00000
GFMPR19	GFMDM19	-9290.00000	MARGIN	-133.00000
GFMPR19	CASHSP	80.00000		
OASGPR	LAND01	1.00000	LAND02	1.00000
OASGPR	LAND03	1.00000	LAND04	1.00000

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OASGPR	LAND05	1.00000	LAND06	1.00000
OASGPR	LAND07	1.00000	LAND08	1.00000
OASGPR	LAND09	1.00000	LAND22	1.00000
OASGPR	LAND23	1.00000	LAND24	1.00000
OASGPR	LAND25	1.00000	LAND26	1.00000
OASGPR	LAV10	-1.00000	LUS22	1.00000
OASGPR	OASGDM	-8070.00000	MARGIN	-252.00000
OASGPR	LAND21	1.00000	CASHAU	90.00000
OASGPR	CASHSP	110.00000	CAPITAL	81.00000
OAPR03	LAND01	1.00000	LAND02	1.00000
OAPR03	LAND03	1.00000	LAND22	1.00000
OAPR03	LAND23	1.00000	LAND24	1.00000
OAPR03	LAND25	1.00000	LAND26	1.00000
OAPR03	LAV07	-1.00000	LUS22	1.00000
OAPR03	OADM03	-3490.00000	MARGIN	-125.00000
OAPR03	LAND21	1.00000	CASHAU	90.00000
OAPR04	LAND01	1.00000	LAND02	1.00000
OAPR04	LAND03	1.00000	LAND04	1.00000
OAPR04	LAND22	1.00000	LAND23	1.00000
OAPR04	LAND24	1.00000	LAND25	1.00000
OAPR04	LAND26	1.00000	LAV07	-1.00000
OAPR04	LUS22	1.00000	OADM04	-4320.00000
OAPR04	MARGIN	-125.00000	LAND21	1.00000
OAPR04	CASHAU	90.00000		
OAPR05	LAND01	1.00000	LAND02	1.00000
OAPR05	LAND03	1.00000	LAND04	1.00000
OAPR05	LAND05	1.00000	LAND22	1.00000
OAPR05	LAND23	1.00000	LAND24	1.00000
OAPR05	LAND25	1.00000	LAND26	1.00000
OAPR05	LAV07	-1.00000	LUS22	1.00000
OAPR05	OADM05	-5320.00000	MARGIN	-125.00000
OAPR05	LAND21	1.00000	CASHAU	90.00000
OAPR06	LAND01	1.00000	LAND02	1.00000
OAPR06	LAND03	1.00000	LAND04	1.00000
OAPR06	LAND05	1.00000	LAND06	1.00000
OAPR06	LAND22	1.00000	LAND23	1.00000
OAPR06	LAND24	1.00000	LAND25	1.00000
OAPR06	LAND26	1.00000	LAV07	-1.00000
OAPR06	LUS22	1.00000	OADM06	-6300.00000
OAPR06	MARGIN	-125.00000	LAND21	1.00000
OAPR06	CASHAU	90.00000		
OAPR07	LAND01	1.00000	LAND02	1.00000
OAPR07	LAND03	1.00000	LAND04	1.00000
OAPR07	LAND05	1.00000	LAND06	1.00000
OAPR07	LAND07	1.00000	LAND22	1.00000
OAPR07	LAND23	1.00000	LAND24	1.00000
OAPR07	LAND25	1.00000	LAND26	1.00000
OAPR07	LAV10	-1.00000	LUS22	1.00000
OAPR07	OADM07	-7050.00000	MARGIN	-125.00000
OAPR07	LAND21	1.00000	CASHAU	90.00000

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OAFR08	LAND01	1.00000	LAND02	1.00000
OAFR08	LAND03	1.00000	LAND04	1.00000
OAFR08	LAND05	1.00000	LAND06	1.00000
OAFR08	LAND07	1.00000	LAND08	1.00000
OAFR08	LAND22	1.00000	LAND23	1.00000
OAFR08	LAND24	1.00000	LAND25	1.00000
OAFR08	LAND26	1.00000	LAV10	-1.00000
OAFR08	LUS22	1.00000	OADM08	-7380.00000
OAFR08	MARGIN	-125.00000	LAND21	1.00000
OAFR08	CASHAU	90.00000		
OAFR09	LAND01	1.00000	LAND02	1.00000
OAFR09	LAND03	1.00000	LAND04	1.00000
OAFR09	LAND05	1.00000	LAND06	1.00000
OAFR09	LAND07	1.00000	LAND08	1.00000
OAFR09	LAND09	1.00000	LAND22	1.00000
OAFR09	LAND23	1.00000	LAND24	1.00000
OAFR09	LAND25	1.00000	LAND26	1.00000
OAFR09	LAV10	-1.00000	LUS22	1.00000
OAFR09	OADM09	-8060.00000	MARGIN	-125.00000
OAFR09	LAND21	1.00000	CASHAU	90.00000
CT307PR	LAND01	1.00000	LAND02	1.00000
CT307PR	LAND03	1.00000	LAND04	1.00000
CT307PR	LAND05	1.00000	LAND08	1.00000
CT307PR	LAND06	1.00000	LAND07	1.00000
CT307PR	LAND22	1.00000	LAND23	1.00000
CT307PR	LAND24	1.00000	LAND25	1.00000
CT307PR	LAND26	1.00000	LAV10	-1.00000
CT307PR	LUS22	1.00000	CTDM03	-690.00000
CT307PR	CTDM07	-420.00000	MARGIN	-125.00000
CT307PR	CTDM04	-620.00000	CTDM05	-500.00000
CT307PR	CTDM06	-440.00000	CTDM08	-360.00000
CT307PR	CTDM09	-345.00000	CTDM01	-580.00000
CT307PR	CTDM02	-640.00000	CASHAU	90.00000
SXPR	LAND10	1.00000	LAND11	1.00000
SXPR	LAND12	1.00000	LAND13	1.00000
SXPR	LAND14	1.00000	LAND15	1.00000
SXPR	LAND16	1.00000	LAND17	1.00000
SXPR	LAND18	1.00000	LAND19	1.00000
SXPR	LAND20	1.00000	LAND21	1.00000
SXPR	LAND22	1.00000	LUS10	1.00000
SXPR	LAV23	-1.00000	SXDM15	-1070.00000
SXPR	SXDM16	-1220.00000	SXDM17	-1100.00000
SXPR	SXDM18	-1150.00000	SXDM19	-1290.00000
SXPR	SXDM20	-860.00000	SXDM21	-540.00000
SXPR	SXDM22	-410.00000	MARGIN	-133.00000
SXPR	CASHSP	70.00000		
TURPR	LAND10	1.00000	LAND11	1.00000
TURPR	LAND12	1.00000	LAND13	1.00000
TURPR	LAND14	1.00000	LAND15	1.00000
TURPR	LAND16	1.00000	LAND17	1.00000

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TURPR	LAND18	1.00000	LAND19	1.00000
TURPR	TURDM	-4500.00000	MARGIN	-90.00000
TURPR	LAND07	1.00000	LAND08	1.00000
TURPR	LAND09	1.00000	LUS07	1.00000
TURPR	LAV22	-1.00000	CASHSP	55.00000
RCPR	LAND01	2.00000	LAND02	2.00000
RCPR	LAND03	2.00000	LAND04	2.00000
RCPR	LAND05	2.00000	LAND06	2.00000
RCPR	LAND07	3.00000	LAND08	3.00000
RCPR	LAND09	3.00000	LAND10	3.00000
RCPR	LAND11	3.00000	LAND12	3.00000
RCPR	LAND13	3.00000	LAND14	3.00000
RCPR	LAND15	3.00000	LAND16	3.00000
RCPR	LAND17	3.00000	LAND18	3.00000
RCPR	LAND19	3.00000	LAND20	3.00000
RCPR	LAND21	3.00000	LAND22	2.00000
RCPR	LAND23	2.00000	LAND24	2.00000
RCPR	LAND25	2.00000	LAND26	2.00000
RCPR	LUS07	1.00000	LAV22	-1.00000
RCPR	RCDM08	-480.00000	RCDM09	-320.00000
RCPR	RCDM11	-2970.00000	RCDM12	-3020.00000
RCPR	RCDM13	-3130.00000	RCDM14	-2950.00000
RCPR	RCDM15	-2330.00000	RCDM16	-1710.00000
RCPR	RCDM17	-1260.00000	RCDM18	-1260.00000
RCPR	RCDM19	-1230.00000	RCDM20	-1150.00000
RCPR	RCDM21	-1120.00000	RCDM22	-520.00000
RCPR	RCDM23	-2420.00000	MARGIN	-178.00000
RCPR	CASHSP	115.00000		
SCPR	LAND01	1.00000	LAND02	1.00000
SCPR	LAND03	1.00000	LAND04	1.00000
SCPR	LAND05	1.00000	LAND06	1.00000
SCPR	LAND07	1.00000	LAND08	1.00000
SCPR	LAND09	1.00000	LAND23	1.00000
SCPR	LAND24	1.00000	LAND25	1.00000
SCPR	LAND26	1.00000	LAV10	-1.00000
SCPR	LUS23	1.00000	SCDM07	-1040.00000
SCPR	SCDM08	-1240.00000	SCDM09	-1220.00000
SCPR	SCDM10	-1320.00000	MARGIN	-5.00000
WLPR	LAND01	1.00000	LAND02	1.00000
WLPR	LAND03	1.00000	LAND04	1.00000
WLPR	LAND05	1.00000	LAND06	1.00000
WLPR	LAND07	1.00000	LAND08	1.00000
WLPR	LAND09	1.00000	LAND22	1.00000
WLPR	LAND23	1.00000	LAND24	1.00000
WLPR	LAND25	1.00000	LAND26	1.00000
WLPR	LAV10	-1.00000	LUS22	1.00000
WLPR	WLDM08	-2640.00000	WLDM09	-2960.00000
WLPR	MARGIN	-50.00000	LAND21	1.00000
WLPR	WLDM07	-2400.00000	CASHAO	15.00000
KUSGPR	LAND01	1.00000	LAND02	1.00000

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KUSGPR	LAND03	1.00000	LAND04	1.00000
KUSGPR	LAND05	1.00000	LAND06	1.00000
KUSGPR	LAND22	1.00000	LAND23	1.00000
KUSGPR	LAND24	1.00000	LAND25	1.00000
KUSGPR	LAND26	1.00000	LAV07	-1.00000
KUSGPR	LUS22	1.00000	KUSGDM	-7940.00000
KUSGPR	MARGIN	-252.00000	LAND21	1.00000
KUSGPR	CASHAU	90.00000	CASHSP	110.00000
KUSGPR	CAPITAL	79.00000		
FW23	LAV07	-1.00000	LUS23	1.00000
FW23	LAND01	1.00000	LAND02	1.00000
FW23	LAND06	1.00000	LAND03	1.00000
FW23	LAND04	1.00000	LAND05	1.00000
FW23	LAND23	1.00000	LAND24	1.00000
FW23	LAND25	1.00000	LAND26	1.00000
LPOOL07	LAV07	1.00000	LUS07	-1.00000
FW07	LUS07	1.00000	LAV10	-1.00000
FW07	LAND07	1.00000	LAND08	1.00000
FW07	LAND09	1.00000		
LPOOL10	LAV10	1.00000	LUS10	-1.00000
FW10	LUS10	1.00000	LAV22	-1.00000
FW10	LAND10	1.00000	LAND11	1.00000
FW10	LAND12	1.00000	LAND13	1.00000
FW10	LAND14	1.00000	LAND21	1.00000
FW10	LAND15	1.00000	LAND16	1.00000
FW10	LAND17	1.00000	LAND18	1.00000
FW10	LAND19	1.00000	LAND20	1.00000
LPOOL22	LAV22	1.00000	LUS22	-1.00000
FW22	LUS22	1.00000	LAV23	-1.00000
FW22	LAND22	1.00000		
LPOOL23	LAV23	1.00000	LUS23	-1.00000
PSSV02	PLA/B02	1.00000	PLB/B03	1.00000
PSSV02	PSDM02	230.00000	PSDM03	-230.00000
PSSV03	PLA/B03	1.00000	PLB/B04	1.00000
PSSV03	PSDM03	291.00000	PSDM04	-291.00000
PSSV04	PLA/B04	1.00000	PLB/B05	1.00000
PSSV04	PSDM04	372.00000	PSDM05	-372.00000
PSSV05	PLA/B05	1.00000	PLB/B06	1.00000
PSSV05	PSDM05	422.00000	PSDM06	-422.00000
PSSV06	PLA/B06	1.00000	PLB/B07	1.00000
PSSV06	PSDM06	438.00000	PSDM07	-438.00000
PSSV07	PLA/B07	1.00000	PLB/B08	1.00000
PSSV07	PSDM07	518.00000	PSDM08	-518.00000
PSSV08	PLA/B08	1.00000	PLB/B09	1.00000
PSSV08	PSDM08	572.00000	PSDM09	-572.00000
PSSV09	PLA/B09	1.00000	PLB/B10	1.00000
PSSV09	PSDM09	627.00000	PSDM10	-627.00000
PSSV10	PLA/B10	1.00000	PLB/B11	1.00000
PSSV10	PSDM10	689.00000	PSDM11	-689.00000
PSSV11	PLA/B11	1.00000	PLB/B12	1.00000

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PSSV11	PSDM11	602.00000	PSDM12	-602.00000
PSSV12	PLA/B12	1.00000	PLB/B13	1.00000
PSSV12	PSDM12	572.00000	PSDM13	-572.00000
PSSV13	PLA/B13	1.00000	PLB/B14	1.00000
PSSV13	PSDM13	448.00000	PSDM14	-448.00000
PSSV14	PLA/B14	1.00000	PLB/B15	1.00000
PSSV14	PSDM14	384.00000	PSDM15	-384.00000
PSSV15	PLA/B15	1.00000	PLB/B16	1.00000
PSSV15	PSDM15	157.50000	PSDM16	-141.80000
PSSV16	PLA/B16	1.00000	PLB/B17	1.00000
PSSV16	PSDM16	174.60000	PSDM17	-139.70000
PSSV17	PLA/B17	1.00000	PLB/B18	1.00000
PSSV17	PSDM17	144.90000	PSDM18	-101.40000
PSSV18	PLA/B18	1.00000	PLB/B19	1.00000
PSSV18	PSDM18	135.90000	PSDM19	-108.70000
PSSV19	PLA/B19	1.00000	PLB/B20	1.00000
PSSV19	PSDM19	127.80000	PSDM20	-115.00000
PSSV20	PLA/B20	1.00000	PLB/B21	1.00000
PSSV20	PSDM20	132.30000	PSDM21	-132.30000
PSSV21	PLA/B21	1.00000	PLB/B22	1.00000
PSSV21	PSDM21	143.00000	PSDM22	-143.00000
PSSV22	PLA/B22	1.00000	PLB/B23	1.00000
PSSV22	PSDM22	176.00000	PSDM23	-176.00000
PSSV23	PLA/B23	1.00000	PLB/B24	1.00000
PSSV23	PSDM23	251.00000	PSDM24	-251.00000
PSSV24	PLA/B24	1.00000	PLB/B25	1.00000
PSSV24	PSDM24	284.00000	PSDM25	-284.00000
PSSV25	PLA/B25	1.00000	PLB/B26	1.00000
PSSV25	PSDM25	240.00000	PSDM26	-240.00000
PSSV26	PLA/B26	1.00000	PLB/B01	1.00000
PSSV26	PSDM26	201.00000	PSDM01	-201.00000
PSSV01	PLA/B01	1.00000	PLB/B02	1.00000
PSSV01	PSDM01	214.00000	PSDM02	-214.00000
PSFG01	PSDM01	1.00000	COWDM01	-1.00000
PSFG01	COWME01	-11.30000	COWCP01	-0.26000
PSFG02	PSDM02	1.00000	COWDM02	-1.00000
PSFG02	COWME02	-11.60000	COWCP02	-0.26000
PSFG03	PSDM03	1.00000	COWDM03	-1.00000
PSFG03	COWME03	-11.70000	COWCP03	-0.27000
PSFG04	PSDM04	1.00000	COWDM04	-1.00000
PSFG04	COWME04	-11.90000	COWCP04	-0.26000
PSFG05	PSDM05	1.00000	COWDM05	-1.00000
PSFG05	COWME05	-12.00000	COWCP05	-0.26000
PSFG06	PSDM06	1.00000	COWDM06	-1.00000
PSFG06	COWME06	-12.10000	COWCP06	-0.25000
PSFG07	PSDM07	1.00000	COWDM07	-1.00000
PSFG07	COWME07	-12.00000	COWCP07	-0.24000
PSFG08	PSDM08	1.00000	COWDM08	-1.00000
PSFG08	COWME08	-11.90000	COWCP08	-0.24000
PSFG09	PSDM09	1.00000	COWDM09	-1.00000

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PSFG09	COWME09	-11.70000	COWCP09	-0.23000
PSFG10	PSDM10	1.00000	COWDM10	-1.00000
PSFG10	COWME10	-11.40000	COWCP10	-0.23000
PSFG11	PSDM11	1.00000	COWDM11	-1.00000
PSFG11	COWME11	-11.00000	COWCP11	-0.22000
PSFG12	PSDM12	1.00000	COWDM12	-1.00000
PSFG12	COWME12	-10.60000	COWCP12	-0.22000
PSFG13	PSDM13	1.00000	COWDM13	-1.00000
PSFG13	COWME13	-10.30000	COWCP13	-0.21000
PSFG14	PSDM14	1.00000	COWDM14	-1.00000
PSFG14	COWME14	-9.90000	COWCP14	-0.21000
PSFG15	PSDM15	1.00000	COWDM15	-1.00000
PSFG15	COWME15	-9.50000	COWCP15	-0.20000
PSFG16	PSDM16	1.00000	COWDM16	-1.00000
PSFG16	COWME16	-9.30000	COWCP16	-0.20000
PSFG17	PSDM17	1.00000	COWDM17	-1.00000
PSFG17	COWME17	-9.20000	COWCP17	-0.16000
PSFG18	PSDM18	1.00000	COWDM18	-1.00000
PSFG18	COWME18	-9.30000	COWCP18	-0.16000
PSFG19	PSDM19	1.00000	COWDM19	-1.00000
PSFG19	COWME19	-9.70000	COWCP19	-0.16000
PSFG20	PSDM20	1.00000	COWDM20	-1.00000
PSFG20	COWME20	-10.10000	COWCP20	-0.17000
PSFG21	PSDM21	1.00000	COWDM21	-1.00000
PSFG21	COWME21	-10.30000	COWCP21	-0.20000
PSFG22	PSDM22	1.00000	COWDM22	-1.00000
PSFG22	COWME22	-10.50000	COWCP22	-0.22000
PSFG23	PSDM23	1.00000	COWDM23	-1.00000
PSFG23	COWME23	-10.60000	COWCP23	-0.24000
PSFG24	PSDM24	1.00000	COWDM24	-1.00000
PSFG24	COWME24	-10.80000	COWCP24	-0.25000
PSFG25	PSDM25	1.00000	COWDM25	-1.00000
PSFG25	COWME25	-11.10000	COWCP25	-0.25000
PSFG26	PSDM26	1.00000	COWDM26	-1.00000
PSFG26	COWME26	-11.20000	COWCP26	-0.25000
GFMFG14	GFMDM14	1.00000	COWDM14	-1.00000
GFMFG14	COWME14	-9.60000	COWCP14	-0.16000
GFMFG15	GFMDM15	1.00000	COWDM15	-1.00000
GFMFG15	COWME15	-9.70000	COWCP15	-0.14000
GFMFG16	GFMDM16	1.00000	COWDM16	-1.00000
GFMFG16	COWME16	-9.80000	COWCP16	-0.12000
GFMFG17	GFMDM17	1.00000	COWDM17	-1.00000
GFMFG17	COWME17	-9.90000	COWCP17	-0.11000
GFMFG18	GFMDM18	1.00000	COWDM18	-1.00000
GFMFG18	COWME18	-10.00000	COWCP18	-0.10000
GFMFG19	GFMDM19	1.00000	COWDM19	-1.00000
GFMFG19	COWME19	-10.30000	COWCP19	-0.08000
OAFG03	OADM03	1.00000	COWDM03	-1.00000
OAFG03	COWME03	-10.50000	COWCP03	-0.17000
OAFG04	OADM04	1.00000	COWDM04	-1.00000

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OAF G04	COWME04	-10.60000	COWCP04	-0.15000
OAF G05	OADM05	1.00000	COWDM05	-1.00000
OAF G05	COWME05	-10.70000	COWCP05	-0.13000
OAF G06	OADM06	1.00000	COWDM06	-1.00000
OAF G06	COWME06	-10.20000	COWCP06	-0.12000
OAF G07	OADM07	1.00000	COWDM07	-1.00000
OAF G07	COWME07	-10.00000	COWCP07	-0.11000
OAF G08	OADM08	1.00000	COWDM08	-1.00000
OAF G08	COWME08	-9.80000	COWCP08	-0.10000
OAF G09	OADM09	1.00000	COWDM09	-1.00000
OAF G09	COWME09	-9.60000	COWCP09	-0.11000
CTF G01	COWDM01	-1.00000	CTDM01	1.00000
CTF G01	COWME01	-10.50000	COWCP01	-0.17000
CTF G02	CTDM02	1.00000	COWDM02	-1.00000
CTF G02	COWME02	-10.50000	COWCP02	-0.17000
CTF G03	CTDM03	1.00000	COWDM03	-1.00000
CTF G03	COWME03	-10.50000	COWCP03	-0.17000
CTF G04	CTDM04	1.00000	COWDM04	-1.00000
CTF G04	COWME04	-10.50000	COWCP04	-0.16000
CTF G05	CTDM05	1.00000	COWDM05	-1.00000
CTF G05	COWME05	-10.50000	COWCP05	-0.15000
CTF G06	CTDM06	1.00000	COWDM06	-1.00000
CTF G06	COWME06	-10.50000	COWCP06	-0.14000
CTF G07	CTDM07	1.00000	COWDM07	-1.00000
CTF G07	COWME07	-10.50000	COWCP07	-0.14000
CTF G08	CTDM08	1.00000	COWDM08	-1.00000
CTF G08	COWME08	-10.50000	COWCP08	-0.14000
CTF G09	CTDM09	1.00000	COWDM09	-1.00000
CTF G09	COWME09	-10.50000	COWCP09	-0.14000
SXF G15	SXDM15	1.00000	COWDM15	-1.00000
SXF G15	COWME15	-10.70000	COWCP15	-0.14000
SXF G16	SXDM16	1.00000	COWDM16	-1.00000
SXF G16	COWME16	-9.50000	COWCP16	-0.12000
SXF G17	SXDM17	1.00000	COWDM17	-1.00000
SXF G17	COWME17	-9.40000	COWCP17	-0.10000
SXF G18	SXDM18	1.00000	COWDM18	-1.00000
SXF G18	COWME18	-10.50000	COWCP18	-0.12000
SXF G19	SXDM19	1.00000	COWDM19	-1.00000
SXF G19	COWME19	-10.50000	COWCP19	-0.12000
SXF G20	SXDM20	1.00000	COWDM20	-1.00000
SXF G20	COWME20	-10.50000	COWCP20	-0.12000
SXF G21	SXDM21	1.00000	COWDM21	-1.00000
SXF G21	COWME21	-10.30000	COWCP21	-0.12000
SXF G22	SXDM22	1.00000	COWDM22	-1.00000
SXF G22	COWME22	-10.30000	COWCP22	-0.12000
TUF G13	TURDM	1.00000	COWDM13	-1.00000
TUF G13	COWME13	-11.80000	COWCP13	-0.10000
TUF G14	TURDM	1.00000	COWDM14	-1.00000
TUF G14	COWME14	-12.00000	COWCP14	-0.10000
TUF G15	TURDM	1.00000	COWDM15	-1.00000

