THE APPLICATION OF EXPERT SYSTEM METHODOLOGY TO FEED MANAGEMENT

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Preface

Computers are becoming an increasing part of the range of tools available to farmers in carrying out their farm management activities. However, there is a range of utilisation of computers within the farming sector. This Research Report provides an application which farmers would find of value in assisting with decision regarding feed conservation and feed surplus utilisation. Earlier publications in this Series present systems applicable to drenching decisions and weaning and a farmer evaluation of the use of the type of computer assistance.

This final publication in the series incorporates many of the developments described in earlier reports. This successful research subject has collected information from producers and developed computer based support systems which can provide valuable assistance in decision making.

The Agribusiness and Economics Research Unit is pleased to be associated with this research project and is grateful to the AGMARDT Trust for funding the project.

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CHAPTER ONE

INTRODUCTION

The efficient production of animal feed and its utilisation is a vital component of the New Zealand economy. Pastoral products constitute some 72% of land based primary production exports which in turn make up 63% of all exports. This leaves pastoral products at 45% of all exports (Nuthall and Bishop-Hurley, 1994). Furthermore, it would appear from per hectare pasture production figures relative to animal numbers carried that greater efficiency is possible (Nuthall and Bishop-Hurley, 1994). This means either greater exports from the same resources, or a decrease in the inputs necessary to achieve a similar output, are possible.

Improving efficiency can result from greater physical production through better technology (for example, better cultivars, better fertilization policy, a better understanding of disease symptoms and so on), or through better utilisation (management) of what is produced. This study is concerned with the latter aspect of efficiency.

The majority of farmers make feed management decisions (when to shift stock, how much fodder to conserve, when to feed hay, and how much to feed, when to purchase additional animals, when to wean, how many animals to have grazing an area .....) without any kind of formal analysis. That is, they rely on experience and hunches. This occurs despite the availability of simple management assistance techniques such as formal feed budgeting (calculating the period by period supply and demand for feed and subsequent adjustments to ensure demand does not exceed supply) through to quite complex planning utilities like linear programming and systems simulation. Effectively contemporary research and development scientists have not yet as yet succeeded in producing acceptable models. Part of the problem, no doubt, is the lack of appropriate computer power and the associated software. Currently some 19% of New Zealand farmers have a business computer (Nuthall and Bishop-Hurley, 1994), and some 21% maintain they use formal feed budgeting.

Another reason for not using formal analyses could be that currently available feed management techniques are too complex and time consuming to implement relative to the perceived gains. If systems that are rather more 'user friendly' were available, farmers might well find them acceptable. One such technique that many regard as having promise is a branch of artificial intelligence called 'expert systems'. Bramer (1986) defines such a system as:

> 'A computing system which consists of organised human knowledge concerning some specific area of expertise sufficient to perform as a skilful and cost effective consultant'.

The basis of the concept is that experts (consultants) can make advantageous decisions almost instantaneously after observing and noting all the parameter values impinging on the problem.

Their decision and recommendation is based on stored knowledge built up through experience and consists of many IF-THEN rules (rules of thumb). An expert system, then, is a package which contains all this knowledge (rules) and can mimic the expert.

The study reported in this bulletin involves the evaluation of three feed management expert systems. The objective was to test the hypothesis that an appropriate expert system will provide practical on farm guidance to farm managers. An equally important objective was to actually develop some expert systems capable of use by farmers. Clearly, the two objectives go hand in hand.

Around the calendar whole farm feed management involves large numbers of problem areas and decisions. This complexity means it was necessary to select components of the total problem for development into suitable expert systems. Based on farmers' common problems (Nuthall and Bishop-Hurley, 1994) and an objective of exploring different types of systems, expert systems were developed for the three problem areas of lamb weaning decisions, deciding whether to drench a mob of ewes and lambs, and for the decision on how to utilise surplus pasture production. A full description of each of these expert systems is given in Bishop-Hurley and Nuthall, (1994 (a), (b) and (c)). The drenching problem is a very specific and focused problem that involves diagnostic conclusions, whereas the weaning and surplus pasture problems are more general, though the weaning problem is to a certain extent specific in that the choice is to either wean or wait a while longer. Deciding whether a surplus exists, and if so, what to do with it involves considering many more options (conserve, sell, buy more stock, leave in-situ) and is therefore at the other end of the scale in terms of potential complexity. The choice of these systems meant the farmers were exposed to a full range of possibilities. Having developed and tested the systems, they were sent to a sample of farmers who were asked to experiment and use the systems prior to recording their use and views of the systems. These responses form the basis of this report and evaluation.

The interface of any computer system is likely to affect its acceptance and use. Questions such as 'does the user want to be able to easily move forward and backwards through the system to enable review and changes?, is it better to input data through the keyboard or through the use of a mouse?, can summary data be requested (e.g. current level of stored dry matter), or is it better to request the components of summary data (paddock by paddock pasture heights and densities) and from this calculate the data required' all need to be addressed. The list of unknowns is quite extensive - this study provides answers to some of these design factors. Other questions of relevance include deciding on the appropriate form and length of decision explanations, the best way to present a conclusion, whether providing graphic and photographic representations of choices are useful, and so on.

Given the human genetic and environmental influence differences and variability that exist, it is also highly likely that the views and opinions of individual farmers will vary. In developing and assessing expert systems it is of value if some of this variation can be explained and subsequently predicted. It is, therefore, also hypothesised that individuals' personality affects their use of, and subsequent benefit obtained from, a system. Thus, questions of whether personality affects a farmer's opinion of the benefits, of the form, and of the best way of using a particular system are all relevant. If personality is in fact important then it should be necessary to develop a range of systems as clearly a diversity of personalities exist.

There is a wide range of views of what constitutes personality and how it can be described. Similarly, the business of quantifying a personality has always been the subject of considerable discussion and research. For the purpose of this study personality has been (character and temperament) defined according to Keirsey and Bates (1984) who provide a series of questions that can be used to elucidate an individual's categorization. Keirsey and Bates draw upon the work of several psychologists, but more particularly Myers (1962) and Jung (1923). According to these workers, individuals can be classified through considering four continuous parameters - extroversion/introversion, sensation/intuitiveness, thinking/feeling and judging/receiving. The extroversion/introversion parameter is largely self explanatory, 'sensibles' rely on experience and facts whereas the intuitive person relies on hunches and imagination. Individuals can be classed, therefore, into being either extroverts or introverts, and either sensate or intuitive. In reality of course, there is a full spectrum between the extremes. Thinking people are defined as being logical and objective whereas at the other end of this category, 'feeling' people make decisions based on emotion. Finally, 'judging' personalities make decisions quickly, deadlines are important to them and 'work before play' tends to be a maxim. In contrast, 'perceivers' keep their options open and feel uncomfortable if they have to make decisions before they are ready to do so.

Keirsey and Bates provide a battery of seventy questions, the answers to which enable classification of a subject into one of the sixteen basic personality types made up of the combinations of extroversion (E), introversion (I), sensation (S) or intuitive (N), thinking (T) or feeling (F) and judging(J) or perceiving (P). Two examples of the questions are 'are you more inclined to be easy to approach or somewhat reserved?', and 'are you drawn more to fundamentals or overtones?' The answer to each gives a mark towards one of the types. If there are more positive extrovert answers than introvert ones the individual is classified as extrovert. On the other hand, if the number are equal then the person is neutral so that the number of categories is in fact greater than sixteen. This approach, however, is a simplification as there is more than likely an infinite number of personalities.

The hypothesis proposed is that farmers' attitude to computer systems, their preferences and their views on expert systems could well be influenced by their character type. For example, introverts may be content to use packages that are long and involved, sensates may not accept computer based conclusions as they lack the imagination to conceive of how a software package can assist in their very practical problem. Judging people, on the other hand, may be quite happy to use a computer system as it assists them to make a quick decision, whereas feeling people might be quite the opposite as the computer package may appear to take too much of a clinical approach. This study, then, was also set up to explore whether personality was in fact relevant in assessing expert system packages and their value and use.

This report has been divided into five sections besides this introduction. The next chapter contains a discussion on the background to the expert systems, the following chapter has details of the form of the systems as described by example screen pictures. The details of the farmer respondents are covered in the next chapter and this is followed by the presentation of the collected data and its analysis. The report is rounded off with a chapter containing a discussion and conclusions.

CHAPTER TWO

BACKGROUND TO THE SYSTEMS

2.1 Expert Systems as Decision Tools

The concept of a computer based expert system has been in existence for many years. Many agricultural systems have been developed. Despite this, very few have been extensively evaluated and few, if any, appear to have been used by farmers for any length of time.

The process of creating an expert system is very simple in theory, but very much more difficult in practice for a number of reasons including the fact that very few experts can actually unambiguously describe the procedures and rules they use and, where they can approach this state, there are often such a large number of rules and 'ifs and buts' that the computer package necessary to encapsulate their procedure is often very complex.

Developing an expert system involves defining the bounds of the problem, isolating suitable experts, formalizing their knowledge and decision procedures, encapsulating this in, usually, a computer package and, finally, validating the system. Many books have been written describing this system. In the farm management area Evans, Mondor and Flaten (1989) have produced a useful synopsis. In the end expert systems take many different forms as most problems are unique. Furthermore, different workers have a range of views of the best way to construct a system. Batchelor, McLendon and Wetzstein (1992), for example, compare and contrast two approaches to knowledge acquisition. One approach might be to find out the exact thought process an expert follows and then to mimic these, another might consider the end results and not be so concerned with exact mimicry. In that expert system development is not an exact science there will be a constant discussion on the best approach.

The types of agricultural problems that have been developed with expert systems are many and varied and range from purely financial analysis through to technical advice systems. Examples are McGrann, Karkosh and Osborne's (1989) system which proffers advice on whether a banker should lend to a farmer (based on past profitability and current indebtedness), Oltjen et al's (1990) package for deciding whether a particular cow should be culled (based on the expected value of each cow and various culling rules involving health, condition score and so on), and McGregor and Thorton's (1990) winter wheat cultivar selection package which enables a farmer to sort out an appropriate cultivar for specific fields.

Irrigation scheme management formed the basis of Srinivasan et al's (1991) expert system developed for use in Thailand. This system relied on site specific information and a new index based on the stream flowrates. Land allocation between competing crops is another common more broadly based decision often tackled in a research setting with a linear programming model. Nevo and Amir (1991), however, approached this problem through an expert system. It is often argued that mechanistic linear programming fails to encapsulate

some of the subtleties necessary in designing a successful crop rotation whereas there are no such strictures on an expert system. Indeed, whatever is appropriate and used by the experts as guidelines can be built in.

In Nero and Amir's case they define and use what they call crop suitability factors. Furthermore, there is nothing to stop multi-faceted systems being developed and one such example is provided by Nevo, Oad and Podmore (1994) in which linear programming is combined with a traditional expert system to create an integrated crop planning system. Closer to the feed management problem Gray et al (1992) developed a dairy cow drying off expert system based on the more traditional IF-THEN rule system. Many more examples could be quoted of systems that have been reported in the literature. Those quoted, however, do indicate the range of work that has been undertaken. As a rule the reports talk about development and validation, but seldom about farmer use and experience.

With respect to feed planning and grazing management there have been only one or two systems developed. Gray et al, as noted above, worked on the cow drying off problem and this clearly has an important feeding component. Most feed planning work has concerned feed budgeting and associated models. Examples include Durham and Nieuwoudt (1982), Baars and Rollo (1987) Baars (1990), Nicol (1987), and Lodge and Frecker (1990). This latter work is termed an expert system but in reality it is an automated feed supply and demand calculator. Effectively, there is considerable scope for developing feed management systems for use in grazing situations. The work described in this Report is a step in this direction.

Formulating and committing to paper an expert's knowledge (knowledge acquisition) is, as noted earlier, the central and key component of developing an expert system. Furthermore, it is the most difficult component. Many authors have written in this area. Spangler et al (1989) is one such example and generally reviews the major approaches possible. In the end the knowledge acquisition must be regarded as much an art as a methodical and scientific procedure. One approach, however, that often seems to be ignored is the collation, integration and use of research results. While an expert should clearly build research results into their expertise, it is also possible to bypass the expert and use the published results in formulating rules in cases where the research provides a complete and logical answer. In this current work the case of drenching for internal parasites is an example. Essentially the rule set evolved from published work rather than experts, though they were used for checking purposes.

Besides ensuring the computer package works as intended, the validation of the system is clearly important. Various validation and evaluation procedures have been reported. Hochman and Peason (1991), for example, report how they took a number of actual farm cases and fed them into an expert system for recommendations. These same cases were given to a number of advisors and then all recommendations were presented to four independent experts for rating. The experts did not know whether the recommendation had originated form the computer package or an advisor. As it turned out, their computer package results were rated higher than those of the advisors. Other workers have used a similar procedure. Harrison (1991) provides a review of the main methods and discusses the question of statistical tests. Harrison (p 282) concludes 'There is perhaps no better test of an expert system than whether farmers are prepared to make commercial decisions based on the recommendations it generates' This point is hard to refute. Huirne et al (1991), in

outlining their approach to validating a sow-herd performance expert system, talk about some of the difficulties in evaluating a system that does not have an objective yardstick. In many cases the experts cannot agree on all aspects.

Thus, while every effort must be made to ensure experts agree with an expert systems' conclusion, in the end it is the farmer that must decide whether an expert system is useful. It is this approach that has been taken in this study. The procedure used did not involve an extensive formal validation, but rather an heuristic process of working with a range of experts to ensure they accepted the basis of the systems. Once this point was reached, the packages were given to the farmers for assessment. It must also be noted that for any one problem there may be in fact a range of equally acceptable solutions even given a single objective. This is why, in some cases, experts will provide different answers that the majority of farmers might be indifferent between, or at least only distinguish between them on minor points and factors.

Acceptability to farmers probably depends on a number of factors including the efficacy of the results. Some of these factors will be the ease of use, the way in which the questions are presented, the degree and type of assistance and help provided, and so on. All these presentation factors can be collectively called the interface and provide as much of a challenge to the developer as the knowledge base itself.

A number of authors have produced articles on creating a good interface, but most of these have been personal views, even if based on years of experience. Few objective studies have been reported, though again it might be argued that the users have clearly indicated their preference through the types of software purchased and actually used. Furthermore, most commercial packages undergo extensive field testing over which time the testers provide strongly worded suggestions - again the development process is heuristic.

Indeed, most articles stress the need for the potential users to be a key component of any design and development procedure. Gould and Lewis (1985) for example talk about the 'early and continual focus on users' (p 300). Similarly, Morland (1983) stresses that systems should be designed 'for the people'. In another article Gould, Boies and Lewis (1991) note that their recommended procedures do not seem to have been followed and this might be due to managers not allowing sufficient iteration and heuristics. This could well be the case in time and budget constrained situations faced in most commercial operations. In the end this narrow view could be counterproductive. A formal validation process that simply analyses a package and concludes it is acceptable may not be appropriate (have details of an unacceptable system ever been reported?). In general, the principles for a good interface design in expert systems are unlikely to be different from those applicable to other applications. Cradwick (1991) specifically addresses expert system interfaces but in reality discusses principles that apply to all systems.

As noted, to date most work on evaluating and developing interfaces has been informal. This study, however, was specifically designed to obtain users' views of the interface. Indeed, alternative systems were developed to enable comparisons to be made. The first systems developed were regarded as prototypes and were used to draw conclusions for the development of improved systems. This kind of approach has only generally appeared in recent years. For example, Simpson et al (1993) set out a framework for the objective assessment of a system, and demonstrates this with an example. They note that part of the

evaluation relates to how easy it is to learn the package and so discuss evaluating the learning process itself. Davis and Bostrom (1993) emphasise this point and objectively compare two training methods. In the study described in this Report it was felt unnecessary to analyze training methods as it was believed the packages had been so well constructed that they were self evident. In that all the users had no problems in installing the system and subsequently using them without any personal contact at all, clearly indicates that this was in fact the case.

Finally, it should be noted that training has more than one component. There is the training related to using the package itself, but using the package may also provide training in the subject of the package. That is while the package can provide an answer to the decision problem, the provision of the answer may be secondary to the fact that using the package trains the farmer in the components and analyses of the decision problem. Evidence will be presented later that indicates this decision training may well be as important as the decision conclusion itself. Indeed Gum and Blank (1990) go so far as to talk about designing an expert system specifically for extension purposes. This is an area that has not had sufficient attention in the past.

2.2 Developing the Feed Management Systems

It was initially assumed that an expert system to cover most aspects of grazing management would be developed. It was very soon obvious that this was an impossible task given the funds and time available. Discussions with a number of 'field experts', people with professional experience of farm consultancy, research, teaching and extension, indicated that a common sub-problem was that of deciding whether to wean a mob of lambs. Furthermore, this was a relatively easily bounded problem that was seen to be tractable and consequently eminently suitable for using as a means to evolve procedures for the development of further systems. The overall approach, then, was to divide the grazing management problem into a series of sub-problems.

As noted, interface design is important. Consequently four alternative forms of the weaning expert system were developed and exposed to the field experts for formal analysis. The rules and conclusions giving rise to the knowledge base were identical, thus allowing a comparison of the interfaces. One system was developed using an expert system shell (VPEXPERT (1987)), and the others using an objected orientated programming package (Level 5 (1990)) as the latter allowed more sophistication and control in the interface. The differences are described in the next chapter, but essentially the first system had simple questions, one per screen, whereas system four was completely mouse controlled with all questions on one screen.

The interface conclusions reached were then used to further enhance the weaning system. The result was three slightly different packages developed using another object orientated programming system (KnowledgePro Windows (1991)). This particular package was used as it enabled developing run-time systems for distribution to farmers without large royalties being due. Again, details of these systems are presented in the next chapter.

