Department of Agriculture
Government of Western Australia

NPDECIDE

USER'S GUIDE

A COMPUTER PROGRAM TO HELP WITH NITROGEN AND PHOSPORUS FERTILISER DECISIONS FOR CEREALS

S.J. BURGESS, J.W. BOWDEN AND A.J. DIGGLE

1991

Table of Contents

Table of Figures

1 INTRODUCTION

1.1 What is NPDECIDE?

NPDECIDE is not the way things really are. It is a simplified computer model of the effects of nitrogen and phosphorus fertilisers on wheat production and profitability. When used with a bit of common sense and local knowledge, it should be an aid to making better fertiliser decisions.

It is designed to handle questions relating to
- application rates
- times of application (including split applications)
- method of applications
- fertiliser source (including compound fertilisers)

As affected by
- soil type
- paddock history
- seasonal conditions
- economic conditions
- level of productivity
- disease interaction

It should be used as an adjunct to other sources of advice, and does not remove the need to have a good understanding of the many factors involved in fertiliser decisions. It does, however, let you combine this understanding with quantitative assessments of the possible outcomes of different fertilisation plans. It is particularly good at helping to answer speculative questions like:

- 'How much profit do I miss out on if I fertilise with the expectation of a poor season and I get a good season?'
- 'What are the likely consequences of using DAP instead of AGRAS?'
- 'Do I need more nitrogen after that huge fall of rain?'
- 'Am I likely to be financially better off by topdressing before planting, even though it is not as effective for plant uptake as drilling at seeding?'
- 'If I don't put out any super, what will the consequences be, both for this year and in the future?'
- 'Has last year's lupin crop increased or decreased my nitrogen requirements for this year's wheat crop?'

Or
- 'I can only spend $20/ha on fertiliser, what is the best way to do it?'

These are questions that demand answers with numbers in them. They cannot be easily dealt with by standard recommendation systems, or by having a purely qualitative understanding of fertilisers and crop production.

Each copy of NPDECIDE works from it's own database of factors affecting fertiliser decisions. This feature lets you personalise your copy so that it can be calibrated for local conditions and for the way that you want to use it.

1.2 How to use this manual

There are three main sections in this manual. Chapter 2 explains the theory and assumptions behind the mathematical model used by NPDECIDE, chapter 3 explains how to use the NPDECIDE computer program itself, and chapter 4 illustrates how NPDECIDE can be used to address some interesting fertiliser decisions. It really is important that you understand what is presented in these three sections, if you are to use the program responsibly. However, after you have worked through and understood this manual, the NPDECIDE quick reference guide that accompanies it should be sufficient to jog your memory about many aspects of using the program.

If you are really in a tearing hurry to start the program up and have a look at it, section 3.1 (A brief introduction to NPDECIDE) contains the information needed to start the program, get some idea of what it does, and quit the program, without causing any major problems.

2 THEORY

2.1 Properties of fertiliser recommendation systems

The value of any fertiliser to a farmer depends on many factors. There are factors associated with the soil characteristics (nutrient status, hydraulic properties, nutrient buffering power, microbial activity etc. , the nature of the fertiliser and nutrient or nutrients in question (soil-mobility, stability, particle size, hydroscopicity etc.), the plant demand and foraging characteristics (species, root morphology, growth rate etc.), the environmental variables (rainfall, temperature, radiation, disease, insects etc.), management variables (fertiliser placement, grazing intensity, cropping frequency or rotation etc.) and most importantly, the interactions between them.

There is little wonder that attempts to isolate any one of the important response parameters in the field have proven difficult and resulted in estimates with large variance (or poor precision). It is also obvious that there are no simple answers to the many and varied questions which are asked of fertiliser recommendation systems and that no simple system will answer all of them.

What are some of the questions?

- Will I get a response to an addition of this nutrient?
- Will responses to fertiliser addition justify the use of fertiliser and if so, how much is needed?
- When should it be applied?
- When, if at all, should it be reapplied?
- How should it be applied?
- What is the best source of the nutrient(s)?
- What happens to responses and returns if...?

Different systems answer (some or all) of the questions with differing degrees of accuracy. Some systems may provide inaccurate answers to some questions but have the virtue of being able to address a lot of other questions. The answers to all questions will be interdependent and often will depend on subjective judgments by the user. Any system that addresses only a limited number of the questions will obviously be found wanting by some users.

It is our objective with NPDECIDE to produce a system which gets the directional movement of fertiliser rates right for any questions put to it, the relative impacts of the various factors right for most of the effects and the absolute values correct where possible.

Thus NPDECIDE does not only try to answer the first two questions above. It tries to address any of the questions when asked, and it tries to give a (semi-) quantitative background for the answer.

It's greatest power of persuasion lies in the sensitivity analysis it allows. If there are doubts about the magnitude of parameters or the uncertainties of outcomes associated with unpredictable events (such as poor finishes, sudden leaching rains, disease and pest attacks), then the adviser/farmer can use NPDECIDE to investigate the effect on yield and profit of varying the inputs. This process does not predict outcomes but does give a feel for the effect of uncertain events interacting with management options.

The absolute precision of optimum rates predicted by any method is poor because profit does not usually change much with fertiliser rate near the optimum. The errors that result from not knowing what the seasonal conditions will be, however, tend to be much greater. NPDECIDE allows rational decisions to be made in spite of this uncertainty by allowing the farmer to see the consequences of using more or less than the "optimum" rates of a fertiliser. He can see how a chosen level of fertiliser will perform if he has a good season or if he has a poor season and so can adjust the level according to how he wants to balance the risks of various seasons against the dollar outlay on fertiliser. In like fashion the decision maker can see the effect of changing fertiliser source, timing and placement, all of which can also have a bigger impact on the fertiliser decision than the simple question of "how much?".