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TUFG15	COWME15	-12.20000	COWCP15	-0.10000
TUFG16	TURDM	1.00000	COWDM16	-1.00000
TUFG16	COWME16	-12.40000	COWCP16	-0.10000
TUFG17	TURDM	1.00000	COWDM17	-1.00000
TUFG17	COWME17	-12.60000	COWCP17	-0.10000
TUFG18	TURDM	1.00000	COWDM18	-1.00000
TUFG18	COWME18	-12.80000	COWCP18	-0.10000
TUFG19	TURDM	1.00000	COWDM19	-1.00000
TUFG19	COWME19	-13.00000	COWCP19	-0.10000
RCFG11	RCDM11	1.00000	COWDM11	-1.00000
RCFG11	COWME11	-10.60000	COWCP11	-0.21000
RCFG12	RCDM12	1.00000	COWDM12	-1.00000
RCFG12	COWME12	-10.60000	COWCP12	-0.20000
RCFG13	RCDM13	1.00000	COWDM13	-1.00000
RCFG13	COWME13	-10.30000	COWCP13	-0.18000
RCFG14	RCDM14	1.00000	COWDM14	-1.00000
RCFG14	COWME14	-10.00000	COWCP14	-0.16000
RCFG15	RCDM15	1.00000	COWDM15	-1.00000
RCFG15	COWME15	-10.40000	COWCP15	-0.19000
RCFG16	RCDM16	1.00000	COWDM16	-1.00000
RCFG16	COWME16	-10.40000	COWCP16	-0.19000
RCFG17	RCDM17	1.00000	COWDM17	-1.00000
RCFG17	COWME17	-10.40000	COWCP17	-0.19000
RCFG18	RCDM18	1.00000	COWDM18	-1.00000
RCFG18	COWME18	-10.10000	COWCP18	-0.18000
RCFG19	RCDM19	1.00000	COWDM19	-1.00000
RCFG19	COWME19	-10.10000	COWCP19	-0.18000
RCFG20	RCDM20	1.00000	COWDM20	-1.00000
RCFG20	COWME20	-10.10000	COWCP20	-0.18000
RCFG21	RCDM21	1.00000	COWDM21	-1.00000
RCFG21	COWME21	-9.70000	COWCP21	-0.17000
RCFG22	RCDM22	1.00000	COWDM22	-1.00000
RCFG22	COWME22	-9.70000	COWCP22	-0.17000
RCFG23	RCDM23	1.00000	COWDM23	-1.00000
RCFG23	COWME23	-9.50000	COWCP23	-0.15000
RCFG08	RCDM08	1.00000	COWDM08	-1.00000
RCFG08	COWME08	-10.00000	COWCP08	-0.28000
RCFG09	RCDM09	1.00000	COWDM09	-1.00000
RCFG09	COWME09	-10.00000	COWCP09	-0.28000
SCFG07	SCDM07	1.00000	COWDM07	-1.00000
SCFG07	COWME07	-10.00000	COWCP07	-0.20000
SCFG08	SCDM08	1.00000	COWDM08	-1.00000
SCFG08	COWME08	-10.20000	COWCP08	-0.20000
SCFG09	SCDM09	1.00000	COWDM09	-1.00000
SCFG09	COWME09	-10.00000	COWCP09	-0.20000
SCFG10	SCDM10	1.00000	COWDM10	-1.00000
SCFG10	COWME10	-10.20000	COWCP10	-0.20000
WLFG07	WLDM07	1.00000	COWDM07	-1.00000
WLFG07	COWME07	-9.10000	COWCP07	-0.16000
WLFG08	WLDM08	1.00000	COWDM08	-1.00000

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WLFG08	COWME08	-9.10000	COWCP08	-0.16000
WLFG09	WLDM09	1.00000	COWDM09	-1.00000
WLFG09	COWME09	-9.10000	COWCP09	-0.16000
PSGP0709	PSDM07	668.00000	PSDM08	872.00000
PSGP0709	PSDM09	927.00000	PSGDM	-3500.00000
PSGP0709	MARGIN	-80.00000	PSDM10	689.00000
PSGP0709	PSDM11	301.00000	CASHSP	60.00000
PSGP0709	CAPITAL	35.00000	SIL	1.00000
PSGP0810	PSDM08	872.00000	PSDM09	927.00000
PSGP0810	PSDM10	689.00000	PSGDM	-3500.00000
PSGP0810	MARGIN	-80.00000	PSDM11	602.00000
PSGP0810	PSDM12	286.00000	CASHSO	60.00000
PSGP0810	CAPITAL	35.00000	SIL	1.00000
PSGP0911	PSDM09	927.00000	PSDM10	689.00000
PSGP0911	PSDM11	602.00000	PSDM12	572.00000
PSGP0911	PSDM13	224.00000	PSGDM	-3000.00000
PSGP0911	MARGIN	-75.00000	CASHSU	60.00000
PSGP0911	CAPITAL	30.00000	SIL	1.00000
PSGFG01	PSGDM	1.00000	COWDM01	-1.00000
PSGFG01	COWME01	-9.50000	COWCP01	-0.14000
PSGFG01	MARGIN	-0.00850		
PSGFG02	PSGDM	1.00000	COWDM02	-1.00000
PSGFG02	COWME02	-9.50000	COWCP02	-0.14000
PSGFG02	MARGIN	-0.00850		
PSGFG03	PSGDM	1.00000	COWDM03	-1.00000
PSGFG03	COWME03	-9.50000	COWCP03	-0.14000
PSGFG03	MARGIN	-0.00850		
PSGFG04	PSGDM	1.00000	COWDM04	-1.00000
PSGFG04	COWME04	-9.50000	COWCP04	-0.14000
PSGFG04	MARGIN	-0.00850		
PSGFG05	PSGDM	1.00000	COWDM05	-1.00000
PSGFG05	COWME05	-9.50000	COWCP05	-0.14000
PSGFG05	MARGIN	-0.00850		
PSGFG06	PSGDM	1.00000	COWDM06	-1.00000
PSGFG06	COWME06	-9.50000	COWCP06	-0.14000
PSGFG06	MARGIN	-0.00850		
PSGFG07	PSGDM	1.00000	COWDM07	-1.00000
PSGFG07	COWME07	-9.50000	COWCP07	-0.14000
PSGFG07	MARGIN	-0.00850		
PSGFG08	PSGDM	1.00000	COWDM08	-1.00000
PSGFG08	COWME08	-9.50000	COWCP08	-0.14000
PSGFG08	MARGIN	-0.00850		
PSGFG09	PSGDM	1.00000	COWDM09	-1.00000
PSGFG09	COWME09	-9.50000	COWCP09	-0.14000
PSGFG09	MARGIN	-0.00850		
PSGFG10	PSGDM	1.00000	COWDM10	-1.00000
PSGFG10	COWME10	-9.50000	COWCP10	-0.14000
PSGFG10	MARGIN	-0.00850		
PSGFG11	PSGDM	1.00000	COWDM11	-1.00000
PSGFG11	COWME11	-9.50000	COWCP11	-0.14000

PSGFG11	MARGIN	-0.00850		
PSGFG12	PSGDM	1.00000	COWDM12	-1.00000
PSGFG12	COWME12	-9.50000	COWCP12	-0.14000
PSGFG12	MARGIN	-0.00850		
PSGFG13	PSGDM	1.00000	COWDM13	-1.00000
PSGFG13	COWME13	-9.50000	COWCP13	-0.14000
PSGFG13	MARGIN	-0.00850		
PSGFG14	PSGDM	1.00000	COWDM14	-1.00000
PSGFG14	COWME14	-9.50000	COWCP14	-0.14000
PSGFG14	MARGIN	-0.00850		
PSGFG15	PSGDM	1.00000	COWDM15	-1.00000
PSGFG15	COWME15	-9.50000	COWCP15	-0.14000
PSGFG15	MARGIN	-0.00850		
PSGFG16	PSGDM	1.00000	COWDM16	-1.00000
PSGFG16	COWME16	-9.50000	COWCP16	-0.14000
PSGFG16	MARGIN	-0.00850		
PSGFG17	PSGDM	1.00000	COWDM17	-1.00000
PSGFG17	COWME17	-9.50000	COWCP17	-0.14000
PSGFG17	MARGIN	-0.00850		
PSGFG18	PSGDM	1.00000	COWDM18	-1.00000
PSGFG18	COWME18	-9.50000	COWCP18	-0.14000
PSGFG18	MARGIN	-0.00850		
PSGFG19	PSGDM	1.00000	COWDM19	-1.00000
PSGFG19	COWME19	-9.50000	COWCP19	-0.14000
PSGFG19	MARGIN	-0.00850		
PSGFG20	PSGDM	1.00000	COWDM20	-1.00000
PSGFG20	COWME20	-9.50000	COWCP20	-0.14000
PSGFG20	MARGIN	-0.00850		
PSGFG21	PSGDM	1.00000	COWDM21	-1.00000
PSGFG21	COWME21	-9.50000	COWCP21	-0.14000
PSGFG21	MARGIN	-0.00850		
PSGFG22	PSGDM	1.00000	COWDM22	-1.00000
PSGFG22	COWME22	-9.50000	COWCP22	-0.14000
PSGFG22	MARGIN	-0.00850		
PSGFG23	PSGDM	1.00000	COWDM23	-1.00000
PSGFG23	COWME23	-9.50000	COWCP23	-0.14000
PSGFG23	MARGIN	-0.00850		
PSGFG24	PSGDM	1.00000	COWDM24	-1.00000
PSGFG24	COWME24	-9.50000	COWCP24	-0.14000
PSGFG24	MARGIN	-0.00850		
PSGFG25	PSGDM	1.00000	COWDM25	-1.00000
PSGFG25	COWME25	-9.50000	COWCP25	-0.14000
PSGFG25	MARGIN	-0.00850		
PSGFG26	PSGDM	1.00000	COWDM26	-1.00000
PSGFG26	COWME26	-9.50000	COWCP26	-0.14000
PSGFG26	MARGIN	-0.00850		
MZSGFG01	MZSGDM	1.00000	COWDM01	-1.00000
MZSGFG01	COWME01	-10.60000	COWCP01	-0.09000
MZSGFG01	MARGIN	-0.00850		
MZSGFG02	MZSGDM	1.00000	COWDM02	-1.00000

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MZSGFG02  COWME02   -10.60000   COWCP02   -0.09000
MZSGFG02  MARGIN     -0.00850
MZSGFG03  MZSGDM      1.00000   COWDM03   -1.00000
MZSGFG03  COWME03   -10.60000   COWCP03   -0.09000
MZSGFG03  MARGIN     -0.00850
MZSGFG04  MZSGDM      1.00000   COWDM04   -1.00000
MZSGFG04  COWME04   -10.60000   COWCP04   -0.09000
MZSGFG04  MARGIN     -0.00850
MZSGFG05  MZSGDM      1.00000   COWDM05   -1.00000
MZSGFG05  COWME05   -10.60000   COWCP05   -0.09000
MZSGFG05  MARGIN     -0.00850
MZSGFG06  MZSGDM      1.00000   COWDM06   -1.00000
MZSGFG06  COWME06   -10.60000   COWCP06   -0.09000
MZSGFG06  MARGIN     -0.00850
MZSGFG07  MZSGDM      1.00000   COWDM07   -1.00000
MZSGFG07  COWME07   -10.60000   COWCP07   -0.09000
MZSGFG07  MARGIN     -0.00850
MZSGFG08  MZSGDM      1.00000   COWDM08   -1.00000
MZSGFG08  COWME08   -10.60000   COWCP08   -0.09000
MZSGFG08  MARGIN     -0.00850
MZSGFG09  MZSGDM      1.00000   COWDM09   -1.00000
MZSGFG09  COWME09   -10.60000   COWCP09   -0.09000
MZSGFG09  MARGIN     -0.00850
MZSGFG10  MZSGDM      1.00000   COWDM10   -1.00000
MZSGFG10  COWME10   -10.60000   COWCP10   -0.09000
MZSGFG10  MARGIN     -0.00850
MZSGFG11  MZSGDM      1.00000   COWDM11   -1.00000
MZSGFG11  COWME11   -10.60000   COWCP11   -0.09000
MZSGFG11  MARGIN     -0.00850
MZSGFG12  MZSGDM      1.00000   COWDM12   -1.00000
MZSGFG12  COWME12   -10.60000   COWCP12   -0.09000
MZSGFG12  MARGIN     -0.00850
MZSGFG13  MZSGDM      1.00000   COWDM13   -1.00000
MZSGFG13  COWME13   -10.60000   COWCP13   -0.09000
MZSGFG13  MARGIN     -0.00850
MZSGFG14  MZSGDM      1.00000   COWDM14   -1.00000
MZSGFG14  COWME14   -10.60000   COWCP14   -0.09000
MZSGFG14  MARGIN     -0.00850
MZSGFG15  MZSGDM      1.00000   COWDM15   -1.00000
MZSGFG15  COWME15   -10.60000   COWCP15   -0.09000
MZSGFG15  MARGIN     -0.00850
MZSGFG16  MZSGDM      1.00000   COWDM16   -1.00000
MZSGFG16  COWME16   -10.60000   COWCP16   -0.09000
MZSGFG16  MARGIN     -0.00850
MZSGFG17  MZSGDM      1.00000   COWDM17   -1.00000
MZSGFG17  COWME17   -10.60000   COWCP17   -0.09000
MZSGFG17  MARGIN     -0.00850
MZSGFG18  MZSGDM      1.00000   COWDM18   -1.00000
MZSGFG18  COWME18   -10.60000   COWCP18   -0.09000
MZSGFG18  MARGIN     -0.00850
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MZSGFG19	MZSGDM	1.00000	COWDM19	-1.00000
MZSGFG19	COWME19	-10.60000	COWCP19	-0.09000
MZSGFG19	MARGIN	-0.00850		
MZSGFG20	MZSGDM	1.00000	COWDM20	-1.00000
MZSGFG20	COWME20	-10.60000	COWCP20	-0.09000
MZSGFG20	MARGIN	-0.00850		
MZSGFG21	MZSGDM	1.00000	COWDM21	-1.00000
MZSGFG21	COWME21	-10.60000	COWCP21	-0.09000
MZSGFG21	MARGIN	-0.00850		
MZSGFG22	MZSGDM	1.00000	COWDM22	-1.00000
MZSGFG22	COWME22	-10.60000	COWCP22	-0.09000
MZSGFG22	MARGIN	-0.00850		
MZSGFG23	MZSGDM	1.00000	COWDM23	-1.00000
MZSGFG23	COWME23	-10.60000	COWCP23	-0.09000
MZSGFG23	MARGIN	-0.00850		
MZSGFG24	MZSGDM	1.00000	COWDM24	-1.00000
MZSGFG24	COWME24	-10.60000	COWCP24	-0.09000
MZSGFG24	MARGIN	-0.00850		
MZSGFG25	MZSGDM	1.00000	COWDM25	-1.00000
MZSGFG25	COWME25	-10.60000	COWCP25	-0.09000
MZSGFG25	MARGIN	-0.00850		
MZSGFG26	MZSGDM	1.00000	COWDM26	-1.00000
MZSGFG26	COWME26	-10.60000	COWCP26	-0.09000
MZSGFG26	MARGIN	-0.00850		
OASGFG01	OASGDM	1.00000	COWDM01	-1.00000
OASGFG01	COWME01	-8.90000	COWCP01	-0.09000
OASGFG01	MARGIN	-0.00850		
OASGFG02	OASGDM	1.00000	COWDM02	-1.00000
OASGFG02	COWME02	-8.90000	COWCP02	-0.09000
OASGFG02	MARGIN	-0.00850		
OASGFG03	OASGDM	1.00000	COWDM03	-1.00000
OASGFG03	COWME03	-8.90000	COWCP03	-0.09000
OASGFG03	MARGIN	-0.00850		
OASGFG04	OASGDM	1.00000	COWDM04	-1.00000
OASGFG04	COWME04	-8.90000	COWCP04	-0.09000
OASGFG04	MARGIN	-0.00850		
OASGFG05	OASGDM	1.00000	COWDM05	-1.00000
OASGFG05	COWME05	-8.90000	COWCP05	-0.09000
OASGFG05	MARGIN	-0.00850		
OASGFG06	OASGDM	1.00000	COWDM06	-1.00000
OASGFG06	COWME06	-8.90000	COWCP06	-0.09000
OASGFG06	MARGIN	-0.00850		
OASGFG07	OASGDM	1.00000	COWDM07	-1.00000
OASGFG07	COWME07	-8.90000	COWCP07	-0.09000
OASGFG07	MARGIN	-0.00850		
OASGFG08	OASGDM	1.00000	COWDM08	-1.00000
OASGFG08	COWME08	-8.90000	COWCP08	-0.09000
OASGFG08	MARGIN	-0.00850		
OASGFG09	OASGDM	1.00000	COWDM09	-1.00000
OASGFG09	COWME09	-8.90000	COWCP09	-0.09000

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OASGFG09	MARGIN	-0.00850		
OASGFG10	OASGDM	1.00000	COWDM10	-1.00000
OASGFG10	COWME10	-8.90000	COWCP10	-0.09000
OASGFG10	MARGIN	-0.00850		
OASGFG11	OASGDM	1.00000	COWDM11	-1.00000
OASGFG11	COWME11	-8.90000	COWCP11	-0.09000
OASGFG11	MARGIN	-0.00850		
OASGFG12	OASGDM	1.00000	COWDM12	-1.00000
OASGFG12	COWME12	-8.90000	COWCP12	-0.09000
OASGFG12	MARGIN	-0.00850		
OASGFG13	OASGDM	1.00000	COWDM13	-1.00000
OASGFG13	COWME13	-8.90000	COWCP13	-0.09000
OASGFG13	MARGIN	-0.00850		
OASGFG14	OASGDM	1.00000	COWDM14	-1.00000
OASGFG14	COWME14	-8.90000	COWCP14	-0.09000
OASGFG14	MARGIN	-0.00850		
OASGFG15	OASGDM	1.00000	COWDM15	-1.00000
OASGFG15	COWME15	-8.90000	COWCP15	-0.09000
OASGFG15	MARGIN	-0.00850		
OASGFG16	OASGDM	1.00000	COWDM16	-1.00000
OASGFG16	COWME16	-8.90000	COWCP16	-0.09000
OASGFG16	MARGIN	-0.00850		
OASGFG17	OASGDM	1.00000	COWDM17	-1.00000
OASGFG17	COWME17	-8.90000	COWCP17	-0.09000
OASGFG17	MARGIN	-0.00850		
OASGFG18	OASGDM	1.00000	COWDM18	-1.00000
OASGFG18	COWME18	-8.90000	COWCP18	-0.09000
OASGFG18	MARGIN	-0.00850		
OASGFG19	OASGDM	1.00000	COWDM19	-1.00000
OASGFG19	COWME19	-8.90000	COWCP19	-0.09000
OASGFG19	MARGIN	-0.00850		
OASGFG20	OASGDM	1.00000	COWDM20	-1.00000
OASGFG20	COWME20	-8.90000	COWCP20	-0.09000
OASGFG20	MARGIN	-0.00850		
OASGFG21	OASGDM	1.00000	COWDM21	-1.00000
OASGFG21	COWME21	-8.90000	COWCP21	-0.09000
OASGFG21	MARGIN	-0.00850		
OASGFG22	OASGDM	1.00000	COWDM22	-1.00000
OASGFG22	COWME22	-8.90000	COWCP22	-0.09000
OASGFG22	MARGIN	-0.00850		
OASGFG23	OASGDM	1.00000	COWDM23	-1.00000
OASGFG23	COWME23	-8.90000	COWCP23	-0.09000
OASGFG23	MARGIN	-0.00850		
OASGFG24	OASGDM	1.00000	COWDM24	-1.00000
OASGFG24	COWME24	-8.90000	COWCP24	-0.09000
OASGFG24	MARGIN	-0.00850		
OASGFG25	OASGDM	1.00000	COWDM25	-1.00000
OASGFG25	COWME25	-8.90000	COWCP25	-0.09000
OASGFG25	MARGIN	-0.00850		
OASGFG26	OASGDM	1.00000	COWDM26	-1.00000

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    OASGFG26   COWME26        -8.90000    COWCP26        -0.09000
    OASGFG26   MARGIN         -0.00850
    KUSGFG01   KUSGDM          1.00000    COWDM01        -1.00000
    KUSGFG01   COWME01        -8.90000    COWCP01        -0.09000
    KUSGFG01   MARGIN         -0.00850
    KUSGFG02   KUSGDM          1.00000    COWDM02        -1.00000
    KUSGFG02   COWME02        -8.90000    COWCP02        -0.09000
    KUSGFG02   MARGIN         -0.00850
    KUSGFG03   KUSGDM          1.00000    COWDM03        -1.00000
    KUSGFG03   COWME03        -8.90000    COWCP03        -0.09000
    KUSGFG03   MARGIN         -0.00850
    KUSGFG04   KUSGDM          1.00000    COWDM04        -1.00000
    KUSGFG04   COWME04        -8.90000    COWCP04        -0.09000
    KUSGFG04   MARGIN         -0.00850
    KUSGFG05   KUSGDM          1.00000    COWDM05        -1.00000
    KUSGFG05   COWME05        -8.90000    COWCP05        -0.09000
    KUSGFG05   MARGIN         -0.00850
    KUSGFG06   KUSGDM          1.00000    COWDM06        -1.00000
    KUSGFG06   COWME06        -8.90000    COWCP06        -0.09000
    KUSGFG06   MARGIN         -0.00850
    KUSGFG07   KUSGDM          1.00000    COWDM07        -1.00000
    KUSGFG07   COWME07        -8.90000    COWCP07        -0.09000
    KUSGFG07   MARGIN         -0.00850
    KUSGFG08   KUSGDM          1.00000    COWDM08        -1.00000
    KUSGFG08   COWME08        -8.90000    COWCP08        -0.09000
    KUSGFG08   MARGIN         -0.00850
    KUSGFG09   KUSGDM          1.00000    COWDM09        -1.00000
    KUSGFG09   COWME09        -8.90000    COWCP09        -0.09000
    KUSGFG09   MARGIN         -0.00850
    KUSGFG10   KUSGDM          1.00000    COWDM10        -1.00000
    KUSGFG10   COWME10        -8.90000    COWCP10        -0.09000
    KUSGFG10   MARGIN         -0.00850
    KUSGFG11   KUSGDM          1.00000    COWDM11        -1.00000
    KUSGFG11   COWME11        -8.90000    COWCP11        -0.09000
    KUSGFG11   MARGIN         -0.00850
    KUSGFG12   KUSGDM          1.00000    COWDM12        -1.00000
    KUSGFG12   COWME12        -8.90000    COWCP12        -0.09000
    KUSGFG12   MARGIN         -0.00850
    KUSGFG13   KUSGDM          1.00000    COWDM13        -1.00000
    KUSGFG13   COWME13        -8.90000    COWCP13        -0.09000
    KUSGFG13   MARGIN         -0.00850
    KUSGFG14   KUSGDM          1.00000    COWDM14        -1.00000
    KUSGFG14   COWME14        -8.90000    COWCP14        -0.09000
    KUSGFG14   MARGIN         -0.00850
    KUSGFG15   KUSGDM          1.00000    COWDM15        -1.00000
    KUSGFG15   COWME15        -8.90000    COWCP15        -0.09000
    KUSGFG15   MARGIN         -0.00850
    KUSGFG16   KUSGDM          1.00000    COWDM16        -1.00000
    KUSGFG16   COWME16        -8.90000    COWCP16        -0.09000
    KUSGFG16   MARGIN         -0.00850
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KUSGFG17	KUSGDM	1.00000	COWDM17	-1.00000
KUSGFG17	COWME17	-8.90000	COWCP17	-0.09000
KUSGFG17	MARGIN	-0.00850		
KUSGFG18	KUSGDM	1.00000	COWDM18	-1.00000
KUSGFG18	COWME18	-8.90000	COWCP18	-0.09000
KUSGFG18	MARGIN	-0.00850		
KUSGFG19	KUSGDM	1.00000	COWDM19	-1.00000
KUSGFG19	COWME19	-8.90000	COWCP19	-0.09000
KUSGFG19	MARGIN	-0.00850		
KUSGFG20	KUSGDM	1.00000	COWDM20	-1.00000
KUSGFG20	COWME20	-8.90000	COWCP20	-0.09000
KUSGFG20	MARGIN	-0.00850		
KUSGFG21	KUSGDM	1.00000	COWDM21	-1.00000
KUSGFG21	COWME21	-8.90000	COWCP21	-0.09000
KUSGFG21	MARGIN	-0.00850		
KUSGFG22	KUSGDM	1.00000	COWDM22	-1.00000
KUSGFG22	COWME22	-8.90000	COWCP22	-0.09000
KUSGFG22	MARGIN	-0.00850		
KUSGFG23	KUSGDM	1.00000	COWDM23	-1.00000
KUSGFG23	COWME23	-8.90000	COWCP23	-0.09000
KUSGFG23	MARGIN	-0.00850		
KUSGFG24	KUSGDM	1.00000	COWDM24	-1.00000
KUSGFG24	COWME24	-8.90000	COWCP24	-0.09000
KUSGFG24	MARGIN	-0.00850		
KUSGFG25	KUSGDM	1.00000	COWDM25	-1.00000
KUSGFG25	COWME25	-8.90000	COWCP25	-0.09000
KUSGFG25	MARGIN	-0.00850		
KUSGFG26	KUSGDM	1.00000	COWDM26	-1.00000
KUSGFG26	COWME26	-8.90000	COWCP26	-0.09000
KUSGFG26	MARGIN	-0.00850		
RCHPRJA	RCDM12	1010.00000	RCDM13	1030.00000
RCHPRJA	RCDM14	980.00000	RCDM15	840.00000
RCHPRJA	RCHAYDM	-3230.00000	MARGIN	-129.00000
RCHPRFE	RCDM14	980.00000	RCDM15	840.00000
RCHPRFE	RCDM16	570.00000	RCDM17	420.00000
RCHPRFE	RCHAYDM	-2350.00000	MARGIN	-94.00000
RCHFG01	RCHAYDM	1.00000	COWDM01	-1.00000
RCHFG01	COWME01	-9.50000	COWCP01	-0.15000
RCHFG02	RCHAYDM	1.00000	COWDM02	-1.00000
RCHFG02	COWME02	-9.50000	COWCP02	-0.15000
RCHFG03	RCHAYDM	1.00000	COWDM03	-1.00000
RCHFG03	COWME03	-9.50000	COWCP03	-0.15000
RCHFG04	RCHAYDM	1.00000	COWDM04	-1.00000
RCHFG04	COWME04	-9.50000	COWCP04	-0.15000
RCHFG05	RCHAYDM	1.00000	COWDM05	-1.00000
RCHFG05	COWME05	-9.50000	COWCP05	-0.15000
RCHFG06	RCHAYDM	1.00000	COWDM06	-1.00000
RCHFG06	COWME06	-9.50000	COWCP06	-0.15000
RCHFG07	RCHAYDM	1.00000	COWDM07	-1.00000
RCHFG07	COWME07	-9.50000	COWCP07	-0.15000