Reasonable success was obtained from the weaning system. Rather than select further sub-systems based on field experts' views of major problems it was decided to conduct a national survey to elucidate producers' views of their important problems. The detailed results of this

study are reported in Nuthall and Bishop-Hurley (1994). A stratified sample of 3097 properties was selected and each sent an extensive questionnaire.

Following the attainment of a response rate of 37.1 percent a non-responders survey was conducted. This suggested the responding sample was representative.

Besides enquiring about feed management problems information was obtained on the farmers' personal attributes, on their feed management practices, including feed budgeting and on their ownership and use of computers. Some 20 percent of the farmers indicated they carried out formal feed budgeting (it is suspected the definition of 'formal' was liberally interpreted. It was defined as calculating and writing down estimates of feed supply and demand), 24 percent said they had a computer and 19 percent used a computer for business. It was believed important to enquire about computer use as the development of management aids is very likely to depend on computer ownership and use. A wide range of other data was collected and analyzed. This is fully reported in the Report.

Of immediate significance is the fact that two feed related problems seen as being important were the management of surplus pasture and the drenching of stock for internal parasite control. The latter is no doubt seen as important due to the reports of the build up of resistant strains. While other important problem areas were also mentioned, the fact that these two represented quite different aspects of feed management meant they could be used to explore the full spectrum of feed management expert system possibilities. Thus the development of the drenching and feed surplus systems using KnowledgePro (1991) as the development tool was undertaken.

All packages were developed and validated in conjunction with a range of experts (as reported in the Research Reports (Bishop-Hurley and Nuthall (1994), a, b and c). The drenching system relied heavily on a review of the literature as the source of the rules, but it was then checked using a committee of experts. The weaning system relied on research results, to a certain extent, for its knowledge base, but the experts also had an input through the validation process. On the other hand, the surplus system relied on experts for both its development and validation. Clearly, any one system must be developed using the best information available, and this will vary from case to case.

Once developed the packages had manuals developed in the form of both installation and 'how-to-use' booklets. These, together with the compiled systems, were then forwarded to suitable volunteering farmers for use and evaluation. Three advanced versions of the weaning systems were created for distribution to enable the farmers to express their views on some interface variations. The other systems were subsequently developed and distributed in turn over a period of 12 months. The weaning systems were forwarded in February 1993, the drenching package in November 1993, and the surplus system in February 1994. The data obtained from the farmers, and its analysis, is presented in chapter five. The farmers' detailed views on the components and nature of each specific system is reported in Bishop-Hurley and Nuthall ((1994), a, b and c).

CHAPTER THREE

DETAILS OF THE TRIAL SYSTEMS

3.1 Introduction

While full details of the knowledge bases are provided in Bishop-Hurley and Nuthall ((1994) a, b and c), it is necessary to provide details of the appearances of the packages here to enable an appreciation of the analysis. The evaluation analyses of the package rules and advice, however, are self explanatory and do not require an understanding of the specific knowledge bases. This chapter contains these appearance descriptions largely through providing 'screen dumps'. As developing the farmer distributed packages relied on initial field expert trials, the results of these trials are also presented.

3.2 The Weaning Systems Developed for the Field Expert Trials

Seven field experts were asked to use four different versions of the initial weaning system and to comment on various factors. The responses were recorded using a questionnaire. In addition, the field experts were asked to record details of their computer experience and to answer a series of questions designed to ascertain their personality type as outlined in chapter one. Appendix one contains the questionnaire used for recording their general views and comments, appendices two and three the questionnaire obtaining computer experience, system comparison and personality data respectively.

Figures one to nine contain screen excerpts from each of the four systems which, as noted earlier, had identical weaning rule bases and conclusions. An examination of these tables clearly indicates the differences between the versions. Figures one to three represent system one developed using the VPExpert (1987) shell. Figure one A is the introductory screen whereas Figure one B is an example of the questions asked on a one per screen basis. Figure two A is another data entry question example that contains some help instructions. Figure two B contains a list of all the questions asked and some example answers together with the conclusion emanating from the sample set of answers. Figure three A is an example of an explanation of the conclusion whereas Figure three B shows the options available after a particular consultation has been completed. Overall, the questioning procedure is rather slow given the one question per screen approach, and, furthermore, the new user is somewhat unsure where the process is leading as each question appears to be independent.

Systems two to four are quite different to system one and make varying degrees of mouse use (mechanical pointing device). System two has the same 'one question per screen' approach as system one but has a more professional look being coded in a modern graphical user interface (GUI) package (Level 5 (1990)). It also requires some keyboard data entry. System three is similar in the questioning procedure, but uses a presented range of options (pick list) as answers to each questions which are selected by pointing and clicking with the mouse. Finally, system four combines all questions into one screen so that the totality of the situation is obvious to the user. It is also completely mouse controlled.

FIGURE ONE
EXPERIMENTAL WEANING SYSTEM ONE

A. INTRODUCTION

```
                    Weaning Expert

              An expert system to advise you when
                to wean a mob of ewes and lambs.

You would use this expert system if you wish to know whether or
not to wean a specific mob of ewes and lambs.   It will ask you
a series of questions  and then render  an opinion based on the
answers given.  Then you will be asked if you wish  to be given
the reason(s) for the opinion.  The question for  consideration
is, should a given mob of ewes and lambs be weaned or not?

                    (Press any key to begin.)
```

B. DATA ENTRY

```
What is the average live weight (kgs) of the lambs in the mob?

 15
-----------------------------------------------------------------
Enter to select     ? & Enter for Unknown     /Q to quit
```

FIGURE TWO
EXPERIMENTAL WEANING SYSTEM ONE

A. DATA ENTRY

```
What is the quality of the available lamb feed.

 - Good quality,     Pasture with 30% legume content
                     Lucerne stand preferably older with some weeds.
 - Average quality,  Pasture that has some legume and fresh grass in
                     bottom.
 - Poor quality,     Pasture that is rank gone to seed, with no or
                     very little legume.

There should be at least two weeks of feed in front of the lambs?

 Good                        Average                    Poor
-------------------------------------------------------------------
↑ ↓ →← Enter to select  END to complete  /Q to Quit  ? for Unknown
```

B. RESULT PRESENTATION

```
                          Weaning Expert

                 An expert system to advise you when
                   to wean a mob of ewes and lambs.

    Age of Lambs: 10 weeks
 Weight of Lambs: 15 kgs
      Mob Status: Mixture
   Mob Prolificy: No
   Feed Quantity: Medium
    Feed Quality: Poor

You should NOT wean this mob of ewes and lambs.

Do you want an explanation of the recommendation?

 Yes                         No
-------------------------------------------------------------------
↑ ↓ →← Enter to select  END to complete  /Q to Quit  ? for Unknown
```

FIGURE THREE
EXPERIMENTAL WEANING SYSTEM ONE

A. EXPLANATION OF A CONCLUSION

To wean early good quality legume pasture needs to be available for the lambs to go onto. Without good quality pasture for the lambs to go onto they are better left with the ewes. Ewes convert poor quality feed into a high quality energy source for the lambs in the form of milk. By weaning time some good quality legume pasture needs to be ready for the lambs to go onto. One way of achieving this is to make supplements from the surplus feed. After a few weeks these paddocks will provide the high quality feed needed by the lambs at weaning time.

(Press any key to continue.)

B. OPTIONS AVAILABLE FOLLOWING A CONSULTATION

Please choose your desired action.

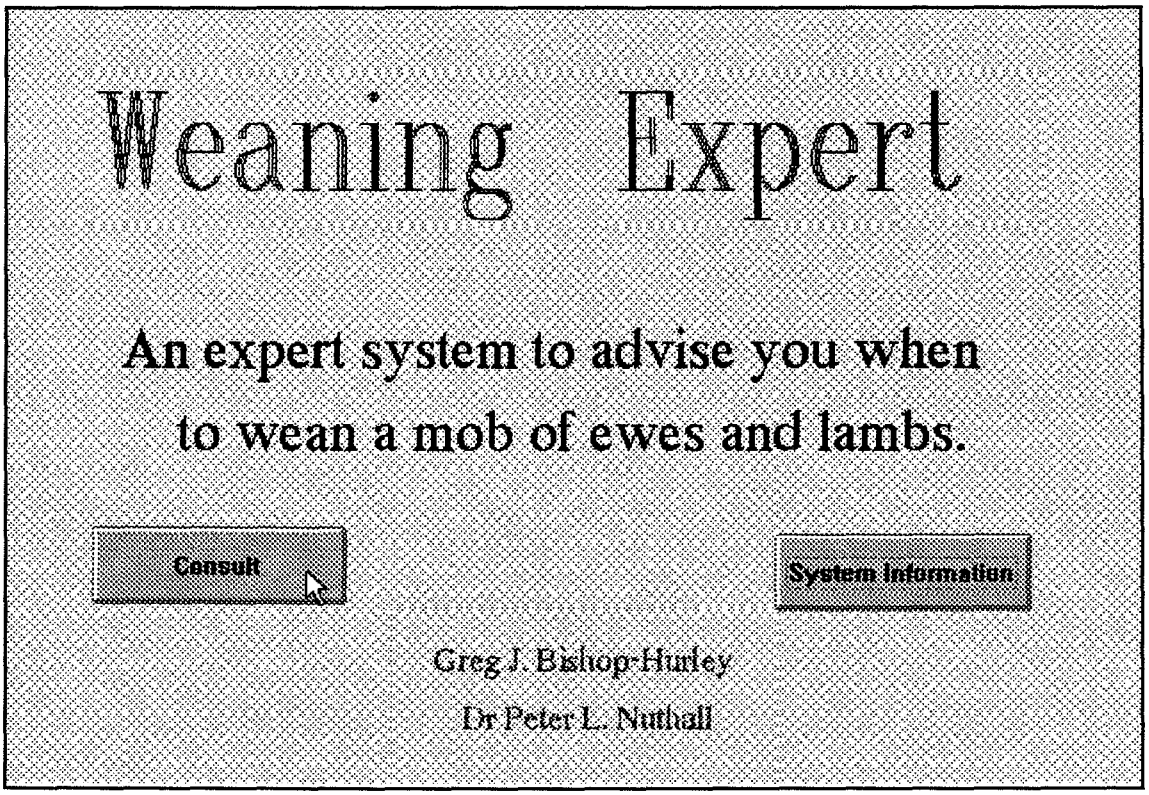
Exit Weaning Expert	Restart Consultation	Change Variable

Which variable do you wish to change.

Lambage	Lambwt	Status
Prolific	Feedquantity	Feedquality
Breeddam	Priceewe	

↑ ↓ →← Enter to select END to complete /Q to Quit ? for Unknown

FIGURE FOUR
EXPERIMENTAL WEANING SYSTEMS - INTRODUCTORY SCREEN SYSTEMS TWO, THREE AND FOUR



You would use this expert system if you wish to know whether or not to wean a specific mob of ewes and lambs. It will ask you a series of questions and then render an opinion based on the answers given. Then you will be asked if you wish to be given the reasons for the opinion.
The question being considered by the system is:

Should this mob of ewes and lambs be weaned?

Return

Eight factors are considered to be important in the decision of whether or not a mob of ewes and lambs should be weaned.
They are:
- Age of the lamb
- Weight of the lamb
- Status of the lamb, this refers to how individual lambs are related to others in the mob
- Prolificacy of the mob, used to determine the proportion of twins in the mob
- Quantity of feed available for the mob
- Quantity of feed available for the lambs if weaned
- Breed of the ewe, influences overfat problems through high milk production
- Cull ewe Price

Initially the system asks the age of the lambs. The answer given determines what the next question will be. During a consultation the user may or may not be required to answer questions related to all eight factors. By the end of a consultation a conclusion is reached as to whether the mob in question should be weaned.

FIGURE FIVE
EXPERIMENTAL WEANING SYSTEMS-DATA ENTRY SYSTEMS 2 AND 3

A. SYSTEM TWO

What is the average liveweight (kgs) of the lambs in the mob?

18

Continue

B. SYSTEMS TWO AND THREE

Select the appropriate birth rank of the lambs in the mob:

Choose One

- ○ Singles
- ◉ Mixture
- ○ Twins

- Singles, each ewe in the mob has only one lamb
- Mixture, the mob consists of some ewes with singles and some with twins
- Twins, Each ewe in the mob has two lambs

Continue

FIGURE SIX
EXPERIMENTAL WEANING SYSTEMS - RESULTS, SYSTEMS 2, 3 AND 4

A. SYSTEMS TWO AND THREE

Based upon the information provided weaning expert advices the following.

Don't wean this mob of ewes and lambs.

Explanation | Restart | Exit

B. SYSTEMS TWO, THREE AND FOUR

The following explains the advice given by the system.

These lambs can be left with the ewes for the time being. Care will need to be taken to ensure that the quality of the lamb feed does not decrease over the next few weeks. It may be a good idea to conserve some feed or se ll lt. Paddocks that have been cut for hay or silage will produce good quality lamb feed in a few weeks.

Return

FIGURE SEVEN
EXPERIMENTAL WEANING SYSTEMS - DATA ENTRY FOR SYSTEM THREE

What is the average age (weeks) of the lambs in the mob?

Choose One

- (●) Age Range 1 - Up to 4 weeks old
- ( ) Age Range 2 - From 4 weeks and up to 6 weeks old
- ( ) Age Range 3 - From 6 weeks and up to 10 weeks old
- ( ) Age Range 4 - From 10 weeks and up to 13 weeks old
- ( ) Age Range 5 - From 13 weeks and up to 20 weeks old
- ( ) Age Range 6 - From 20 weeks old and over

Continue

What is the average liveweight (kgs) of the lambs in the mob?

Choose One

- ( ) Weight Range 1 - Up to 7 kgs liveweight
- (●) Weight Range 2 - From 7 kgs and up to 13 kgs liveweight
- ( ) Weight Range 3 - From 13 kgs and up to 20 kgs liveweight
- ( ) Weight Range 4 - Over 20 kgs liveweight

Continue

FIGURE EIGHT
EXPERIMENTAL WEANING SYSTEMS - INSTRUCTIONS FOR SYSTEMS TWO, THREE AND FOUR

Weaning Expert

This is a Expert system that can help you to decide when to wean a mob of ewes and lambs.

Start at the top left of the screen and select the value from each box that best describes your set of circumstances. When you have entered enough data the system will display the result down the bottom. You can then change any factors to see how this effrects the advice and explanation made by the system. Explanations can be viewed at any time.

To make aselectian move the mouse pointer to the factor and click the left button to make a selection.

To get a description of each of the factors move the mouse pointer to the heading and when the hand appears click the left mouse button.

Return Detail

FIGURE NINE
EXPERIMENTAL WEANING SYSTEMS - SYSTEM FOUR DATA ENTRY

Age of Lambs (wks)	Weight of Lambs (kgs)	Feed Quantity	Feed Quality
○ : 0 to 4 ○ : 4 to 6 ○ : 6 to 10 ◉ : 10 to 13 ○ : 13 to 20 ○ : 20 plus	○ : 0 to 7 ○ : 7 to 13 ◉ : 13 to 20 ○ : 20 plus	○ High ◉ Medium ○ Low	○ Good ◉ Average ○ Poor
Status of Lamb	**Prolificacy of Flock**	**Price of Ewe**	**Breed of Dam**
○ Singles ○ Mixture ○ Twins	○ Yes ○ No	○ High ○ Not High	○ High ○ Not High

Exit Wean the mob Restart

Explanation of Advice

Figure four gives the introductory screens for systems two, three and four (same in all cases), data entry screens for systems two and three are presented in Figure five, whereas an example of a conclusion and explanation for systems two, three and four are given in Figure six. Data entry screens for system three are presented in Figure seven, whereas Figure nine gives the entire data entry screen for system four. Finally, Figure eight shows the instruction screen used for systems two, three and four. While all the systems appear on the surface to be somewhat simple, the code consumed 500 Kilobytes of storage indicating the complexity of the package necessary to provide ease of use and screen simplicity.

3.3 The Results of the Field Experts Trial

Only the results that relate to a comparison of the systems is presented. Many general comments on the weaning problem itself were made and many of these were subsequently incorporated into the systems developed for the farmers.

Table 1 gives the average computer use and self rated experience of the field experts.

Table 1
Field Expert's Computer Use and Self Rated Computer Skills

	Mean	std *
Computer Use (days/month)	18.29	7.76
Computer Use (hours/week)	10.29	5.36
General Computer Skills (1 = very good, 10 = very poor)	5.43	2.06
Keyboard Skills (1 = very good, 10 = very poor)	5.29	2.31
Mouse Use Frequency (1 = never, 10 = regularly)	1.57	0.73
GUI Use Frequency (1 = never, 10 = regularly)	1.57	0.73

* Standard deviation

These people are not heavy computer users, believe they have average skills, and seldom use a mouse and graphical user interface. Thus, they are used to traditional command driven operations.

Table 2 presents the experts' scoring of the four systems with respect to various presentation and assistance questions. Scores are based on 1 = very good/excellent to 10 = very difficult/not acceptable.

Table 2
Field Experts' Scoring of the Four Trial Systems
With Respect to Various Presentation and Assistance Attributes
(1 = highest score, 10 = lowest score,
Standard deviation in brackets)

Attribute	System Number			
	1	2	3	4
Ease of Use	1.43 (0.49)	3.1 (2.29)	2.29 (1.75)	1.43 (0.73)
Appearance and Layout	2.71 (0.45)	2.00 (1.31)	1.86 (1.36)	1.71 (0.88)
Advice given by Version	3.43 (1.50)	3.14 (1.25)	3.29 (1.39)	3.14 (1.25)
Explanation to the Advice	3.57 (1.50)	2.86 (0.64)	3.00 (1.07)	3.00 (1.07)
Help, Guidance, Messages	2.14 (0.64)	2.43 (0.49)	2.57 (0.49)	3.00 (1.51)
Importance of a Printout	4.71 (3.15)	4.71 (3.15)	5.00 (2.88)	2.14 (2.90)

It will be noted that most attributes are scored at the upper end of the scales. This may be a function of the experts' inexperience at using expert systems. In general systems two and four are as good as the others, but not always so. The slightly higher rating for system two may be a function of the visual comparison between one and two being quite marked. Regression analysis of the data is presented later and provides a more detailed analysis.