2.2 History

2.2.1 Phosphorus

Phosphorus recommendations for wheat in WA were originally made on a simple biological basis. For each region there was a table with an optimum rate for each combination of soil type and phosphorus history class. These tables were derived by meaning the results of simple field trials carried in each region, and the optimum rates were the amount of phosphorus required to get to 95% of maximum yield.

This system was convenient for all concerned. A farmer had to answer two simple questions and they were given a simple answer, and everybody was happy (and there is probably a nostalgic impulse in some quarters to bring this system back). Unfortunately, however, the numbers produced weren't all that optimum. In particular, they took no account of the relative value of wheat and the fertiliser.

In order to overcome this limitation, the system was changed in the early 1970's with the development of DECIDE. DECIDE pretended to reconstruct a phosphorus fertiliser response curve for any situation (defined by soil type, species, nitrogen status, placement and timing of application, etc). A simple economic analysis could be applied to the predicted response curve to provide recommendations of optimum fertiliser rates. During the development and extension of DECIDE it was recognized that although farmers stated that they wanted only a simple single figure fertiliser recommendation, what they in fact needed was an estimate of the consequences of using more or less than the recommended rate. The recommendation system had to provide this facility so that it could cater for differences between farmers in their attitudes towards spending dollars on fertiliser.

By 1971 the fertiliser company in Western Australia, CSBP and Farmers Ltd., had developed a soil test based fertiliser recommendation system. This service initially provided single figure fertiliser recommendations using a calibration curve from the CSIRO National Soil Fertility Project.

2.2.2 Nitrogen

As for phosphorus, the traditional nitrogen fertiliser recommendation system for cereals is based on the segregation of state wide nitrogen trial results into soil type, rainfall region and cropping history categories. In developing this system the trial data were handled in two ways. Response curves were fitted to the individual trials and then:

- The response curve parameters were averaged within a category and the resultant curve was used for an economic analysis to give the profit maximising rate of nitrogen for that category.
- Individual economic analyses were carried out on each trial within a category and the rate of nitrogen above which 60% of trials in that category gave maximum profit, was taken as the recommended rate for that category.

The final recommendations were a subjective combination of the results of these two analyses. Computer technology has allowed this system to be updated for changes in prices. However it depends largely on regression techniques and so does not have the flexibility to adjust in any but a qualitative way, for changes in cropping practices such as minimum tillage, the impact of weeds and disease and the introduction of the new high yielding packages.

2.2.3 Nitrogen and phosphorus

In all of the single nutrient recommendation systems so far mentioned the assumption is made that the other nutrients are present at non-limiting levels. This is because the trials on which those recommendations were based were done with basal additions of other nutrients. Unhappily, however, this assumption results in an over estimate of the best amount of fertiliser to apply. The calculation that is relevant to the farm situation is the optimum level of each nutrient at the optimum level of the other. A response curve for both nitrogen and phosphorus, referred to as a response surface, is required to make calculations of this sort. An additional advantage to using a response surface in a recommendation system is that it is easier to handle the compound nitrogen and phosphorus fertilisers which have been increasingly popular in recent years.

In the late 1970's various attempts were made to produce a combined recommendation system. These efforts culminated in the Drought Service of the summer of 1979-80 when 7000 recommendations were processed in 100 days, in an early use of computer technology. This system contained the basics of nitrogen and phosphorus fertiliser use. Like the updated CSBP system that followed it, it could handle changes in yield potential and could give simple nitrogen phosphorus response surfaces.

It could not handle the effects of leaching, the differences between fertiliser sources in their availability in different circumstances, the impact of disease or the effects of time of application. Further, the method of estimating soil nitrogen status had categories that were far too broad. The resultant system therefore lacked flexibility; could not be used in a tactical sense and exhibited extreme variation in fertiliser recommendations within a nitrogen category.

In an attempt to fare up to these shortfalls and specifically to try to address the problem of variability of response, a major commitment of resources was made to the development of a new and comprehensive model. This model (now named NPDECIDE) would serve as a tool for:

- developing recommendation system for nitrogen and phosphorus fertiliser use on cereals understanding the system
- developing extension materials for use with farmers
- providing input for whole farm models
- providing a focus for research at the WADA, UWA and CSIRO
- answering questions of policy

2.3 Philosophy behind the design of NPDECIDE

The following points have guided the development of NPDECIDE:

- It is designed to provide, at one level of approximation or another, answers to most of the main queries which are made about nitrogen and phosphorus use on cereal crops in WA.
- It is designed to be calibrated to specific regional data on soil types, rotations and crop and pasture production. Often there is a lack of actual field data for specific regional calibrations and so default values have to be estimated, usually in consultation with discipline and regional experts.
- The functional forms have been chosen to reproduce the principle behaviour of the system and to behave reasonably for extreme input values so that the dangers of extrapolation are minimized. Simplicity and utility are preferred to complexity that is built in, only when essential for the reproduction of major effects.

- To address the problems of uncertainty, risk and inadequate data, emphasis has been placed on the ease of carrying out sensitivity analyses.

2.4 Overview

In order to model the response of grain yield to nitrogen and phosphorus for any given situation, NPDECIDE starts with an estimate of potential grain yield. The potential yield is the maximum yield that can be achieved by changing the levels of nitrogen and phosphorus available to the crop. It is used to account for all the factors which affect yield that are not dealt with specifically in the model. These can be site and soil type specific limitations, effect of season, or such factors as weeds, disease, or time of sowing. This is then scaled down by factors related to phosphorus and nitrogen nutrition to give an estimate of actual yield, according to the following formula:

$$GY = A*Psc*Nsc \tag{2.1}$$

Where GY is the estimated grain yield, A is the potential grain yield, Psc is the phosphorus scalar, and Nsc is the nitrogen scalar.