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RCHFG08	RCHAYDM	1.00000	COWDM08	-1.00000
RCHFG08	COWME08	-9.50000	COWCP08	-0.15000
RCHFG09	RCHAYDM	1.00000	COWDM09	-1.00000
RCHFG09	COWME09	-9.50000	COWCP09	-0.15000
RCHFG10	RCHAYDM	1.00000	COWDM10	-1.00000
RCHFG10	COWME10	-9.50000	COWCP10	-0.15000
RCHFG11	RCHAYDM	1.00000	COWDM11	-1.00000
RCHFG11	COWME11	-9.50000	COWCP11	-0.15000
RCHFG12	RCHAYDM	1.00000	COWDM12	-1.00000
RCHFG12	COWME12	-9.50000	COWCP12	-0.15000
RCHFG13	RCHAYDM	1.00000	COWDM13	-1.00000
RCHFG13	COWME13	-9.50000	COWCP13	-0.15000
RCHFG14	RCHAYDM	1.00000	COWDM14	-1.00000
RCHFG14	COWME14	-9.50000	COWCP14	-0.15000
RCHFG15	RCHAYDM	1.00000	COWDM15	-1.00000
RCHFG15	COWME15	-9.50000	COWCP15	-0.15000
RCHFG16	RCHAYDM	1.00000	COWDM16	-1.00000
RCHFG16	COWME16	-9.50000	COWCP16	-0.15000
RCHFG17	RCHAYDM	1.00000	COWDM17	-1.00000
RCHFG17	COWME17	-9.50000	COWCP17	-0.15000
RCHFG18	RCHAYDM	1.00000	COWDM18	-1.00000
RCHFG18	COWME18	-9.50000	COWCP18	-0.15000
RCHFG19	RCHAYDM	1.00000	COWDM19	-1.00000
RCHFG19	COWME19	-9.50000	COWCP19	-0.15000
RCHFG20	RCHAYDM	1.00000	COWDM20	-1.00000
RCHFG20	COWME20	-9.50000	COWCP20	-0.15000
RCHFG21	RCHAYDM	1.00000	COWDM21	-1.00000
RCHFG21	COWME21	-9.50000	COWCP21	-0.15000
RCHFG22	RCHAYDM	1.00000	COWDM22	-1.00000
RCHFG22	COWME22	-9.50000	COWCP22	-0.15000
RCHFG23	RCHAYDM	1.00000	COWDM23	-1.00000
RCHFG23	COWME23	-9.50000	COWCP23	-0.15000
RCHFG24	RCHAYDM	1.00000	COWDM24	-1.00000
RCHFG24	COWME24	-9.50000	COWCP24	-0.15000
RCHFG25	RCHAYDM	1.00000	COWDM25	-1.00000
RCHFG25	COWME25	-9.50000	COWCP25	-0.15000
RCHFG26	RCHAYDM	1.00000	COWDM26	-1.00000
RCHFG26	COWME26	-9.50000	COWCP26	-0.15000
MMBUY	MMDM	-1.00000	MARGIN	-0.30000
MMBUY	CASHSU	0.30000		
MMFG01	COWDM01	-1.00000	COWME01	-10.00000
MMFG01	COWCP01	-0.90000	MMDM	1.00000
MMFG02	COWDM02	-1.00000	COWME02	-10.00000
MMFG02	COWCP02	-0.90000	MMDM	1.00000
MMFG03	COWDM03	-1.00000	COWME03	-10.00000
MMFG03	COWCP03	-0.90000	MMDM	1.00000
MMFG04	COWDM04	-1.00000	COWME04	-10.00000
MMFG04	COWCP04	-0.90000	MMDM	1.00000
MMFG05	COWDM05	-1.00000	COWME05	-10.00000
MMFG05	COWCP05	-0.90000	MMDM	1.00000

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MMFG06	COWDM06	-1.00000	COWME06	-10.00000
MMFG06	COWCP06	-0.90000	MMDM	1.00000
MMFG07	COWDM07	-1.00000	COWME07	-10.00000
MMFG07	COWCP07	-0.90000	MMDM	1.00000
MMFG08	COWDM08	-1.00000	COWME08	-10.00000
MMFG08	COWCP08	-0.90000	MMDM	1.00000
MMFG09	COWDM09	-1.00000	COWME09	-10.00000
MMFG09	COWCP09	-0.90000	MMDM	1.00000
MMFG10	COWDM10	-1.00000	COWME10	-10.00000
MMFG10	COWCP10	-0.90000	MMDM	1.00000
MMFG11	COWDM11	-1.00000	COWME11	-10.00000
MMFG11	COWCP11	-0.90000	MMDM	1.00000
MMFG12	COWDM12	-1.00000	COWME12	-10.00000
MMFG12	COWCP12	-0.90000	MMDM	1.00000
MMFG13	COWDM13	-1.00000	COWME13	-10.00000
MMFG13	COWCP13	-0.90000	MMDM	1.00000
MMFG14	COWDM14	-1.00000	COWME14	-10.00000
MMFG14	COWCP14	-0.90000	MMDM	1.00000
MMFG15	COWDM15	-1.00000	COWME15	-10.00000
MMFG15	COWCP15	-0.90000	MMDM	1.00000
MMFG16	COWDM16	-1.00000	COWME16	-10.00000
MMFG16	COWCP16	-0.90000	MMDM	1.00000
MMFG17	COWDM17	-1.00000	COWME17	-10.00000
MMFG17	COWCP17	-0.90000	MMDM	1.00000
MMFG18	COWDM18	-1.00000	COWME18	-10.00000
MMFG18	COWCP18	-0.90000	MMDM	1.00000
MMFG19	COWDM19	-1.00000	COWME19	-10.00000
MMFG19	COWCP19	-0.90000	MMDM	1.00000
MMFG20	COWDM20	-1.00000	COWME20	-10.00000
MMFG20	COWCP20	-0.90000	MMDM	1.00000
MMFG21	COWDM21	-1.00000	COWME21	-10.00000
MMFG21	COWCP21	-0.90000	MMDM	1.00000
MMFG22	COWDM22	-1.00000	COWME22	-10.00000
MMFG22	COWCP22	-0.90000	MMDM	1.00000
MMFG23	COWDM23	-1.00000	COWME23	-10.00000
MMFG23	COWCP23	-0.90000	MMDM	1.00000
MMFG24	COWDM24	-1.00000	COWME24	-10.00000
MMFG24	COWCP24	-0.90000	MMDM	1.00000
MMFG25	COWDM25	-1.00000	COWME25	-10.00000
MMFG25	COWCP25	-0.90000	MMDM	1.00000
MMFG26	COWDM26	-1.00000	COWME26	-10.00000
MMFG26	COWCP26	-0.90000	MMDM	1.00000
JFLOCV01	COWDM01	146.16000	COWDM02	183.82000
JFLOCV01	COWDM03	196.94000	COWDM04	202.16000
JFLOCV01	COWDM05	206.36000	COWDM06	210.14000
JFLOCV01	COWDM07	213.92000	COWDM08	215.04000
JFLOCV01	COWDM09	215.60000	COWDM10	213.50000
JFLOCV01	COWDM11	206.32000	COWDM12	203.14000
JFLOCV01	COWDM13	197.82000	COWDM14	189.00000
JFLOCV01	COWDM15	182.00000	COWDM16	172.76000

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JFLOCV01	COWDM17	163.80000	COWDM18	156.38000
JFLOCV01	COWDM19	149.10000	COWDM20	142.80000
JFLOCV01	COWDM21	137.76000	COWDM22	135.10000
JFLOCV01	COWDM23	135.80000	COWDM24	136.50000
JFLOCV01	COWDM25	137.90000	COWDM26	141.12000
JFLOCV01	COWME01	1365.00000	COWME02	1814.40000
JFLOCV01	COWME03	2041.20000	COWME04	2102.80000
JFLOCV01	COWME05	2185.40000	COWME06	2224.60000
JFLOCV01	COWME07	2216.20000	COWME08	2185.40000
JFLOCV01	COWME09	2153.20000	COWME10	2111.20000
JFLOCV01	COWME11	2039.80000	COWME12	1933.40000
JFLOCV01	COWME13	1773.80000	COWME14	1717.80000
JFLOCV01	COWME15	1666.00000	COWME16	1625.40000
JFLOCV01	COWME17	1573.60000	COWME18	1570.80000
JFLOCV01	COWME19	1537.20000	COWME20	1418.20000
JFLOCV01	COWME21	995.40000	COWME22	704.20000
JFLOCV01	COWME23	736.40000	COWME24	774.20000
JFLOCV01	COWME25	621.80000	COWME26	886.20000
JFLOCV01	COWCP01	16.24000	COWCP02	22.67000
JFLOCV01	COWCP03	26.19000	COWCP04	27.19000
JFLOCV01	COWCP05	28.40000	COWCP06	28.97000
JFLOCV01	COWCP07	28.81000	COWCP08	28.30000
JFLOCV01	COWCP09	27.77000	COWCP10	27.11000
JFLOCV01	COWCP11	26.01000	COWCP12	24.36000
JFLOCV01	COWCP13	22.00000	COWCP14	21.13000
JFLOCV01	COWCP15	20.38000	COWCP16	19.79000
JFLOCV01	COWCP17	19.05000	COWCP18	19.01000
JFLOCV01	COWCP19	18.55000	COWCP20	16.87000
JFLOCV01	COWCP21	10.80000	COWCP22	6.63000
JFLOCV01	COWCP23	6.99000	COWCP24	7.66000
JFLOCV01	COWCP25	9.06000	COWCP26	9.39000
JFLOCV01	MILKFAT	-161.00000		
JFLOCV03	COWDM03	146.16000	COWDM04	183.82000
JFLOCV03	COWDM05	198.94000	COWDM06	202.16000
JFLOCV03	COWDM07	206.36000	COWDM08	210.14000
JFLOCV03	COWDM09	213.92000	COWDM10	215.04000
JFLOCV03	COWDM11	215.60000	COWDM12	213.50000
JFLOCV03	COWDM13	208.32000	COWDM14	203.14000
JFLOCV03	COWDM15	197.82000	COWDM16	189.00000
JFLOCV03	COWDM17	182.00000	COWDM18	172.76000
JFLOCV03	COWDM19	163.80000	COWDM20	156.38000
JFLOCV03	COWDM21	149.10000	COWDM22	142.80000
JFLOCV03	COWDM23	137.76000	COWDM24	135.10000
JFLOCV03	COWDM25	135.80000	COWDM26	136.50000
JFLOCV03	COWDM01	146.16000	COWDM02	183.82000
JFLOCV03	COWME03	1365.00000	COWCP03	16.24000
JFLOCV03	COWME04	1814.40000	COWCP04	22.67000
JFLOCV03	COWME05	2041.20000	COWCP05	26.19000
JFLOCV03	COWME06	2102.80000	COWCP06	27.19000
JFLOCV03	COWME07	2185.40000	COWCP07	28.40000

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JFLOCV03	COWME08	2224.60000	COWCP08	28.97000
JFLOCV03	COWME09	2216.20000	COWCP09	28.81000
JFLOCV03	COWME10	2185.40000	COWCP10	28.30000
JFLOCV03	COWME11	2153.20000	COWCP11	27.77000
JFLOCV03	COWME12	2111.20000	COWCP12	27.11000
JFLOCV03	COWME13	2039.80000	COWCP13	26.01000
JFLOCV03	COWME14	1933.40000	COWCP14	24.36000
JFLOCV03	COWME15	1773.80000	COWCP15	22.00000
JFLOCV03	COWME16	1717.80000	COWCP16	21.13000
JFLOCV03	COWME17	1666.00000	COWCP17	20.38000
JFLOCV03	COWME18	1625.40000	COWCP18	19.79000
JFLOCV03	COWME19	1573.60000	COWCP19	19.05000
JFLOCV03	COWME20	1570.80000	COWCP20	19.01000
JFLOCV03	COWME21	1537.20000	COWCP21	18.55000
JFLOCV03	COWME22	1418.20000	COWCP22	16.87000
JFLOCV03	COWME23	995.40000	COWCP23	10.80000
JFLOCV03	COWME24	704.20000	COWCP24	6.63000
JFLOCV03	COWME25	736.40000	COWCP25	6.99000
JFLOCV03	COWME26	774.20000	COWCP26	7.66000
JFLOCV03	COWME01	821.80000	COWCP01	9.06000
JFLOCV03	COWME02	886.20000	COWCP02	9.39000
JFLOCV03	MILKFAT	-161.00000		
JFLOCV05	COWDM05	146.16000	COWDM06	183.82000
JFLOCV05	COWDM07	196.94000	COWDM08	202.16000
JFLOCV05	COWDM09	206.36000	COWDM10	210.14000
JFLOCV05	COWDM11	213.92000	COWDM12	215.04000
JFLOCV05	COWDM13	215.60000	COWDM14	213.50000
JFLOCV05	COWDM15	206.32000	COWDM16	203.14000
JFLOCV05	COWDM17	197.82000	COWDM18	189.00000
JFLOCV05	COWDM19	182.00000	COWDM20	172.76000
JFLOCV05	COWDM21	163.80000	COWDM22	156.38000
JFLOCV05	COWDM23	149.10000	COWDM24	142.80000
JFLOCV05	COWDM25	137.76000	COWDM26	135.10000
JFLOCV05	COWDM01	135.80000	COWDM02	136.50000
JFLOCV05	COWDM03	137.90000	COWDM04	141.12000
JFLOCV05	COWME05	1365.00000	COWCP05	16.24000
JFLOCV05	COWME06	1614.40000	COWCP06	22.67000
JFLOCV05	COWME07	2041.20000	COWCP07	26.19000
JFLOCV05	COWME08	2102.80000	COWCP08	27.19000
JFLOCV05	COWME09	2185.40000	COWCP09	28.40000
JFLOCV05	COWME10	2224.60000	COWCP10	28.97000
JFLOCV05	COWME11	2216.20000	COWCP11	28.81000
JFLOCV05	COWME12	2185.40000	COWCP12	28.30000
JFLOCV05	COWME13	2153.20000	COWCP13	27.77000
JFLOCV05	COWME14	2111.20000	COWCP14	27.11000
JFLOCV05	COWME15	2039.80000	COWCP15	26.01000
JFLOCV05	COWME16	1933.40000	COWCP16	24.36000
JFLOCV05	COWME17	1773.80000	COWCP17	22.00000
JFLOCV05	COWME18	1717.80000	COWCP18	21.13000
JFLOCV05	COWME19	1666.00000	COWCP19	20.38000

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JFLOCV05	COWME20	1625.40000	COWCP20	19.79000
JFLOCV05	COWME21	1573.60000	COWCP21	19.05000
JFLOCV05	COWME22	1570.80000	COWCP22	19.01000
JFLOCV05	COWME23	1537.20000	COWCP23	18.55000
JFLOCV05	COWME24	1418.20000	COWCP24	16.87000
JFLOCV05	COWME25	995.40000	COWCP25	10.80000
JFLOCV05	COWME26	704.20000	COWCP26	6.63000
JFLOCV05	COWME01	736.40000	COWCP01	6.99000
JFLOCV05	COWME02	774.20000	COWCP02	7.66000
JFLOCV05	COWME03	821.80000	COWCP03	9.06000
JFLOCV05	COWME04	886.20000	COWCP04	9.39000
JFLOCV05	MILKFAT	-161.00000		
JFLOCV07	COWDM07	146.16000	COWDM08	183.82000
JFLOCV07	COWDM09	196.94000	COWDM10	202.16000
JFLOCV07	COWDM11	206.36000	COWDM12	210.14000
JFLOCV07	COWDM13	213.92000	COWDM14	215.04000
JFLOCV07	COWDM15	215.60000	COWDM16	213.50000
JFLOCV07	COWDM17	208.32000	COWDM18	203.14000
JFLOCV07	COWDM19	197.82000	COWDM20	189.00000
JFLOCV07	COWDM21	182.00000	COWDM22	172.76000
JFLOCV07	COWDM23	163.80000	COWDM24	156.36000
JFLOCV07	COWDM25	149.10000	COWDM26	142.80000
JFLOCV07	COWDM01	137.76000	COWDM02	135.10000
JFLOCV07	COWDM03	135.80000	COWDM04	136.50000
JFLOCV07	COWDM05	137.90000	COWDM06	141.12000
JFLOCV07	COWME07	1365.00000	COWCP07	12.69800
JFLOCV07	COWME08	1814.40000	COWCP08	20.14600
JFLOCV07	COWME09	2041.20000	COWCP09	24.69600
JFLOCV07	COWME10	2102.80000	COWCP10	25.64800
JFLOCV07	COWME11	2185.40000	COWCP11	27.53800
JFLOCV07	COWME12	2224.60000	COWCP12	28.02800
JFLOCV07	COWME13	2216.20000	COWCP13	27.48200
JFLOCV07	COWME14	2185.40000	COWCP14	27.10400
JFLOCV07	COWME15	2153.20000	COWCP15	26.26400
JFLOCV07	COWME16	2111.20000	COWCP16	25.76000
JFLOCV07	COWME17	2039.80000	COWCP17	24.68200
JFLOCV07	COWME18	1933.40000	COWCP18	22.82000
JFLOCV07	COWME19	1773.80000	COWCP19	20.39800
JFLOCV07	COWME20	1717.80000	COWCP20	19.58600
JFLOCV07	COWME21	1666.00000	COWCP21	18.66200
JFLOCV07	COWME22	1625.40000	COWCP22	18.20000
JFLOCV07	COWME23	1573.60000	COWCP23	17.45800
JFLOCV07	COWME24	1570.80000	COWCP24	17.12200
JFLOCV07	COWME25	1537.20000	COWCP25	16.75800
JFLOCV07	COWME26	1418.20000	COWCP26	15.17600
JFLOCV07	COWME01	995.40000	COWCP01	9.45000
JFLOCV07	COWME02	704.20000	COWCP02	5.48800
JFLOCV07	COWME03	736.40000	COWCP03	5.74000
JFLOCV07	COWME04	774.20000	COWCP04	6.03400
JFLOCV07	COWME05	821.80000	COWCP05	6.41200

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JFLOCV07	COWME06	886.20000	COWCP06	7.26600
JFLOCV07	MILKFAT	-161.00000		
JFLOCV21	COWDM21	146.16000	COWDM22	183.82000
JFLOCV21	COWDM23	198.94000	COWDM24	202.16000
JFLOCV21	COWDM25	206.36000	COWDM26	210.14000
JFLOCV21	COWDM01	213.92000	COWDM02	215.04000
JFLOCV21	COWDM03	215.60000	COWDM04	213.50000
JFLOCV21	COWDM05	208.32000	COWDM06	203.14000
JFLOCV21	COWDM07	197.82000	COWDM08	189.00000
JFLOCV21	COWDM09	182.00000	COWDM10	172.76000
JFLOCV21	COWDM11	163.80000	COWDM12	156.38000
JFLOCV21	COWDM13	149.10000	COWDM14	142.80000
JFLOCV21	COWDM15	137.76000	COWDM16	135.10000
JFLOCV21	COWDM17	135.80000	COWDM18	136.50000
JFLOCV21	COWDM19	137.90000	COWDM20	141.12000
JFLOCV21	COWME21	1365.00000	COWCP21	16.24000
JFLOCV21	COWME22	1814.40000	COWCP22	22.67000
JFLOCV21	COWME23	2041.20000	COWCP23	26.19000
JFLOCV21	COWME24	2102.80000	COWCP24	27.19000
JFLOCV21	COWME25	2185.40000	COWCP25	28.40000
JFLOCV21	COWME26	2224.60000	COWCP26	28.97000
JFLOCV21	COWME01	2216.20000	COWCP01	28.81000
JFLOCV21	COWME02	2185.40000	COWCP02	28.30000
JFLOCV21	COWME03	2153.20000	COWCP03	27.77000
JFLOCV21	COWME04	2111.20000	COWCP04	27.11000
JFLOCV21	COWME05	2039.80000	COWCP05	26.01000
JFLOCV21	COWME06	1933.40000	COWCP06	24.36000
JFLOCV21	COWME07	1773.80000	COWCP07	22.00000
JFLOCV21	COWME08	1717.80000	COWCP08	21.13000
JFLOCV21	COWME09	1666.00000	COWCP09	20.38000
JFLOCV21	COWME10	1625.40000	COWCP10	19.79000
JFLOCV21	COWME11	1573.60000	COWCP11	19.05000
JFLOCV21	COWME12	1570.80000	COWCP12	19.01000
JFLOCV21	COWME13	1537.20000	COWCP13	18.55000
JFLOCV21	COWME14	1418.20000	COWCP14	16.87000
JFLOCV21	COWME15	995.40000	COWCP15	10.80000
JFLOCV21	COWME16	704.20000	COWCP16	6.63000
JFLOCV21	COWME17	736.40000	COWCP17	6.99000
JFLOCV21	COWME18	774.20000	COWCP18	7.66000
JFLOCV21	COWME19	821.80000	COWCP19	9.06000
JFLOCV21	COWME20	886.20000	COWCP20	9.39000
JFLOCV21	MILKFAT	-161.00000		
JFLOCV23	COWDM23	146.16000	COWDM24	183.82000
JFLOCV23	COWDM25	198.94000	COWDM26	202.16000
JFLOCV23	COWDM01	206.36000	COWDM02	210.14000
JFLOCV23	COWDM03	213.92000	COWDM04	215.04000
JFLOCV23	COWDM05	215.60000	COWDM06	213.50000
JFLOCV23	COWDM07	208.32000	COWDM08	203.14000
JFLOCV23	COWDM09	197.82000	COWDM10	189.00000
JFLOCV23	COWDM11	182.00000	COWDM12	172.76000