Table 3 contains the ranking averages for each attribute (1 = highest rank, 4 = lowest rank) and the Friedman rank test probabilities.

Table 3
Field Experts' Ranking of the Four Trial Systems With Respect to Various Presentation Attributes
(Ranked on a 1 to 4 scale, standard deviation in brackets)

Attribute	System Number				
	1	2	3	4	Friedman Rank Test Probability
Ease of Use, Functionality	2.86 (1.25)	2.57 (0.73)	2.00 (0.53)	1.14 (0.35)	0.027
Appearance and Layout	3.14 (0.83)	2.57 (0.49)	2.00 (0.53)	1.29 (0.70)	0.016
Advice given by Version	1.86 (0.99)	1.71 (0.70)	1.86 (0.64)	1.57 (1.05)	0.815
Overall best Version	3.00 (0.93)	2.71 (0.70)	2.14 (0.64)	1.14 (0.35)	0.021
Best Version (Farmer)	2.71 (0.88)	2.86 (0.83)	2.29 (0.70)	1.14 (0.35)	0.028

The Ease of Use and Functionality ranking clearly places system four as the most preferred and these differences are significant. The same applies to Appearance and Layout, Overall Best Version, and Best Version (Farmer). This latter stems from asking how the field experts believed the farmers would rank the system. When it came to the advice preferred there is little difference in the average rankings and furthermore, the difference is not significant. It would be surprising if the result had been any different as the rules and advice were identical for each system.

The overwhelming conclusion must be that at least the field experts prefer a GUI based system that is mouse controlled with pick lists and has all questions displayed on one screen. There is, however, clearly a limit to how many questions can be presented at one time and screen cluttering, and consequent confusion, must eventually be a factor. For the weaning system this point has clearly not been reached.

It must also be noted, however, that different people might prefer different systems due to their computer background and experience, as well as their individual personalities, as noted before. In addition, the computer systems themselves have various attributes that need to be elucidated when explaining the preferences. To test these hypotheses, regressions between the attribute scores (Table 1) as the dependent variable and various components of computer skill, personality and system attributes as the independent variables were estimated.

Computer experience (X_1) was defined as:

X_1 = (days of computer use/month ÷ 4.3) x (hours/week)

Computer skill (X_2) was defined as:

X_2 = (11 - general computer skills score)
+ (11 - keyboard skills score)
+ (mouse use score)
+ (GUI use score)

(Note - the subtractions were necessary to convert the scale to an ascending one)

Extroversion/Introversion variable (X_3) was defined on a scale of 1 = 'extroversion', 0 = indifference and -1 = 'introversion'.

Similarly the other personality attributes were defined:

X_4 = 1 for, 'sensate' 0 for indifference, -1 for 'intuitive'
X_5 = 1 for, 'thinking', 0 for indifference, -1 for 'feeling'
X_6 = 1 for, 'judging', 0 for indifference, -1 for 'perceiving'.

The authors also scored the package on a one to ten scale for the following factors:-

X_7 = Professionalism (1 = unprofessional (setting out, grammar, spelling, colour combinations, wording, screen simplicity), through to 10 = totally professional)

X_8 = Data entry skills required (1 = all keyboard, through to 10 = all point and click from pick lists)

X_9 = On line help and advice (1 = no help, through to 10 = extensive, helpful and professional help and advice)

X_{10} = Number of data entry items/screen (1 = an excessive quantity of information required with clutter and comprehension difficulty, through to 10 = easily assimilable quantity but with a sufficient number of items to allow relationship to be clear).

For variables X_7 to X_{10} the trial systems were scored as follows:

System Number				
Attribute	One	Two	Three	Four
Professionalism	3	4	7	8
Data entry skills	1	7	9	10
On-line help	7	7	8	7
Data entry items	10	9	9	7

With respect to personality, Table 4 contains the field experts' characteristics.

Table 4
The Personality Features of the Field Experts
(e = extrovert, i = introvert; s = sensate, n = intuitive;
t = thinking, f = feeling; j = judging, p = perceiving, o = neutral)

Field Expert	Characteristics			
	e/i	s/n	t/f	j/p
1	e	s	t	j
2	e	s	o	j
3	i	s	t	j
4	e	s	f	j
5	i	s	f	j
6	e	n	t	j
7	i	s	t	j

For the population at large, Keirsey and Bates (1984) note that 75 percent are extroverts, 75 percent are sensate, and 50 percent are thinking and judging. This sample tends towards these norms except in the case of the judging/perceiving feature.

For the 'ease of use' score it was found the following relationship was useful in explaining the differences (two stars are used to indicate significance at greater than 1 percent, and one star for greater than 10 percent).

$$\text{Ease of use score} = 0.24X_2^{**} - .20X_3^{**} - .15X_4 - .51X_7^{**} + .36X_{10}^{**}$$
$$R^2 = 0.82^{**}$$

As might be expected the greater the computer skills of the operator, the greater the score (the more critical they are). Surprisingly, the more easily assimable is the data entry screen/s, the greater the score. On the other hand, extroversion decreases the score as does the 'sensate' attribute. The extroversion effect is somewhat surprising in that you would expect introverts to be more likely to be content to spend time at a computer working through a system. Sensate people can probably find their way around computer systems that to less experienced people don't always seem to be logical. Note, however that the X_4 coefficient was not significant at the 10% level (in fact it was 11%).

For the appearance and layout score the equation found to be most useful was:

$$\text{Appearance and layout score} = 0.17X_2^{**} - 0.20X_3^{**} + 0.18X_6^{**} - 0.11X_8$$
$$R^2 = 0.91^{**}$$

Similar conclusions apply but note that the judging/perceiving factor (X_6) comes into play and that an increasing use of the mouse (X_8) tends to lower the score (the users prefer this), though the variable is only significant at the 11.6% level.

When it comes to scoring the advice offered (remember, each system had exactly the same rule set and advice), the score can be explained using:

$$\text{Advice score} = 0.24X_2^{**} - 0.04X_1^{**} - 0.15X_3^{**} - 0.14X_4^{*} + 0.18X_5^{**} + 0.53X_6^{**}$$
$$R^2 = 0.98^{**}$$

Effectively, personality (X_3 to X_6) plays an important part in how people view advice, as does their computer skill (X_2) and experience (X_1), though this latter factor only has a marginal effect.

For explaining the different scores on the explanations to the advice it was found computer skill was the most significant variable. The equation was:

$$\text{Explanation to the advice score} = 0.19X_2^{**}$$
$$R^2 = 0.75^{**}$$

Perhaps people with greater computer skills (self assessed) are less able to accept the 'computer advice' without a detailed justification.

In explaining the field experts score on whether a printout of the results was important the following equation was obtained:-

$$\text{Printout importance score} = 9.98^{**} + 0.12X_1^{**} - 0.82X_2^{**} + 0.58X_3 + 0.74X_4^{**} - 0.73X_6^{**}$$
$$R^2 = 0.92^{**}$$

Most people clearly prefer a printout but those with more computer skill (X_2) and a more judging (X_6) personality tend to place a higher importance on printouts. Overall, the message is clear, however.

It was not possible to find any important relationships which logically explained the field experts' views on the help and guidance scores. In that they were identical this is not completely surprising, though personality may well have affected how the different presentations were viewed.

The relationships discussed explain the one to ten scores provided. In interpreting the results it must be remembered that the scores are not absolute measures in that different subjects have non-comparable views on what is good and bad. Personality is probably important in explaining the difference, and this certainly seems to be the case. When it comes to ranking the systems the individual results are comparable in that if one system is preferred by all subjects it can be concluded that they all agree it is better. In contrast, if a system is given a score of say 8, by one subject and, say, 6 by another, this data in itself does not indicate one person believes anymore in the system than the other person.

Turning then to explaining the rankings it was found that:

Ease of use/functionality ranking = $0.12X_2^{**} + 0.25X_7^{**}$
$R^2 = 0.63^{**}$

Appearance and layout ranking = $0.32X_7^{**}$
$R^2 = 0.59^{**}$

Overall best version ranking = $0.10X_2^{*} + 0.28X_7^{**}$
$R^2 = 0.62^{**}$

and that a strong relationship did not exist for the advice ranking (as might be expected).

None of their relationships are particularly strong (see R^2). Clearly the 'professionalism' (X_7) variable is important, and to a lesser extent the computer skills measure. Note that personality is not a factor in explaining the rankings which do not, of course, rely on a non-comparable scoring scale.

In reviewing the analysis as a whole, it is clear the field experts preferred system four (mouse driven, as many questions as possible on one screen, pick lists) and that components of personality are important in how they interpret the systems. This would suggest that it may be preferable to offer a range of systems to enable high acceptance levels. However, it must be remembered that the field expert trials were designed to provide information and experience that could be used in developing improved systems for use by farmers. This was certainly the case.

3.4 Details of the Presentation Aspects of the Systems Developed for Farm Use

To further explore presentation aspects three different weaning packages were developed, though each included the lessons learnt from the field expert trials. All farmer systems were developed using Knowledge Pro (1991).

The three different weaning systems will be referred to as Wean One, Wean Two and Wean Three. The other systems will be termed Drench and Surplus. All systems relied heavily on the use of a mouse, but in the case of Wean One the questions were presented one per screen. This system, however, was enhanced with the use of 'picture help'. To help decide, for example, the average live weight of a lamb, photographs of a range of lambs were taken, scanned and read into files which were incorporated into the expert system. These pictures

could then be called up on the screen on demand. The one most akin to the average lamb weight could then be selected (by pointing and clicking) in order to answer the question. Similarly, pictures of different pasture quantities and qualities were provided as 'help pictures'. A major question, then, was whether farmers would find this picture assistance beneficial. The cost of providing this assistance was the difficulty of obtaining suitable pictures and the extra disk storage required (520 Kilobytes).

In addition, as will be seen from the 'screen dump' figures, the KnowledgePro (1991) systems could be called rather more professional than the earlier systems in that the presentation is neater and more logical and extensive use is made of selection buttons.

Wean Two differs from Wean One in that picture help is not provided, and the questions are all presented on a single screen. Wean Three, to provide the contrast, is the same as Wean Two, except that picture help has been added back.

A study of Figures ten, eleven and twelve provides an understanding of how the three wean systems appear and operate including the picture help. Figure thirteen and fourteen indicate how the general procedures developed for the weaning systems appear when applied to the drenching and surplus feed problems. Each of these figures consists of more than one screen excerpt (each box is a snapshot of one screen display).

The farmers' views and opinions of all these systems are presented in Chapter Five. In analyzing this data it is necessary to quantify the features of the systems using the scales defined in Chapter Three. The authors, using these criteria, scored each system as follows:

	System				
	Wean One	Wean Two	Wean Three	Drenc h	Surplus
Professionalism	5	7	9	10	10
Data Entry Skills	7	9	9	10	10
On-line help	9	7	10	10	8
Data entry items	9	8	7	6	7

FIGURE TEN

SCREEN EXCERPTS FROM WEAN ONE - DESIGNED FOR FARMER USE

INTRODUCTION

Weaning Expert

An expert system to advise you when to wean a mob of ewes and lambs.

Greg J. Bishop-Hurley

Dr Peter L. Nuthall

You would use this expert system if you wish to know whether or not to wean a specific mob of ewes and lambs. It will ask you a series of questions and then render an opinion based on the answers given. Then you will be asked if you wish to be given the reasons for the opinion.

The question being considered by the system is:
Should this mob of ewes and lambs be weaned?

Eight factors are considered to be important in the decision of whether or not a mob of ewes and lambs should be weaned. They are:

- Age of the lamb
- Weight of the lamb
- Status of the lamb, this refers to how individual lambs are related to others in the mob
- Prolificacy of the mob, used to determine the proportion of twins in the mob
- Quantity of feed available for the mob
- Quantity of feed available for the lambs if weaned
- Breed of the ewe, influences overfat problems through high milk production
- Cull ewe Price

Initially the system asks the age of the lambs. The answer given determines what the next question will be. During a consultation the user may or may not be required to answer questions related to all eight factors. By the end of a consultation a conclusion is reached as to whether the mob in question should be weaned.

Return

FIGURE TEN (cont)

DATA ENTRY

Weight of the Lamb

What is the average liveweight (kgs) of the lambs in the mob?

- ○ Up to 7 kgs liveweight
- ○ From 7 kgs and up to 13 kgs liveweight
- ○ From 13 kgs and up to 20 kgs liveweight
- ○ Over 20 kgs liveweight

Picture Help

Continue | Help | Readme | Restart | Quit

PICTURE HELP - LAMB WEIGHTS

0-6 kgs | 7-12 kgs | 13-19 kgs | 20+ kgs

Move the mouse pointer to the picture which best represents the average lamb in the mob and click the left mouse button to select it. Point and click on return to continue.

Note: These images have been used to show you a working system. We need to get more accurate pictures of lambs.

Return

FIGURE TEN (cont)

DATA ENTRY

Quantity of Feed Available

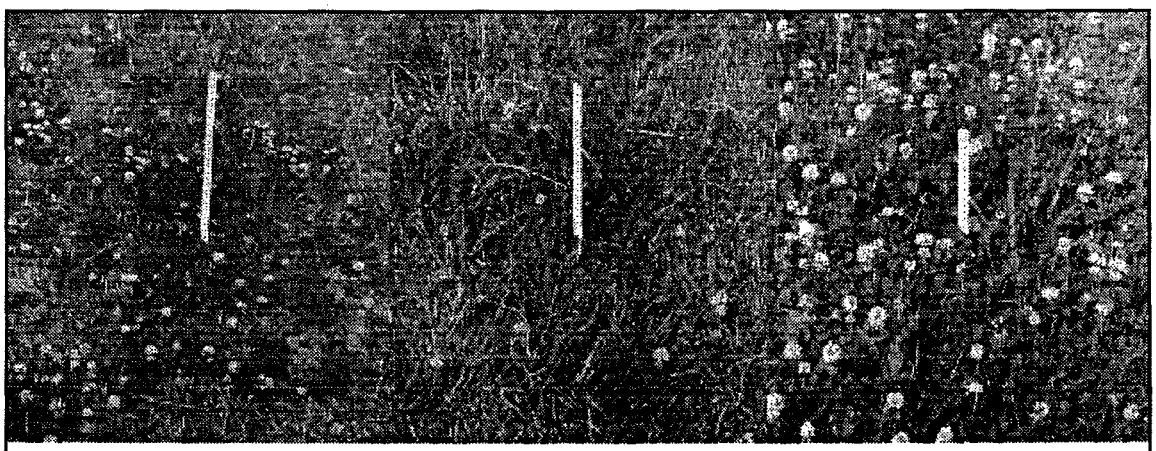
Indicate how much feed you have for this mob now and in the future?

- ○ **High** - More than enough feed for maintenance
- ○ **Medium** - Only enough feed for maintenance
- ○ **Low** - Not enough feed for maintenance

Picture Help

Continue | **Help** | **Readme** | **Restart** | **Quit**

PICTURE HELP - FEED QUANTITY



Low **Medium** **High**

Move the mouse pointer to the picture which best represents the average quantity of pasture and click the left mouse button to select it. Point and click on return to continue.

Return

FIGURE TEN (cont)

DATA ENTRY

Quality of Feed Available

What is the quality of the available feed?

- ○ **Good** - Good quality legume dominant pasture
- ○ **Average** - An average spring pasture
- ○ **Poor** - Rank pasture with little legume content

Picture Help

Continue | **Help** | **Readme** | **Restart** | **Quit**

WORD HELP

This questions tries to determine the quality of the available feed.

Good quality legume dominant pasture can be pasture with at least a 30 percent legume content or older lucerne stands with some weeds. Pastures that have regrown after being cut for supplements make good lamb feed. A pasture that has some legume and fresh grass grass in the bottom is considered to be of average quality. Pastures that are rank and gone to seed and have little or no legume are considered to be of poor quality.

Close

Continue | **Help** | **Readme** | **Restart** | **Quit**

FIGURE TEN (cont)

RECOMMENDATION AND ASSOCIATED CONDITIONS

An expert system to advise you when
to wean a mob of ewes and lambs.

Age of Lambs: From 6 weeks and up to 10 weeks old
Weight of Lambs: From 13 kgs and up to 20 kgs liveweight
Mob Status: Mixture
Mob Prolificacy: No
Feed Quantity: Medium
Feed Quality: Average
Breed of Dam: Not High
Price of Ewe: Not High

Don't wean this mob of ewes and lambs.

Explanation | Help | Print | Restart | Quit

RECOMMENDATION EXPLANATION

An expert system to advise you when
to wean a mob of ewes and lambs.

Things appear to be going along quite nicely at the moment. Ensure good quality legume pasture will be available for the lambs when they are weaned. Regrowth on paddocks that have been cut for hay or silage makes good lamb feed.

Close

Don't wean this mob of ewes and lambs.

Explanation | Help | Print | Restart | Quit

FIGURE ELEVEN

SCREEN EXCERPTS FROM WEAN TWO - DESIGNED FOR FARMER USE

DATA ENTRY AND RECOMMENDATION

Age of Lambs	Weight of Lambs	Feed Quantity	Feed Quality
○ 0 up to 4	○ 0 up to 7	○ High	○ Good
○ 4 up to 6	○ 7 up to 13	◉ Medium	◉ Average
◉ 6 up to 10	◉ 13 up to 20	○ Low	○ Poor
○ 10 up to 13	○ 20 plus		
○ 13 up to 20			
○ 20 plus			
Status	**Prolificacy**	**Price of Culls**	**Breed of Dam**
○ Singles	◉ No	○ High	○ High
◉ Mixture	○ Yes	◉ Not High	◉ Not High
○ Twins			

Don't wean this mob of ewes and lambs.