On a given soil type, the yield limitation due to phosphorus nutrition depends on the type and amount of phosphate fertiliser added, the method of fertiliser application, the phosphorus soil test level and an interaction with the nitrogen limited yield potential as follows:

$$Psc = (1-exp(-Kp*ReP*Pf/(A*Nsc)-Cst*Pst)) \tag{2.2}$$

where Pf is the amount of fertiliser phosphorus added, ReP is the effectiveness of the phosphate application relative to drilled superphosphate (this is affected by fertiliser type and method of application) and Pst is the phosphorus soil test value. Kp reflects the responsiveness of a particular soil type to added phosphorus, and Cst calibrates the value of the soil test level appropriately for that particular soil.

The limitation due to nitrogen nutrition is made up of the supply of nitrogen to the crop, the crop's demand for nitrogen, and its ability to convert nitrogen uptake to grain yield and protein. It is approximated by the following two equations:

$$Nsc = 2*Nup/(A*G)-(Nip/(A*G))Z \tag{2.3}$$

$$Nup = Mn*tanh(Navail/Mn) \tag{2.4}$$

where Navail is the amount of nitrogen available to be taken up by the plants, Mn is the maximum uptake of nitrogen which could occur if supply was unlimited and Nup is the actual amount of nitrogen uptake that occurs. G controls the relationship between nitrogen uptake and grain yield.

Navail represents the supply of nitrogen to the crop. Factors affecting this include the rates of biological cycling of nitrogen in the soil, the movement of nitrogen with soil water, the pattern of root growth through time, the timing of fertiliser applications and nitrogen sources used.

Mn represents the limit placed on nitrogen uptake by other factors which affect crop growth. In a way, it represents the demand for nitrogen. Usually, an independent estimate of Mn is not available, and we relate it to A (potential grain yield). In the absence of any better information, we usually use 0.06*A as an estimate of Mn.

In theory, G, can be altered for varying circumstances. It sets an upper limit on the efficiency with which nitrogen uptake can be converted into grain. In NPDECIDE, however, it is fixed at 0.04 , which corresponds to an maximum efficiency of 50 kg grain per kg of nitrogen uptake. The actual conversion efficiency implied by NPDECIDE will always be less than this upper limit.

In converting yield to dollars profit account is taken of future returns associated with the residual value of phosphorus fertilisers, the interest rate which would have been paid on an alternative investment of funds, and the other costs associated with growing the crop including costs of application of fertiliser.

$$\text{Profit} = GY*Yp-Pf*Fp*(1+R-V)-OC*(1+R) \qquad (2.5)$$

Fp is the fertiliser price, Yp is the price of grain, V is future value of phosphate, R is the interest rate, and OC is the other costs.

2.5 Potential yield

The grain yield potential is defined as the yield obtained in any situation when nitrogen and phosphorus are in non-limiting supply. As such it depends on many factors. Some of these factors cannot be controlled and the effects of varying most of them cannot be quantitatively predicted. Thus in NPDECIDE, no attempt is made to predict potential yield. Rather, it is used as an adjustable parameter in sensitivity analyses. This allows the user to answer questions such as "What happens to the outcome if...?". Potential yield is used as a surrogate for a lot of factors that affect the demand by the wheat crop for nutrients. In some cases it is an over simplification, only to adjust potential yield to reflect the impact of a given factor (for example in the case of root rot in cereals, an adjustment also has to be made to the nutrient uptake efficiency functions), but it is a reasonable first stab in most cases.

Some of the factors for which potential yield serves as a surrogate are listed below. In some cases adjusting potential yield alone is adequate to account for the effect, and in others information is given about what other types of parameters need adjusting:

- The nature of the start of the season affects potential yield, and can also affect nitrogen uptake efficiency through its effect on leaching and mineralisation of nitrogen (NAVAIL) and demand for nitrogen by the plants (the relationship between potential yield and maximum nitrogen uptake is discussed under nitrogen, below).
- The finish of the season, particularly the crop water relations, directly affects potential yield.

- Time of seeding and the related variety choice obviously affect potential yield. This means that strategies on fertiliser use are best planned in advance but the decision is best left until the actual seeding date, which is dictated by the initial seasonal conditions.
- Soil type has many effects on potential yield, some of the most obvious are related to soil depth and drainage: Others include fertility (other than nitrogen and phosphorus) and soil acidity. Again these interact with other factors affecting nitrogen and phosphorus nutrition. For example acidity affects root growth which can effect potential yield via changed water relations but can also affect the plan ability to use soil and fertiliser phosphorus (see phosphorus nutrition) and the plants ability to take up nitrate at depth (NAVAIL). In like manner, a compaction pan will affect the value of potential yield and also nitrogen supply through its impact on rooting depth (NAVAIL).
- Diseases, weeds and other pests influence potential yield usually in an unpredictable way. They can also affect some of the other response curve parameters in ways that are difficult to specify.
- Cultivation method can affect the yield potential and can interact with disease, weeds and available nutrient level

2.6 Phosphorus nutrition

Phosphorus availability depends on the supply to the crop from both soil and fertiliser sources as well as the demand for phosphorus by the crop. Supply from the soil in Western Australia comes largely from fertiliser residues although some soils do contain useful amounts of plant available phosphorus in their native state (these tend to be the sorts of soils that were used for agriculture before the days of superphosphate). The availability of both soil and fertiliser phosphorus depends on the amount present, and on chemical and physical factors. Chemical availability can change with time (usually decreasing) as soluble components of fertiliser or phosphorus in plant residues undergo reversion reactions in the granule or with the soil. Positional availability depends on the relative locations of the available phosphorus and active plant roots in the soil. Obviously phosphorus will be quite plant unavailable if it occurs in a region of dry soil, even if it is in a chemically available form. The plant availability will be related to the dynamics of root growth and function, the dynamics of the moisture supply, and the quantity of mineral surfaces and ions with which phosphorus can form insoluble complexes.

In NPDECIDE, two parameters indicate the amount of phosphorus that is present. These are the amount of fertiliser phosphorus added, and the phosphorus soil test. The phosphorus soil test is a chemical approximation to the amount of soil phosphorus that is plant available, and for this reason it is made up of availability information as well as quantity information. Unfortunately the relationship between the chemical test and actual plant availability is far from perfect and for this reason a third parameter is included to adjust the soil test for each soil type. (Cst equation 2.2) A forth parameter takes account of both chemical and physical effects on the availability of the fertiliser phosphorus (Kp equation 2.2).