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JFLOCV23	COWDM13	163.80000	COWDM14	156.38000	
JFLOCV23	COWDM15	149.10000	COWDM16	142.80000	
JFLOCV23	COWDM17	137.76000	COWDM18	135.10000	
JFLOCV23	COWDM19	135.80000	COWDM20	136.50000	
JFLOCV23	COWDM21	137.90000	COWDM22	141.12000	
JFLOCV23	COWME23	1365.00000	COWCP23	16.24000	
JFLOCV23	COWME24	1614.40000	COWCP24	22.67000	
JFLOCV23	COWME25	2041.20000	COWCP25	26.19000	
JFLOCV23	COWME26	2102.80000	COWCP26	27.19000	
JFLOCV23	COWME01	2185.40000	COWCP01	28.40000	
JFLOCV23	COWME02	2224.60000	COWCP02	28.97000	
JFLOCV23	COWME03	2216.20000	COWCP03	28.81000	
JFLOCV23	COWME04	2185.40000	COWCP04	28.30000	
JFLOCV23	COWME05	2153.20000	COWCP05	27.77000	
JFLOCV23	COWME06	2111.20000	COWCP06	27.11000	
JFLOCV23	COWME07	2039.80000	COWCP07	26.01000	
JFLOCV23	COWME08	1933.40000	COWCP08	24.36000	
JFLOCV23	COWME09	1773.80000	COWCP09	22.00000	
JFLOCV23	COWME10	1717.80000	COWCP10	21.13000	
JFLOCV23	COWME11	1666.00000	COWCP11	20.38000	
JFLOCV23	COWME12	1625.40000	COWCP12	19.79000	
JFLOCV23	COWME13	1573.60000	COWCP13	19.05000	
JFLOCV23	COWME14	1570.80000	COWCP14	19.01000	
JFLOCV23	COWME15	1537.20000	COWCP15	18.55000	
JFLOCV23	COWME16	1416.20000	COWCP16	16.87000	
JFLOCV23	COWME17	995.40000	COWCP17	10.80000	
JFLOCV23	COWME18	704.20000	COWCP18	6.63000	
JFLOCV23	COWME19	736.40000	COWCP19	6.99000	
JFLOCV23	COWME20	774.20000	COWCP20	7.66000	
JFLOCV23	COWME21	621.80000	COWCP21	9.06000	
JFLOCV23	COWME22	886.20000	COWCP22	9.39000	
JFLOCV23	MILKFAT	-161.00000			
JFLOCV25	COWDM25	146.16000	COWDM26	183.82000	
JFLOCV25	COWDM01	198.94000	COWDM02	202.16000	
JFLOCV25	COWDM03	206.36000	COWDM04	210.14000	
JFLOCV25	COWDM05	213.92000	COWDM06	215.04000	
JFLOCV25	COWDM07	215.60000	COWDM08	213.50000	
JFLOCV25	COWDM09	208.32000	COWDM10	203.14000	
JFLOCV25	COWDM11	197.82000	COWDM12	189.00000	
JFLOCV25	COWDM13	182.00000	COWDM14	172.76000	
JFLOCV25	COWDM15	163.80000	COWDM16	156.38000	
JFLOCV25	COWDM17	149.10000	COWDM18	142.80000	
JFLOCV25	COWDM19	137.76000	COWDM20	135.10000	
JFLOCV25	COWDM21	135.80000	COWDM22	136.50000	
JFLOCV25	COWDM23	137.90000	COWDM24	141.12000	
JFLOCV25	COWME25	1365.00000	COWCP25	16.24000	
JFLOCV25	COWME26	1614.40000	COWCP26	22.67000	
JFLOCV25	COWME01	2041.20000	COWCP01	26.19000	
JFLOCV25	COWME02	2102.80000	COWCP02	27.19000	
JFLOCV25	COWME03	2185.40000	COWCP03	28.40000	

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JFLOCV25	COWME04	2224.60000	COWCP04	28.97000
JFLOCV25	COWME05	2216.20000	COWCP05	28.81000
JFLOCV25	COWME06	2185.40000	COWCP06	28.30000
JFLOCV25	COWME07	2153.20000	COWCP07	27.77000
JFLOCV25	COWME08	2111.20000	COWCP08	27.11000
JFLOCV25	COWME09	2039.80000	COWCP09	26.01000
JFLOCV25	COWME10	1933.40000	COWCP10	24.36000
JFLOCV25	COWME11	1773.80000	COWCP11	22.00000
JFLOCV25	COWME12	1717.80000	COWCP12	21.13000
JFLOCV25	COWME13	1666.00000	COWCP13	20.38000
JFLOCV25	COWME14	1625.40000	COWCP14	19.79000
JFLOCV25	COWME15	1573.60000	COWCP15	19.05000
JFLOCV25	COWME16	1570.80000	COWCP16	19.01000
JFLOCV25	COWME17	1537.20000	COWCP17	18.55000
JFLOCV25	COWME18	1418.20000	COWCP18	16.87000
JFLOCV25	COWME19	995.40000	COWCP19	10.80000
JFLOCV25	COWME20	704.20000	COWCP20	6.63000
JFLOCV25	COWME21	736.40000	COWCP21	6.99000
JFLOCV25	COWME22	774.20000	COWCP22	7.60000
JFLOCV25	COWME23	821.80000	COWCP23	9.06000
JFLOCV25	COWME24	886.20000	COWCP24	9.39000
JFLOCV25	MILKFAT	-161.00000		
JFLOCV19	COWDM19	146.16000	COWME19	1365.00000
JFLOCV19	COWCP19	16.24000	COWDM20	183.82000
JFLOCV19	COWME20	1814.40000	COWCP20	22.67000
JFLOCV19	COWDM21	198.94000	COWME21	2041.20000
JFLOCV19	COWCP21	26.19000	COWDM22	202.16000
JFLOCV19	COWME22	2102.80000	COWCP22	27.19000
JFLOCV19	COWDM23	206.36000	COWME23	2185.40000
JFLOCV19	COWCP23	28.40000	COWDM24	210.14000
JFLOCV19	COWME24	2224.60000	COWCP24	28.97000
JFLOCV19	COWDM25	213.92000	COWME25	2216.20000
JFLOCV19	COWCP25	28.81000	COWDM26	215.04000
JFLOCV19	COWME26	2185.40000	COWCP26	28.30000
JFLOCV19	COWDM01	215.60000	COWME01	2153.20000
JFLOCV19	COWCP01	27.77000	COWDM02	213.50000
JFLOCV19	COWME02	2111.20000	COWCP02	27.11000
JFLOCV19	COWDM03	208.32000	COWME03	2039.80000
JFLOCV19	COWCP03	26.01000	COWDM04	203.14000
JFLOCV19	COWME04	1933.40000	COWCP04	24.36000
JFLOCV19	COWDM05	197.82000	COWME05	1773.80000
JFLOCV19	COWCP05	22.00000	COWDM06	189.00000
JFLOCV19	COWME06	1717.80000	COWCP06	21.13000
JFLOCV19	COWDM07	182.00000	COWME07	1666.00000
JFLOCV19	COWCP07	20.38000	COWDM08	172.76000
JFLOCV19	COWME08	1625.40000	COWCP08	19.79000
JFLOCV19	COWDM09	163.80000	COWME09	1573.60000
JFLOCV19	COWCP09	19.05000	COWDM10	156.38000
JFLOCV19	COWME10	1570.80000	COWCP10	19.01000
JFLOCV19	COWDM11	149.10000	COWME11	1537.20000

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JFLDCV19	COWCP11	18.55000	COWDM12	142.80000
JFLDCV19	COWME12	1418.20000	COWCP12	16.87000
JFLDCV19	COWDM13	137.76000	COWME13	995.40000
JFLDCV19	COWCP13	10.80000	COWDM14	135.10000
JFLDCV19	COWME14	704.20000	COWCP14	6.63000
JFLDCV19	COWDM15	135.80000	COWME15	736.40000
JFLDCV19	COWCP15	6.99000	COWDM16	136.50000
JFLDCV19	COWME16	774.20000	COWCP16	7.66000
JFLDCV19	COWDM17	137.90000	COWME17	821.80000
JFLDCV19	COWCP17	9.06000	COWDM18	141.12000
JFLDCV19	COWME18	886.20000	COWCP18	9.39000
JFLDCV19	MILKFAT	-161.00000		
JFLDCV17	COWDM17	146.16000	COWME17	1365.00000
JFLDCV17	COWCP17	12.69800	COWDM18	183.82000
JFLDCV17	COWME18	1614.40000	COWCP18	20.14600
JFLDCV17	COWDM19	198.94000	COWME19	2041.20000
JFLDCV17	COWCP19	24.69600	COWDM20	202.16000
JFLDCV17	COWME20	2102.80000	COWCP20	25.64800
JFLDCV17	COWDM21	206.36000	COWME21	2185.40000
JFLDCV17	COWCP21	27.53800	COWDM22	210.14000
JFLDCV17	COWME22	2224.60000	COWCP22	28.02800
JFLDCV17	COWDM23	213.92000	COWME23	2216.20000
JFLDCV17	COWCP23	27.48200	COWDM24	215.04000
JFLDCV17	COWME24	2185.40000	COWCP24	27.10400
JFLDCV17	COWDM25	215.60000	COWME25	2153.20000
JFLDCV17	COWCP25	26.26400	COWDM26	213.50000
JFLDCV17	COWME26	2111.20000	COWCP26	25.76000
JFLDCV17	COWDM01	208.32000	COWME01	2039.80000
JFLDCV17	COWCP01	24.68200	COWDM02	203.14000
JFLDCV17	COWME02	1933.40000	COWCP02	22.82000
JFLDCV17	COWDM03	197.82000	COWME03	1773.80000
JFLDCV17	COWCP03	20.39800	COWDM04	189.00000
JFLDCV17	COWME04	1717.60000	COWCP04	19.58600
JFLDCV17	COWDM05	182.00000	COWME05	1666.00000
JFLDCV17	COWCP05	18.66200	COWDM06	172.76000
JFLDCV17	COWME06	1625.40000	COWCP06	18.20000
JFLDCV17	COWDM07	163.80000	COWME07	1573.60000
JFLDCV17	COWCP07	17.45800	COWDM08	156.38000
JFLDCV17	COWME08	1570.80000	COWCP08	17.12200
JFLDCV17	COWDM09	149.10000	COWME09	1537.20000
JFLDCV17	COWCP09	16.75800	COWDM10	142.80000
JFLDCV17	COWME10	1418.20000	COWCP10	15.17600
JFLDCV17	COWDM11	137.76000	COWME11	995.40000
JFLDCV17	COWCP11	9.45000	COWDM12	135.10000
JFLDCV17	COWME12	704.20000	COWCP12	5.46800
JFLDCV17	COWDM13	135.80000	COWME13	736.40000
JFLDCV17	COWCP13	5.74000	COWDM14	136.50000
JFLDCV17	COWME14	774.20000	COWCP14	6.03400
JFLDCV17	COWDM15	137.90000	COWME15	821.80000
JFLDCV17	COWCP15	6.41200	COWDM16	141.12000

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JFLOCV17	COWME16	686.20000	COWCP16	7.26600
JFLOCV17	MILKFAT	-161.00000		
JFLOCV15	COWDM15	146.16000	COWME15	1365.00000
JFLOCV15	COWCP15	12.69800	COWDM16	183.82000
JFLOCV15	COWME16	1614.40000	COWCP16	20.14600
JFLOCV15	COWDM17	198.94000	COWME17	2041.20000
JFLOCV15	COWCP17	24.69600	COWDM18	202.16000
JFLOCV15	COWME18	2102.80000	COWCP18	25.64800
JFLOCV15	COWDM19	206.36000	COWME19	2185.40000
JFLOCV15	COWCP19	27.53800	COWDM20	210.14000
JFLOCV15	COWME20	2224.60000	COWCP20	28.02800
JFLOCV15	COWDM21	213.92000	COWME21	2216.20000
JFLOCV15	COWCP21	27.48200	COWDM22	215.04000
JFLOCV15	COWME22	2185.40000	COWCP22	27.10400
JFLOCV15	COWDM23	215.60000	COWME23	2153.20000
JFLOCV15	COWCP23	26.26400	COWDM24	213.50000
JFLOCV15	COWME24	2111.20000	COWCP24	25.76000
JFLOCV15	COWDM25	208.32000	COWME25	2039.80000
JFLOCV15	COWCP25	24.68200	COWDM26	203.14000
JFLOCV15	COWME26	1933.40000	COWCP26	22.82000
JFLOCV15	COWDM01	197.82000	COWME01	1773.80000
JFLOCV15	COWCP01	20.39800	COWDM02	189.00000
JFLOCV15	COWME02	1717.80000	COWCP02	19.58600
JFLOCV15	COWDM03	182.00000	COWME03	1666.00000
JFLOCV15	COWCP03	18.66200	COWDM04	172.76000
JFLOCV15	COWME04	1625.40000	COWCP04	18.20000
JFLOCV15	COWDM05	163.80000	COWME05	1573.60000
JFLOCV15	COWCP05	17.45800	COWDM06	156.38000
JFLOCV15	COWME06	1570.80000	COWCP06	17.12200
JFLOCV15	COWDM07	149.10000	COWME07	1537.20000
JFLOCV15	COWCP07	16.75800	COWDM08	142.80000
JFLOCV15	COWME08	1418.20000	COWCP08	15.17600
JFLOCV15	COWDM09	137.76000	COWME09	995.40000
JFLOCV15	COWCP09	9.45000	COWDM10	135.10000
JFLOCV15	COWME10	704.20000	COWCP10	5.40800
JFLOCV15	COWDM11	135.80000	COWME11	736.40000
JFLOCV15	COWCP11	5.74000	COWDM12	136.50000
JFLOCV15	COWME12	774.20000	COWCP12	6.03400
JFLOCV15	COWDM13	137.90000	COWME13	821.80000
JFLOCV15	COWCP13	6.41200	COWDM14	141.12000
JFLOCV15	COWME14	886.20000	COWCP14	7.26600
JFLOCV15	MILKFAT	-161.00000		
JFLOCV13	COWDM13	146.16000	COWME13	1365.00000
JFLOCV13	COWCP13	12.69800	COWDM14	183.82000
JFLOCV13	COWME14	1614.40000	COWCP14	20.14600
JFLOCV13	COWDM15	198.94000	COWME15	2041.20000
JFLOCV13	COWCP15	24.69600	COWDM16	202.16000
JFLOCV13	COWME16	2102.80000	COWCP16	25.64800
JFLOCV13	COWDM17	206.36000	COWME17	2185.40000
JFLOCV13	COWCP17	27.53800	COWDM18	210.14000

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JFLOCV13	COWME18	2224.60000	COWCP18	28.02800
JFLOCV13	COWDM19	213.92000	COWME19	2216.20000
JFLOCV13	COWCP19	27.48200	COWDM20	215.04000
JFLOCV13	COWME20	2185.40000	COWCP20	27.10400
JFLOCV13	COWDM21	215.60000	COWME21	2153.20000
JFLOCV13	COWCP21	26.26400	COWDM22	213.50000
JFLOCV13	COWME22	2111.20000	COWCP22	25.76000
JFLOCV13	COWDM23	208.32000	COWME23	2039.80000
JFLOCV13	COWCP23	24.68200	COWDM24	203.14000
JFLOCV13	COWME24	1933.40000	COWCP24	22.82000
JFLOCV13	COWDM25	197.82000	COWME25	1773.80000
JFLOCV13	COWCP25	20.39800	COWDM26	189.00000
JFLOCV13	COWME26	1717.80000	COWCP26	19.58600
JFLOCV13	COWDM01	182.00000	COWME01	1666.00000
JFLOCV13	COWCP01	18.66200	COWDM02	172.76000
JFLOCV13	COWME02	1625.40000	COWCP02	18.20000
JFLOCV13	COWDM03	163.80000	COWME03	1573.60000
JFLOCV13	COWCP03	17.45800	COWDM04	156.38000
JFLOCV13	COWME04	1570.80000	COWCP04	17.12200
JFLOCV13	COWDM05	149.10000	COWME05	1537.20000
JFLOCV13	COWCP05	16.75800	COWDM06	142.80000
JFLOCV13	COWME06	1418.20000	COWCP06	15.17600
JFLOCV13	COWDM07	137.76000	COWME07	995.40000
JFLOCV13	COWCP07	9.45000	COWDM08	135.10000
JFLOCV13	COWME08	704.20000	COWCP08	5.48800
JFLOCV13	COWDM09	135.80000	COWME09	736.40000
JFLOCV13	COWCP09	5.74000	COWDM10	136.50000
JFLOCV13	COWME10	774.20000	COWCP10	6.03400
JFLOCV13	COWDM11	137.90000	COWME11	821.80000
JFLOCV13	COWCP11	6.41200	COWDM12	141.12000
JFLOCV13	COWME12	886.20000	COWCP12	7.26600
JFLOCV13	MILKFAT	-161.00000		
AF267F0	COWDM01	213.92000	COWME01	2216.20000
AF267F0	COWCP01	28.81000	COWDM02	215.04000
AF267F0	COWME02	2185.40000	COWCP02	28.30000
AF267F0	COWDM03	215.60000	COWME03	2153.20000
AF267F0	COWCP03	27.77000	COWDM04	213.50000
AF267F0	COWME04	2111.20000	COWCP04	27.11000
AF267F0	COWDM05	208.32000	COWME05	2040.00000
AF267F0	COWCP05	26.01000	COWDM06	203.14000
AF267F0	COWME06	1933.00000	COWCP06	24.36000
AF267F0	COWDM07	197.82000	COWME07	1774.00000
AF267F0	COWCP07	22.00000	COWDM08	189.00000
AF267F0	COWME08	1718.00000	COWCP08	21.13000
AF267F0	COWDM09	182.00000	COWME09	1666.00000
AF267F0	COWCP09	20.38000	COWDM10	172.76000
AF267F0	COWME10	1625.00000	COWCP10	19.79000
AF267F0	COWDM11	163.80000	COWME11	1574.00000
AF267F0	COWCP11	19.05000	COWDM12	156.38000
AF267F0	COWME12	1571.00000	COWCP12	19.01000

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AP267F0	COWDM13	149.10000	COWME13	1537.00000
AP267F0	COWCP13	18.55000	COWDM14	142.80000
AP267F0	COWME14	1418.00000	COWCP14	16.87000
AP267F0	COWDM15	137.76000	COWME15	995.00000
AP267F0	COWCP15	10.80000	COWDM16	135.10000
AP267F0	COWME16	704.00000	COWCP16	6.63000
AP267F0	COWDM17	135.80000	COWME17	736.00000
AP267F0	COWCP17	6.99000	COWDM18	136.50000
AP267F0	COWME18	774.00000	COWCP18	7.66000
AP267F0	COWDM19	137.90000	COWME19	822.00000
AP267F0	COWCP19	9.06000	COWDM20	141.12000
AP267F0	COWME20	886.00000	COWCP20	9.39000
AP267F0	COWDM21	146.16000	COWME21	1365.00000
AP267F0	COWCP21	16.24000	COWDM22	183.82000
AP267F0	COWME22	1814.40000	COWCP22	22.67000
AP267F0	COWDM23	198.94000	COWME23	2041.20000
AP267F0	COWCP23	26.19000	COWDM24	202.16000
AP267F0	COWME24	2102.80000	COWCP24	27.19000
AP267F0	COWDM25	206.36000	COWME25	2185.40000
AP267F0	COWCP25	28.40000	COWDM26	210.14000
AP267F0	COWME26	2224.60000	COWCP26	28.97000
AP267F0	MILKFAT	-161.00000	COWS	1.00000
AP267F0	APCOWS	1.00000		
AP267F1	COWDM01	213.92000	COWME01	2216.20000
AP267F1	COWCP01	28.81000	COWDM02	215.04000
AP267F1	COWME02	2185.40000	COWCP02	28.30000
AP267F1	COWDM03	215.60000	COWME03	2153.20000
AP267F1	COWCP03	27.77000	COWDM04	213.50000
AP267F1	COWME04	2006.00000	COWCP04	25.47000
AP267F1	COWDM05	208.32000	COWME05	1835.00000
AP267F1	COWCP05	22.94000	COWDM06	203.14000
AP267F1	COWME06	1740.00000	COWCP06	21.49000
AP267F1	COWDM07	197.82000	COWME07	1596.00000
AP267F1	COWCP07	19.31000	COWDM08	189.00000
AP267F1	COWME08	1540.00000	COWCP08	18.63000
AP267F1	COWDM09	182.00000	COWME09	1499.00000
AP267F1	COWCP09	17.99000	COWDM10	172.70000
AP267F1	COWME10	1463.00000	COWCP10	17.44000
AP267F1	COWDM11	163.80000	COWME11	1417.00000
AP267F1	COWCP11	16.79000	COWDM12	156.38000
AP267F1	COWME12	1414.00000	COWCP12	16.76000
AP267F1	COWDM13	149.10000	COWME13	1383.00000
AP267F1	COWCP13	16.28000	COWDM14	142.80000
AP267F1	COWME14	1277.00000	COWCP14	14.69000
AP267F1	COWDM15	137.76000	COWME15	1044.00000
AP267F1	COWCP15	11.52000	COWDM16	135.10000
AP267F1	COWME16	868.00000	COWCP16	9.11000
AP267F1	COWDM17	135.80000	COWME17	1029.00000
AP267F1	COWCP17	11.68000	COWDM18	136.50000
AP267F1	COWME18	1124.00000	COWCP18	13.13000

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AP267F1	COWDM19	137.90000	COWME19	1072.00000
AP267F1	COWCP19	12.31000	COWDM20	141.12000
AP267F1	COWME20	933.00000	COWCP20	10.08000
AP267F1	COWDM21	146.16000	COWME21	1365.00000
AP267F1	COWCP21	16.24000	COWDM22	183.82000
AP267F1	COWME22	1814.40000	COWCP22	22.67000
AP267F1	COWDM23	198.94000	COWME23	2041.20000
AP267F1	COWCP23	26.19000	COWDM24	202.16000
AP267F1	COWME24	2102.80000	COWCP24	27.19000
AP267F1	COWDM25	206.36000	COWME25	2185.40000
AP267F1	COWCP25	28.40000	COWDM26	210.14000
AP267F1	COWME26	2224.60000	COWCP26	28.97000
AP267F1	MILKFAT	-155.00000	COWS	1.00000
AP267F1	APCOWS	1.00000		
AP267F2	COWDM01	213.92000	COWME01	2216.20000
AP267F2	COWCP01	26.81000	COWDM02	215.04000
AP267F2	COWME02	2185.40000	COWCP02	28.30000
AP267F2	COWDM03	215.60000	COWME03	2153.20000
AP267F2	COWCP03	27.77000	COWDM04	213.50000
AP267F2	COWME04	1900.00000	COWCP04	23.94000
AP267F2	COWDM05	208.32000	COWME05	1632.00000
AP267F2	COWCP05	19.88000	COWDM06	203.14000
AP267F2	COWME06	1547.00000	COWCP06	18.64000
AP267F2	COWDM07	197.82000	COWME07	1420.00000
AP267F2	COWCP07	16.76000	COWDM08	189.00000
AP267F2	COWME08	1375.00000	COWCP08	16.09000
AP267F2	COWDM09	182.00000	COWME09	1333.00000
AP267F2	COWCP09	15.48000	COWDM10	172.76000
AP267F2	COWME10	1301.00000	COWCP10	15.01000
AP267F2	COWDM11	163.80000	COWME11	1259.00000
AP267F2	COWCP11	14.42000	COWDM12	156.38000
AP267F2	COWME12	1257.00000	COWCP12	14.39000
AP267F2	COWDM13	149.10000	COWME13	1229.00000
AP267F2	COWCP13	13.91000	COWDM14	142.80000
AP267F2	COWME14	1134.00000	COWCP14	12.50000
AP267F2	COWDM15	137.76000	COWME15	1044.00000
AP267F2	COWCP15	11.52000	COWDM16	135.10000
AP267F2	COWME16	1054.00000	COWCP16	12.12000
AP267F2	COWDM17	135.80000	COWME17	1436.00000
AP267F2	COWCP17	17.81000	COWDM18	136.50000
AP267F2	COWME18	1430.00000	COWCP18	17.73000
AP267F2	COWDM19	137.90000	COWME19	1322.00000
AP267F2	COWCP19	16.04000	COWDM20	141.12000
AP267F2	COWME20	1096.00000	COWCP20	12.60000
AP267F2	COWDM21	146.16000	COWME21	1365.00000
AP267F2	COWCP21	16.24000	COWDM22	183.82000
AP267F2	COWME22	1814.40000	COWCP22	22.67000
AP267F2	COWDM23	198.94000	COWME23	2041.20000
AP267F2	COWCP23	26.19000	COWDM24	202.16000
AP267F2	COWME24	2102.80000	COWCP24	27.19000