Advice | Explanation | Print | Clear | Quit

RECOMMENDATION EXPLANATION

Things appear to be going along quite nicely at the moment. Ensure good quality legume pasture will be available for the lambs when they are weaned. Regrowth on paddocks that have been cut for hay or silage makes good lamb feed.

Close

Don't wean this mob of ewes and lambs.

Advice | Explanation | Print | Clear | Quit

FIGURE ELEVEN (cont)

WORD HELP

Select the range that best covers the weight of the lambs in the mob.

If none of the choices available cover the range of weights of the lambs in the mob then choose the one that is closest. Consider what is the average weight of the lambs in the mob and choose the option that covers this value.

If you are uncertain of the weight then make an estimate and see what advice the system gives you. Standing on bathroom scales holding a few of the lambs is a good way to estimate lamb weight.

If you are still uncertain of the weight you can run the system several times to see how sensitive it is to this factor.

Return

EXAMPLE INSTRUCTIONS

You have not provided enough information for weaning expert to advise you.

Move the mouse to the "Close" button and click the right mouse button to continue.

Close

Advice | Help | Readme | Clear | Quit

FIGURE TWELVE
SCREEN EXCERPTS FROM WEAN THREE - DESIGNED FOR FARMER USE

DATA ENTRY AND RECOMMENDATION

Age of Lambs	Weight of Lambs	Feed Quantity	Feed Quality
○ 0 up to 4	○ 0 up to 7	○ High	○ Good
○ 4 up to 6	◉ 7 up to 13	○ Medium	○ Average
◉ 6 up to 10	○ 13 up to 20	○ Low	○ Poor
○ 10 up to 13	○ 20 plus		
○ 13 up to 20			
○ 20 plus			
Help	Help / Pic Help	Help / Pic Help	Help / Pic Help

Status	Prolificacy	Price of Culls	Breed of Dam
○ Singles	○ No	○ High	○ High
○ Mixture	○ Yes	○ Not High	○ Not High
○ Twins			
Help	Help	Help	Help

Don't wean this mob of ewes and lambs.

Advice | Explanation | Print | Clear | Quit

RECOMMENDATION EXPLANATION

These lambs are too small to be weaned. Even if there is a feed shortage it is not advisable to wean lambs that have not reached 13 kgs. Should a feed shortage not be the cause of these lambs being so small then you should seek expert help in trying to determine what the problem is.

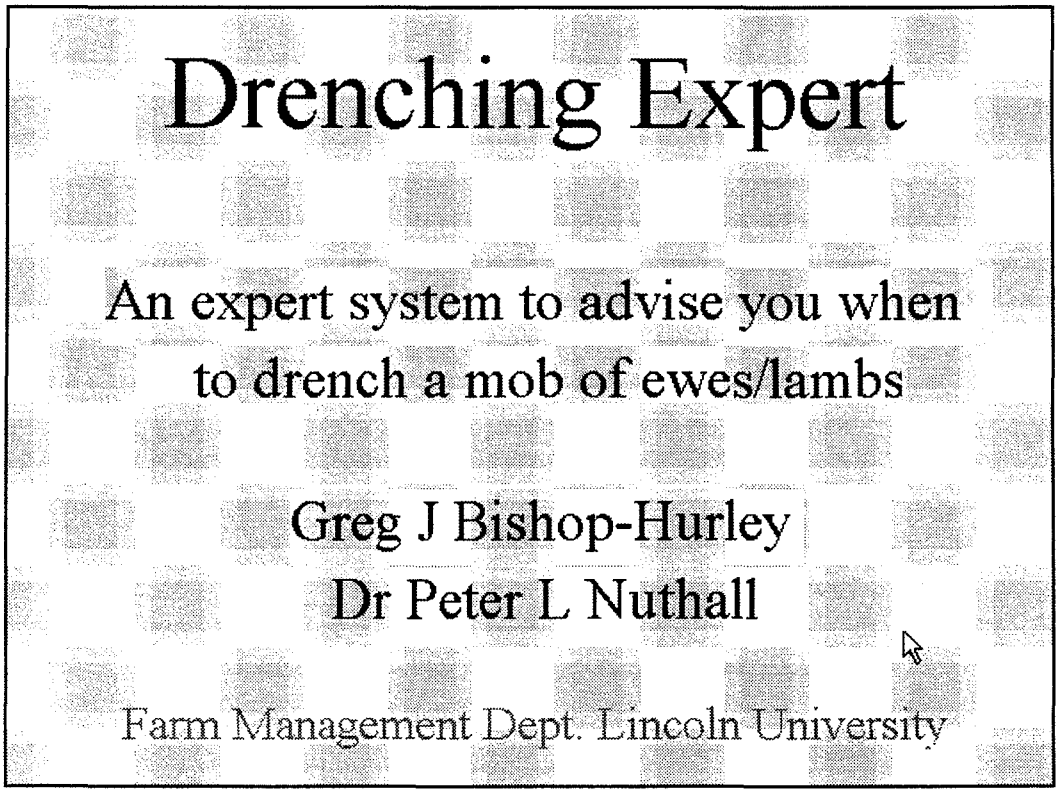
Close

Don't wean this mob of ewes and lambs.

Advice | Explanation | Print | Clear | Quit

FIGURE THIRTEEN
SCREEN EXCERPTS FROM DRENCH - DESIGNED FOR FARMER USE

INTRODUCTION



DATA ENTRY

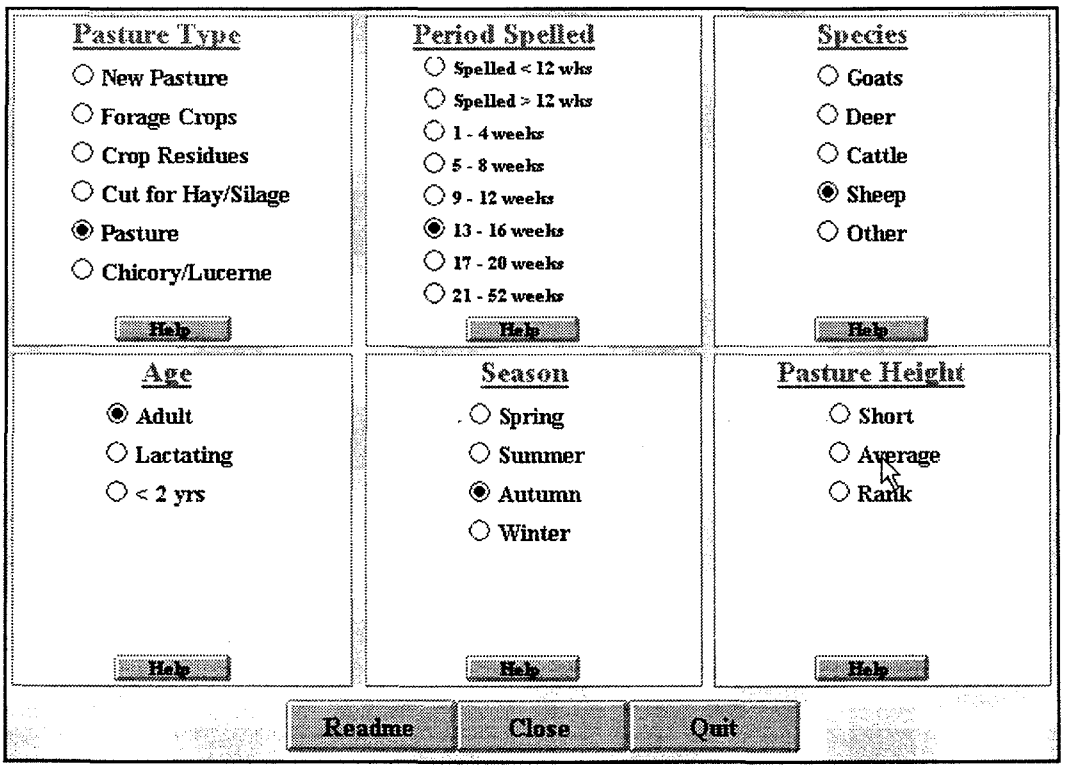


FIGURE THIRTEEN (cont)

DATA ENTRY - ALTERNATIVE FORM

Class of Stock
- (●) Works Lambs
- ( ) Repl. Lambs
- ( ) Hoggets
- ( ) Ewes/Lambs
- ( ) Adult Sheep

Help

Reason to Drench
- (●) Scouring
- ( ) Ill Thrift
- ( ) Shifting
- ( ) Due to be
- ( ) Traditional
- ( ) Ret./New

Help

Faecal Egg Count
- ( ) Low (<250eggs/g)
- ( ) Ave (250-500eggs/g)
- ( ) High (>500eggs/g)
- (●) No FEC Value

Help

Prevention Prog.
- ( ) Due
- ( ) Not Due
- (●) No Program

Help

Stock Condition
- ( ) Good
- (●) Average
- ( ) Poor

InDepth Help

Feed Stress
- ( ) High
- (●) Moderate
- ( ) Low

InDepth Help

Safe Pasture
- ( ) Safe
- (●) Safer
- ( ) Unsafe

InDepth Help

Stocking Rate
- ( ) Low (<10su/ha)
- ( ) Ave (10-15su/ha)
- (●) High (>15su/ha)

Help

Do drench this Mob of Works Lambs

Explanation | ReEvaluate | ReadMe | Restart | Quit

RECOMMENDATION

Don't drench this Mob of Works Lambs

Because animal condition is average and there is no safe pasture for them to go onto after drenching these animals should not be drenched.

We advise putting lambs on an internal parasite prevention programme starting at weaning.

Five drench preventive programme

Three lamb drenches starting from weaning at 22 day intervals, followed by two lamb drenches at 28 day intervals, followed by drenching only on the basis of the results of faecal egg count (FEC).

Close

FIGURE FOURTEEN
SCREEN EXCERPTS FROM SURPLUS - DESIGNED FOR FARMER USE

INTRODUCTION

Supplement/Surplus Expert

An expert system to advise you about feed conservation and surpluses.

Greg J Bishop-Hurley
Dr Peter L Nuthall

Farm Management Dept. Lincoln University

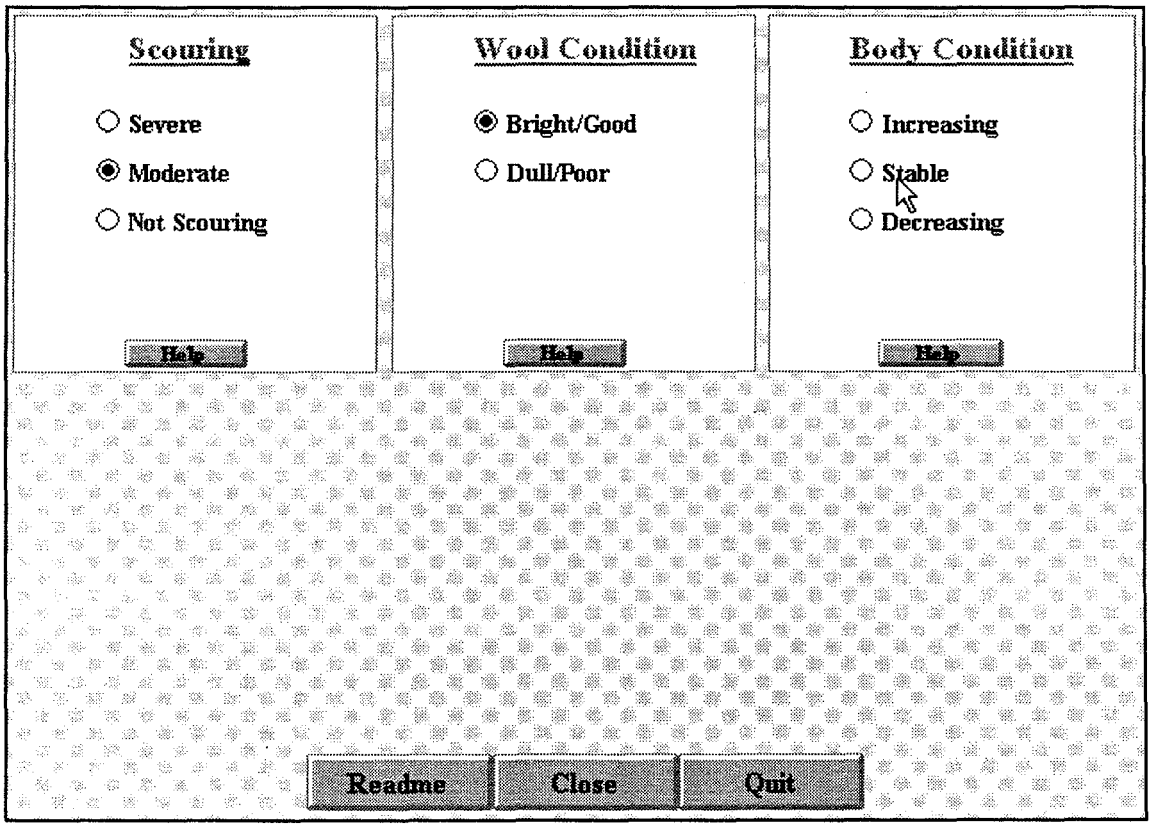
This expert system is designed to assist the user make decisions regarding making supplements and feed surpluses. The system asks the user a series of questions and then renders an opinion based on the answers given by the user. When the system has given its advice the user can get an explanation if required.

The system is best used with a mouse although it can be used without one. When the system is started it will ask its first question. The user should select the item for the factor that best describes the current situation. This can be done by moving the mouse pointer to the item and pressing and releasing the left mouse button. The system will then respond by either displaying the next question (factor) or giving its conclusion. At the bottom of the screen are a series of buttons and those that are highlighted can be activated. As before this is done by moving the mouse pointer to the button and pressing and releasing the left mouse button.

Close

FIGURE FOURTEEN (cont)

FURTHER DATA ENTRY



DATA ENTRY - ANOTHER EXAMPLE

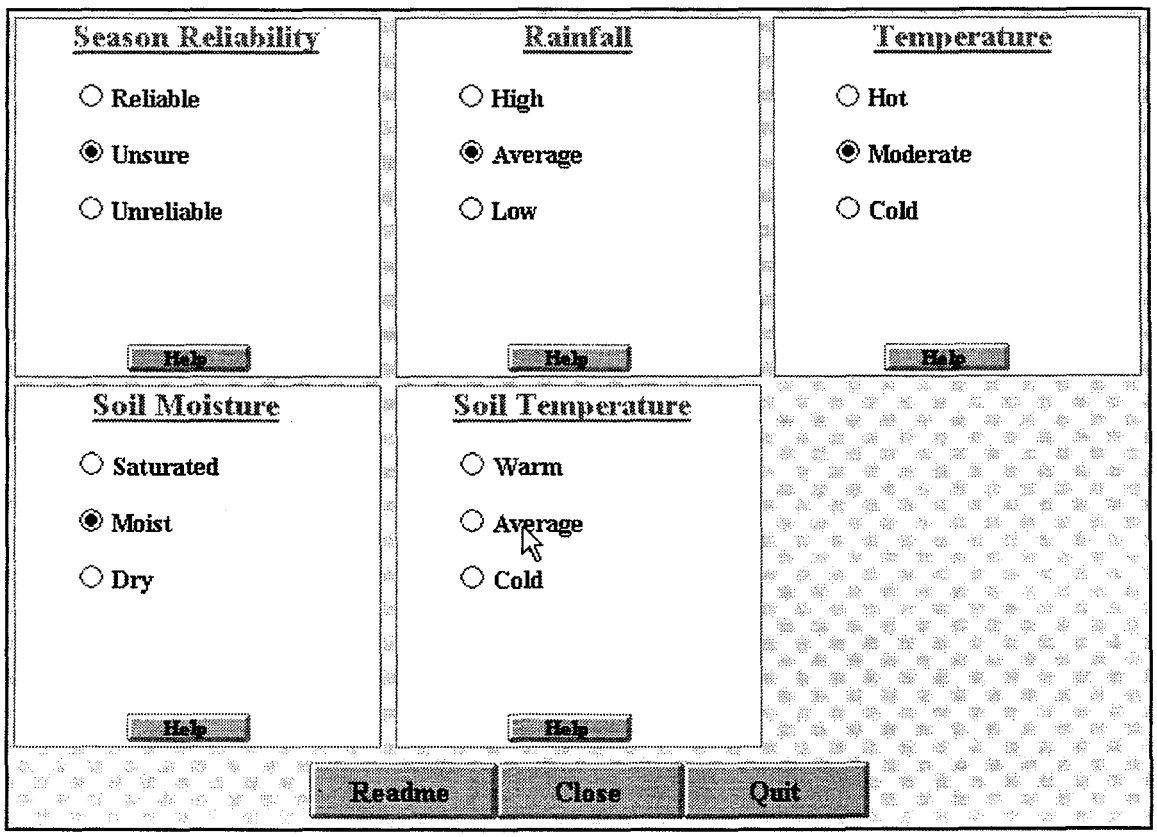


FIGURE FOURTEEN (cont)

DATA ENTRY - ONE EXAMPLE

Pasture Production	Reserves Held	Season/Terrain	Stock Condition
◉ Surplus	◉ Yes	◉ Yes	○ Good
○ Balanced	○ No	○ No	◉ Average
○ Shortage			○ Poor
Help	Help	Help	InDepth Help

Storage Space	Weather Outlook	Weaned	Surplus Quality
○ Yes	○ Good	○ Most	○ High
◉ No	◉ Average	◉ Half	◉ Average
	○ Poor	○ Few	○ Low
Help	InDepth Help	Help	Help

You should consider the following options:-
Sell Grazing, Sell Hay/Feed, Buy Stock, Feed Stock Better.

Explanation | ReEvaluate | ReadMe | Restart | Quit

RECOMMENDATION

You should consider the following:- Sell Grazing, Sell Hay/Feed, Buy Stock, Feed Stock Better.