2.6.1 Residual value of phosphorus

In general phosphorus tends to be very strongly held by soil, and it becomes more strongly held as time goes on. This means that plants get only a small part of the fertiliser phosphorus that is added in any year. On the other hand, fertiliser added in one year goes on supplying phosphorus at an ever-decreasing rate for many years into the future. This behaviour is important because the history of past applications will change the value of current additions, and also because the value of current additions includes the benefit which will result in future years.

Several types of reactions influence the residual value of phosphorus. The dominant process in most situations is immobilisation of phosphorus by reaction with the surfaces of soil particles, especially those containing iron and aluminium compounds. This process is particularly important in soils with high iron and aluminium contents (often soils with finer texture and red or yellow colour). The capacity of soils to immobilise phosphorus in this way does tend to decrease as more and more phosphorus is added, however, all but the least fixing soils have huge fixation capacities when soil depth is taken into account.

Immobilisation into organic forms, by means of incorporation into plants, animals, and microorganisms, can be an important process in loss of availability of phosphorus. It is most important during the phase of fertility build up during land development. On older country, the losses of inorganic phosphorus to the organic forms tend to equal the returns from those forms.

Unlike the inorganic immobilisation processes, the organic processes can cause increases in phosphorus availability as well as decreases. This can occur in some cases after tillage, when the rate of breakdown of organic material can increase, causing organic phosphates to mineralise. Also organic immobilisation is indirectly responsible for development of uneven phosphorus levels, because of transport of organically held phosphorus via animals to camp sites or night paddocks. Furthermore, a major cause of loss of phosphorus from the system is through removal of plant materials.

Loss of phosphorus from the system can also occur through erosion events or, in soils with extremely low fixation capacity, through leaching. However, these inorganic transport processes usually account for only a very small part of the loss of phosphorus availability through time.

The net result of this complex of loss processes, each of which proceeds to varying degrees depending on the season and situation in question, is that residual value functions cannot be plotted with any precision. However approximate functions can still be of considerable value for updating soil tests and for estimating the future value of a current dressing of phosphorus fertiliser.

2.6.2 Estimating soil phosphorus status

There are two common methods for estimating soil phosphorus status. One is a soil test, and the second is through fertiliser history. The soil test method measures the phosphorus removed from soil by a particular extraction procedure (bicarbonate extract, Colwell *1963).* This fraction does not include the very tightly bound forms of phosphorus, and it is supposed to approximate the fraction that is available for plants to take up. There are some problems with this procedure. One of these is measurement error, which results mainly from variable phosphate levels from spot to spot in the paddock. Another problem arises because only the top 10-cm of soil is sampled. In some cases, especially where the phosphorus fixation capacity is very small, leaching may have occurred, and much of the soil phosphorus may be below this depth

In the fertiliser history method a calculation is done based on the amount of phosphorus that was added in each of the recent years, and an assumed rate of rundown in the availability of that phosphorus. This method does not suffer from the sampling errors or problems with depth of phosphorus, but it is somewhat inaccurate due to limitations in knowledge of rundown rates in various conditions. In addition, accurate records of phosphorus history have not necessarily been recorded.

NPDECIDE uses a combination of these two methods to estimate soil phosphorus status, and for this reason it can deliver the best of both worlds. It can use a current soil test, together with any available soil tests up to five years old. It also uses the amount time since clearing, the amount of fertiliser added more than five years ago, and the amount of fertiliser added in each of the last five years if available. The program then predicts the soil test that should result from the history information and combines this estimate with the measured values to produce a most probable current soil test level. A soil type dependent parameter is used in this calculation to specify the rate of rundown of availability of phosphorus in its first year after addition.

2.6.3 How efficiently is soil phosphorus used?

A problem which affects both the soil test and fertiliser history methods is that the soil test estimate of available phosphorus is completely arbitrary and its relationship with the amount of phosphorus which the plants actually get is variable. Part of this problem is due to the sort of soil type dependent phosphorus reactions that were described in the *Residual value of phosphorus* section. Another part of the problem is due to seasonally dependent factors, such as the dynamics of root growth and the wetting and drying of the soil.

NPDECIDE includes a soil test calibration parameter that has the effect of scaling the effectiveness of the phosphorus soil test for particular circumstances (Cst, equation *2.2* and *2.6).* In theory this parameter should be determined for each soil type addressed by the model. In practice the parameter is difficult to determine and, because it varies from year to year, an exact value is not possible. For this reason robust default values are used, and these values will be improved as better data becomes available.

The soil test calibration parameter for a particular soil is best determined by running a series of phosphorus rate trials over a series of seasons on that soil. A soil test value is obtained for each site and the maximum yield response as a fraction of the maximum yield is fitted to those soil test levels using the following equation:

$$GYf = 1 - \exp(-Cst * Pst) \qquad (2.6)$$

where GYf is the fraction of maximum yield on the trial that is obtained with no addition of fertiliser, Cst is the soil test calibration parameter, and Pst is the phosphorus soil test on the site.

2.6.4 How efficiently is fertiliser phosphorus used?

The effectiveness of fertiliser phosphorus is variable from site to site and from season to season in a similar fashion to the effectiveness of soil phosphorus. As for soil phosphorus this effectiveness varies for reasons such as the moisture and temperature conditions, phosphorus and pH buffering power, bulk density, gravel content, etc. In addition the effectiveness of fertiliser phosphorus varies with the type of fertiliser, its placement, time of application, and particle size.

NPDECIDE includes a fertiliser response calibration parameter, which adjusts the effectiveness of the fertiliser phosphorus accordingly (Kp, equation *2.2* and *2.7). As* with the soil test calibration parameter, exact values for this parameter cannot be derived because the exact conditions in which the crop will grow are not known. Approximate values relevant to particular soil types do, however, exist.