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AP267F2	COWDM25	206.36000	COWME25	2185.40000
AP267F2	COWCP25	26.40000	COWDM26	210.14000
AP267F2	COWME26	2224.60000	COWCP26	28.97000
AP267F2	MILKFAT	-148.00000	COWS	1.00000
AP267F2	APCOWS	1.00000		
AP239F0	COWDM01	213.92000	COWME01	2216.20000
AP239F0	COWCP01	28.81000	COWDM02	215.04000
AP239F0	COWME02	2185.40000	COWCP02	28.30000
AP239F0	COWDM03	215.60000	COWME03	2153.20000
AP239F0	COWCP03	27.77000	COWDM04	213.50000
AP239F0	COWME04	2111.20000	COWCP04	27.11000
AP239F0	COWDM05	208.32000	COWME05	2040.00000
AP239F0	COWCP05	26.01000	COWDM06	203.14000
AP239F0	COWME06	1933.00000	COWCP06	24.36000
AP239F0	COWDM07	197.82000	COWME07	1774.00000
AP239F0	COWCP07	22.00000	COWDM08	189.00000
AP239F0	COWME08	1718.00000	COWCP08	21.13000
AP239F0	COWDM09	182.00000	COWME09	1666.00000
AP239F0	COWCP09	20.38000	COWDM10	172.76000
AP239F0	COWME10	1625.00000	COWCP10	19.79000
AP239F0	COWDM11	163.80000	COWME11	1574.00000
AP239F0	COWCP11	19.05000	COWDM12	156.38000
AP239F0	COWME12	1571.00000	COWCP12	19.01000
AP239F0	COWDM13	149.10000	COWME13	1131.00000
AP239F0	COWCP13	12.36000	COWDM14	142.80000
AP239F0	COWME14	764.00000	COWCP14	6.71000
AP239F0	COWDM15	137.76000	COWME15	734.00000
AP239F0	COWCP15	6.68000	COWDM16	135.10000
AP239F0	COWME16	704.00000	COWCP16	6.63000
AP239F0	COWDM17	135.80000	COWME17	736.00000
AP239F0	COWCP17	6.99000	COWDM18	136.50000
AP239F0	COWME18	774.00000	COWCP18	7.66000
AP239F0	COWDM19	137.90000	COWME19	822.00000
AP239F0	COWCP19	9.06000	COWDM20	141.12000
AP239F0	COWME20	886.00000	COWCP20	9.39000
AP239F0	COWDM21	146.16000	COWME21	1365.00000
AP239F0	COWCP21	16.24000	COWDM22	183.82000
AP239F0	COWME22	1814.40000	COWCP22	22.67000
AP239F0	COWDM23	198.94000	COWME23	2041.20000
AP239F0	COWCP23	26.19000	COWDM24	202.16000
AP239F0	COWME24	2102.80000	COWCP24	27.19000
AP239F0	COWDM25	206.36000	COWME25	2185.40000
AP239F0	COWCP25	26.40000	COWDM26	210.14000
AP239F0	COWME26	2224.60000	COWCP26	28.97000
AP239F0	MILKFAT	-150.00000	COWS	1.00000
AP239F0	APCOWS	1.00000		
AP239F1	COWDM01	213.92000	COWME01	2216.20000
AP239F1	COWCP01	28.81000	COWDM02	215.04000
AP239F1	COWME02	2185.40000	COWCP02	28.30000
AP239F1	COWDM03	215.60000	COWME03	2153.20000

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AP239F1	COWCP03	27.77000	COWDM04	213.50000
AP239F1	COWME04	2006.00000	COWCP04	25.47000
AP239F1	COWDM05	208.32000	COWME05	1835.00000
AP239F1	COWCP05	22.94000	COWDM06	203.14000
AP239F1	COWME06	1740.00000	COWCP06	21.49000
AP239F1	COWDM07	197.82000	COWME07	1596.00000
AP239F1	COWCP07	19.31000	COWDM08	189.00000
AP239F1	COWME08	1546.00000	COWCP08	18.63000
AP239F1	COWDM09	182.00000	COWME09	1499.00000
AP239F1	COWCP09	17.99000	COWDM10	172.76000
AP239F1	COWME10	1463.00000	COWCP10	17.44000
AP239F1	COWDM11	163.80000	COWME11	1417.00000
AP239F1	COWCP11	16.79000	COWDM12	156.38000
AP239F1	COWME12	1414.00000	COWCP12	16.76000
AP239F1	COWDM13	149.10000	COWME13	1131.00000
AP239F1	COWCP13	12.38000	COWDM14	142.80000
AP239F1	COWME14	855.00000	COWCP14	8.12000
AP239F1	COWDM15	137.76000	COWME15	884.00000
AP239F1	COWCP15	9.06000	COWDM16	135.10000
AP239F1	COWME16	864.00000	COWCP16	9.20000
AP239F1	COWDM17	135.80000	COWME17	910.00000
AP239F1	COWCP17	9.86000	COWDM18	136.50000
AP239F1	COWME18	699.00000	COWCP18	9.66000
AP239F1	COWDM19	137.90000	COWME19	822.00000
AP239F1	COWCP19	8.41000	COWDM20	141.12000
AP239F1	COWME20	886.00000	COWCP20	9.37000
AP239F1	COWDM21	146.16000	COWME21	1365.00000
AP239F1	COWCP21	16.24000	COWDM22	183.82000
AP239F1	COWME22	1814.40000	COWCP22	22.67000
AP239F1	COWDM23	198.94000	COWME23	2041.20000
AP239F1	COWCP23	26.19000	COWDM24	202.16000
AP239F1	COWME24	2102.80000	COWCP24	27.19000
AP239F1	COWDM25	206.36000	COWME25	2185.40000
AP239F1	COWCP25	28.40000	COWDM26	210.14000
AP239F1	COWME26	2224.60000	COWCP26	28.97000
AP239F1	MILKFAT	-144.00000	COWS	1.00000
AP239F1	APCOWS	1.00000		
AP239F2	COWDM01	213.92000	COWME01	2216.20000
AP239F2	COWCP01	28.81000	COWDM02	215.04000
AP239F2	COWME02	2185.40000	COWCP02	28.30000
AP239F2	COWDM03	215.60000	COWME03	2153.20000
AP239F2	COWCP03	27.77000	COWDM04	213.50000
AP239F2	COWME04	1900.00000	COWCP04	23.94000
AP239F2	COWDM05	208.32000	COWME05	1632.00000
AP239F2	COWCP05	19.88000	COWDM06	203.14000
AP239F2	COWME06	1547.00000	COWCP06	18.64000
AP239F2	COWDM07	197.82000	COWME07	1420.00000
AP239F2	COWCP07	16.76000	COWDM08	189.00000
AP239F2	COWME08	1375.00000	COWCP08	16.09000
AP239F2	COWDM09	182.00000	COWME09	1333.00000

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AP239F2	COWCP09	15.48000	COWDM10	172.76000
AP239F2	COWME10	1301.00000	COWCP10	15.01000
AP239F2	COWDM11	163.80000	COWME11	1259.00000
AP239F2	COWCP11	14.42000	COWDM12	156.38000
AP239F2	COWME12	1257.00000	COWCP12	14.39000
AP239F2	COWDM13	149.10000	COWME13	1131.00000
AP239F2	COWCP13	12.38000	COWDM14	142.80000
AP239F2	COWME14	946.00000	COWCP14	9.60000
AP239F2	COWDM15	137.76000	COWME15	1084.00000
AP239F2	COWCP15	12.20000	COWDM16	135.10000
AP239F2	COWME16	1076.00000	COWCP16	12.45000
AP239F2	COWDM17	135.80000	COWME17	1143.00000
AP239F2	COWCP17	13.43000	COWDM18	136.50000
AP239F2	COWME18	993.00000	COWCP18	11.12000
AP239F2	COWDM19	137.90000	COWME19	822.00000
AP239F2	COWCP19	8.41000	COWDM20	141.12000
AP239F2	COWME20	886.00000	COWCP20	9.37000
AP239F2	COWDM21	146.16000	COWME21	1365.00000
AP239F2	COWCP21	16.24000	COWDM22	183.82000
AP239F2	COWME22	1814.40000	COWCP22	22.67000
AP239F2	COWDM23	198.94000	COWME23	2041.20000
AP239F2	COWCP23	26.19000	COWDM24	202.16000
AP239F2	COWME24	2102.80000	COWCP24	27.19000
AP239F2	COWDM25	206.36000	COWME25	2185.40000
AP239F2	COWCP25	28.40000	COWDM26	210.14000
AP239F2	COWME26	2224.60000	COWCP26	28.97000
AP239F2	MILKFAT	-138.00000	COWS	1.00000
AP239F2	APCOWS	1.00000		
AP211F0	COWDM01	213.92000	COWME01	2216.20000
AP211F0	COWCP01	28.81000	COWDM02	215.04000
AP211F0	COWME02	2185.40000	COWCP02	28.30000
AP211F0	COWDM03	215.60000	COWME03	2153.20000
AP211F0	COWCP03	27.77000	COWDM04	213.50000
AP211F0	COWME04	2111.20000	COWCP04	27.11000
AP211F0	COWDM05	208.32000	COWME05	2040.00000
AP211F0	COWCP05	26.01000	COWDM06	203.14000
AP211F0	COWME06	1933.00000	COWCP06	24.36000
AP211F0	COWDM07	197.82000	COWME07	1774.00000
AP211F0	COWCP07	22.00000	COWDM08	189.00000
AP211F0	COWME08	1718.00000	COWCP08	21.13000
AP211F0	COWDM09	182.00000	COWME09	1666.00000
AP211F0	COWCP09	20.38000	COWDM10	172.76000
AP211F0	COWME10	1625.00000	COWCP10	19.79000
AP211F0	COWDM11	163.80000	COWME11	1170.00000
AP211F0	COWCP11	12.96000	COWDM12	156.38000
AP211F0	COWME12	724.00000	COWCP12	6.12000
AP211F0	COWDM13	149.10000	COWME13	752.00000
AP211F0	COWCP13	6.54000	COWDM14	142.80000
AP211F0	COWME14	764.00000	COWCP14	6.71000
AP211F0	COWDM15	137.76000	COWME15	734.00000

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AP211F0	COWCP15	6.68000	COWDM16	135.10000
AP211F0	COWME16	704.00000	COWCP16	6.63000
AP211F0	COWDM17	135.80000	COWME17	736.00000
AP211F0	COWCP17	6.99000	COWDM18	136.50000
AP211F0	COWME18	774.00000	COWCP18	7.66000
AP211F0	COWDM19	137.90000	COWME19	822.00000
AP211F0	COWCP19	9.06000	COWDM20	141.12000
AP211F0	COWME20	886.00000	COWCP20	9.39000
AP211F0	COWDM21	146.16000	COWME21	1365.00000
AP211F0	COWCP21	16.24000	COWDM22	183.82000
AP211F0	COWME22	1814.40000	COWCP22	22.67000
AP211F0	COWDM23	196.94000	COWME23	2041.20000
AP211F0	COWCP23	26.19000	COWDM24	202.16000
AP211F0	COWME24	2102.80000	COWCP24	27.19000
AP211F0	COWDM25	206.36000	COWME25	2185.40000
AP211F0	COWCP25	26.40000	COWDM26	210.14000
AP211F0	COWME26	2224.60000	COWCP26	28.97000
AP211F0	MILKFAT	-137.00000	COWS	1.00000
AP211F0	APCOWS	1.00000		
AP211F1	COWDM01	213.92000	COWME01	2216.20000
AP211F1	COWCP01	26.81000	COWDM02	215.04000
AP211F1	COWME02	2185.40000	COWCP02	28.30000
AP211F1	COWDM03	215.60000	COWME03	2153.20000
AP211F1	COWCP03	27.77000	COWDM04	213.50000
AP211F1	COWME04	2006.00000	COWCP04	25.47000
AP211F1	COWDM05	208.32000	COWME05	1835.00000
AP211F1	COWCP05	22.94000	COWDM06	203.14000
AP211F1	COWME06	1740.00000	COWCP06	21.49000
AP211F1	COWDM07	197.82000	COWME07	1596.00000
AP211F1	COWCP07	19.31000	COWDM08	189.00000
AP211F1	COWME08	1546.00000	COWCP08	18.63000
AP211F1	COWDM09	182.00000	COWME09	1499.00000
AP211F1	COWCP09	17.99000	COWDM10	172.76000
AP211F1	COWME10	1463.00000	COWCP10	17.44000
AP211F1	COWDM11	163.80000	COWME11	1270.00000
AP211F1	COWCP11	14.54000	COWDM12	156.38000
AP211F1	COWME12	899.00000	COWCP12	8.81000
AP211F1	COWDM13	149.10000	COWME13	927.00000
AP211F1	COWCP13	9.18000	COWDM14	142.80000
AP211F1	COWME14	864.00000	COWCP14	8.25000
AP211F1	COWDM15	137.76000	COWME15	784.00000
AP211F1	COWCP15	7.45000	COWDM16	135.10000
AP211F1	COWME16	754.00000	COWCP16	7.39000
AP211F1	COWDM17	135.80000	COWME17	761.00000
AP211F1	COWCP17	7.50000	COWDM18	136.50000
AP211F1	COWME18	774.00000	COWCP18	7.66000
AP211F1	COWDM19	137.90000	COWME19	822.00000
AP211F1	COWCP19	8.41000	COWDM20	141.12000
AP211F1	COWME20	886.00000	COWCP20	9.37000
AP211F1	COWDM21	146.16000	COWME21	1365.00000

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AP211F1	COWCP21	16.24000	COWDM22	183.82000
AP211F1	COWME22	1814.40000	COWCP22	22.67000
AP211F1	COWDM23	198.94000	COWME23	2041.20000
AP211F1	COWCP23	26.19000	COWDM24	202.16000
AP211F1	COWME24	2102.80000	COWCP24	27.19000
AP211F1	COWDM25	206.36000	COWME25	2185.40000
AP211F1	COWCP25	28.40000	COWDM26	210.14000
AP211F1	COWME26	2224.60000	COWCP26	28.97000
AP211F1	MILKFAT	-133.00000	COWS	1.00000
AP211F1	APCOWS	1.00000		
AP211F2	COWDM01	213.92000	COWME01	2216.20000
AP211F2	COWCP01	28.81000	COWDM02	215.04000
AP211F2	COWME02	2185.40000	COWCP02	28.30000
AP211F2	COWDM03	215.60000	COWME03	2153.20000
AP211F2	COWCP03	27.77000	COWDM04	213.50000
AP211F2	COWME04	1900.00000	COWCP04	23.94000
AP211F2	COWDM05	208.32000	COWME05	1632.00000
AP211F2	COWCP05	19.88000	COWDM06	203.14000
AP211F2	COWME06	1547.00000	COWCP06	18.64000
AP211F2	COWDM07	197.82000	COWME07	1420.00000
AP211F2	COWCP07	16.76000	COWDM08	189.00000
AP211F2	COWME08	1375.00000	COWCP08	16.09000
AP211F2	COWDM09	182.00000	COWME09	1333.00000
AP211F2	COWCP09	15.48000	COWDM10	172.76000
AP211F2	COWME10	1301.00000	COWCP10	15.01000
AP211F2	COWDM11	163.80000	COWME11	1270.00000
AP211F2	COWCP11	14.54000	COWDM12	156.38000
AP211F2	COWME12	974.00000	COWCP12	10.03000
AP211F2	COWDM13	149.10000	COWME13	1052.00000
AP211F2	COWCP13	11.26000	COWDM14	142.80000
AP211F2	COWME14	1014.00000	COWCP14	10.68000
AP211F2	COWDM15	137.76000	COWME15	934.00000
AP211F2	COWCP15	9.81000	COWDM16	135.10000
AP211F2	COWME16	904.00000	COWCP16	9.76000
AP211F2	COWDM17	135.80000	COWME17	836.00000
AP211F2	COWCP17	8.78000	COWDM18	136.50000
AP211F2	COWME18	774.00000	COWCP18	7.66000
AP211F2	COWDM19	137.90000	COWME19	822.00000
AP211F2	COWCP19	8.41000	COWDM20	141.12000
AP211F2	COWME20	886.00000	COWCP20	9.37000
AP211F2	COWDM21	146.16000	COWME21	1365.00000
AP211F2	COWCP21	16.24000	COWDM22	183.82000
AP211F2	COWME22	1814.40000	COWCP22	22.67000
AP211F2	COWDM23	198.94000	COWME23	2041.20000
AP211F2	COWCP23	26.19000	COWDM24	202.16000
AP211F2	COWME24	2102.80000	COWCP24	27.19000
AP211F2	COWDM25	206.36000	COWME25	2185.40000
AP211F2	COWCP25	28.40000	COWDM26	210.14000
AP211F2	COWME26	2224.60000	COWCP26	28.97000
AP211F2	MILKFAT	-128.00000		

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AP183F0	COWDM01	213.92000	COWME01	2216.20000
AP183F0	COWCP01	28.81000	COWDM02	215.04000
AP183F0	COWME02	2185.40000	COWCP02	28.30000
AP183F0	COWDM03	215.60000	COWME03	2153.20000
AP183F0	COWCP03	27.77000	COWDM04	213.50000
AP183F0	COWME04	2111.20000	COWCP04	27.11000
AP183F0	COWDM05	208.32000	COWME05	2040.00000
AP183F0	COWCP05	26.01000	COWDM06	203.14000
AP183F0	COWME06	1933.00000	COWCP06	24.36000
AP183F0	COWDM07	197.82000	COWME07	1774.00000
AP183F0	COWCP07	22.00000	COWDM08	189.00000
AP183F0	COWME08	1718.00000	COWCP08	21.13000
AP183F0	COWDM09	182.00000	COWME09	1237.00000
AP183F0	COWCP09	13.98000	COWDM10	172.76000
AP183F0	COWME10	686.00000	COWCP10	5.42000
AP183F0	COWDM11	163.80000	COWME11	680.00000
AP183F0	COWCP11	5.37000	COWDM12	156.38000
AP183F0	COWME12	724.00000	COWCP12	6.12000
AP183F0	COWDM13	149.10000	COWME13	752.00000
AP183F0	COWCP13	6.54000	COWDM14	142.80000
AP183F0	COWME14	764.00000	COWCP14	6.71000
AP183F0	COWDM15	137.76000	COWME15	734.00000
AP183F0	COWCP15	6.68000	COWDM16	135.10000
AP183F0	COWME16	704.00000	COWCP16	6.63000
AP183F0	COWDM17	135.80000	COWME17	736.00000
AP183F0	COWCP17	6.99000	COWDM18	136.50000
AP183F0	COWME18	774.00000	COWCP18	7.66000
AP183F0	COWDM19	137.90000	COWME19	822.00000
AP183F0	COWCP19	9.06000	COWDM20	141.12000
AP183F0	COWME20	886.00000	COWCP20	9.39000
AP183F0	COWDM21	146.16000	COWME21	1365.00000
AP183F0	COWCP21	16.24000	COWDM22	183.82000
AP183F0	COWME22	1814.40000	COWCP22	22.67000
AP183F0	COWDM23	198.94000	COWME23	2041.20000
AP183F0	COWCP23	26.19000	COWDM24	202.16000
AP183F0	COWME24	2102.80000	COWCP24	27.19000
AP183F0	COWDM25	206.36000	COWME25	2185.40000
AP183F0	COWCP25	26.40000	COWDM26	210.14000
AP183F0	COWME26	2224.60000	COWCP26	28.97000
AP183F0	MILKFAT	-124.00000	COWS	1.00000
AP183F0	APCOWS	1.00000		
AP183F1	COWDM01	213.92000	COWME01	2216.20000
AP183F1	COWCP01	28.81000	COWDM02	215.04000
AP183F1	COWME02	2185.40000	COWCP02	28.30000
AP183F1	COWDM03	215.60000	COWME03	2153.20000
AP183F1	COWCP03	27.77000	COWDM04	213.50000
AP183F1	COWME04	2006.00000	COWCP04	25.47000
AP183F1	COWDM05	208.32000	COWME05	1835.00000
AP183F1	COWCP05	22.94000	COWDM06	203.14000
AP183F1	COWME06	1740.00000	COWCP06	21.49000

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AP183F1	COWDM07	197.82000	COWME07	1596.00000
AP183F1	COWCP07	19.31000	COWDM08	189.00000
AP183F1	COWME08	1546.00000	COWCP08	18.63000
AP183F1	COWDM09	182.00000	COWME09	1237.00000
AP183F1	COWCP09	13.98000	COWDM10	172.76000
AP183F1	COWME10	686.00000	COWCP10	5.14000
AP183F1	COWDM11	163.80000	COWME11	680.00000
AP183F1	COWCP11	5.10000	COWDM12	156.38000
AP183F1	COWME12	724.00000	COWCP12	6.08000
AP183F1	COWDM13	149.10000	COWME13	752.00000
AP183F1	COWCP13	6.54000	COWDM14	142.80000
AP183F1	COWME14	764.00000	COWCP14	6.72000
AP183F1	COWDM15	137.76000	COWME15	734.00000
AP183F1	COWCP15	6.68000	COWDM16	135.10000
AP183F1	COWME16	704.00000	COWCP16	6.62000
AP183F1	COWDM17	135.80000	COWME17	736.00000
AP183F1	COWCP17	7.14000	COWDM18	136.50000
AP183F1	COWME18	774.00000	COWCP18	7.66000
AP183F1	COWDM19	137.90000	COWME19	822.00000
AP183F1	COWCP19	6.41000	COWDM20	141.12000
AP183F1	COWME20	686.00000	COWCP20	9.37000
AP183F1	COWDM21	146.16000	COWME21	1365.00000
AP183F1	COWCP21	16.24000	COWDM22	183.82000
AP183F1	COWME22	1814.40000	COWCP22	22.67000
AP183F1	COWDM23	198.94000	COWME23	2041.20000
AP183F1	COWCP23	26.19000	COWDM24	202.16000
AP183F1	COWME24	2102.80000	COWCP24	27.19000
AP183F1	COWDM25	206.36000	COWME25	2185.40000
AP183F1	COWCP25	28.40000	COWDM26	210.14000
AP183F1	COWME26	2224.60000	COWCP26	28.97000
AP183F1	MILKFAT	-120.00000	COWS	1.00000
AP183F1	APCOWS	1.00000		
AP183F2	COWDM01	213.92000	COWME01	2216.20000
AP183F2	COWCP01	26.81000	COWDM02	215.04000
AP183F2	COWME02	2185.40000	COWCP02	28.30000
AP183F2	COWDM03	215.60000	COWME03	2153.20000
AP183F2	COWCP03	27.77000	COWDM04	213.50000
AP183F2	COWME04	1900.00000	COWCP04	23.94000
AP183F2	COWDM05	208.32000	COWME05	1632.00000
AP183F2	COWCP05	19.88000	COWDM06	203.14000
AP183F2	COWME06	1547.00000	COWCP06	18.64000
AP183F2	COWDM07	197.82000	COWME07	1420.00000
AP183F2	COWCP07	16.76000	COWDM08	189.00000
AP183F2	COWME08	1375.00000	COWCP08	16.09000
AP183F2	COWDM09	182.00000	COWME09	1237.00000
AP183F2	COWCP09	13.98000	COWDM10	172.76000
AP183F2	COWME10	686.00000	COWCP10	5.14000
AP183F2	COWDM11	163.80000	COWME11	680.00000
AP183F2	COWCP11	6.28000	COWDM12	156.38000
AP183F2	COWME12	774.00000	COWCP12	6.89000