Since stock condition is only average you should make sure that the stock is fed better. With a surplus and plenty of feed in storage the stock should be doing very well. If you think that the stock should be doing better than they are perhaps they need to be drenched.
Although there are plenty of reserves already in storage you could make more hay to be sold now or later.
You might also consider purchasing additional animals or taking on some grazers.
If you are prepared to have other farmers' animals on the property then grazing is an option. It's important to take precautions when moving animals from one farm to another so that resistant worms are not introduced(quarantine drenching). The problem is that if you have surplus feed others in your area are also likely to have a surplus. This could make it difficult to acquire grazers on a casual basis.
You could sell the surplus feed as either bales of hay or standing hay. The important question that needs to be answered is what are the market opportunities for selling feed either as hay or standing.
It might be possible to make extra hay in the hope that there is a market for it at some later date.
If a contractor and/or equipment is required you will need to ensure that it is available. This will allow the pasture to recover and should provide you with high quality feed in 4-6 weeks.
Buying additional stock to utilise the surplus is an option provided the animals on the farm are being fed adequately. Availability of cash to purchase the extra stock is an important consideration as is the expected margin (costs and returns). Probable market trends and availability of suitable animals are also important factors.

Close

CHAPTER FOUR

DETAILS OF THE FARMER RESPONDENTS

4.1 Introduction

The expert systems were developed using contemporary object orientated based windows software. It was believed important to design and develop for the future in that computer technology is moving quite rapidly so that systems developed for the technology that is currently common would soon become obsolete. This meant the majority of farmers with computers did not have technology sufficiently powerful to run the package.

To isolate suitable farmers all producers on a data base of people interested in receiving a computer newsletter[1] were sorted according to computer type. The data base held some 5,000 names. In addition, all Ministry of Agriculture and Fisheries offices were contacted for the names of potentially suitable farmers. In the end nearly 400 farmers were sent a letter asking if they had a suitable computer and would be prepared to use and comment on the systems. Ninety-two responded, but 54 did not in fact have a suitable computer. The remaining 38 were sent the weaning package and associated questionnaire. After reminders and phone calls 25 completed responses were received. This same group were contacted for the evaluation of the drenching and surplus systems. As time went by, the numbers responding declined. Seventeen completed questionnaires were received for the surplus system. As noted earlier the first systems were sent in February 1993, the last in February 1994.

Various questionnaires were forwarded. The first asked the respondents to provide details of their farm, their personal situation (age and education), and to answer personality specifying questions. Experience with the field experts suggested the set of personality questions be somewhat reduced, particularly as the survey was postal based. Appendix four contains the questionnaire.

4.2 Characteristics of the Farms and Farmers

The following tables contain the information collected.

[1]The Kellogg Farm Management Unit's (Lincoln University) Newsletter

Table 5 Farm Area Distribution	
Ha Range	Percentage of Farms
0 - 200	33.3
201 - 400	29.2
401 - 600	12.5
600+	25.0

The sample probably contains a greater number of larger farms than the population of all farmers. The Valuation NZ data base (Nuthall and Bishop-Hurley, 1994) has 70.56 percent in the 200 or less ha. group and 17.73 percent in the 201-400 ha. group. The comparison cannot be extended as the groupings do not match.

The stock unit distribution is presented in Table 6. All stock and crops were converted to a common stock unit base using the conversions given in Nuthall and Bishop-Hurley (1994).

Table 6 The Stock Unit Distribution	
S.U. Range	Percentage of Farms
0 - 2000	12.5
2001 - 4000	41.7
4001 - 6000	25.0
6000+	20.8

Again the sample tends to have larger numbers of larger farms compared to the population as given in Nuthall and Bishop-Hurley (1994). The comparable figures are 38.2 percent, 33.5 percent, 15.3 percent, and 13.0 percent.

The average area of cash crop on the farms was 3.43 hectares so clearly the farms are essentially stock properties. Eighty-three percent had no cash crop at all. The average area of fodder crops was 9.5 hectares with 70.8 percent having zero fodder crop.

The farmers had an average age of 40.8 years with a distribution as shown in table 7.

Table 7 **The Farmers' Age Distribution**	
Age Range (years)	Percentage of Farmers
0 - 30	13.0
31 - 40	39.2
41 - 50	34.8
50+	13.0

The farmers in the Nuthall and Bishop-Hurley (1994) survey had a generally similar distribution but with a shift to a greater age (respective percentages - 9.4, 29.0, 31.3 and 30.3).

Table 8 contains the education distribution.

Table 8 **The Farmers' Highest Formal Education Level**	
Highest Education Reached	Percentage of Farmers
Secondary - 4 or less years	50.0
Secondary - greater than 4 years	12.5
Tertiary - 2 or less years	12.5
Tertiary - greater than 2 years	25.0

A comparison with the Nuthall and Bishop-Hurley (1994) figures suggest the sample has received more formal education than the norm. The respective percentages are 63.7, 11.0, 14.4 and 10.9.

Turning to the farmers' computer experience the following table gives the time spent on a computer, the type of experience, and their self rated skill levels.

Table 9 Days Per Month Computer Turned On	
Days/Month	Percentage of Farmers
0.0 - 6.0	34.8
6.1 -12.0	17.4
12.1 - 18.0	13.0
18.1 - 24.0	17.4
24.0+	17.4
Average = 13.2 days/month	

Table 10 Hours Per Week Spent on a Computer	
Hours/Week	Percentage of Farmers
0.0 - 5.0	43.5
5.1 - 10.0	30.5
10.1 - 15.0	8.7
15.1 - 20.0	4.3
20.0+	13.0
Average = 10.09 hours/week	

Table 11 Computer Skills Rating (1 = very good - 10 = very poor)	
Rating Range	Percentage of Farmers
1 - 2	25.0
3 - 4	45.9
5 - 6	8.3
7 - 8	20.8
9 - 10	0.0
Average rating = 4.04	

Table 12 Keyboard Skills Rating (1 = very good - 10 = very poor)	
Rating Range	Percentage of Farmers
1 - 2	4.2
3 - 4	29.2
5 - 6	37.4
7 - 8	16.7
9 - 10	12.5
Average rating = 5.46	

Table 13 Frequency of Using a Mouse Ratings (1 = never - 10 = regularly)	
Rating Range	Percentage of Farmers
1 - 2	4.2
3 - 4	4.2
5 - 6	4.2
7 - 8	8.4
9 - 10	79.0
Average rating = 8.96	

Table 14 Frequency of Using Graphical User Interface Rating (1 = never - 10 = regularly)	
Rating Range	Percentage of Farmers
1 - 2	4.2
3 - 4	8.4
5 - 6	4.2
7 - 8	20.8
9 - 10	62.4
Average rating = 8.25	

These farmers believe they use a mouse and 'graphical user interface' software quite frequently. This is in contrast to the field experts. They rate themselves somewhat higher than the field experts with respect to computer skills. The time spent on a computer each week is similar to the field experts, but they use the computer on rather less days per month (13.2 as against 18.3). However, compared with the 'average' farmer (Nuthall and Bishop-Hurley (1994)), they spend much more time on a computer.

Finally, table 15 presents the information on the farmers' personality typing.

Table 15
The Farmers' Personality Types

Characteristics	Percentage of Farmers' Reflecting		
	The First Stated Characteristic	Neutral Between the Two Characteristics	The Last Stated Characteristics
Extroversion/Introversion	16.7	58.3	25.0
Sensate/Intuitive	79.2	12.5	8.3
Thinking/Feeling	54.2	37.5	8.3
Judging/Perceiving	70.9	8.3	20.8

With respect to the field experts this sample has less extroverts. Also, there are rather more neutral people due to the number of questions being reduced to a total of eight - two for each characteristic. This meant the chance of a 'tie' was much greater.

It is interesting to note that these computer owning farmers that are very likely to be the more experienced farm users (this is a subjective assessment based on their questionnaire responses and the ease with which they installed and used the systems) tend to have different personality types than the population at large (tend to be 75 percent extrovert, 75 percent sensate, 50 percent thinking and 50 percent judging, according to Kiersey and Bates (1984) though they do not allow for the intermediate categories).

The information collected on the farmers and farms was used to explain their views on the packages. The results of the analysis are reported in the next chapter.

CHAPTER FIVE

THE FARMERS' OPINIONS OF THE EXPERT SYSTEMS

5.1 Introduction

A detailed questionnaire was sent to each farmer for each system to enable them to record their opinions and views. The questionnaire varied with the particular package as clearly the problem specific factors varied. This latter data has been reported in Bishop-Hurley and Nuthall (1994 a, b and c). However, the questions relating to expert systems in general were the same for each system. Appendix five contains the questionnaire used for the weaning package. This is used to indicate the form of these questions. The section that follows contains the data collected and its analysis. It must be noted that it would be useful to re-visit the farmers after another year or two to gain additional insight into the package and the farmers' views. Suffice to comment, at this stage, that the farmers have had the packages for varying periods up to just over one year so their views in the case of drench and surplus packages have had time to mature.

5.2 A Comparison of the Weaning Systems

When asked to rank the alternative weaning systems the farmers preferred Wean Three (picture help, all questions on a single screen). Table 16 contains the ranking distribution (one is the highest rank).

Table 16
The Farmers' Ranking of Wean One, Two and Three

	Percentage of Farmers' Giving Each Rank		
Rank	Wean One	Wean Two	Wean Three
1	8	12	80
2	24	60	16
3	68	28	4

The preferences are very distinctly Three, Two and One. The Friedman test re-inforced that the differences were highly significant. The result backs up the field expert trials in confirming the requirement to put as many questions on one screen as is sensible through pick lists and mouse selection. It also stresses what might have been predicted - that picture help is useful, though there could be some doubt about this as Wean Two (no pictures) is rated second. This factor is further analyzed in later sections.

For the various factors scored (on a 1 to 10 scale with higher figures denoting difficulty/less acceptability) Tables 17 and 18 contain the data. As would be expected the scores generally reflect the ranking, though the differences are not great, and in some cases (e.g. System 'Helps') the scores do not reflect a simple Three, Two, One ranking. Also it should be recalled that the advice provided is identical. An analysis of variance indicated the lack of significant differences between the mean scores, though recall the ranking differences were significant. This probably means there are definite preferences, but that the degree of preference is not great, so that while one package is in fact preferred, the others were still acceptable.

Table 17
Comparison of Wean One, Two and Three
(Ease of Use, Appearance and Layout, Advice Given)
Column Percentage Falling in Each Category

Score Range	Ease of Use			Appearance and Layout			Advice Given		
	Wean : One	Two	Three	Wean: One	Two	Three	Wean: One	Two	Three
1 - 2	61.0	56.6	78.0	30.4	36.4	63.7	27.3	33.3	38.1
3 - 4	13.0	21.7	5.5	34.9	36.4	9.1	36.4	28.6	28.6
5 - 6	13.0	8.7	0.0	30.4	18.2	13.6	22.7	28.6	23.8
7 - 8	8.7	4.3	11.0	0.0	4.5	4.5	13.6	9.5	9.5
9 - 10	4.3	8.7	5.5	4.3	4.5	9.1	0.0	0.0	0.0
Average Score	3.04	2.96	2.27	3.74	3.41	3.09	3.82	3.62	3.19

Table 18
Comparison of Wean One, Two and Three
(Explanation Method, System 'Helps', Printout Importance)
Column Percentages Falling in Each Category

Score Range	Ease of Use			System 'Helps'			Printout Importance		
	Wean: One	Two	Three	Wean: One	Two	Three	Wean: One	Two	Three
1 - 2	20.0	23.8	40.0	42.8	36.4	61.9	28.6	27.3	28.6
3 - 4	40.0	28.6	20.0	28.6	18.2	9.5	9.5	11.0	9.5
5 - 6	25.0	23.8	20.0	19.0	31.9	19.0	42.8	42.6	42.8
7 - 8	15.0	23.8	15.0	4.8	4.5	4.8	4.8	5.5	4.8
9 - 10	0.0	0.0	5.0	4.8	9.0	4.8	14.3	13.6	14.3
Average Score	3.95	4.05	3.75	3.52	3.68	3.09	4.71	4.73	4.71

5.3 Farmers' Attitudes to the Ease of Use and the Appearance and Layout of the Systems

The farmers were asked to score (1 = very good/excellent to 10 = unacceptable) the 'ease of use' and the 'appearance and layout' of each of the packages. Table 19 contains the score distributions. The weaning system is Wean Three.

Table 19
Farmers' Scoring of the Ease of Use and the Appearance and Layout of Wean, Drench and Surplus
Column Percentages Falling in Each Category

	Ease of Use			Appearance & Layout		
Score Range	Wean	Drench	Surplus	Wean	Drench	Surplus
1 - 2	78.0	76.2	72.2	63.7	28.6	50.0
3 - 4	5.5	19.0	27.8	9.1	57.1	27.8
5 - 6	0.0	4.8	0.0	13.6	9.5	11.1
7 - 8	11.0	0.0	0.0	4.5	4.8	11.1
9 - 10	5.5	0.0	0.0	9.1	0.0	0.0
Average Score	2.27	1.95	1.80	3.09	3.24	3.08

It is clear the systems evolved following all the experiments were generally regarded as very easy to use and had a reasonable appearance and layout, though this later aspect could be improved. An analysis of variance indicated the differences in the system averages were not significant.

In exploring whether farmers' background and personality influenced their scoring of the 'ease of use' of the systems it was found they were quite independent. This might be expected as the systems tend to be highly rated by all respondents. This is in contrast to the field experts. This is likely to be due to the improvements made and that the farmers' had considerable computer experience. For 'appearance and layout' the farmers' personality traits as well as their experience partly explained the scoring. The relationship obtained was:

$$\text{Appearance and Layout Score} = 0.15X_1^{**} - 0.002X_1^{2(**)} + 0.000004X_1^{3(**)} - 1.07X_3^{**} + 0.93X_5^{**} + 0.22X_6$$

$R^2 = 0.63^{**}$

(X_6 was not significant)

As you would expect there are similarities with the field experts' relationship, but there are also differences. Computer experience replaces skill and another personality trait becomes important. This suggests peoples' perceptions of experience and skill may vary. It should also be noted the personality questions asked were a reduced set in the farmers case due to the limitations of a postal questionnaire.

Generally, however, it is clear peoples' perception of an expert systems' appearance and layout is due to their computer background and personality in contrast to the features of the systems themselves, though it must be remembered that the systems were not markedly different as earlier trials had indicated where changes should be made. The other factor of note is that the scores are not as high as those returned by the field experts - this suggests the farmers are more critical in their scoring approach.

5.4 Farmers' Attitudes to the Presentation, Help and Guidance Provided

It is important to consider the reasons the respondents viewed the expert systems in the way outlined above. In this sense they were asked to comment on their attitude to putting as many questions as possible on one screen, to the provision of picture help, to the provision of printouts of the advice and explanations (which the packages did not provide), and to the on-screen help and guidance proffered. The Figures of the systems presented earlier clearly show how all questions, at least in the weaning system, could be presented on one screen, the form of the picture help and the type of help and guidance available. The results give clear guidelines for future development.

An overwhelming 95.8 percent of the respondents said they preferred all the questions on one screen. The reasons given were:

Faster	29.2 percent of respondents
Easier to change/experiment	29.2 percent of respondents
Easier to see the variable relationships	41.7 percent of respondents

Similar views about the value of picture help were expressed. Figure 20 contains the results.

Table 20
The Usefulness of Picture Help

System	Whether Farmers Considered Picture Help Useful	
	% Agreeing	% Disagreeing
Wean	87.0	13.0
Drench	80.0	20.0
Surplus	44.4	55.6
Average	70.5	29.5

It is useful to note the attitude does change with the type of system. This is to be expected. The main reason given for preferring pictures was of the form 'need a reference point to give meaning to the words used'. This is understandable. Of course most experts use pictures (visual observation) heavily in the process of arriving at a conclusion. The old adage ' a picture is worth a thousand words' is crucially relevant.

To help explain the type of farmer that would prefer picture help a LOGIT (Pindyck and Rubenfeld, 1976, p237) analysis was carried out. The dependent variable is a log of the form:

$$Z = \log\left(\frac{P_i}{1-P_i}\right)$$

where P_i is the probability, in this case, if i^{the} individual preferring to have picture help. The best logical equation obtained was:

$$Z = 0.61X_{11}^{**} + 0.60X_{12}^{**} - 2.08X_3^{**} + 1.31X_5^{**} + 0.73X_6^{**} - 1.65X_{13}^{**}$$

Where X_3, X_5 and X_6 are the same as previously defined, X_{11} is an education level code, and X_{12} is a codified form of X_2 (computer skill), and X_{13} is a code to represent the particular expert system. The code values are:

Computer Skill

(as previously defined)

Score	Code
< 20	1
20-25	2
26-30	3
31-35	4
> 35	5

Education Codes

Highest Level	Code
No formal education	1
Primary School	2
Four or less years secondary school	3
> four years secondary school	4
< = two years tertiary	5
> two years tertiary	6

Expert System Codes

System	Code
Wean	1
Drench	2
Surplus	3

The relationship was highly significant and had a Tau-c of 0.887 indicating a good ranking between observed and predicted outcomes. The relationship re-inforces that the type of system (X_{13}) influences whether pictures are useful, that extroverts (X_3) do not tend to find pictures useful, and that greater formal education (X_{11}), computer skill (X_{12}), thinking (X_5) and judging (X_6) give a preference for pictures. These responses would be expected as people with these attributes are more likely to be critical of a system and consequently wish to be sure of their responses. The equation can be used to provide a probability estimate of whether a particular individual will prefer picture help. Table 21 contains some example combinations.