The fertiliser response parameter for a soil type is found by aggregating the results of fertiliser response trials on that soil type. The data is then fitted to the following equation:

$$GYf = 1\text{-}\exp(-Kp*Pf/(A*Nsc)) \tag{6}$$

where GYf is the fraction of maximum yield on the trial that is obtained at each rate of addition of fertiliser, Kp is the fertiliser response calibration parameter, and Pf is the rate of fertiliser phosphorus added, A is the potential yield of the site, and Nsc is the Nitrogen Scalar as defined for Equation 2.1.

The effects of fertiliser type and application method are accounted for in NPDECIDE with a scaling factor that is part of the definition of the fertiliser application strategy. This factor adjusts the effectiveness of the source used to that of drilled ordinary superphosphate.

2.7 Nitrogen nutrition of wheat

2.7.1 Nitrogen in NPDECIDE

NPDECIDE classifies nitrogen sources as stable organic nitrogen, residue nitrogen and the various fertiliser forms (ammonium, nitrate and urea). Organic sources are mineralised using

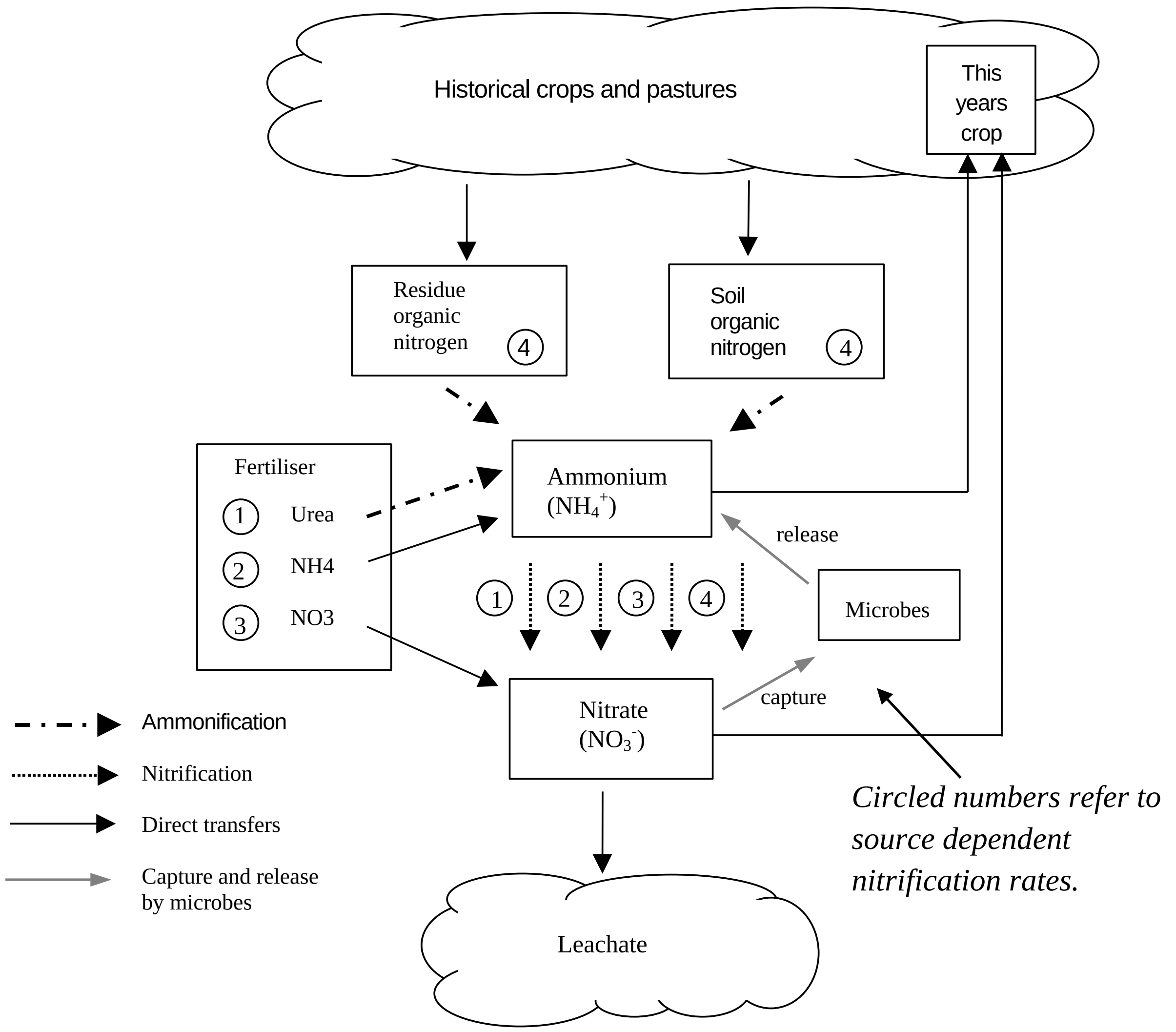

Figure 2-1 Flow diagram of the nitrogen transformations in NAVAIL.

source specific net ammonification rates. Ammonium is then transformed to nitrate using nitrification rates that can depend on the source, the soil pH-buffering etc (Figure 2.1). The subroutine NAVAIL, using crude models of leaching and root growth then calculates an availability index of nitrogen from the various soil and fertiliser sources. This availability index is an integral through time, of the fractional amount of mineral nitrogen, derived from a given nitrogen source, which resides in the root zone of a growing wheat plant. (Gaseous losses from denitrification or ammonia volatilisation, are not specifically accounted for in the model, but they can be allowed for by manually adjusting the availability index).

Thus the impact of soil type, rainfall intensity, time of (fertiliser) application, source of nitrogen, mineralisation over summer (pre-incubation), as well as factors which affect root growth such as aluminium toxicity and soil hardpans, can all be calculated into the availability index.