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AP183F2	COWDM13	149.10000	COWME13	802.00000
AP183F2	COWCP13	7.34000	COWDM14	142.80000
AP183F2	COWME14	614.00000	COWCP14	7.45000
AP183F2	COWDM15	137.76000	COWME15	784.00000
AP183F2	COWCP15	7.53000	COWDM16	135.10000
AP183F2	COWME16	779.00000	COWCP16	7.79000
AP183F2	COWDM17	135.80000	COWME17	836.00000
AP183F2	COWCP17	8.74000	COWDM18	136.50000
AP183F2	COWME18	774.00000	COWCP18	7.66000
AP183F2	COWDM19	137.90000	COWME19	822.00000
AP183F2	COWCP19	8.41000	COWDM20	141.12000
AP183F2	COWME20	686.00000	COWCP20	9.37000
AP183F2	COWDM21	146.16000	COWME21	1365.00000
AP183F2	COWCP21	16.24000	COWDM22	183.82000
AP183F2	COWME22	1614.40000	COWCP22	22.67000
AP183F2	COWDM23	196.94000	COWME23	2041.20000
AP183F2	COWCP23	26.19000	COWDM24	202.16000
AP183F2	COWME24	2102.80000	COWCP24	27.19000
AP183F2	COWDM25	206.36000	COWME25	2185.40000
AP183F2	COWCP25	28.40000	COWDM26	210.14000
AP183F2	COWME26	2224.60000	COWCP26	28.97000
AP183F2	MILKFAT	-116.00000	COWS	1.00000
AP183F2	APCOWS	1.00000		
JY267F0	COWDM01	146.16000	COWME01	1365.00000
JY267F0	COWCP01	16.24000	COWDM02	183.82000
JY267F0	COWME02	1614.40000	COWCP02	22.67000
JY267F0	COWDM03	196.94000	COWME03	2041.20000
JY267F0	COWCP03	26.19000	COWDM04	202.16000
JY267F0	COWME04	2102.80000	COWCP04	27.19000
JY267F0	COWDM05	206.36000	COWME05	2185.40000
JY267F0	COWCP05	28.40000	COWDM06	210.14000
JY267F0	COWME06	2224.60000	COWCP06	28.97000
JY267F0	COWDM07	213.92000	COWME07	2216.20000
JY267F0	COWCP07	26.81000	COWDM08	215.04000
JY267F0	COWME08	2185.40000	COWCP08	28.30000
JY267F0	COWDM09	215.60000	COWME09	2153.20000
JY267F0	COWCP09	27.77000	COWDM10	213.50000
JY267F0	COWME10	2111.20000	COWCP10	27.11000
JY267F0	COWDM11	208.32000	COWME11	2040.00000
JY267F0	COWCP11	26.01000	COWDM12	203.14000
JY267F0	COWME12	1933.00000	COWCP12	24.36000
JY267F0	COWDM13	197.82000	COWME13	1774.00000
JY267F0	COWCP13	22.00000	COWDM14	189.00000
JY267F0	COWME14	1716.00000	COWCP14	21.13000
JY267F0	COWDM15	182.00000	COWME15	1666.00000
JY267F0	COWCP15	20.38000	COWDM16	172.70000
JY267F0	COWME16	1625.00000	COWCP16	19.79000
JY267F0	COWDM17	163.80000	COWME17	1574.00000
JY267F0	COWCP17	19.05000	COWDM18	156.38000
JY267F0	COWME18	1571.00000	COWCP18	19.01000

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JY267F0	COWDM19	149.10000	COWME19	1537.00000
JY267F0	COWCP19	18.55000	COWDM20	142.80000
JY267F0	COWME20	1418.00000	COWCP20	16.87000
JY267F0	COWDM21	137.76000	COWME21	995.00000
JY267F0	COWCP21	10.80000	COWDM22	135.10000
JY267F0	COWME22	704.00000	COWCP22	6.63000
JY267F0	COWDM23	135.80000	COWME23	736.00000
JY267F0	COWCP23	6.99000	COWDM24	136.50000
JY267F0	COWME24	774.00000	COWCP24	7.66000
JY267F0	COWDM25	137.90000	COWME25	822.00000
JY267F0	COWCP25	9.06000	COWDM26	141.12000
JY267F0	COWME26	886.00000	COWCP26	9.39000
JY267F0	MILKFAT	-161.00000	COWS	1.00000
JY267F0	JYCOWS	1.00000		
JY267F1	COWDM01	146.16000	COWME01	1365.00000
JY267F1	COWCP01	16.24000	COWDM02	183.82000
JY267F1	COWME02	1814.40000	COWCP02	22.67000
JY267F1	COWDM03	198.94000	COWME03	2041.20000
JY267F1	COWCP03	26.19000	COWDM04	202.16000
JY267F1	COWME04	2102.80000	COWCP04	27.19000
JY267F1	COWDM05	206.36000	COWME05	2185.40000
JY267F1	COWCP05	26.40000	COWDM06	210.14000
JY267F1	COWME06	2224.60000	COWCP06	28.97000
JY267F1	COWDM07	213.92000	COWME07	2216.20000
JY267F1	COWCP07	28.81000	COWDM08	215.04000
JY267F1	COWME08	2185.40000	COWCP08	28.30000
JY267F1	COWDM09	215.60000	COWME09	2153.20000
JY267F1	COWCP09	27.77000	COWDM10	213.50000
JY267F1	COWME10	2006.00000	COWCP10	25.47000
JY267F1	COWDM11	206.32000	COWME11	1835.00000
JY267F1	COWCP11	22.94000	COWDM12	203.14000
JY267F1	COWME12	1740.00000	COWCP12	21.49000
JY267F1	COWDM13	197.82000	COWME13	1596.00000
JY267F1	COWCP13	19.31000	COWDM14	189.00000
JY267F1	COWME14	1546.00000	COWCP14	18.63000
JY267F1	COWDM15	182.00000	COWME15	1499.00000
JY267F1	COWCP15	17.99000	COWDM16	172.76000
JY267F1	COWME16	1463.00000	COWCP16	17.44000
JY267F1	COWDM17	163.80000	COWME17	1417.00000
JY267F1	COWCP17	16.79000	COWDM18	156.38000
JY267F1	COWME18	1414.00000	COWCP18	16.76000
JY267F1	COWDM19	149.10000	COWME19	1383.00000
JY267F1	COWCP19	16.28000	COWDM20	142.80000
JY267F1	COWME20	1277.00000	COWCP20	14.69000
JY267F1	COWDM21	137.76000	COWME21	1044.00000
JY267F1	COWCP21	11.52000	COWDM22	135.10000
JY267F1	COWME22	868.00000	COWCP22	9.11000
JY267F1	COWDM23	135.80000	COWME23	1029.00000
JY267F1	COWCP23	11.68000	COWDM24	136.50000
JY267F1	COWME24	1124.00000	COWCP24	13.13000

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JY267F1	COWDM25	137.90000	COWME25	1072.00000
JY267F1	COWCP25	12.31000	COWDM26	141.12000
JY267F1	COWME26	933.00000	COWCP26	10.08000
JY267F1	MILKFAT	-155.00000	COWS	1.00000
JY267F1	JYCOWS	1.00000		
JY267F2	COWDM01	146.16000	COWME01	1365.00000
JY267F2	COWCP01	16.24000	COWDM02	183.82000
JY267F2	COWME02	1814.40000	COWCP02	22.67000
JY267F2	COWDM03	196.94000	COWME03	2041.20000
JY267F2	COWCP03	26.19000	COWDM04	202.16000
JY267F2	COWME04	2102.80000	COWCP04	27.19000
JY267F2	COWDM05	206.36000	COWME05	2185.40000
JY267F2	COWCP05	28.40000	COWDM06	210.14000
JY267F2	COWME06	2224.60000	COWCP06	28.97000
JY267F2	COWDM07	213.92000	COWME07	2216.20000
JY267F2	COWCP07	28.81000	COWDM08	215.04000
JY267F2	COWME08	2185.40000	COWCP08	28.30000
JY267F2	COWDM09	215.60000	COWME09	2153.20000
JY267F2	COWCP09	27.77000	COWDM10	213.50000
JY267F2	COWME10	1900.00000	COWCP10	23.94000
JY267F2	COWDM11	208.32000	COWME11	1632.00000
JY267F2	COWCP11	19.88000	COWDM12	203.14000
JY267F2	COWME12	1547.00000	COWCP12	18.64000
JY267F2	COWDM13	197.82000	COWME13	1420.00000
JY267F2	COWCP13	16.76000	COWDM14	189.00000
JY267F2	COWME14	1375.00000	COWCP14	16.09000
JY267F2	COWDM15	182.00000	COWME15	1333.00000
JY267F2	COWCP15	15.48000	COWDM16	172.76000
JY267F2	COWME16	1301.00000	COWCP16	15.01000
JY267F2	COWDM17	163.80000	COWME17	1259.00000
JY267F2	COWCP17	14.42000	COWDM18	156.38000
JY267F2	COWME18	1257.00000	COWCP18	14.39000
JY267F2	COWDM19	149.10000	COWME19	1229.00000
JY267F2	COWCP19	13.91000	COWDM20	142.80000
JY267F2	COWME20	1134.00000	COWCP20	12.50000
JY267F2	COWDM21	137.76000	COWME21	1044.00000
JY267F2	COWCP21	11.52000	COWDM22	135.10000
JY267F2	COWME22	1054.00000	COWCP22	12.12000
JY267F2	COWDM23	135.80000	COWME23	1436.00000
JY267F2	COWCP23	17.81000	COWDM24	136.50000
JY267F2	COWME24	1430.00000	COWCP24	17.73000
JY267F2	COWDM25	137.90000	COWME25	1322.00000
JY267F2	COWCP25	16.04000	COWDM26	141.12000
JY267F2	COWME26	1096.00000	COWCP26	12.60000
JY267F2	MILKFAT	-146.00000	COWS	1.00000
JY267F2	JYCOWS	1.00000		
JY239F0	COWDM01	146.16000	COWME01	1365.00000
JY239F0	COWCP01	16.24000	COWDM02	183.82000
JY239F0	COWME02	1814.40000	COWCP02	22.67000
JY239F0	COWDM03	196.94000	COWME03	2041.20000

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JY239F0	COWCP03	26.19000	COWDM04	202.16000
JY239F0	COWME04	2102.80000	COWCP04	27.19000
JY239F0	COWDM05	206.36000	COWME05	2185.40000
JY239F0	COWCP05	26.40000	COWDM06	210.14000
JY239F0	COWME06	2224.60000	COWCP06	28.97000
JY239F0	COWDM07	213.92000	COWME07	2216.20000
JY239F0	COWCP07	26.81000	COWDM08	215.04000
JY239F0	COWME08	2185.40000	COWCP08	28.30000
JY239F0	COWDM09	215.60000	COWME09	2153.20000
JY239F0	COWCP09	27.77000	COWDM10	213.50000
JY239F0	COWME10	2111.20000	COWCP10	27.11000
JY239F0	COWDM11	206.32000	COWME11	2040.00000
JY239F0	COWCP11	26.01000	COWDM12	203.14000
JY239F0	COWME12	1933.00000	COWCP12	24.36000
JY239F0	COWDM13	197.82000	COWME13	1774.00000
JY239F0	COWCP13	22.00000	COWDM14	189.00000
JY239F0	COWME14	1716.00000	COWCP14	21.13000
JY239F0	COWDM15	182.00000	COWME15	1666.00000
JY239F0	COWCP15	20.38000	COWDM16	172.76000
JY239F0	COWME16	1625.00000	COWCP16	19.79000
JY239F0	COWDM17	163.80000	COWME17	1574.00000
JY239F0	COWCP17	19.05000	COWDM18	156.38000
JY239F0	COWME18	1455.00000	COWCP18	19.01000
JY239F0	COWDM19	149.10000	COWME19	1052.00000
JY239F0	COWCP19	12.36000	COWDM20	142.80000
JY239F0	COWME20	764.00000	COWCP20	6.71000
JY239F0	COWDM21	137.76000	COWME21	734.00000
JY239F0	COWCP21	6.68000	COWDM22	135.10000
JY239F0	COWME22	704.00000	COWCP22	6.63000
JY239F0	COWDM23	135.80000	COWME23	736.00000
JY239F0	COWCP23	6.99000	COWDM24	136.50000
JY239F0	COWME24	774.00000	COWCP24	7.60000
JY239F0	COWDM25	137.90000	COWME25	822.00000
JY239F0	COWCP25	9.06000	COWDM26	141.12000
JY239F0	COWME26	886.00000	COWCP26	9.39000
JY239F0	MILKFAT	-150.00000	COWS	1.00000
JY239F0	JYCOWS	1.00000		
JY239F1	COWDM01	146.16000	COWME01	1365.00000
JY239F1	COWCP01	16.24000	COWDM02	183.82000
JY239F1	COWME02	1814.40000	COWCP02	22.67000
JY239F1	COWDM03	198.94000	COWME03	2041.20000
JY239F1	COWCP03	26.19000	COWDM04	202.16000
JY239F1	COWME04	2102.80000	COWCP04	27.19000
JY239F1	COWDM05	206.36000	COWME05	2185.40000
JY239F1	COWCP05	26.40000	COWDM06	210.14000
JY239F1	COWME06	2224.60000	COWCP06	28.97000
JY239F1	COWDM07	213.92000	COWME07	2216.20000
JY239F1	COWCP07	26.81000	COWDM08	215.04000
JY239F1	COWME08	2185.40000	COWCP08	28.30000
JY239F1	COWDM09	215.60000	COWME09	2153.20000

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JY239F1	COWCP09	27.77000	COWDM10	213.50000
JY239F1	COWME10	2006.00000	COWCP10	25.47000
JY239F1	COWDM11	208.32000	COWME11	1835.00000
JY239F1	COWCP11	22.94000	COWDM12	203.14000
JY239F1	COWME12	1740.00000	COWCP12	21.49000
JY239F1	COWDM13	197.82000	COWME13	1596.00000
JY239F1	COWCP13	19.31000	COWDM14	189.00000
JY239F1	COWME14	1546.00000	COWCP14	18.63000
JY239F1	COWDM15	182.00000	COWME15	1499.00000
JY239F1	COWCP15	17.99000	COWDM16	172.76000
JY239F1	COWME16	1463.00000	COWCP16	17.44000
JY239F1	COWDM17	163.80000	COWME17	1417.00000
JY239F1	COWCP17	16.79000	COWDM18	156.38000
JY239F1	COWME18	1414.00000	COWCP18	16.76000
JY239F1	COWDM19	149.10000	COWME19	1131.00000
JY239F1	COWCP19	12.38000	COWDM20	142.80000
JY239F1	COWME20	855.00000	COWCP20	8.12000
JY239F1	COWDM21	137.76000	COWME21	884.00000
JY239F1	COWCP21	9.06000	COWDM22	135.10000
JY239F1	COWME22	864.00000	COWCP22	9.20000
JY239F1	COWDM23	135.80000	COWME23	910.00000
JY239F1	COWCP23	9.86000	COWDM24	136.50000
JY239F1	COWME24	899.00000	COWCP24	9.60000
JY239F1	COWDM25	137.90000	COWME25	822.00000
JY239F1	COWCP25	8.41000	COWDM26	141.12000
JY239F1	COWME26	686.00000	COWCP26	9.37000
JY239F1	MILKFAT	-145.00000	COWS	1.00000
JY239F1	JYCOWS	1.00000		
JY239F2	COWDM01	146.16000	COWME01	1365.00000
JY239F2	COWCP01	16.24000	COWDM02	183.82000
JY239F2	COWME02	1814.40000	COWCP02	22.67000
JY239F2	COWDM03	198.94000	COWME03	2041.20000
JY239F2	COWCP03	26.19000	COWDM04	202.16000
JY239F2	COWME04	2102.80000	COWCP04	27.19000
JY239F2	COWDM05	206.36000	COWME05	2185.40000
JY239F2	COWCP05	28.40000	COWDM06	210.14000
JY239F2	COWME06	2224.60000	COWCP06	28.97000
JY239F2	COWDM07	213.92000	COWME07	2216.20000
JY239F2	COWCP07	28.81000	COWDM08	215.04000
JY239F2	COWME08	2185.40000	COWCP08	28.30000
JY239F2	COWDM09	215.60000	COWME09	2153.20000
JY239F2	COWCP09	27.77000	COWDM10	213.50000
JY239F2	COWME10	1900.00000	COWCP10	23.94000
JY239F2	COWDM11	208.32000	COWME11	1632.00000
JY239F2	COWCP11	19.88000	COWDM12	203.14000
JY239F2	COWME12	1547.00000	COWCP12	18.64000
JY239F2	COWDM13	197.82000	COWME13	1420.00000
JY239F2	COWCP13	16.76000	COWDM14	189.00000
JY239F2	COWME14	1375.00000	COWCP14	16.09000
JY239F2	COWDM15	182.00000	COWME15	1333.00000

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JY239F2	COWCP15	15.48000	COWDM16	172.76000
JY239F2	COWME16	1301.00000	COWCP16	15.01000
JY239F2	COWDM17	163.80000	COWME17	1259.00000
JY239F2	COWCP17	14.42000	COWDM18	156.38000
JY239F2	COWME18	1257.00000	COWCP18	14.39000
JY239F2	COWDM19	149.10000	COWME19	1131.00000
JY239F2	COWCP19	12.38000	COWDM20	142.80000
JY239F2	COWME20	946.00000	COWCP20	9.60000
JY239F2	COWDM21	137.76000	COWME21	1084.00000
JY239F2	COWCP21	12.20000	COWDM22	135.10000
JY239F2	COWME22	1076.00000	COWCP22	12.45000
JY239F2	COWDM23	135.80000	COWME23	1143.00000
JY239F2	COWCP23	13.43000	COWDM24	136.50000
JY239F2	COWME24	993.00000	COWCP24	11.12000
JY239F2	COWDM25	137.90000	COWME25	822.00000
JY239F2	COWCP25	8.41000	COWDM26	141.12000
JY239F2	COWME26	886.00000	COWCP26	9.37000
JY239F2	MILKFAT	*139.00000	COWS	1.00000
JY239F2	JYCOWS	1.00000		
JY211F0	COWDM01	146.16000	COWME01	1365.00000
JY211F0	COWCP01	16.24000	COWDM02	183.82000
JY211F0	COWME02	1814.40000	COWCP02	22.67000
JY211F0	COWDM03	198.94000	COWME03	2041.20000
JY211F0	COWCP03	26.19000	COWDM04	202.16000
JY211F0	COWME04	2102.80000	COWCP04	27.19000
JY211F0	COWDM05	206.36000	COWME05	2185.40000
JY211F0	COWCP05	28.40000	COWDM06	210.14000
JY211F0	COWME06	2224.60000	COWCP06	28.97000
JY211F0	COWDM07	213.92000	COWME07	2216.20000
JY211F0	COWCP07	28.81000	COWDM08	215.04000
JY211F0	COWME08	2185.40000	COWCP08	28.30000
JY211F0	COWDM09	215.60000	COWME09	2153.20000
JY211F0	COWCP09	27.77000	COWDM10	213.50000
JY211F0	COWME10	2111.20000	COWCP10	27.11000
JY211F0	COWDM11	208.32000	COWME11	2040.00000
JY211F0	COWCP11	26.01000	COWDM12	203.14000
JY211F0	COWME12	1933.00000	COWCP12	24.36000
JY211F0	COWDM13	197.82000	COWME13	1774.00000
JY211F0	COWCP13	22.00000	COWDM14	189.00000
JY211F0	COWME14	1718.00000	COWCP14	21.13000
JY211F0	COWDM15	182.00000	COWME15	1666.00000
JY211F0	COWCP15	20.38000	COWDM16	172.76000
JY211F0	COWME16	1487.00000	COWCP16	19.79000
JY211F0	COWDM17	163.80000	COWME17	1004.00000
JY211F0	COWCP17	12.96000	COWDM18	156.38000
JY211F0	COWME18	724.00000	COWCP18	6.12000
JY211F0	COWDM19	149.10000	COWME19	752.00000
JY211F0	COWCP19	6.54000	COWDM20	142.80000
JY211F0	COWME20	764.00000	COWCP20	6.71000
JY211F0	COWDM21	137.76000	COWME21	734.00000

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JY211F0	COWCP21	6.68000	COWDM22	135.10000
JY211F0	COWME22	704.00000	COWCP22	6.63000
JY211F0	COWDM23	135.80000	COWME23	736.00000
JY211F0	COWCP23	6.99000	COWDM24	136.50000
JY211F0	COWME24	774.00000	COWCP24	7.60000
JY211F0	COWDM25	137.90000	COWME25	822.00000
JY211F0	COWCP25	9.06000	COWDM26	141.12000
JY211F0	COWME26	886.00000	COWCP26	9.39000
JY211F0	MILKFAT	-137.00000	COWS	1.00000
JY211F0	JYCOWS	1.00000		
JY211F1	COWDM01	146.16000	COWME01	1365.00000
JY211F1	COWCP01	16.24000	COWDM02	183.82000
JY211F1	COWME02	1814.40000	COWCP02	22.67000
JY211F1	COWDM03	198.94000	COWME03	2041.20000
JY211F1	COWCP03	26.19000	COWDM04	202.16000
JY211F1	COWME04	2102.80000	COWCP04	27.19000
JY211F1	COWDM05	206.36000	COWME05	2185.40000
JY211F1	COWCP05	26.40000	COWDM06	210.14000
JY211F1	COWME06	2224.60000	COWCP06	28.97000
JY211F1	COWDM07	213.92000	COWME07	2216.20000
JY211F1	COWCP07	26.81000	COWDM08	215.04000
JY211F1	COWME08	2185.40000	COWCP08	28.30000
JY211F1	COWDM09	215.60000	COWME09	2153.20000
JY211F1	COWCP09	27.77000	COWDM10	213.50000
JY211F1	COWME10	2006.00000	COWCP10	25.47000
JY211F1	COWDM11	208.32000	COWME11	1835.00000
JY211F1	COWCP11	22.94000	COWDM12	203.14000
JY211F1	COWME12	1740.00000	COWCP12	21.49000
JY211F1	COWDM13	197.82000	COWME13	1596.00000
JY211F1	COWCP13	19.31000	COWDM14	189.00000
JY211F1	COWME14	1546.00000	COWCP14	18.63000
JY211F1	COWDM15	182.00000	COWME15	1499.00000
JY211F1	COWCP15	17.99000	COWDM16	172.76000
JY211F1	COWME16	1463.00000	COWCP16	17.44000
JY211F1	COWDM17	163.80000	COWME17	1270.00000
JY211F1	COWCP17	14.54000	COWDM18	156.38000
JY211F1	COWME18	899.00000	COWCP18	8.81000
JY211F1	COWDM19	149.10000	COWME19	927.00000
JY211F1	COWCP19	9.18000	COWDM20	142.80000
JY211F1	COWME20	864.00000	COWCP20	8.25000
JY211F1	COWDM21	137.76000	COWME21	784.00000
JY211F1	COWCP21	7.45000	COWDM22	135.10000
JY211F1	COWME22	754.00000	COWCP22	7.39000
JY211F1	COWDM23	135.80000	COWME23	761.00000
JY211F1	COWCP23	7.50000	COWDM24	136.50000
JY211F1	COWME24	774.00000	COWCP24	7.66000
JY211F1	COWDM25	137.90000	COWME25	822.00000
JY211F1	COWCP25	8.41000	COWDM26	141.12000
JY211F1	COWME26	886.00000	COWCP26	9.37000
JY211F1	MILKFAT	-133.00000	COWS	1.00000