Table 21
Probability Estimates of Preferring Picture Help

Education Code	Computer skill Code	s/n personality	t/f personality	j/p personality	System type	Probability
1	1	-1	-1	-1	1	0.6437
1	1	-1	-1	-1	3	0.0625
1	1	1	1	-1	1	0.2803
1	1	1	1	1	1	0.6268
1	5	-1	-1	-1	3	0.7846
1	5	1	1	1	1	0.9892
1	5	1	-1	-1	3	0.0541
6	1	-1	-1	-1	1	0.9738
6	1	-1	-1	-1	3	0.5783
6	1	1	1	-1	1	0.8889
6	1	1	1	1	1	0.9718
6	5	-1	-1	-1	3	0.9868
6	5	1	1	1	1	0.9995
6	5	1	-1	-1	3	0.5405

Note: For personality, 1 represents the first character in a pair, and -1 the other end of the spectrum.

The effect of education and computer skill is very clear, as is system type.

Turning now to the help and guidance provided, Table 22 contains the scores (1 = excellent to 10 = poor) given by the farmers for each system. It also contains the scores for the farmers' views of whether a printout is important.

Table 22
Farmers' Scoring of the Help and Guidance Provided and the Need for Printouts for Wean, Drench and Surplus

	Help & Guidance			Printout Importance		
Score Range	Wean	Drench	Surplus	Wean	Drench	Surplus
1 - 2	61.9	42.8	55.5	28.6	4.8	23.5
3 - 4	9.5	33.4	27.8	9.5	28.6	17.6
5 - 6	19.0	9.5	16.7	42.8	19.0	29.5
7 - 8	4.8	14.3	0.0	4.8	38.1	23.5
9 - 10	4.8	0.0	0.0	14.3	9.5	5.9
Average score	3.09	3.38	2.83	4.71	5.86	4.79

Generally the farmers scored the help and guidance as being acceptable, but they were not so definite about the need for a printout. When comparing the systems there are slight differences in the averages, but an analysis of variance indicated they were not significantly different. With respect to the printouts the scores probably mean the farmers find screen output useful, but the backup of a printout would be helpful.

In analyzing the farmers' views of a printout it seems there are few personal attributes correlated to the scoring. For the views on 'help and guidance', however, the 'thinking/feeling' personality trait explained 60 percent of the attitudes. The relationship was:

$$\text{Help and Guidance Score} = 4.7X_5^{2**} - 1.5X_5^{3**}$$
$$R^2 = 0.58^{**}$$

Again, recall that the 'help and guidance' procedures were similar in all systems. The more feeling a person is, the more they appreciate the provision of 'help and guidance'.

5.5 Farmers' Attitudes to the Advice and Explanations Provided

The two major questions are, firstly, whether the farmers agree and accept the actual advice and conclusions of the expert systems, and similarly for the explanations, or reasoning, offered for the advice, and secondly, whether the farmers have suggestions about the form and method of presentation of the advice and explanations.

Table 23 contains the farmers' views of whether they agree with the advice and explanations.

Table 23
Farmers' Agreement of the Advice and Explanations
Row Percentages

System	Advice		Explanations	
	Agree	Do Not Agree	Agree	Do Not Agree
Wean	84.0	16.0	84.0	16.0
Drench	80.0	20.0	76.2	23.8
Surplus	77.8	22.2	93.7	6.3
Column Average	80.6	19.4	84.6	15.4

When asked to score (1 = very good to 10 = not acceptable) the advice and explanations the data in Table 24 was obtained.

Table 24
Farmers' Scoring of the Advice and Explanations
Provided in Wean, Drench and Surplus
(Column Percentages Falling in Each Category)

Score Range	Advice			Explanations		
	Wean	Drench	Surplus	Wean	Drench	Surplus
1 - 2	38.1	14.3	22.3	40.0	33.3	44.4
3 - 4	28.6	57.1	72.2	20.0	47.6	38.9
5 - 6	23.8	14.3	0.0	20.0	14.3	16.7
7 - 8	9.5	9.5	0.0	15.0	4.8	0.0
9 - 10	0.0	4.8	5.5	5.0	0.0	0.0
Average Score	3.19	3.81	3.36	3.75	3.19	2.94

It is clear the farmers in general agree with the advice and explanations provided. That is, they at least do not find themselves in disagreement and presumably are prepared to take action based on the result of their expert system experience. The scores are acceptable, but whether a group of critical farmers would in fact provide lower (i.e. better) scores for 'better' systems is not clear. In the case of the Weaning system the field experts gave similar responses. The difference in the means of the different systems were not significant.

In explaining the variation in the advice scoring the following regression equation was obtained:

$$\text{Advice Score} = 3.12X_3^{2**} - 1.04X_5^{**} + 1.48X_5^{2**}$$
$$R^2 = 0.72^{**}$$

and in the case of the explanations:

$$\text{Explanation Score} = 9.07X_{13}^{**} - 5.79X_{13}^{2**} + 1.06X_{13}^{3**} - 1.17X_4^{**} + 0.62X_5^2$$
$$R^2 = 0.82^{**}$$

That is, personality aspects (X_3 - X_5) and the type of systems (X_{13}) explain a major part of the scores. The more feeling (as against thinking) (X_5) a person is the better the rating they provide whereas the greater the extroversion the lower the rating (higher score). These are logical relationships, and clearly the system type must influence the explanation required.

The advice provided in the wean and drench systems was in the very simple form of 'wean (drench) this mob', or 'do not wean (drench) this mob'. A major question is whether farmers find this acceptable. Table 25 contains their responses.

Table 25
Farmers' View on Whether the Advice Should be a Simple Yes/No Answer
(Row Percentages)

System	Acceptable	Not Acceptable
Wean	31.8	68.2
Drench	47.6	52.4
Surplus	0.0	100.0
Column Average	26.5	73.5

This data provides a clear indication that while they generally agree with the advice offered, they would prefer to have fuller conclusions. Common suggestions were 'need provisos and conditions', 'need instructions on what to do given a slight variation on the conditions'.

When trying to understand the factors which influenced the acceptable/not acceptable conclusion the following LOGIT relationship was obtained ($Z = \log (P_i/(1-P_i))$)

$$Z = 0.086X_7^{**} + 45.09X_8^{**} + 4.75X_9^{**}$$

This relationship was highly significant and had a Tau-c of 0.69. These explanatory factors indicate the probability of whether a person will be happy with a simple yes/no answer is dependent on the professionalism (X_7), the ease of data entry (X_8) and the on-line help and advice (X_9). That is, the features of the package itself are more important than a person's personality in predicting their view of the form of the answer. Clearly with plenty of on-line help and advice the answer can be less complex. The same can be said for professionalism, though this variable is not really important (small coefficient). Clearly, the data entry ease and mouse use effect must be due to allowing easy change and therefore a quick re-evaluation of the answer. Under these conditions it is less important to have a lengthy conclusion.

With respect to the explanations the farmers were asked a range of questions to assess potential improvements. These included items like whether references should be included, whether greater length and/or detail was required and so on. Table 26 contains the farmers' responses. Only the percentages answering Yes to the questions is presented as the percentage answering No is obvious.

Table 26
Farmers' Comments on Various Questions About the Explanations Provided
(Percentage Answering Yes to Each Question)

Question	System			
	Wean	Drench	Surplus	Average
Should references be provided?	60.0	47.6	52.9	53.5
Are explanations at the correct level?	70.8	95.2	88.2	84.7
Is more detail required?	68.0	57.1	68.7	64.6
Is the length about right?	76.0	85.7	88.9	83.5

There is a variation in the answers. Most would agree references (further reading suggestions)should be included and certainly providing references cannot detract from the system. The explanations are generally regarded as being at the correct level (see the Figures for examples) and about the correct length, but clearly many would like greater detail. It is not clear how this can be obtained without increasing their length.

To further explore the reasons why people might require references a LOGIT analyses was performed. Both education and personality factors were important in predicting the probability of a farmer indicating s/he would prefer to have references. The relationship was:

$$Z = 0.41X_{11}^{**} + 0.65X_5^{**} + 0.56X_6^{**} - 2.21^{**}$$

The relationship was highly significant and had a Tau-c of 0.73 indicating a reasonable predictive ability. Recall that X_5 is the thinking/feeling trait and X_6 the judging/perceiving characteristic. That is, thinking and judging people are likely to prefer references as would those with a greater degree of formal education.

5.6 Farmers' Attitudes to the Use and Value of Expert Systems

The farmers were probably exposed to expert systems for the first time through this research. Not only was it important to assess their likely use of the development systems, but also to determine whether they believed expert systems as a procedure would be useful to them. The following data was obtained to explore these questions. This analysis culminates in determining the economic value the farmers placed on the packages.

Tables 27 and 28 contain the farmers' views on how frequently they would use the systems.

Table 27
Farmers' Views on the Frequency of Using Wean
Column Percentages Falling into Each Category

Number of Uses	Use for Each Mob	Use During the Spring
0	9.1	4.2
1	27.3	0.0
2	50.0	8.4
3	13.6	74.8
4	0.0	4.2
5	0.0	8.4
Average Uses	1.68	3.0

Table 28
Farmers' Views on the Frequency with which a Typical Farmer Would Using Wean, Drench and Surplus Over One Year.
Column Percentages Falling into Each Category

Number of Uses	Wean	Drench	Surplus
0	9.1	0.0	0.0
1 - 2	54.6	15.0	35.3
3 - 4	18.2	80.0	47.1
5 - 6	9.1	5.0	17.6
>7	9.0	0.0	0.0
Average Uses	3.0	3.35	3.41

There are some discrepancies in these figures but at least the average for Wean use in the spring (see Table 27 - 3.0) and throughout the year are identical even if the distribution is different. The Wean data suggests farmers have two main mobs of lambs. This is doubtful. With respect to Table 28 it appears the "test" farmers do not believe farmers' in general would use the systems on a constant and regular basis.

This suggests the systems might be used at the start of the relevant season as a means to focus their management. Table 29 contains the answer to this query, and also the farmers' views on whether the systems would provide a regular check of the factors involved in the decisions and whether they would make decisions in the relevant areas easier. Only the percentage agreeing with the questions is given as the reverse is obvious.

Table 29
Farmers' Views on Whether the Systems Would Provide A Season Beginning Check, A Regular Reminder, and Improved Ease of Decision Making,
Percentage Agreeing With Each Question

Question	System			
	Wean	Drench	Surplus	Average
Would E/S* remind at season beginning?	76.0	94.7	78.9	83.2
Would E/S* remind regularly?	81.8	57.1	72.2	70.4
Would E/S* make the decision easier?	70.8	80.2	77.8	76.2

* E/S refers to Expert System

Except in the case of the Drench system the respondents clearly agree with the questions. In the Drench case virtually all the farmers thought this system would clearly focus in their mind at the beginning of the season the factors they should be considering. This response is understandable in that the package forces the user to provide answers to all the factors considered important. This data combined with the frequency of use information clearly indicates the farmers believe the teaching functions of the package are important. It appears use of the package could well train the decision makers in the important factors so that their intuitive responses are sharpened and improved.

When asked why an expert system would not make a decision easier, typical of the very few such comments were 'already know answers', 'need whole farm system', 'need the answer in the paddock - can't go back to the office'. The latter two responses are understandable. They re-enforce the concept of using expert systems as training and reminding procedures for enhancing an understanding of the problem and consequently improved intuitive decisions.

An interesting question is whether it is possible to predict the characteristics of farmers that would use the systems in the ways suggested. The result of LOGIT analyses of the responding farmers provided the following relationships for predicting the log of $(P_i/(1-P_i))$:

(i) Whether a farmer would use an expert system as a beginning of season reminder

$$= 1.04X_5^{**} + 0.65X_6^{**}$$

(Highly significant with Tau-c = 0.76)

(ii) Whether a farmer would use an expert system as a regular reminder of the factors

$$= 2.09^{**} + 0.24X_1^{**} - 0.79X_{14}^{**}$$

(Highly significant with Tau-c = 0.68)

(iii) Whether a farmer believes an expert system would make the decision easier

$$= 2.69^{**} - 1.06X_3^{**} - 0.3X_{11}^{**}$$

(Highly significant with Tau-c = 0.68)

Recall that X_3 - X_6 are the personality traits, X_1 computer experience, and X_{11} education. A new variable, X_{14}, has also been introduced. This represents the farmers' age using:

Range of Years	Code
0 - 30	1
31 - 40	2
41 - 50	3
51 - 60	4
61 - 70	5
>70	6

Clearly, whether a farmer believes the system would make a decision easier must influence whether it would be used. Overall, as might be expected, use of the systems is dependent on education, age and personality. This becomes clearer from looking at the calculated probabilities obtained from the equations. Tables 30, 31 and 32 give the parameter combinations and the predicted probability that a farmer with these characteristics would, respectively, use the expert system as (i) a beginning of season reminder, (ii) a regular reminder of the factors, and (iii) believe the system would make the decision easier.

Table 30
Probability of a Farmer Believing an Expert System Would be Used as a Beginning of Season Reminder

Personality Trait Combinations		
Thinking/Feeling	Judging/Perceiving	Probability
Feeling	Perceiving	0.1557
Feeling	Neutral	0.2614
Feeling	Judging	0.4044
Neutral	Perceiving	0.3426
Neutral	Neutral	0.5000
Neutral	Judging	0.6574
Thinking	Perceiving	0.5956
Thinking	Neutral	0.7386
Thinking	Judging	0.8443

That is feeling - perceiving type people are less likely to believe an expert system would be a useful reminder than thinking - judging type characters.

Table 31
Probability of a Farmer Believing an Expert System Would be Used as a Regular Reminder of the Important Factors in a Decision

Age Code*	Experience Code*	Probability	Age Code*	Experience Code*	Probability
1	1	0.8241	4	1	0.3062
1	2	0.8565	4	2	0.3599
1	3	0.8837	4	3	0.4173
1	4	0.9064	4	4	0.4770
1	5	0.9250	4	5	0.5374
1	6	0.9401	4	6	0.5967
2	1	0.6807	5	1	0.1673
2	2	0.7309	5	2	0.2037
2	3	0.7757	5	3	0.2458
2	4	0.8150	5	4	0.2933
2	5	0.8487	5	5	0.3458
2	6	0.8772	5	6	0.4024
3	1	0.4924	6	1	0.0837
3	2	0.5527	6	2	0.1043
3	3	0.6115	6	3	0.1291
3	4	0.6672	6	4	0.1588
3	5	0.7185	6	5	0.1939
3	6	0.7648	6	6	0.2345

* See the text for the code meanings

Clearly, as age increases a farmer is less likely to use an expert system, but in contrast, as computer experience increases the reverse holds.

Table 32
Probability of a Farmer Believing an Expert System Would Make a Decision Easier

Education Code*	Extrovert or Introvert	Probability
1	Introvert	0.9691
1	Neutral	0.9155
1	Extrovert	0.7890
2	Introvert	0.9586
2	Neutral	0.8888
2	Extrovert	0.7340
3	Introvert	0.9448
3	Neutral	0.8551
3	Extrovert	0.6708
4	Introvert	0.9266
4	Neutral	0.8134
4	Extrovert	0.6007
5	Introvert	0.9031
5	Neutral	0.7629
5	Extrovert	0.5261
6	Introvert	0.8731
6	Neutral	0.7037
6	Extrovert	0.4505

The probabilities indicate the greater the level of formal education the less likely a person believes decisions will be made easier (perhaps this is a case of a little knowledge being a dangerous thing), and introverts tend to think a machine is more likely to make decisions easier. Even so the probabilities are reasonably high for all situations.

The respondents were also asked whether farmers 'in general' would use the system (in contrast to themselves - people with powerful computers and reasonable experience). They were not as confident about the general farmer and believed 31.3 percent would use the wean system, 50.0 percent the drench package and 62.5 percent the surplus system.

It is interesting to note that as they acquired a greater exposure to the systems (they received wean first and surplus last) the percentage increased so, perhaps, their confidence of the general acceptability of expert systems increased.

Turning now to the crucial parameter of the economic value, farmers were asked to give both a verbal rating response as well as a quantified one. Tables 33 and 34 contain the responses.

Table 33
Respondents' Belief in Various Economic Value Categories for Wean, Drench and Surplus

	Percentage Believing a Category Applies			
Category	Wean	Drench	Surplus	Average
No economic value	8.0	14.3	5.5	9.3
Some economic value	84.0	76.2	94.5	84.9
Considerable economic value	8.0	9.5	0.0	5.8
Extremely high economic value	0.0	0.0	0.0	0.0

Table 34 Respondents' Belief in the Monetary Value of Wean, Drench and Surplus On a 'Per Ewe' Basis			
	Column Percentages of Respondents in Each Category		
Value/Ewe ($)	Wean	Drench	Surplus
0.00 - 0.30	52.4	63.1	60.2
0.31 - 0.60	15.8	15.8	13.3
0.61 - 0.90	5.3	5.3	6.6
0.91 - 1.20	5.3	15.8	13.3
1.21 - 1.50	5.3	0.0	0.0
1.51 - 1.80	5.3	0.0	0.0
1.81 - 2.10	5.3	0.0	6.6
2.11 - 2.40	5.3	0.0	0.0
Average Value (Based on the mid points)	0.63	0.37	0.47

The majority do believe the systems confer some economic value, but only a small dollar amount per ewe. Wean is valued more than the other two systems (indicating this was a good choice for development). A producer with 4900 ewes, for example, believes s/he would benefit by approximately $3100, $1800 and $2300 for Wean, Drench and Surplus. These returns would clearly more than cover the likely costs of the software and the time to operate them. The 4900 figure was chosen as this is the average stock unit level of the responders - however note that this is not the number of ewes as conversions were used, but it does provide a useful approximation.