NAVAIL calculates the mineral nitrogen in the root zone of a crop by determining the extent of the nitrogen transformations, the rooting depth, the water movement in the soil and its effect on nitrate movement, all as a function of time.

A wheat crop can utilise nitrogen only when it is in a mineral form in the soil. In the nitrogen calculations in NPDECIDE an attempt is made to match the dynamics of mineral nitrogen supply to the root zone of a crop, with the demand of that crop for nitrogen. The demand for nitrogen is dictated by factors other than nitrogen which affect the growth of the crop and as have been discussed earlier (Potential yield).

Thus the determination of the nitrogen supply to a crop involves the calculation of the amounts of nitrogen in the various forms in the system and the rates of transformation of those forms into mineral nitrogen. The calculated amount of mineral nitrogen from any source (i) which resides in the root zone of the crop as a function of time, is used to develop an index of nitrogen availability from that source (Kr,). The product of the availability index with the amount originally present, gives the supply of nitrogen from that source (quadrant a in Figure 2.2).

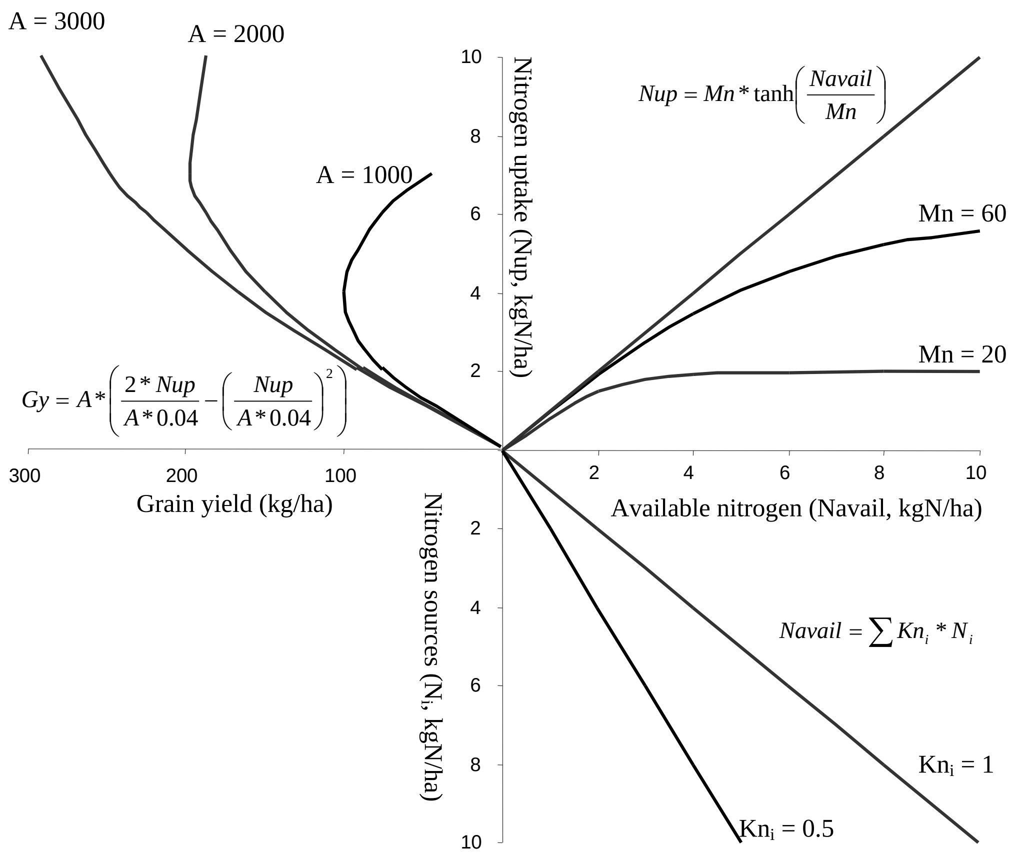

Figure 2-2 Spider diagram

The summed supply from all sources gives the nitrogen availability which is then used to determine an internal variable of the system which represents the amount of nitrogen that is taken up by the crop (quadrant b in Figure 2.2). The uptake of available nitrogen is here governed by the demand for the nutrient as represented by the parameter Mn, the maximum nitrogen uptake. This is influenced by the many factors other than nitrogen which affect vegetative plant growth (e.g. time of seeding, other nutrients, water supply, variety etc). There is necessarily a strong correlation between maximum nitrogen uptake and the grain yield with nitrogen in non-limiting supply. In NPDECIDE, this correlation between Mn and A (potential yield) has a default setting of Mn (kgN/ha) = 0.06*A (kg grain per ha). Variation in this relationship changes the shape of the grain yield response to fertiliser nitrogen curve beyond the level of nitrogen supply for yield maximum and by default this also affects the predicted grain protein levels at high nitrogen supply.

Grain yield is determined by nitrogen uptake (quadrant c in Figure 2.2) and also by other growth factors, the most important of which is end of season water status. These other factors are parameterised by the potential yield with phosphorus and nitrogen in non-limiting supply (A).

2.7.2 Sources of nitrogen

The supply side of nitrogen availability to the wheat crop involves the determination of the amount of nitrogen in the various sources in the system. In the case of fertiliser sources this involves a statement of the amount of nitrogen present in the nitrate, ammonium and urea forms. In the case of soil nitrogen this involves determining the amount of nitrogen in either the stable form (SON) or the labile form (RON- residue organic nitrogen). This subdivision of soil nitrogen is quite arbitrary and is less related to the chemical form of the nitrogen and more related to the recent history of the carbon originally compounded with it. Thus RON is an expression of *nitrogen which* was *in* crop and pasture residue material in the last two or three years but can now be still contained *in* the residues or be part of the soil microbial biomass. Obviously there are many soil nitrogen pools. *In* NPDECIDE they are kept to the minimum necessary to characterise the dynamics of nitrogen availability. In any situation, the SON and RON pools are characterised by an amount (kgN/ha) and an average rate of ammonification (fraction mineralised per week).