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JY211F1	JYCOWS	1.00000		
JY211F2	COWDM01	146.16000	COWME01	1365.00000
JY211F2	COWCP01	16.24000	COWDM02	183.82000
JY211F2	COWME02	1614.40000	COWCP02	22.67000
JY211F2	COWDM03	196.94000	COWME03	2041.20000
JY211F2	COWCP03	26.19000	COWDM04	202.16000
JY211F2	COWME04	2102.80000	COWCP04	27.19000
JY211F2	COWDM05	206.36000	COWME05	2185.40000
JY211F2	COWCP05	28.40000	COWDM06	210.14000
JY211F2	COWME06	2224.60000	COWCP06	28.97000
JY211F2	COWDM07	213.92000	COWME07	2216.20000
JY211F2	COWCP07	28.61000	COWDM08	215.04000
JY211F2	COWME08	2185.40000	COWCP08	28.30000
JY211F2	COWDM09	215.60000	COWME09	2153.20000
JY211F2	COWCP09	27.77000	COWDM10	213.50000
JY211F2	COWME10	1900.00000	COWCP10	23.94000
JY211F2	COWDM11	208.32000	COWME11	1632.00000
JY211F2	COWCP11	19.88000	COWDM12	203.14000
JY211F2	COWME12	1547.00000	COWCP12	18.64000
JY211F2	COWDM13	197.82000	COWME13	1420.00000
JY211F2	COWCP13	16.76000	COWDM14	189.00000
JY211F2	COWME14	1375.00000	COWCP14	16.09000
JY211F2	COWDM15	182.00000	COWME15	1333.00000
JY211F2	COWCP15	15.48000	COWDM16	172.76000
JY211F2	COWME16	1301.00000	COWCP16	15.01000
JY211F2	COWDM17	163.80000	COWME17	1270.00000
JY211F2	COWCP17	14.54000	COWDM18	156.38000
JY211F2	COWME18	974.00000	COWCP18	10.03000
JY211F2	COWDM19	149.10000	COWME19	1052.00000
JY211F2	COWCP19	11.26000	COWDM20	142.80000
JY211F2	COWME20	1014.00000	COWCP20	10.60000
JY211F2	COWDM21	137.76000	COWME21	934.00000
JY211F2	COWCP21	9.81000	COWDM22	135.10000
JY211F2	COWME22	904.00000	COWCP22	9.76000
JY211F2	COWDM23	135.80000	COWME23	836.00000
JY211F2	COWCP23	6.78000	COWDM24	136.50000
JY211F2	COWME24	774.00000	COWCP24	7.60000
JY211F2	COWDM25	137.90000	COWME25	822.00000
JY211F2	COWCP25	8.41000	COWDM26	141.12000
JY211F2	COWME26	880.00000	COWCP26	9.37000
JY211F2	MILKFAT	-129.00000	COWS	1.00000
JY211F2	JYCOWS	1.00000		
JY183F0	COWDM01	146.16000	COWME01	1365.00000
JY183F0	COWCP01	16.24000	COWDM02	183.82000
JY183F0	COWME02	1614.40000	COWCP02	22.67000
JY183F0	COWDM03	196.94000	COWME03	2041.20000
JY183F0	COWCP03	26.19000	COWDM04	202.16000
JY183F0	COWME04	2102.80000	COWCP04	27.19000
JY183F0	COWDM05	206.36000	COWME05	2185.40000
JY183F0	COWCP05	28.40000	COWDM06	210.14000

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JY183F0	COWME06	2224.60000	COWCP06	28.97000
JY183F0	COWDM07	213.92000	COWME07	2216.20000
JY183F0	COWCP07	28.81000	COWDM08	215.04000
JY183F0	COWME08	2185.40000	COWCP08	28.30000
JY183F0	COWDM09	215.60000	COWME09	2153.20000
JY183F0	COWCP09	27.77000	COWDM10	213.50000
JY183F0	COWME10	2111.20000	COWCP10	27.11000
JY183F0	COWDM11	208.32000	COWME11	2040.00000
JY183F0	COWCP11	26.01000	COWDM12	203.14000
JY183F0	COWME12	1933.00000	COWCP12	24.36000
JY183F0	COWDM13	197.82000	COWME13	1774.00000
JY183F0	COWCP13	22.00000	COWDM14	189.00000
JY183F0	COWME14	1579.00000	COWCP14	21.13000
JY183F0	COWDM15	182.00000	COWME15	1050.00000
JY183F0	COWCP15	13.98000	COWDM16	172.76000
JY183F0	COWME16	686.00000	COWCP16	5.42000
JY183F0	COWDM17	163.80000	COWME17	680.00000
JY183F0	COWCP17	5.37000	COWDM18	156.38000
JY183F0	COWME18	724.00000	COWCP18	6.12000
JY183F0	COWDM19	149.10000	COWME19	752.00000
JY183F0	COWCP19	6.54000	COWDM20	142.80000
JY183F0	COWME20	764.00000	COWCP20	6.71000
JY183F0	COWDM21	137.76000	COWME21	734.00000
JY183F0	COWCP21	6.68000	COWDM22	135.10000
JY183F0	COWME22	704.00000	COWCP22	6.63000
JY183F0	COWDM23	135.80000	COWME23	736.00000
JY183F0	COWCP23	6.99000	COWDM24	136.50000
JY183F0	COWME24	774.00000	COWCP24	7.66000
JY183F0	COWDM25	137.90000	COWME25	822.00000
JY183F0	COWCP25	9.06000	COWDM26	141.12000
JY183F0	COWME26	880.00000	COWCP26	9.39000
JY183F0	MILKFAT	-124.00000	COWS	1.00000
JY183F0	JYCOWS	1.00000		
JY183F1	COWDM01	146.16000	COWME01	1365.00000
JY183F1	COWCP01	16.24000	COWDM02	183.82000
JY183F1	COWME02	1614.40000	COWCP02	22.67000
JY183F1	COWDM03	196.94000	COWME03	2041.20000
JY183F1	COWCP03	26.19000	COWDM04	202.16000
JY183F1	COWME04	2102.80000	COWCP04	27.19000
JY183F1	COWDM05	206.36000	COWME05	2185.40000
JY183F1	COWCP05	28.40000	COWDM06	210.14000
JY183F1	COWME06	2224.60000	COWCP06	28.97000
JY183F1	COWDM07	213.92000	COWME07	2216.20000
JY183F1	COWCP07	28.81000	COWDM08	215.04000
JY183F1	COWME08	2185.40000	COWCP08	28.30000
JY183F1	COWDM09	215.60000	COWME09	2153.20000
JY183F1	COWCP09	27.77000	COWDM10	213.50000
JY183F1	COWME10	2006.00000	COWCP10	25.47000
JY183F1	COWDM11	206.32000	COWME11	1835.00000
JY183F1	COWCP11	22.94000	COWDM12	203.14000

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JY183F1	COWME12	1740.00000	COWCP12	21.49000
JY183F1	COWDM13	197.82000	COWME13	1596.00000
JY183F1	COWCP13	19.31000	COWDM14	189.00000
JY183F1	COWME14	1546.00000	COWCP14	18.63000
JY183F1	COWDM15	182.00000	COWME15	1237.00000
JY183F1	COWCP15	13.98000	COWDM16	172.76000
JY183F1	COWME16	686.00000	COWCP16	5.14000
JY183F1	COWDM17	163.80000	COWME17	680.00000
JY183F1	COWCP17	5.10000	COWDM18	156.38000
JY183F1	COWME18	724.00000	COWCP18	6.08000
JY183F1	COWDM19	149.10000	COWME19	752.00000
JY183F1	COWCP19	6.54000	COWDM20	142.80000
JY183F1	COWME20	764.00000	COWCP20	6.72000
JY183F1	COWDM21	137.76000	COWME21	734.00000
JY183F1	COWCP21	6.68000	COWDM22	135.10000
JY183F1	COWME22	704.00000	COWCP22	6.62000
JY183F1	COWDM23	135.80000	COWME23	736.00000
JY183F1	COWCP23	7.14000	COWDM24	136.50000
JY183F1	COWME24	774.00000	COWCP24	7.66000
JY183F1	COWDM25	137.90000	COWME25	822.00000
JY183F1	COWCP25	8.41000	COWDM26	141.12000
JY183F1	COWME26	880.00000	COWCP26	9.37000
JY183F1	MILKFAT	-121.00000	COWS	1.00000
JY183F1	JYCOWS	1.00000		
JY183F2	COWDM01	146.16000	COWME01	1365.00000
JY183F2	COWCP01	16.24000	COWDM02	183.82000
JY183F2	COWME02	1614.40000	COWCP02	22.67000
JY183F2	COWDM03	198.94000	COWME03	2041.20000
JY183F2	COWCP03	26.19000	COWDM04	202.16000
JY183F2	COWME04	2102.80000	COWCP04	27.19000
JY183F2	COWDM05	206.36000	COWME05	2185.40000
JY183F2	COWCP05	28.40000	COWDM06	210.14000
JY183F2	COWME06	2224.60000	COWCP06	28.97000
JY183F2	COWDM07	213.92000	COWME07	2216.20000
JY183F2	COWCP07	28.81000	COWDM08	215.04000
JY183F2	COWME08	2185.40000	COWCP08	28.30000
JY183F2	COWDM09	215.60000	COWME09	2153.20000
JY183F2	COWCP09	27.77000	COWDM10	213.50000
JY183F2	COWME10	1900.00000	COWCP10	23.94000
JY183F2	COWDM11	206.32000	COWME11	1632.00000
JY183F2	COWCP11	19.88000	COWDM12	203.14000
JY183F2	COWME12	1547.00000	COWCP12	18.64000
JY183F2	COWDM13	197.82000	COWME13	1420.00000
JY183F2	COWCP13	16.76000	COWDM14	189.00000
JY183F2	COWME14	1375.00000	COWCP14	16.09000
JY183F2	COWDM15	182.00000	COWME15	1237.00000
JY183F2	COWCP15	13.98000	COWDM16	172.76000
JY183F2	COWME16	686.00000	COWCP16	5.14000
JY183F2	COWDM17	163.80000	COWME17	680.00000
JY183F2	COWCP17	6.28000	COWDM18	156.38000

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JY183F2	COWME18	774.00000	COWCP18	6.89000
JY183F2	COWDM19	149.10000	COWME19	802.00000
JY183F2	COWCP19	7.34000	COWDM20	142.80000
JY183F2	COWME20	814.00000	COWCP20	7.45000
JY183F2	COWDM21	137.76000	COWME21	784.00000
JY183F2	COWCP21	7.53000	COWDM22	135.10000
JY183F2	COWME22	779.00000	COWCP22	7.79000
JY183F2	COWDM23	135.80000	COWME23	836.00000
JY183F2	COWCP23	8.74000	COWDM24	136.50000
JY183F2	COWME24	774.00000	COWCP24	7.66000
JY183F2	COWDM25	137.90000	COWME25	822.00000
JY183F2	COWCP25	8.41000	COWDM26	141.12000
JY183F2	COWME26	886.00000	COWCP26	9.37000
JY183F2	MILKFAT	-117.00000	COWS	1.00000
JY183F2	JYCOWS	1.00000		
AU267F0	COWDM01	137.90000	COWME01	822.00000
AU267F0	COWCP01	9.06000	COWDM02	141.12000
AU267F0	COWME02	886.00000	COWCP02	9.39000
AU267F0	COWDM03	146.16000	COWME03	1365.00000
AU267F0	COWCP03	16.24000	COWDM04	183.82000
AU267F0	COWME04	1814.40000	COWCP04	22.67000
AU267F0	COWDM05	198.94000	COWME05	2041.20000
AU267F0	COWCP05	26.19000	COWDM06	202.16000
AU267F0	COWME06	2102.80000	COWCP06	27.19000
AU267F0	COWDM07	206.36000	COWME07	2185.40000
AU267F0	COWCP07	28.40000	COWDM08	210.14000
AU267F0	COWME08	2224.60000	COWCP08	28.97000
AU267F0	COWDM09	213.92000	COWME09	2216.20000
AU267F0	COWCP09	28.81000	COWDM10	215.04000
AU267F0	COWME10	2185.40000	COWCP10	28.30000
AU267F0	COWDM11	215.60000	COWME11	2153.20000
AU267F0	COWCP11	27.77000	COWDM12	213.50000
AU267F0	COWME12	2111.20000-	COWCP12	27.11000
AU267F0	COWDM13	208.32000	COWME13	2040.00000
AU267F0	COWCP13	26.01000	COWDM14	203.14000
AU267F0	COWME14	1933.00000	COWCP14	24.36000
AU267F0	COWDM15	197.82000	COWME15	1774.00000
AU267F0	COWCP15	22.00000	COWDM16	189.00000
AU267F0	COWME16	1718.00000	COWCP16	21.13000
AU267F0	COWDM17	182.00000	COWME17	1666.00000
AU267F0	COWCP17	20.38000	COWDM18	172.76000
AU267F0	COWME18	1625.00000	COWCP18	19.79000
AU267F0	COWDM19	163.80000	COWME19	1574.00000
AU267F0	COWCP19	19.05000	COWDM20	156.38000
AU267F0	COWME20	1571.00000	COWCP20	19.01000
AU267F0	COWDM21	149.10000	COWME21	1537.00000
AU267F0	COWCP21	18.55000	COWDM22	142.80000
AU267F0	COWME22	1418.00000	COWCP22	16.87000
AU267F0	COWDM23	137.76000	COWME23	995.00000
AU267F0	COWCP23	10.80000	COWDM24	135.10000

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AU267F0	COWME24	704.00000	COWCP24	6.63000
AU267F0	COWDM25	135.80000	COWME25	736.00000
AU267F0	COWCP25	6.99000	COWDM26	136.50000
AU267F0	COWME26	774.00000	COWCP26	7.66000
AU267F0	MILKFAT	-161.00000	COWS	1.00000
AU267F0	AUCOWS	1.00000		
AU267F1	COWDM01	137.90000	COWME01	1072.00000
AU267F1	COWCP01	12.31000	COWDM02	141.12000
AU267F1	COWME02	933.00000	COWCP02	10.08000
AU267F1	COWDM03	146.16000	COWME03	1365.00000
AU267F1	COWCP03	16.24000	COWDM04	183.82000
AU267F1	COWME04	1814.40000	COWCP04	22.67000
AU267F1	COWDM05	198.94000	COWME05	2041.20000
AU267F1	COWCP05	26.19000	COWDM06	202.16000
AU267F1	COWME06	2102.80000	COWCP06	27.19000
AU267F1	COWDM07	206.36000	COWME07	2185.40000
AU267F1	COWCP07	28.40000	COWDM08	210.14000
AU267F1	COWME08	2224.60000	COWCP08	28.97000
AU267F1	COWDM09	213.92000	COWME09	2216.20000
AU267F1	COWCP09	28.81000	COWDM10	215.04000
AU267F1	COWME10	2185.40000	COWCP10	28.30000
AU267F1	COWDM11	215.60000	COWME11	2153.20000
AU267F1	COWCP11	27.77000	COWDM12	213.50000
AU267F1	COWME12	2006.00000	COWCP12	25.47000
AU267F1	COWDM13	208.32000	COWME13	1835.00000
AU267F1	COWCP13	22.94000	COWDM14	203.14000
AU267F1	COWME14	1740.00000	COWCP14	21.49000
AU267F1	COWDM15	197.82000	COWME15	1596.00000
AU267F1	COWCP15	19.31000	COWDM16	189.00000
AU267F1	COWME16	1546.00000	COWCP16	18.63000
AU267F1	COWDM17	182.00000	COWME17	1499.00000
AU267F1	COWCP17	17.99000	COWDM18	172.76000
AU267F1	COWME18	1463.00000	COWCP18	17.44000
AU267F1	COWDM19	163.80000	COWME19	1417.00000
AU267F1	COWCP19	16.79000	COWDM20	156.38000
AU267F1	COWME20	1414.00000	COWCP20	16.76000
AU267F1	COWDM21	149.10000	COWME21	1383.00000
AU267F1	COWCP21	16.28000	COWDM22	142.80000
AU267F1	COWME22	1277.00000	COWCP22	14.69000
AU267F1	COWDM23	137.76000	COWME23	1044.00000
AU267F1	COWCP23	11.52000	COWDM24	135.10000
AU267F1	COWME24	868.00000	COWCP24	9.11000
AU267F1	COWDM25	135.80000	COWME25	1029.00000
AU267F1	COWCP25	11.68000	COWDM26	136.50000
AU267F1	COWME26	1124.00000	COWCP26	13.13000
AU267F1	MILKFAT	-155.00000	COWS	1.00000
AU267F1	AUCOWS	1.00000		
AU267F2	COWDM01	137.90000	COWME01	1322.00000
AU267F2	COWCP01	16.04000	COWDM02	141.12000
AU267F2	COWME02	1096.00000	COWCP02	12.60000

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AU267F2	COWDM03	146.16000	COWME03	1365.00000
AU267F2	COWCP03	16.24000	COWDM04	183.82000
AU267F2	COWME04	1814.40000	COWCP04	22.67000
AU267F2	COWDM05	198.94000	COWME05	2041.20000
AU267F2	COWCP05	26.19000	COWDM06	202.16000
AU267F2	COWME06	2102.80000	COWCP06	27.19000
AU267F2	COWDM07	206.36000	COWME07	2185.40000
AU267F2	COWCP07	26.40000	COWDM08	210.14000
AU267F2	COWME08	2224.60000	COWCP08	28.97000
AU267F2	COWDM09	213.92000	COWME09	2216.20000
AU267F2	COWCP09	28.81000	COWDM10	215.04000
AU267F2	COWME10	2185.40000	COWCP10	28.30000
AU267F2	COWDM11	215.60000	COWME11	2153.20000
AU267F2	COWCP11	27.77000	COWDM12	213.50000
AU267F2	COWME12	1900.00000	COWCP12	23.94000
AU267F2	COWDM13	208.32000	COWME13	1632.00000
AU267F2	COWCP13	19.88000	COWDM14	203.14000
AU267F2	COWME14	1547.00000	COWCP14	18.64000
AU267F2	COWDM15	197.82000	COWME15	1420.00000
AU267F2	COWCP15	16.76000	COWDM16	189.00000
AU267F2	COWME16	1375.00000	COWCP16	16.09000
AU267F2	COWDM17	182.00000	COWME17	1333.00000
AU267F2	COWCP17	15.48000	COWDM18	172.76000
AU267F2	COWME18	1301.00000	COWCP18	15.01000
AU267F2	COWDM19	163.80000	COWME19	1259.00000
AU267F2	COWCP19	14.42000	COWDM20	156.38000
AU267F2	COWME20	1257.00000	COWCP20	14.39000
AU267F2	COWDM21	149.10000	COWME21	1229.00000
AU267F2	COWCP21	13.91000	COWDM22	142.80000
AU267F2	COWME22	1134.00000	COWCP22	12.50000
AU267F2	COWDM23	137.76000	COWME23	1044.00000
AU267F2	COWCP23	11.52000	COWDM24	135.10000
AU267F2	COWME24	1054.00000	COWCP24	12.12000
AU267F2	COWDM25	135.80000	COWME25	1436.00000
AU267F2	COWCP25	17.81000	COWDM26	136.50000
AU267F2	COWME26	1430.00000	COWCP26	17.73000
AU267F2	MILKFAT	-146.00000	COWS	1.00000
AU267F2	AUCOWS	1.00000		
AU239F0	COWDM01	137.90000	COWME01	822.00000
AU239F0	COWCP01	9.06000	COWDM02	141.12000
AU239F0	COWME02	886.00000	COWCP02	9.39000
AU239F0	COWDM03	146.16000	COWME03	1365.00000
AU239F0	COWCP03	16.24000	COWDM04	183.82000
AU239F0	COWME04	1814.40000	COWCP04	22.67000
AU239F0	COWDM05	198.94000	COWME05	2041.20000
AU239F0	COWCP05	26.19000	COWDM06	202.16000
AU239F0	COWME06	2102.80000	COWCP06	27.19000
AU239F0	COWDM07	206.36000	COWME07	2185.40000
AU239F0	COWCP07	26.40000	COWDM08	210.14000
AU239F0	COWME08	2224.60000	COWCP08	28.97000

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AU239F0	COWDM09	213.92000	COWME09	2216.20000
AU239F0	COWCP09	28.81000	COWDM10	215.04000
AU239F0	COWME10	2185.40000	COWCP10	28.30000
AU239F0	COWDM11	215.60000	COWME11	2153.20000
AU239F0	COWCP11	27.77000	COWDM12	213.50000
AU239F0	COWME12	2111.20000	COWCP12	27.11000
AU239F0	COWDM13	208.32000	COWME13	2040.00000
AU239F0	COWCP13	26.01000	COWDM14	203.14000
AU239F0	COWME14	1933.00000	COWCP14	24.36000
AU239F0	COWDM15	197.82000	COWME15	1774.00000
AU239F0	COWCP15	22.00000	COWDM16	189.00000
AU239F0	COWME16	1718.00000	COWCP16	21.13000
AU239F0	COWDM17	182.00000	COWME17	1666.00000
AU239F0	COWCP17	20.38000	COWDM18	172.70000
AU239F0	COWME18	1625.00000	COWCP18	19.79000
AU239F0	COWDM19	163.80000	COWME19	1574.00000
AU239F0	COWCP19	19.05000	COWDM20	156.38000
AU239F0	COWME20	1455.00000	COWCP20	19.01000
AU239F0	COWDM21	149.10000	COWME21	1052.00000
AU239F0	COWCP21	12.36000	COWDM22	142.80000
AU239F0	COWME22	764.00000	COWCP22	6.71000
AU239F0	COWDM23	137.76000	COWME23	734.00000
AU239F0	COWCP23	6.68000	COWDM24	135.10000
AU239F0	COWME24	704.00000	COWCP24	6.63000
AU239F0	COWDM25	135.80000	COWME25	736.00000
AU239F0	COWCP25	6.99000	COWDM26	136.50000
AU239F0	COWME26	774.00000	COWCP26	7.60000
AU239F0	MILKFAT	-150.00000	COWS	1.00000
AU239F0	AUCOWS	1.00000		
AU239F1	COWDM01	137.90000	COWME01	822.00000
AU239F1	COWCP01	8.41000	COWDM02	141.12000
AU239F1	COWME02	880.00000	COWCP02	9.37000
AU239F1	COWDM03	146.16000	COWME03	1365.00000
AU239F1	COWCP03	16.24000	COWDM04	183.82000
AU239F1	COWME04	1614.40000	COWCP04	22.67000
AU239F1	COWDM05	196.94000	COWME05	2041.20000
AU239F1	COWCP05	26.19000	COWDM06	202.16000
AU239F1	COWME06	2102.80000	COWCP06	27.19000
AU239F1	COWDM07	206.36000	COWME07	2185.40000
AU239F1	COWCP07	26.40000	COWDM08	210.14000
AU239F1	COWME08	2224.60000	COWCP08	28.97000
AU239F1	COWDM09	213.92000	COWME09	2216.20000
AU239F1	COWCP09	26.81000	COWDM10	215.04000
AU239F1	COWME10	2185.40000	COWCP10	28.30000
AU239F1	COWDM11	215.60000	COWME11	2153.20000
AU239F1	COWCP11	27.77000	COWDM12	213.50000
AU239F1	COWME12	2006.00000	COWCP12	25.47000
AU239F1	COWDM13	208.32000	COWME13	1835.00000
AU239F1	COWCP13	22.94000	COWDM14	203.14000
AU239F1	COWME14	1740.00000	COWCP14	21.49000

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AU239F1	COWDM15	197.82000	COWME15	1596.00000
AU239F1	COWCP15	19.31000	COWDM16	189.00000
AU239F1	COWME16	1546.00000	COWCP16	18.63000
AU239F1	COWDM17	182.00000	COWME17	1499.00000
AU239F1	COWCP17	17.99000	COWDM18	172.76000
AU239F1	COWME18	1463.00000	COWCP18	17.44000
AU239F1	COWDM19	163.80000	COWME19	1417.00000
AU239F1	COWCP19	16.79000	COWDM20	156.38000
AU239F1	COWME20	1414.00000	COWCP20	16.76000
AU239F1	COWDM21	149.10000	COWME21	1131.00000
AU239F1	COWCP21	12.38000	COWDM22	142.80000
AU239F1	COWME22	655.00000	COWCP22	8.12000
AU239F1	COWDM23	137.76000	COWME23	884.00000
AU239F1	COWCP23	9.06000	COWDM24	135.10000
AU239F1	COWME24	864.00000	COWCP24	9.20000
AU239F1	COWDM25	135.80000	COWME25	910.00000
AU239F1	COWCP25	9.86000	COWDM26	136.50000
AU239F1	COWME26	899.00000	COWCP26	9.66000
AU239F1	MILKFAT	-145.00000	COWS	1.00000
AU239F1	AUCOWS	1.00000		
AU239F2	COWDM01	137.90000	COWME01	822.00000
AU239F2	COWCP01	8.41000	COWDM02	141.12000
AU239F2	COWME02	886.00000	COWCP02	9.37000
AU239F2	COWDM03	146.16000	COWME03	1365.00000
AU239F2	COWCP03	16.24000	COWDM04	183.82000
AU239F2	COWME04	1814.40000	COWCP04	22.67000
AU239F2	COWDM05	198.94000	COWME05	2041.20000
AU239F2	COWCP05	26.19000	COWDM06	202.16000
AU239F2	COWME06	2102.80000	COWCP06	27.19000
AU239F2	COWDM07	206.36000	COWME07	2185.40000
AU239F2	COWCP07	28.40000	COWDM08	210.14000
AU239F2	COWME08	2224.60000	COWCP08	28.97000
AU239F2	COWDM09	213.92000	COWME09	2216.20000
AU239F2	COWCP09	28.81000	COWDM10	215.04000
AU239F2	COWME10	2185.40000	COWCP10	28.30000
AU239F2	COWDM11	215.60000	COWME11	2153.20000
AU239F2	COWCP11	27.77000	COWDM12	213.50000
AU239F2	COWME12	1900.00000	COWCP12	23.94000
AU239F2	COWDM13	208.32000	COWME13	1632.00000
AU239F2	COWCP13	19.88000	COWDM14	203.14000
AU239F2	COWME14	1547.00000	COWCP14	18.64000
AU239F2	COWDM15	197.82000	COWME15	1420.00000
AU239F2	COWCP15	16.76000	COWDM16	189.00000
AU239F2	COWME16	1375.00000	COWCP16	16.09000
AU239F2	COWDM17	182.00000	COWME17	1333.00000
AU239F2	COWCP17	15.48000	COWDM18	172.76000
AU239F2	COWME18	1301.00000	COWCP18	15.01000
AU239F2	COWDM19	163.80000	COWME19	1259.00000
AU239F2	COWCP19	14.42000	COWDM20	156.38000
AU239F2	COWME20	1257.00000	COWCP20	14.39000