In explaining the differences in the farmers' views of the monetary value the following equation was obtained:

$$\$\text{Value/Ewe} = 0.0005X_{15}^{**} - 1.82X_4^{**} - 0.59X_5^{*} - 0.9X_5^{2**} + 1.04X_6^{**} - 4.22X_6^{2**} + 12.86X_{13}^{**} - 7.51X_{13}^{2**} + 1.32X_{13}^{3**}$$

$$R^2 = 0.76^{**}$$

The new variable, X_{15} (total stock units) is introduced. It does, however, only minimally affect the value. The important variables are the character factors (X_4 - sensate/intuition, X_5 - thinking/feeling and X_6 - judging/perceiving) and the type of system (X_{13}). Clearly, the problem being approached must influence the value. On top of system type, the perceived value depends on the individual personality with sensate, thinking and judging people tending to down play the value.

Finally, in a value sense, the farmers were asked the general question 'Do you think expert systems have potential for decision making in agriculture?' Table 35 contains the responses. They were asked this same question three times (after using each of the packages).

Table 35 Farmers' Views of Whether Expert Systems Have Potential In Agricultural Decision Making		
	Percentage	
	Agreeing	Not Agreeing
First time of asking	94.4	5.6
Second time of asking	85.0	15.0
Third time of asking	86.4	13.6
Column Average	88.6	11.4

After additional experience they clearly reduced their agreement, but overall it must be concluded they are generally favourable to the concept of expert systems, though, not all farmers' agree. In explaining those most likely people to agree, a LOGIT analysis produced for predicting $Z = \log (P_i/(1-P_i))$, P_i being the probability of the ith individual agreeing: -

$$Z = 2.1^{**} + 1.21X_3^{**} - 1.09X_4^{**}$$

That is extroverts (X_3) are more likely to believe in expert systems, as are intuitive people (X_4 = sensate/intuitive). The relationship was highly significant and had a Tau-c of 0.68. Using the equation to produce the probabilities provides the data in Table 36.

Table 36 The Probability of a Particular Farmer Believing Expert Systems Have Potential as Decision Aids		
Personality Traits		
Extrovert/Introvert	Sensate/Intuitive	Probability
introvert	intuitive	0.8777
introvert	neutral	0.7075
introvert	sensate	0.4491
neutral	intuitive	0.9603
neutral	neutral	0.8908
neutral	sensate	0.7332
extrovert	intuitive	0.9879
extrovert	neutral	0.9649
extrovert	sensate	0.9025

These figures clearly show the effect of personality on attitude, though, of course, most respondents did believe expert systems had potential.

5.7 Comments Offered By the Farmers

At all stages of the evaluation process the farmers were given the opportunity to provide written comments and criticisms. A wide range were received, and some of these have already been reported in various parts of the text.

The remaining comments have been summarised and presented in Table 37 below. The very system specific comments are presented in Bishop-Hurley and Nuthall ((1994) a, b and c).

Table 37
Farmers' Comments, Likes and Dislikes of the Systems Wean, Drench and Surplus

Comment	Percentage Making the Comment
Would like better pictures	7.7
More depth, more factors, more quantitative, too simplistic	30.8
Like questions on one screen	15.0
Have value as learning systems	10.8
Require response as discussion, not edict	4.6
Too slow	9.2

The major comment is the requirement for greater depth and the inclusion of quantitive approaches. This is understandable and provides a directive for the future. The cost of developing integrated quantitive systems will be considerable. The packages are already extensive in a computer code sense. The pictures (picture help) can always be improved, as can the speed. As noted before, there is a clear view that expert systems are excellent teaching/reminding procedures. This is easily observed when exposing the systems to undergraduate classes at a university.

When asked what other expert systems the respondent might find useful some of the more common ideas were:

when to sell cattle
deciding on a topping date
deciding on a stocking rate
working out fertilizer rates
managing winter feed
when to shear
a full feed budgeting system

There are many challenges for future system development.

CHAPTER SIX

DISCUSSION AND SUMMARY

As noted, large numbers of expert systems have been developed throughout the world, yet few have been formally evaluated by farmers. This study has concentrated on this obviously important aspect of the development and use of expert systems. Clearly, systems should be designed 'for the people' (Morland, 1983). The particular packages developed in this study evolved as a result of initial feedback from the field experts, and subsequently from the comments of the farmers when exposed to the first package distributed.

The other crucial aspect of the study was the development of actually beneficial expert systems for assisting feed management. In the sense that by far the majority of the testing producers indicated that they found the systems beneficial, this part of the project was successful. The real test, however, must be whether they continue to use the systems for many years, though some would argue that a period of limited use which leads to the learning of new decision skills is a major benefit in itself. Indeed, some of the producers may already have achieved this benefit. The farmers were provided the systems free of charge. After appropriate demonstrations and training, a vital question will be whether large numbers of farmers will be prepared to purchase the packages at a price sufficient to cover development and maintenance.

The results reported in the study relate to particular expert systems and to a particular set of farmers. While the respondents were asked to comment on whether expert systems in general would be useful in agriculture, it must be remembered their answers stem from experience of three narrowly focused systems. The group of twenty five testing farmers do not appear to be typical of all farmers in that, on average, they operate larger farms than most, they are slightly younger than the norm, and their highest level of formal education was greater than the typical farmer. Furthermore, they spend more time every week on a computer than the average, and they rate themselves as having good computer skills and as being familiar with mouse and GUI procedures. They, however, do not believe they have good keyboard skills, but this is undoubtedly common for the 19% or so of New Zealand farmers that currently use a computer for business.

Clearly, the exploration of the new software technology cannot encompass a totally random sample of all farmers as they do not have appropriate computer skills, and clearly they do not have the appropriate hardware. Thus any experimental work that has limited funds and time must utilise those farmers that already have the skills, hardware and a willingness to assist. This is what happened in this case, and the results must be interpreted accordingly.

Overwhelmingly the sample farmers believed the packages were beneficial, easy to use, and gave appropriate advice and explanations. This is not to say they did not have suggestions on how the packages could be improved. When asked about monetary value some were not convinced that this was significant, but they certainly indicated, on average, that the value would be greater than the probable cost of the packages. For the average sized property (as the benefit must depend on the number of stock units) the annual value was considered to range from approximately $1800 to $3000 depending on the problem addressed by the

package.

The good acceptance of the expert systems was due in part to the lessons learned from initial trials with seven field experts (professional agriculturists with experience in consultancy, research, teaching and extension). It was also clear from an analysis of the field experts' responses and their personal attributes that their character traits (personality) and computer experience and ability was equally as important in explaining their views of the packages as were the differences in the packages themselves. This analysis provided a framework to similarly analyze farmers' attitudes and views. It must also be noted, however, that the ranking of the systems provided by the field experts was explained without recourse to personality.

When asked to indicate how often they would most likely use the packages the farmers suggested around three times per year. This is less than what might be expected. However, they indicated strongly that system use would provide at the beginning of each season an excellent means of reminding then of the important factors to be considered when making a decision. Effectively they may well be commenting on the value of expert systems as training or extension devices. It could be, particularly for farmers new to a particular farming situation, that they will absorb the rules inherent in the package through the use of the system and so no longer need to use it constantly. Then an occasional use may provide a decision rule revision procedure.

Farmers new to a package frequently have difficulty in installing and learning it. In the case of the three expert systems this generally was not the case. It seems the installation instructions, manuals, and probably more importantly, the on screen procedures and help systems were such that the users successfully operated the packages with little support. Indeed, the help and guidance offered was rated highly. An examination of the screen figures presented gives an idea of what was offered, though a full understanding is only possible from running the systems.

When asked to indicate their preferences for various alternative presentation approaches the respondents made it clear they preferred to see as many of the parameter value finding questions as possible presented on a single screen. They also preferred answering the questions through pointing to their choice in a pick list using a mouse. This is in contrast to entering a value through the keyboard. The provision of picture help was also favoured in general. The pictures enabled relating adjectives like good, average and poor to an absolute measure. In the case of the surplus feed utilisation package the farmers did not find the pictures as helpful as might be expected. Whether this is a criticism of the concept of picture help itself, or whether of the pictures actually offered is not clear. This needs further work. The respondents also made it clear they would like the expert system conclusions to be rather more than a simple 'do this', or 'do that'.

They wanted a conditional set of suggestions like 'you should follow a course of action involving x, y and z, but if temperature (say) should increase above 15° in the next day or so you should contemplate actioning a, b, c, etc'. This is, of course, in addition to full explanations of why the particular conclusions had been reached. It is worth noting that writing meaningful, unique and useful explanations for, say, four hundred different combinations of parameter situations is a challenging task. Most farmers also indicated they would like references to further reading provided. This makes sense.

Through their general acceptance of the packages the respondents inherently voted for many other presentation factors. To appreciate this it is necessary to run the system, though study of the screen excerpt figures indicate the general approaches taken. The package creators had many years of experience in developing successful systems for farmers and this was, clearly, built into the packages.

Considerable effort went into exploring the factors that might well determine why one approach or system is preferred to another. It was clear that users' personality, age, education and computer skill and experience were all important to varying degrees. Even where a factor was identical across systems (e.g. advice in Wean One, Two and Three), presumably due to the presentation variations, the scoring was not identical. These differences could be partially explained through personality differences. What this means is that people with different personalities have, clearly, different requirements. If systems can be configured in appropriate ways to suit an individual's way of approaching a problem then it will gain greater acceptance and use. It should also be pointed out, however, that the personality analyses were not always consistent. This is an area that requires greater in-depth research. In particular, more intensive personal interviews would be appropriate in elucidating personality traits. Besides personality, education, in particular, but also age and computer experience affect people's views of the packages. In that there is a wide range of age, experience and education levels in the community, configuration of a package to suit an individual's requirements could well be appropriate.

While this work has demonstrated scoring of attributes can be explained by the factors listed, it does not, however, indicate the exact nature of the system and presentation preferred by each type of user. It does also appear that while preferences vary, when it comes to deciding on the ranking of systems, factors other than personality tend to explain the rankings. But, whether or not a particular expert system will be used with benefit could depend on personality (personality is important, for example, in explaining the monetary value of the systems).

The packages distributed to the farmers could be improved in many ways. Some of these developments were considered as the packages were being developed, but time and resources precluded their inclusion. Some of the possible developments stemmed from the farmers' comments. Of the former it would have been interesting to explore the use of a natural language interface (Jones and Spahr, 1990). By this is meant building in a sentence interpreter so that a user can type in any kind of question (provided it is restricted to the domain of the expert) and have the package interpret the question and produce an appropriate answer. Currently the data entry operation and subsequent conclusion is a highly structured procedure. Of course, a natural language system would consume considerable code, memory, storage and computing time.

From the farmers' comments it is clear more and better pictures would assist the picture help component (though the storage requirements are high - perhaps an accompanying book of pictures would be helpful), the addition of data bases of features and information about each specific farm (and thus reduce the need to constantly input farm data each time a package is used) would be beneficial , as would the inclusion of references to further reading in all the explanations.

Following the comment about requiring more depth, it would also be of value to develop calculational and, perhaps, optimization procedures into the package. Instead of asking, for example, for information on future growth levels the package might request basic data and

then proceed to use a simulation model to forecast likely dry matter production. Equally, a dynamic or linear programming model might be attached to work out, for example, the most profitable way of utilising a surplus of food. Many possibilities exist - the problem is relating the potential benefits for the farmer to the cost of developing and maintaining the systems. They must also be readily usable and easily understood if they are not to achieve white elephant status.

When asked whether they thought expert systems as a technique had a place in practical farm management the respondents were clearly of the affirmative. This is encouraging, but it must be interpreted in the light of the comments and data provided. Expert system technology has little structure or theory underpinning it. Its base is the concept of experts being more skilled than the average decision maker and that they can express their rules of thumb and procedure in a form capable of computerisation for use by non-experts. This is acceptable as far as it goes, but the operation of elucidating and capturing the knowledge is not always straightforward. Where this is in fact achieved the result is often a complex and lengthy procedure. In contrast, where a problem has a definable structure that can be studied to find its underlying relationships and parameters this can often be exploited to produce an efficient solution algorithm. Examples are dynamic and linear programming. Problems expressible in these forms should be solved in these ways.

The farmers clearly indicated that expert systems would be valuable in reminding them of the important decision factors at the beginning of a season. Perhaps this extension and management training role will be the most valuable contribution of expert systems in primary production. Farming and horticultural production is extremely complex in that it involves soils and biology, economics and markets, personal relationships and government rules not to mention the weather. Very few other forms of production involve so many components, many of which are not well understood. Furthermore most factors are constantly changing and operate under dynamic conditions. In addition, each farm and farmer is unique in that the particular soil and contour combination, the particular pastoral and cropping history, the particular farm family and objective structure will all be different for each farm. A major question is whether all of these factors can ever be allowed for and included in a single expert system. This is most unlikely, though, of course, experts do in fact allow for all these factors. Perhaps individual farm consulting is best left to the experts.

If this argument is accepted, then the future of expert systems may well lie in the training and extension role as a general rule. There will no doubt be exceptions to this for cases where the totality of the problem can be captured in a precise way. Examples might be disease diagnostic packages with considerable picture help. Such packages can be operated as stand alone systems and involve problems that are not frequently encountered and are therefore unlikely to become familiar to managers.

The packages developed in this study evolved through experience and feedback. The text book approach of development and validation is unlikely to be the best approach. Successful system development is likely to be a heuristic process of trial, error, feedback, improvement and so on. This should be a constant and never ending process. The feed management package presented must be regarded as the first version of systems that the farmers clearly believe have value.

The last ten years or so have seen a significant increase in the number of New Zealand farmers using business computers. While approximately one fifth have a computer this proportion is increasing rapidly and is likely to continue to do so. These farmers primarily

use simple financial software (Nuthall and Bishop-Hurley, 1994), but with time the demand for a wider range of packages will increase. Expert systems of the form developed are very likely to meet some of these demands, particularly with respect to the management training requirements of the farmers. Thus, the research and development work should continue and the systems further enhanced along the lines suggested.

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APPENDIX ONE

Weaning Expert Questionnaire used For the Field Expert's Comments on the Alternative Systems

Name: _____ Date: ___/___/___

A questionnaire to accompany the introduction of 'field experts' to Weaning Expert, a prototype expert system run under the VP-Expert shell. For some questions you may need to refer to the appendix which gives an explanation of the current system. The system aims to determine whether the users mob of ewes and lambs should be weaned.

1. How many expert systems have you seen or used?

2. Of those, how many had a direct or indirect use in agriculture?

3. Do you think that systems capable of expert advice have a place in agricultural decision making?

4. Who do you think would use expert systems in agriculture?
   Notes: Teaching, With farmers, Consultants, Training consultants, other.

5. What are some decisions in agriculture that you think an expert system could help make?

6. What percentage of agriculturalists do you think would use an expert system?
7. What percentage of agriculturalists with computers do you think would use an expert system?

8. Generally, what type of agriculturalist do you think, would use expert systems?
   Notes: Type refers to Farm type and Character Type

9. Why would agriculturalists use expert systems instead of consultants etc?
   Notes: Always available

10. Why would non users stay non users of expert systems?

11. Do you think that weaning date is a decision that farmers could be making better?

12. What do farmers need to make better weaning date decisions?

13. How do agriculturalists decide when to wean a mob of ewes and lambs?
    Notes: Consultant, Historical

14. When do agriculturalists decide the weaning date for a mob of ewes and lambs?

15. Do you think the decision of when to wean a mob of ewes and lambs is suitable for an expert system?

16. Do you think the weaning decision one that agriculturalists would consult an expert system on?

17. Can the weaning 'decision' be made on a mob basis or do whole farm factors need to be considered?
Notes: Pasture quantity, Other stock, Labour etc.

18. What groups of agriculturalists do you think would find a use for a system that can advice on weaning date?
Notes: Farmers, Consultants, Lecturers, Others.

19. How often do you think these people would use such a system for each mob and in each year?
Notes: For each, number of times a year, a mob, etc.

20. Do you think that a system on weaning date should give a yes or no answer to weaning (ie. it answers either wean or do not wean)?

21. If you answered no to the question above, how should advice be given?

22. Are the factors identified here all relevant to the decision of weaning date?
Notes: Refer to appendix for a list of factors

23. What other factors do you think that a system determining weaning date needs to consider?
Notes: Shearing date, Lamb price, Labour, Need for cash, Expected changes in prices, Wool growth, Tupping, Ratio of sheep to other stock, Others.

24. When asking questions do you think that some form of assistance should be provided, perhaps in the form of pictures or charts?

25. Is there any need to allow for weaning of part of a mob?
Note: Mixed age mobs, perhaps weight range with average, ewe lambs, black face, etc

26. Do you think farmers know the age of a mob of lambs accurately to the nearest week?

27. Is it appropriate to group ages as has been done in this current system?
Notes: Refer to appendix for explanation of age groupings

28. If you answered no to the previous question how should this be dealt with?

29. How good are potential users at estimating the weight of lambs?

30. What is the best practical way for users of weaning expert to determine the weight of lambs?

31. Is using a weight around 13 kg as a cut-off point between weaning and not weaning appropriate?
Notes: Refer to appendix for an explanation

32. If you answered no to the question above, how should the weight of the lambs be dealt with?

33. What percentage of twins are required before multiple lamb management needs to be considered?
Notes: This refers to having feed priority. What percentage become prolific.

34. How good are potential users at estimating the quantity of feed now and in the future?

35. What is the best practical way for users of weaning expert to find the quantity of feed available?

36. What is the best practical way for users of weaning expert to determine the quality of the feed?

37. How good are potential users at estimating the quality of feed?

38. Do you think that users can determine the milk producing ability of the ewes from the information given and their own knowledge?
Notes: Refer to appendix for explanation

39. Is the question on the price of cull ewes suitable?
Notes: Should the information needed be asked in some other way, Refer appendix.

40. Does the recommendation made need an explanation?

41. Are the explanations aimed at the right level?
Notes: Should the explanations be more direct or follow a different line of reasoning.