2.7.3 Nitrogen cycling

The nitrogen transformations are calculated by considering each source of nitrogen separately.

The residue nitrogen mineralises relatively rapidly. The rate of mineralisation (RonAr) depends on many factors (physical size, nitrogen percentage, degree of incorporation, soil temperature, soil moisture, microbial population, etc) and can be set at any value in NAVAIL. The default level of RonAr is 4%/week. About 40% to 60% of RON is mineralised each year depending largely on the period of incubation.

The stable nitrogen is the slow release fraction in the soil. Its rate of mineralisation (SonAr) is also affected by a range of factors. Again the amount of mineralisation depends on the incubation period and ranges between 1% and 3% of the SON pool.

Fertiliser nitrogen can be added to the soil in mineral (ammonium and nitrate) or organic (urea) forms. Urea requires the presence of the urease enzyme to cause it to hydrolyse to ammonia and carbon dioxide. Urease is common in surface soils and so the hydrolysis usually takes place quite rapidly. The default value for the hydrolysis is set at 90%/week, which may be a bit slow according to Fillery. Other forms of organic nitrogen addition to the system can be handled if an ammonification rate of the source can be nominated.

The nitrification of ammonium to nitrate in the soil has a rate coefficient dependent on a range of factors including a pH effect, which can depend on the origin of the ammonium. Currently allowance is made for the source dependent nitrification rate while no allowance is made for soil specific effects or the interaction of the two. The pH buffering of the soil would seem to be an important characteristic that will have to be incorporated into the calculations.

A soil microbial biomass pool competes with the leaching process and plant uptake for mineral nitrogen resident in the top 10 cm of soil. The microbes capture nitrate and release ammonium to the soil. Although biologically insignificant (soil microbes utilise mainly ammonium if a choice is available), this process has the net effect of reducing the leaching rate under conditions when nitrification is rapid.

2.7.4 Water-and nitrate movement

A very simple leaching model has been developed assuming that the soils in question are uniform with depth and are well drained.

From an initial water content, infiltrating rainfall wets the soil to field capacity to a depth dictated by conservation of matter and the upper and lower drained limits of the soil in question. Nitrate nitrogen is assumed to be freely mobile in the soil and moves with the wetting front according to a model which predicts outcomes somewhere between the extremes of piston flow and complete pre-equilibration (Bums, 1977). Each input of nitrate is treated separately to give a triangular distribution of concentration with depth. The summed effect of inputs from one source at different times as ammonification and nitrification proceed, can provide quite complex profiles.

The ammonium nitrogen is assume to be immobile in the soil (true, except for soils with very low ration exchange capacity) and so always remains in the top 10 cm of soil (it is assumed that urea does not leach and then hydrolyse at depth). Ammonium is therefore assumed to always be in the root zone of the crop and so is plant available.

2.7.5 Nitrogen availability

The availability of mineral nitrogen in a soil depends very much on whether that nitrogen, is resident within the root zone of the crop for significant time periods. This depends not only on the leaching of nitrate but also on the effective depth of rooting with time. The root depth by time model is characterised by three parameters that are set prior to a run. These parameters govern the initial rate of root penetration, the maximum rate of penetration and the rate of approach to that maximum. Thus the rooting behaviour can be adjusted for factors such as hardpans and sub-soil acidity. Rooting depth can also be restricted by dry soil; ie. the roots cannot penetrate beyond the wetting front.

The nitrogen availability index (ICi) for each source of nitrogen is the mean (as a fraction of the total nitrogen in that source (NO) of the weekly quantifies of mineral nitrogen from that source, residing in the root depth. It is the sum of the ICi*Ni which gives the total supply side availability of nitrogen to the crop.

3 USING THE PROGRAM

The following conventions will be used throughout this chapter:

- Important points will be highlighted in **this typeface**
- ↵ will be used to denote the carriage return or enter key.
- *esc will* be used to denote the escape key.
- BS will be used to denote the backspace or delete key.
- ← → ↓ ↑ will be used to denote the left, right, down and up cursor or arrow keys.
- text that you are expected to type at your keyboard is printed in *Italics*.

3.1 A brief introduction to using NPDECIDE

3.1.1 *What you need to use* NPDECIDE

NPDECIDE is designed to run on any MS-DOS based microcomputer. It does not require a hard disk, numeric co-processor or any particular graphics adaptor. It can be easily configured for different printers and screens.

We assume that you have a basic working knowledge of your MS-DOS machine and operating system. We also assume that you have a good background knowledge of the factors involved in fertiliser decisions and a working understanding of the mathematical model behind NPDECIDE. If you are using the program in an advisory capacity then you will also need an NPDECIDE PIN number to use the program to its full capacity and generate printed reports.

The following files are needed to run the program

- **NPDECIDE.exe** (the program itself)
- **NPDECIDE.dta** (the program's data file)

You may also find some files with names ending with **.stp**. These are setup files that can be used to change the printer and screen configuration of your copy of NPDECIDE. These are simply text files that can be created or changed by any editing or word processing program They are not needed to run the program, and are used only when you want to change the configuration of your copy of the program.

3.1.2 Starting an NPDECIDE session

To use the program as an adviser, type NPDECIDE ↵. The word ADVISER will appear on the screen, followed by a name. If this is your name, simply press ↵. If not, type your name followed by ↵. You will then asked for your PIN number. If you use your correct PIN number, you will then be able to use the program to its full extent. If you give someone else your name and PIN number, you will be held responsible for their printed output as if you had produced it yourself. If you have forgotten your PIN number, you may find out what it is via the person who gave it to you in the first place.

3.1.3 The input and output screens

There are two main parts to the NPDECIDE program, namely the **INPUT** section and the **OUTPUT** section. As their names suggest, the INPUT section is where you can specify a situation for which you require some fertiliser calculations and the OUTPUT section is where you can examine the results of these calculations. It is very easy to move between these parts of the program. Examples of the input and output screens are shown in the quick reference guide that comes with this manual. **When you start up the program, the input section is on the screen**.