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				FREE
AU239F2	COWDM21	149.10000	COWME21	1131.00000
AU239F2	COWCP21	12.38000	COWDM22	142.80000
AU239F2	COWME22	946.00000	COWCP22	9.60000
AU239F2	COWDM23	137.76000	COWME23	1084.00000
AU239F2	COWCP23	12.20000	COWDM24	135.10000
AU239F2	COWME24	1076.00000	COWCP24	12.45000
AU239F2	COWDM25	135.80000	COWME25	1143.00000
AU239F2	COWCP25	13.43000	COWDM26	136.50000
AU239F2	COWME26	993.00000	COWCP26	11.12000
AU239F2	MILKFAT	-139.00000	COWS	1.00000
AU239F2	AUCOWS	1.00000		
AU211F0	COWDM01	137.90000	COWME01	822.00000
AU211F0	COWCP01	9.06000	COWDM02	141.12000
AU211F0	COWME02	886.00000	COWCP02	9.39000
AU211F0	COWDM03	146.16000	COWME03	1365.00000
AU211F0	COWCP03	16.24000	COWDM04	183.82000
AU211F0	COWME04	1614.40000	COWCP04	22.67000
AU211F0	COWDM05	196.94000	COWME05	2041.20000
AU211F0	COWCP05	26.19000	COWDM06	202.16000
AU211F0	COWME06	2102.80000	COWCP06	27.19000
AU211F0	COWDM07	206.36000	COWME07	2185.40000
AU211F0	COWCP07	28.40000	COWDM08	210.14000
AU211F0	COWME08	2224.60000	COWCP08	28.97000
AU211F0	COWDM09	213.92000	COWME09	2216.20000
AU211F0	COWCP09	28.81000	COWDM10	215.04000
AU211F0	COWME10	2185.40000	COWCP10	28.30000
AU211F0	COWDM11	215.60000	COWME11	2153.20000
AU211F0	COWCP11	27.77000	COWDM12	213.50000
AU211F0	COWME12	2111.20000	COWCP12	27.11000
AU211F0	COWDM13	206.32000	COWME13	2040.00000
AU211F0	COWCP13	26.01000	COWDM14	203.14000
AU211F0	COWME14	1933.00000	COWCP14	24.36000
AU211F0	COWDM15	197.82000	COWME15	1774.00000
AU211F0	COWCP15	22.00000	COWDM16	189.00000
AU211F0	COWME16	1716.00000	COWCP16	21.13000
AU211F0	COWDM17	182.00000	COWME17	1666.00000
AU211F0	COWCP17	20.38000	COWDM18	172.70000
AU211F0	COWME18	1487.00000	COWCP18	19.79000
AU211F0	COWDM19	163.80000	COWME19	1004.00000
AU211F0	COWCP19	12.96000	COWDM20	156.38000
AU211F0	COWME20	724.00000	COWCP20	6.12000
AU211F0	COWDM21	149.10000	COWME21	752.00000
AU211F0	COWCP21	6.54000	COWDM22	142.80000
AU211F0	COWME22	764.00000	COWCP22	6.71000
AU211F0	COWDM23	137.76000	COWME23	734.00000
AU211F0	COWCP23	6.68000	COWDM24	135.10000
AU211F0	COWME24	704.00000	COWCP24	6.63000
AU211F0	COWDM25	135.80000	COWME25	736.00000
AU211F0	COWCP25	6.99000	COWDM26	136.50000
AU211F0	COWME26	774.00000	COWCP26	7.66000

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AU211F0	MILKFAT	-137.00000	COWS	1.00000
AU211F0	AUCOWS	1.00000		
AU211F1	COWDM01	137.90000	COWME01	822.00000
AU211F1	COWCP01	8.41000	COWDM02	141.12000
AU211F1	COWME02	886.00000	COWCP02	9.37000
AU211F1	COWDM03	140.16000	COWME03	1365.00000
AU211F1	COWCP03	16.24000	COWDM04	183.82000
AU211F1	COWME04	1614.40000	COWCP04	22.67000
AU211F1	COWDM05	198.94000	COWME05	2041.20000
AU211F1	COWCP05	26.19000	COWDM06	202.16000
AU211F1	COWME06	2102.80000	COWCP06	27.19000
AU211F1	COWDM07	206.36000	COWME07	2185.40000
AU211F1	COWCP07	28.40000	COWDM08	210.14000
AU211F1	COWME08	2224.60000	COWCP08	28.97000
AU211F1	COWDM09	213.92000	COWME09	2216.20000
AU211F1	COWCP09	28.81000	COWDM10	215.04000
AU211F1	COWME10	2185.40000	COWCP10	28.30000
AU211F1	COWDM11	215.60000	COWME11	2153.20000
AU211F1	COWCP11	27.77000	COWDM12	213.50000
AU211F1	COWME12	2008.00000	COWCP12	25.47000
AU211F1	COWDM13	208.32000	COWME13	1835.00000
AU211F1	COWCP13	22.94000	COWDM14	203.14000
AU211F1	COWME14	1740.00000	COWCP14	21.49000
AU211F1	COWDM15	197.82000	COWME15	1596.00000
AU211F1	COWCP15	19.31000	COWDM16	189.00000
AU211F1	COWME16	1546.00000	COWCP16	18.63000
AU211F1	COWDM17	182.00000	COWME17	1499.00000
AU211F1	COWCP17	17.99000	COWDM18	172.76000
AU211F1	COWME18	1463.00000	COWCP18	17.44000
AU211F1	COWDM19	163.80000	COWME19	1270.00000
AU211F1	COWCP19	14.54000	COWDM20	156.38000
AU211F1	COWME20	899.00000	COWCP20	8.81000
AU211F1	COWDM21	149.10000	COWME21	927.00000
AU211F1	COWCP21	9.18000	COWDM22	142.80000
AU211F1	COWME22	864.00000	COWCP22	8.25000
AU211F1	COWDM23	137.76000	COWME23	784.00000
AU211F1	COWCP23	7.45000	COWDM24	135.10000
AU211F1	COWME24	754.00000	COWCP24	7.39000
AU211F1	COWDM25	135.80000	COWME25	761.00000
AU211F1	COWCP25	7.50000	COWDM26	136.50000
AU211F1	COWME26	774.00000	COWCP26	7.66000
AU211F1	MILKFAT	-133.00000	COWS	1.00000
AU211F1	AUCOWS	1.00000		
AU211F2	COWDM01	137.90000	COWME01	822.00000
AU211F2	COWCP01	8.41000	COWDM02	141.12000
AU211F2	COWME02	886.00000	COWCP02	9.37000
AU211F2	COWDM03	140.16000	COWME03	1365.00000
AU211F2	COWCP03	16.24000	COWDM04	183.82000
AU211F2	COWME04	1614.40000	COWCP04	22.67000
AU211F2	COWDM05	198.94000	COWME05	2041.20000

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AU211F2	COWCP05	26.19000	COWDM06	202.16000
AU211F2	COWME06	2102.80000	COWCP06	27.19000
AU211F2	COWDM07	206.36000	COWME07	2185.40000
AU211F2	COWCP07	28.40000	COWDM08	210.14000
AU211F2	COWME08	2224.60000	COWCP08	28.97000
AU211F2	COWDM09	213.92000	COWME09	2216.20000
AU211F2	COWCP09	28.81000	COWDM10	215.04000
AU211F2	COWME10	2185.40000	COWCP10	28.30000
AU211F2	COWDM11	215.60000	COWME11	2153.20000
AU211F2	COWCP11	27.77000	COWDM12	213.50000
AU211F2	COWME12	1900.00000	COWCP12	23.94000
AU211F2	COWDM13	208.32000	COWME13	1632.00000
AU211F2	COWCP13	19.88000	COWDM14	203.14000
AU211F2	COWME14	1547.00000	COWCP14	18.64000
AU211F2	COWDM15	197.82000	COWME15	1420.00000
AU211F2	COWCP15	16.76000	COWDM16	189.00000
AU211F2	COWME16	1375.00000	COWCP16	16.09000
AU211F2	COWDM17	182.00000	COWME17	1333.00000
AU211F2	COWCP17	15.48000	COWDM18	172.76000
AU211F2	COWME18	1301.00000	COWCP18	15.01000
AU211F2	COWDM19	163.80000	COWME19	1270.00000
AU211F2	COWCP19	14.54000	COWDM20	156.38000
AU211F2	COWME20	974.00000	COWCP20	10.03000
AU211F2	COWDM21	149.10000	COWME21	1052.00000
AU211F2	COWCP21	11.26000	COWDM22	142.80000
AU211F2	COWME22	1014.00000	COWCP22	10.68000
AU211F2	COWDM23	137.76000	COWME23	934.00000
AU211F2	COWCP23	9.81000	COWDM24	135.10000
AU211F2	COWME24	904.00000	COWCP24	9.76000
AU211F2	COWDM25	135.80000	COWME25	836.00000
AU211F2	COWCP25	8.78000	COWDM26	136.50000
AU211F2	COWME26	774.00000	COWCP26	7.66000
AU211F2	MILKFAT	-129.00000	COWS	1.00000
AU211F2	AUCOWS	1.00000		
AU183F0	COWDM01	137.90000	COWME01	822.00000
AU183F0	COWCP01	9.06000	COWDM02	141.12000
AU183F0	COWME02	886.00000	COWCP02	9.39000
AU183F0	COWDM03	146.16000	COWME03	1365.00000
AU183F0	COWCP03	16.24000	COWDM04	183.82000
AU183F0	COWME04	1814.40000	COWCP04	22.67000
AU183F0	COWDM05	198.94000	COWME05	2041.20000
AU183F0	COWCP05	26.19000	COWDM06	202.16000
AU183F0	COWME06	2102.80000	COWCP06	27.19000
AU183F0	COWDM07	206.36000	COWME07	2185.40000
AU183F0	COWCP07	28.40000	COWDM08	210.14000
AU183F0	COWME08	2224.60000	COWCP08	28.97000
AU183F0	COWDM09	213.92000	COWME09	2216.20000
AU183F0	COWCP09	28.81000	COWDM10	215.04000
AU183F0	COWME10	2185.40000	COWCP10	28.30000
AU183F0	COWDM11	215.60000	COWME11	2153.20000

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AU183F0	COWCP11	27.77000	COWDM12	213.50000
AU183F0	COWME12	2111.20000	COWCP12	27.11000
AU183F0	COWDM13	208.32000	COWME13	2040.00000
AU183F0	COWCP13	26.01000	COWDM14	203.14000
AU183F0	COWME14	1933.00000	COWCP14	24.36000
AU183F0	COWDM15	197.82000	COWME15	1774.00000
AU183F0	COWCP15	22.00000	COWDM16	189.00000
AU183F0	COWME16	1579.00000	COWCP16	21.13000
AU183F0	COWDM17	182.00000	COWME17	1050.00000
AU183F0	COWCP17	13.98000	COWDM18	172.76000
AU183F0	COWME18	686.00000	COWCP18	5.42000
AU183F0	COWDM19	163.80000	COWME19	680.00000
AU183F0	COWCP19	5.37000	COWDM20	156.38000
AU183F0	COWME20	724.00000	COWCP20	6.12000
AU183F0	COWDM21	149.10000	COWME21	752.00000
AU183F0	COWCP21	6.54000	COWDM22	142.80000
AU183F0	COWME22	764.00000	COWCP22	6.71000
AU183F0	COWDM23	137.76000	COWME23	734.00000
AU183F0	COWCP23	6.68000	COWDM24	135.10000
AU183F0	COWME24	704.00000	COWCP24	6.63000
AU183F0	COWDM25	135.80000	COWME25	736.00000
AU183F0	COWCP25	6.99000	COWDM26	136.50000
AU183F0	COWME26	774.00000	COWCP26	7.66000
AU183F0	MILKFAT	-124.00000	COWS	1.00000
AU183F0	AUCOWS	1.00000		
AU183F1	COWDM01	137.90000	COWME01	822.00000
AU183F1	COWCP01	6.41000	COWDM02	141.12000
AU183F1	COWME02	886.00000	COWCP02	9.37000
AU183F1	COWDM03	146.16000	COWME03	1365.00000
AU183F1	COWCP03	16.24000	COWDM04	183.82000
AU183F1	COWME04	1814.40000	COWCP04	22.67000
AU183F1	COWDM05	198.94000	COWME05	2041.20000
AU183F1	COWCP05	26.19000	COWDM06	202.16000
AU183F1	COWME06	2102.80000	COWCP06	27.19000
AU183F1	COWDM07	206.36000	COWME07	2185.40000
AU183F1	COWCP07	28.40000	COWDM08	210.14000
AU183F1	COWME08	2224.60000	COWCP08	28.97000
AU183F1	COWDM09	213.92000	COWME09	2216.20000
AU183F1	COWCP09	28.81000	COWDM10	215.04000
AU183F1	COWME10	2185.40000	COWCP10	28.30000
AU183F1	COWDM11	215.60000	COWME11	2153.20000
AU183F1	COWCP11	27.77000	COWDM12	213.50000
AU183F1	COWME12	2006.00000	COWCP12	25.47000
AU183F1	COWDM13	208.32000	COWME13	1835.00000
AU183F1	COWCP13	22.94000	COWDM14	203.14000
AU183F1	COWME14	1740.00000	COWCP14	21.49000
AU183F1	COWDM15	197.82000	COWME15	1596.00000
AU183F1	COWCP15	19.31000	COWDM16	189.00000
AU183F1	COWME16	1546.00000	COWCP16	18.63000
AU183F1	COWDM17	182.00000	COWME17	1237.00000

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AU183F1	COWCP17	13.98000	COWDM18	172.76000
AU183F1	COWME18	686.00000	COWCP18	5.14000
AU183F1	COWDM19	163.80000	COWME19	680.00000
AU183F1	COWCP19	5.10000	COWDM20	156.38000
AU183F1	COWME20	724.00000	COWCP20	6.08000
AU183F1	COWDM21	149.10000	COWME21	752.00000
AU183F1	COWCP21	6.54000	COWDM22	142.80000
AU183F1	COWME22	764.00000	COWCP22	6.72000
AU183F1	COWDM23	137.76000	COWME23	734.00000
AU183F1	COWCP23	6.68000	COWDM24	135.10000
AU183F1	COWME24	704.00000	COWCP24	6.62000
AU183F1	COWDM25	135.80000	COWME25	736.00000
AU183F1	COWCP25	7.14000	COWDM26	136.50000
AU183F1	COWME26	774.00000	COWCP26	7.66000
AU183F1	MILKFAT	-121.00000	COWS	1.00000
AU183F1	AUCOWS	1.00000		
AU183F2	COWDM01	137.90000	COWME01	822.00000
AU183F2	COWCP01	6.41000	COWDM02	141.12000
AU183F2	COWME02	686.00000	COWCP02	9.37000
AU183F2	COWDM03	146.16000	COWME03	1365.00000
AU183F2	COWCP03	16.24000	COWDM04	183.82000
AU183F2	COWME04	1614.40000	COWCP04	22.67000
AU183F2	COWDM05	198.94000	COWME05	2041.20000
AU183F2	COWCP05	26.19000	COWDM06	202.16000
AU183F2	COWME06	2102.80000	COWCP06	27.19000
AU183F2	COWDM07	206.36000	COWME07	2185.40000
AU183F2	COWCP07	20.40000	COWDM08	210.14000
AU183F2	COWME08	2224.60000	COWCP08	28.97000
AU183F2	COWDM09	213.92000	COWME09	2216.20000
AU183F2	COWCP09	28.81000	COWDM10	215.04000
AU183F2	COWME10	2185.40000	COWCP10	28.30000
AU183F2	COWDM11	215.60000	COWME11	2153.20000
AU183F2	COWCP11	27.77000	COWDM12	213.50000
AU183F2	COWME12	1900.00000	COWCP12	23.94000
AU183F2	COWDM13	208.32000	COWME13	1632.00000
AU183F2	COWCP13	19.88000	COWDM14	203.14000
AU183F2	COWME14	1547.00000	COWCP14	18.64000
AU183F2	COWDM15	197.82000	COWME15	1420.00000
AU183F2	COWCP15	16.76000	COWDM16	189.00000
AU183F2	COWME16	1375.00000	COWCP16	16.09000
AU183F2	COWDM17	182.00000	COWME17	1237.00000
AU183F2	COWCP17	13.98000	COWDM18	172.76000
AU183F2	COWME18	686.00000	COWCP18	5.14000
AU183F2	COWDM19	163.80000	COWME19	680.00000
AU183F2	COWCP19	6.28000	COWDM20	156.38000
AU183F2	COWME20	774.00000	COWCP20	6.89000
AU183F2	COWDM21	149.10000	COWME21	802.00000
AU183F2	COWCP21	7.34000	COWDM22	142.80000
AU183F2	COWME22	814.00000	COWCP22	7.45000
AU183F2	COWDM23	137.76000	COWME23	784.00000

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AU183F2	COWCP23	7.53000	COWDM24	135.10000
AU183F2	COWME24	779.00000	COWCP24	7.79000
AU183F2	COWDM25	135.80000	COWME25	836.00000
AU183F2	COWCP25	8.74000	COWDM26	136.50000
AU183F2	COWME26	774.00000	COWCP26	7.66000
AU183F2	MILKFAT	-117.00000	COWS	1.00000
AU183F2	AUCOWS	1.00000		
SELLMF	MILKFAT	1.00000	MARGIN	1.60000
MEALBUY	MEALDM	-1.00000	MARGIN	-0.15000
MEALFG01	MEALDM	1.00000	COWDM01	-1.00000
MEALFG01	COWME01	-11.50000	COWCP01	-0.20000
MEALFG02	MEALDM	1.00000	COWDM02	-1.00000
MEALFG02	COWME02	-11.50000	COWCP02	-0.20000
MEALFG03	MEALDM	1.00000	COWDM03	-1.00000
MEALFG03	COWME03	-11.50000	COWCP03	-0.20000
MEALFG04	MEALDM	1.00000	COWDM04	-1.00000
MEALFG04	COWME04	-11.50000	COWCP04	-0.20000
MEALFG05	MEALDM	1.00000	COWDM05	-1.00000
MEALFG05	COWME05	-11.50000	COWCP05	-0.20000
MEALFG06	MEALDM	1.00000	COWDM06	-1.00000
MEALFG06	COWME06	-11.50000	COWCP06	-0.20000
MEALFG07	MEALDM	1.00000	COWDM07	-1.00000
MEALFG07	COWME07	-11.50000	COWCP07	-0.20000
MEALFG08	MEALDM	1.00000	COWDM08	-1.00000
MEALFG08	COWME08	-11.50000	COWCP08	-0.20000
MEALFG09	MEALDM	1.00000	COWDM09	-1.00000
MEALFG09	COWME09	-11.50000	COWCP09	-0.20000
MEALFG10	MEALDM	1.00000	COWDM10	-1.00000
MEALFG10	COWME10	-11.50000	COWCP10	-0.20000
MEALFG11	MEALDM	1.00000	COWDM11	-1.00000
MEALFG11	COWME11	-11.50000	COWCP11	-0.20000
MEALFG12	MEALDM	1.00000	COWDM12	-1.00000
MEALFG12	COWME12	-11.50000	COWCP12	-0.20000
MEALFG13	MEALDM	1.00000	COWDM13	-1.00000
MEALFG13	COWME13	-11.50000	COWCP13	-0.20000
MEALFG14	MEALDM	1.00000	COWDM14	-1.00000
MEALFG14	COWME14	-11.50000	COWCP14	-0.20000
MEALFG15	MEALDM	1.00000	COWDM15	-1.00000
MEALFG15	COWME15	-11.50000	COWCP15	-0.20000
MEALFG16	MEALDM	1.00000	COWDM16	-1.00000
MEALFG16	COWME16	-11.50000	COWCP16	-0.20000
MEALFG17	MEALDM	1.00000	COWDM17	-1.00000
MEALFG17	COWME17	-11.50000	COWCP17	-0.20000
MEALFG18	MEALDM	1.00000	COWDM18	-1.00000
MEALFG18	COWME18	-11.50000	COWCP18	-0.20000
MEALFG19	MEALDM	1.00000	COWDM19	-1.00000
MEALFG19	COWME19	-11.50000	COWCP19	-0.20000
MEALFG20	MEALDM	1.00000	COWDM20	-1.00000
MEALFG20	COWME20	-11.50000	COWCP20	-0.20000
MEALFG21	MEALDM	1.00000	COWDM21	-1.00000

FREE

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    MEALFG21   COWME21        -11.50000   COWCP21      -0.20000
    MEALFG22   MEALDM           1.00000   COWDM22      -1.00000
    MEALFG22   COWME22        -11.50000   COWCP22      -0.20000
    MEALFG23   MEALDM           1.00000   COWDM23      -1.00000
    MEALFG23   COWME23        -11.50000   COWCP23      -0.20000
    MEALFG24   MEALDM           1.00000   COWDM24      -1.00000
    MEALFG24   COWME24        -11.50000   COWCP24      -0.20000
    MEALFG25   MEALDM           1.00000   COWDM25      -1.00000
    MEALFG25   COWME25        -11.50000   COWCP25      -0.20000
    MEALFG26   MEALDM           1.00000   COWDM26      -1.00000
    MEALFG26   COWME26        -11.50000   COWCP26      -0.20000
RHS
    RHS1       LAND01          50.00000   LAND02       50.00000
    RHS1       LAND03          50.00000   LAND04       50.00000
    RHS1       LAND05          50.00000   LAND06       50.00000
    RHS1       LAND07          50.00000   LAND08       50.00000
    RHS1       LAND09          50.00000   LAND10       50.00000
    RHS1       LAND11          50.00000   LAND12       50.00000
    RHS1       LAND13          50.00000   LAND14       50.00000
    RHS1       LAND15          50.00000   LAND16       50.00000
    RHS1       LAND17          50.00000   LAND18       50.00000
    RHS1       LAND19          50.00000   LAND20       50.00000
    RHS1       LAND21          50.00000   LAND22       50.00000
    RHS1       LAND23          50.00000   LAND24       50.00000
    RHS1       LAND25          50.00000   LAND26       50.00000
    RHS1       JYCOWS          79.00000   AUCOWS       78.00000
BOUNDS
 UP BND1       MZSGPR          11.00000
 FX BND1       OASGFG01          .
 FX BND1       OASGFG02          .
 FX BND1       OASGFG03          .
 FX BND1       OASGFG04          .
 FX BND1       OASGFG05          .
 FX BND1       OASGFG06          .
 FX BND1       OASGFG07          .
 FX BND1       OASGFG08          .
 FX BND1       OASGFG21          .
 FX BND1       OASGFG22          .
 FX BND1       OASGFG23          .
 FX BND1       OASGFG24          .
 FX BND1       OASGFG25          .
 FX BND1       OASGFG26          .
 FX BND1       JFLOCV01          .
 FX BND1       JFLOCV03          .
 FX BND1       JFLOCV05          .
 FX BND1       JFLOCV07          .
 FX BND1       JFLOCV21          .
 FX BND1       JFLOCV23          .
 FX BND1       JFLOCV25          .
 FX BND1       JFLOCV19          .
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MASSEY UN

FREE

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 FX BND1        JFLOCV17      ;
 FX BND1        JFLOCV15      ;
 FX BND1        JFLOCV13      ;
ENDATA
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APPENDIX E

MODELLING THE CONTRIBUTION OF FORAGE CROPS TO PRODUCTION, PROFITABILITY AND STABILITY OF NORTH ISLAND DAIRY SYSTEMS

C. P. MILLER

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