42. Is the length of the explanations too short, too long, or about right?

43. Should the explanations contain references and further reading?

44. Should the explanations be more detailed with reference to facts and figures?

45. After this brief introduction to weaning expert, do you think this type of system has potential?

46. What areas do you think need to be improved in this system?

47. How would you improve them?

48. Any additional comments!

APPENDIX TWO

Weaning Expert Questionnaire Used
For The Field Expert's Computer Experience and System Ratings

Name: _____ Date: ___/___/__

A questionnaire to record preferences between different versions of the 'weaning date' expert system. Weaning expert aims to determine whether a mob of ewes and lambs should be weaned.

General Questions
(Enter the value in the box provided)

1. On average, how many days per month do you use your computer? [ ]

2. On average, how many hours per week do you use your computer? [ ]

(Please mark one of the ten numbers for each of the following questions)

3. How would you rate your general computer skills?
(Competence in using a wordprocessor and a spreadsheet.)

(very good) 1 2 3 4 5 6 7 8 9 10 (very poor)

4. How would you rate your keyboard skills?

(very good) 1 2 3 4 5 6 7 8 9 10 (very poor)

5. How often have you used a mouse?

(never) 1 2 3 4 5 6 7 8 9 10 (regularly)

6. How often have you used software with a Graphical User Interface (GUI)?
(GUI is where you select choices shown as pictures, or drawings rather than as text descriptions.)

(never) 1 2 3 4 5 6 7 8 9 10 (regularly)

Rating each version

(Fill out the following table as you look at each of the systems. Each question is written out in full below this table.)

Give each version a value from 1 (very good/excellent) to 10 (very difficult/not acceptable) for each question.

Questions	v1	v2	v3	v4
7. Ease of use				
8. Appearance and Layout				
9. The Advice given by the version				
10. Explanations to Advice				
11. Help, Guidance, Messages				
12. Importance of a Printout				

Notes:

v1 Base system
v2 Level5 Version of the Base System
v3 Point and Click Version
v4 Full Screen Version

Questions:

7. How do you rate each version of the system for ease of use?

8. How do you rate each version of the system for appearance and layout?

9. How do you rate the advice given by each version of the system?

10. How do you rate the method of providing detailed explanations?

11. How do you rate the help/guidance/explanation messages provided?

12. How important is a printout of the advice and associated factor values?

Ranking the Versions

(Please rank each version by placing numbers from 1 to 4 in each box.)

13. Indicate the ranking you would give each version of the system for ease of use and functionality.

Base System	
Level5 Version of the Base System	
Point and Click Version	
Full Screen Version	

14. Indicate the ranking you would give each version of the system for appearance and layout.

Base System	
Level5 Version of the Base System	
Point and Click Version	
Full Screen Version	

15. Indicate the ranking you would give each version of the system for the advice given.

Base System	
Level5 Version of the Base System	
Point and Click Version	
Full Screen Version	

16. Indicate the ranking you would give and each version of the system for the overall best version of the system. Do you think farmers would have a different view? If so, put this ranking in the brackets beside yours.

Base System		( )
Level5 Version of the Base System		( )
Point and Click Version		( )
Full Screen Version		( )

General Comments

17. Any other comments that you would like to make about the system in general.

18. What other stock feeding problems do you think could be solved using an expert system?

APPENDIX THREE

Personality Test Used For The Field Expert's

Could you please complete and return as soon as possible. This is part of our on going research into the feasibility of using computers, and expert systems, in helping agriculturalists make better grazing management decisions. Recently you assisted us by looking at four versions of the weaning date expert system and filling in a questionnaire. Up until now we have been unable to explain some of the results that we got in that questionnaire. Once completed, this questionnaire will allow us to relate our earlier results to personality. We think that personality may be related to how people view computers and computer software.

For each of the statements choose the best one (a or b) and place a check mark on the attached answer sheet beside the correct number in column a or b.

1. At a social gathering do you
   (a) interact with many, including strangers
   (b) interact with few, known to you

2. Are you more
   (a) realistic than speculative
   (b) speculative than realistic

3. Are you more impressed by
   (a) principles (b) emotions

4. Do you tend to choose
   (a) rather carefully (b) somewhat impulsively

5. At social gatherings do you
   (a) stay late, with increasing energy
   (b) leave early, with decreased energy

6. In doing orderly things are you more likely to
   (a) do it the usual way (b) do it your own way

7. Which appeals to you more
   (a) consistency of thought
   (b) harmonious human relationships

8. Are you more
   (a) punctual (b) leisurely

9. In your social groups do you
   (a) keep abreast of other's happenings
   (b) get behind on the news

10. Writers should
    (a) "say what they mean and mean what they say"
    (b) express things more by use of analogy

11. Are you comfortable in making
    (a) logical judgements (b) value judgements

12. Does it bother you more having things
    (a) incomplete (b) completed

13. In phoning do you
    (a) rarely question that it will all be said
    (b) rehearse what you'll say

14. Common sense is
    (a) rarely questionable (b) frequently questionable

15. It is worse to be
    (a) unjust (b) merciless

16. Would you say you are more
    (a) serious and determined (b) easy going

17. In company do you
    (a) initiate conversation (b) wait to be approached

18. Do you go more by facts
    (a) facts (b) principles

19. In making decisions do you feel more comfortable with
    (a) standards (b) feelings

20. Which is more admirable
    (a) the ability to organise and be methodical
    (b) the ability to adapt and make do

21. Does new and non-routine interaction with others
    (a) stimulate and energize you
    (b) tax your reserves

22. Are you more likely to trust your
    (a) experience (b) hunch

23. Which is more satisfying
    (a) to discuss an issue thoroughly
    (b) to arrive at agreement on an issue

24. Do you put more value on
    (a) definite (b) open-ended

25. Do you prefer
    (a) many friends with brief contact
    (b) a few friends with more lengthy contact

26. Do you feel
    (a) more practical than ingenious
    (b) more ingenious than practical

27. Do you value in yourself more that you are
    (a) unwavering (b) devoted

28. Are you more comfortable with work that is
    (a) contacted (b) done on a casual basis

29. Do you
    (a) speak easily and at length with strangers
    (b) find little to say to strangers

30. Do you prize more in yourself
    (a) strong sense of reality (b) a vivid imagination

31. Are inclined more to be
    (a) fair-minded (b) sympathetic

32. Is it preferable mostly to
    (a) make sure things are arranged
    (b) just let things happen

33. When the phone rings do you
    (a) hasten to get to it first
    (b) hope someone else will answer

34. Are you drawn more to
    (a) fundamentals (b) overtones

35. Do you see yourself as basically
    (a) hard-hearted (b) soft-hearted

36. Do you more often prefer the
    (a) final and unalterable statement
    (b) tentative and preliminary statement

37. Are you more inclined to be
    (a) easy to approach (b) somewhat reserved

38. Is it harder for you to
    (a) identify with others (b) utilize others

39. Which do you wish more for yourself
    (a) clarity of reason (b) strength of compassion

40. Do you tend to be more
    (a) deliberate than spontaneous
    (b) spontaneous than deliberate

Answer Sheet

Name: _____ Date: ____/____/____

Enter a check for each answer in the column for a **or** b

	a	b		a	b		a	b		a	b
1			2			3			4		
5			6			7			8		
9			10			11			12		
13			14			15			16		
17			18			19			20		
21			22			23			24		
25			26			27			28		
29			30			31			32		
33			34			35			36		
37			38			39			40		
	E	I		S	N		T	F		J	P

APPENDIX FOUR

FARM AND FARMER DETAILS QUESTIONNAIRE

Please answer all questions. When completed, please return both questionnaires in the return envelope provided (no stamp required). This questionnaire is to be answered before you look at the systems. Weaning Expert Questionnaire Two is to be answered after you have installed and become familiar with the systems.

Section 1 General

1) What is the effective area (ha) of your farm? . . . . . ☐

2) Please write in the estimated number of stock to be wintered (*as at 1 July 1993*).
   a) **Do not have stock.** . . . . . ☐
   b) Sheep. . . . . ☐
   c) Beef Cattle. . . . . ☐
   d) Dairy Cattle. . . . . ☐
   e) Goats. . . . . ☐
   f) Deer. . . . . ☐
   g) Pigs. . . . . ☐
   h) Poultry. . . . . ☐
   i) Horses. . . . . ☐
   j) Other (*please specify*). ..... ☐
   k) Other (*please specify*). ..... ☐

3) Please write in the area of crops (ha) grown this season (*92/93 season*).
   a) **Do not have crops.** . . . . . ☐
   b) Wheat. . . . . ☐
   c) Barley. . . . . ☐
   d) Oats. . . . . ☐
   e) Maize. . . . . ☐
   f) Peas. . . . . ☐
   g) Small Seeds. . . . . ☐
   h) Process Crops. . . . . ☐
   i) Forage & Feed Crops.. . . . . ☐
   j) Other (*please specify*). ..... ☐
   l) Other (*please specify*). ..... ☐

4) What is your age in years? . . . . . ☐

5) At what level did you complete your **formal** education (*please tick one box*)?

a) No formal education. . . . . .
b) Primary. . . . . .
c) Secondary - four or less years.. . . . . .
d) Secondary - more than four . . . . . .
e) Tertiary - two or less years. . . . . .
f) Tertiary - more than two . . . . . .

Section 2 Computer Skills

6) On average, how many days per month do you use your computer? . . .

7) On average, how many hours per week do you use your computer?. . .

*(Please mark **One** of the ten numbers for each of the following questions)*

8) How would you rate your general computer skills?
(Competence in using and obtaining benefit from packages such as wordprocessors, speadsheets and agricultural packages.)

(very good) 1 2 3 4 5 6 7 8 9 10 (very poor)

9) How would you rate your keyboard skills?

(very good) 1 2 3 4 5 6 7 8 9 10 (very poor)

10) How often have you used a computer mouse?

(never) 1 2 3 4 5 6 7 8 9 10 (regularly)

11) How often have you used software with a Graphical User Interface (GUI)? (GUI is where you select choices shown as pictures, or drawings rather than as text descriptions. Windows is an example of a GUI.)

(never) 1 2 3 4 5 6 7 8 9 10 (regularly)

Section 3 Weaning Decisions

12) How do farmers decide when to wean a mob of ewes and lambs?

13) Can the weaning decision be made on a mob basis or do whole farm factors need to be considered? (*Please tick one box.*)

Yes
No

14) If you answered **No** above, please list the whole farm factors that you think need to be considered.

Section 4 User Characteristics

In answering the following questions please tick the box that **best** describes your situation or feelings.

15) In phoning do you
   a) rarely question that it will all be said. . . . . ☐
   or b) rehearse what you'll say? . . . . . ☐

16) Do you prefer
   a) many friends with brief contact . . . . . ☐
   or b) few friends with more lengthy contact?. . . . . ☐

17) Are you more likely to trust your
   a) experience. . . . . ☐
   or b) hunch? . . . . . ☐

18) Do you feel
   a) more practical than ingenious . . . . . ☐
   or b) more ingenious than practical?. . . . . ☐

19) Which is more satisfying
   a) to discuss an issue thoroughly . . . . . ☐
   or b) to arrive at agreement on an issue?. . . . . ☐

20) Which do you wish more for yourself
   a) clarity of reason . . . . . ☐
   or b) strength of compassion?. . . . . ☐

21) Would you say you are more
   a) serious and determined. . . . . ☐
   or b) easy going? . . . . . ☐

22) Which is more admirable

a) the ability to organise and be methodical . . . . . ☐

or b) the ability to adapt and make do? . . . . . ☐

Thank you for your help in completing and returning this questionnaire. Your answers and comments will be kept strictly confidential. Only combined responses will be published.

Serial No. ☐

APPENDIX FIVE

QUESTIONNAIRE USED TO OBTAIN THE FARMERS' VIEWS ON EXPERT SYSTEMS WEANING SYSTEM EXAMPLE

Please answer all questions. When completed, please return both questionnaires in the return envelope provided (no stamp required). This questionnaire is to be answered after you have become familiar with all three systems. Weaning Expert Questionnaire One is to be answered before you look at the systems.

Section 1 Use of Weaning Expert

1) The following table contains a list of the factors currently used in weaning expert. Please indicate how important you think each of these factors are by placing a number from the scale below in the box beside each factor.

(very important) 1 2 3 4 5 6 7 8 9 10 (not important)

a) Age of the lamb.	
b) Weight of the lamb.	
c) Proportion of twins in the mob.	
d) Quantity of feed available for the mob.	
e) Quality of the feed available for the lambs to be weaned onto.	
f) Breed of the ewe (influences overfat problems through milk production).	
g) Cull ewe prices.	

2) What **other** factors do you think that a system determining weaning date needs to conside

Section 2 Explanations

3) How would you describe the length of the explanations? *(Please tick one box.)*

Too Long
About Right
Too Short

4) Should the explanations contain references and further reading? *(Please tick one box.)*

Yes
No

5) Should the explanations be more detailed with reference to facts and figures? *(Please tick one box.)*

Yes
No

6) Do you think the explanations are aimed at the right level? *(Please tick one box.)*

Yes
No

7) If you answered **No** to the previous question, please explain at what level you think the explanations should be aimed?

8) Do you agree with the explanations given by the system? (*Please tick one box.*) Explanations refer to the reasoning for the advice given by the system.

Yes
No

9) If you answered **No** to the previous question, please explain why. Please include any suggestion you may have. (*Please use extra paper if necessary.*)

10) If you have any other comments regarding the explanations and how you think they should be presented please write here? (*Extra space has been provided on page 3 for your answer.*)

Section 3 General

11) After this brief introduction to weaning expert, do you think this type of system has potential for decision making in agriculture? (*Please tick one box.*)

Yes
No

12) How often do you think farmers in general would use such a system for each mob? [ ]

13) How often do you think farmers in general would use such a system in a year? [ ]

14) What areas of the system do you think need to be improved?

15) How would you improve them?

16) If you have any additional comments regarding the systems in general please detail them here.

Section 4 Rating the Systems

Before you answer the remaining questions please be extra sure you are very familiar with all three systems. To do this we suggest you make up and enter into the systems a number of hypothetical situations so the layout and the advice given is very clear.

Give each system a value from 1 (very good/excellent) to 10 (very difficult/not acceptable) for each question.

Questions	Wean 1	Wean 2	Wean 3
17) How do you rate the systems for ease of use?			
18) How do you rate the systems for appearance and layout?			
19) How do you rate the advice given by the systems?			
20) How do you rate the method of providing detailed explanations?			
21) How do you rate the help, guidance, messages provided?			
22) How important is a printout of the advice and explanation?			

Section 5 Specific Questions on the Systems

23) Please outline your likes/dislikes for **Wean 1**?

24) Please outline your likes/dislikes for **Wean 2**?

25) Please outline your likes/dislikes for **Wean 3**? (*Extra space has been provided on page 5 for your answer.*)

26) Do you think that pictures are useful in the systems? (*Please tick one box.*) Yes / No

27) Why do you like/dislike the use of pictures in Weaning Expert?

28) Do you prefer the system with all questions on one screen? (*Please tick one bOx.*) Yes / No

29) Why do you like/dislike the systems with all questions on one screen?

30) Do you agree with the advice given by the system? (*Please tick one box.*) Yes / No
Advice refers to the decision of whether or not to wean the lambs in the mob.

31) If you **do not** agree with the advice please explain why. (*Extra space has been provided on page 6 for your answer.*

32) Do you think weaning expert could be useful to remind you of the important factors at the start of the season? (*Please tick one box.*)

Yes
No

33) Do you think weaning expert could be used regularly to check that you have considered all the factors for each mob? (*Please tick one box.*)

Yes
No

34) Please indicate how often you think you would use such a system during the spring. (*Please tick one box.*)

a) daily. . . . . ☐
b) weekly. . . . . ☐
c) when you think you might wean. . . . . ☐
d) only when the decision is very difficult.. . . . . ☐
e) Other. . . . . ☐

35) Do you think such a system would be of:- (*Please tick one box.*)

a) no economic value. . . . . ☐
b) some economic value. . . . . ☐
c) considerable economic value. . . . . ☐
d) extremely high economic value.. . . . . ☐

36) What do you think the Weaning Expert is worth to you on a per ewe basis (i.e. by how much might it increase profit per ewe)? (*Please tick one box.*)

a)	$0.00 - $0.30	☐	h)	$2.11 - $2.40	☐
b)	$0.31 - $0.60	☐	i)	$2.41 - $2.70	☐
c)	$0.61 - $0.90	☐	j)	$2.71 - $3.00	☐
d)	$0.91 - $1.20	☐	k)	$3.01 - $3.30	☐
e)	$1.21 - $1.50	☐	l)	$3.31 - $3.60	☐
f)	$1.51 - $1.80	☐	m)	$3.61 - $3.90	☐
g)	$1.81 - $2.10	☐	n)	Other (*please specify*)	☐

37) Do you think the system would make the weaning decision easier? (*Please tick one box.*)

Yes
No

38) If you answered **No** to the previous question please explain.

39) Do you think farmers in general would consult an expert system to help make weaning decisions? *(Please tick one box.)*

Yes
No

40) Do you think that a weaning system should give a simple Yes or No answer to whether to wean? *(Please tick one box.)*

Yes
No

41) If you answered **No** to the question above, how do you think advice should be given?

42) Is there any need to allow for weaning part of a mob? *(Please tick one box.)*

Yes
No

43) If you answered **Yes** to the question above, please outline the situation.

Section 6 Ranking the Systems

44) Indicate the ranking you would give each version of the system for the overall best version of the system. *(Please rank each version by placing the numbers 1 to 3 in the three boxes.)*

a) Wean 1.. . . . . .
b) Wean 2.. . . . . .
c) Wean 3.. . . . . .

Section 7 General Comments

45) How could the systems be improved?

46) Any other comments that you would like to make about the system in general.

47) What other feed management decisions do you think could be solved using an expert system?

Thank you for your help in completing and returning this questionnaire. Your answers and comments will be kept strictly confidential. Only combined responses will be published.

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