There are several important features to note about these screens:

- They consist mostly of pieces of information laid out in order on the screen. **Each piece of information in its particular place is called a FIELD**. For example, the "Freight costs" field contains the cost of freighting a ton of fertiliser from the nearest works to the farm in question.
- **The currently selected field is highlighted and marked with an asterisk**. The information in this selected field is currently able to be changed.
- **The arrow keys ← → ↓ ↑ are use to move between fields on the screen.** The screens "wraparound" at the edges. This means that if you press the up arrow when you are at the top of a screen, you will move to the bottom, and vice versa. This also applies in a similar way to the left and right edges of the screen. The arrow keys only allow you to move to fields that you are able to change.
- **There is an INFORMATION LINE at the top of the screen** that briefly explains the currently selected field (this also applies to menu options- see next section).
- Data entered at the keyboard overwrites the data on the NPDECIDE screen**. NPDECIDE ignores attempts to enter data that are out of range or of the wrong type**. If the program does not seem to be responding to what you are entering, check that what you are entering is sensible (look at the information line for help).
- **The backspace key (BS) is used to correct any typing mistakes** that occur as you enter information into a field. It deletes the last character of the line you are typing.
- Some fields are used to select data from NPDECIDE's internal database. For example, the 'Soil "'field allows you to choose a soil type, by typing an index key for the soil type you want to select. The field displays the name of the soil type with that particular index key. **All the information associated with that choice is not retrieved from the internal database until you leave the field, or until you press the return or enter key (↵)**. This lets you browse through all the available options without causing the program to continually recalculate everything that depends on that field.
- **Some fields contain values that are calculated by NPDECIDE from the data that has already been entered**. It is possible to deliberately overwrite some of these fields, when you want to override those particular NPDECIDE calculations. When you do this, the field is marked with a hash (#) until the value is re-calculated. The hash indicates that the field is no longer consistent with the data in the other input fields.

3.1.4 Using the menu options

The program is controlled by a system of menus that appear when needed on the right side of the screen.

- **The slash (/) used to activate and deactivate menus.** If either the input or the output screen is currently active, then pressing the slash key will transfer control of the program to the menus. Pressing the slash key while a menu is active will return control of the program to the input or output screen. In effect, the slash key is used to switch control between the input and output screens and the menus.
- **The currently selected menu option is highlighted with an asterisk.**
- **The ↑ and ↓ keys move you between menu options**. These menus "wrap around" at the top and bottom. This means that if you press the up arrow when you are at the top of a menu, you will move to the bottom, and vice versa.
- **Pressing ↵ while in the menu area of the screen** will **activate the currently selected menu option.**

3.1.5 Quitting the program

The last (bottom) option on the main menu is labelled 'Quit'. **It is important that you use the 'Quit' option from the NPDECIDE menus when you wish to stop using the program.** The quit command makes the program save all the data from the current session onto disk. If you don't do this, any changes that have been made to the program's internal database in the current session will be lost. Also, it is worth remembering that you need to have entered an NPDECIDE PIN number on starting the program to affect any changes to the information in the database.

3.2 The NPDECIDE Database

Each copy of NPDECIDE maintains its own database of factors that affect fertiliser decisions. This is loaded from disk into memory when the program starts up, and is saved back onto disk when you quit the program by using the 'Quit' option on the main menu. Specifically, this database contains information on up to 36 soil types, 36 fertilisers, 36 fertiliser strategies and 36 sets of other economic and agronomic factors (called 'situations') which influence fertiliser decisions. It also contains all the other parameter settings used by the model.

Each set of information is associated with an alphanumeric character. For example, there could be a soil type indexed by the 'A' key and another indexed by the 'S' key and so on. There may also be fertilisers, fertiliser strategies or situations indexed by the '5' key and the 'A' key, but these are not necessarily related. We have established a convention that **the numeric keys relate to soil types, fertilisers and fertiliser strategies that are common to all copies of NPDECIDE, and that the alphabetic keys are available for people to set up their own local definitions.** This gives some degree of compatibility between different copies.

3.2.1 Soil types

A soil type definition in NPDECIDE consists of a descriptive title, which allows the soil type to be identified locally, and some parameters relating to:

- the pattern of root growth through time on that soil,
- the water-holding characteristics of the soil
- the behaviour of phosphorus in the soil.

3.2.2 Fertilisers

- A fertiliser definition consists of a descriptive title (usually its name) and:
- its analysis (NH4, N03, urea, and phosphorus contents)
- its price
- some parameters relating to its local effect on soil microorganisms (specifically nitrifying bacteria and take-all fungus).

3.2.3 Fertiliser strategies

A fertiliser strategy definition consists of the details of a pair of fertiliser applications. For each application, the following information is recorded:

- the fertiliser type (it actually stores the index key for one of the fertilisers in the database, this means that changes in the stored fertilisers automatically change the strategies that contain those fertilisers)
- a brief description of the method of application (eg. 'Top dressed')
- any additional application costs per hectare. (independent of the rate of application)
- the time of application
- how effective the method of application is for phosphorus nutrition (relative to super drilled at seeding).

3.2.4 Situations

In NPDECIDE jargon, a situation refers to the entire set of information that can be displayed on the INPUTS screen at any one time. It includes a reference to a soil type and a fertiliser strategy and all the other economic and agronomic factors that NPDECIDE accounts for in its calculations. It also includes a descriptive title, which lets you label an entire set of factors with a suitable name, eg. 'Top paddock, 3.5 t potential yield, no take-all'.

The program associates all the information currently on the input screen with the '1' (one) key. If you like, situation 1 is the default used to store all the information currently on the input screen when you leave the input screen. Therefore, it is important not to use the '1' key as an index to situations you want to use later, as it will probably be overwritten.

3.2.5 Accessing and changing the database - RECALL and RECORD

Sections 3.3 and 3.5 of this manual will explain the information in the database in more detail, as well as describing how the information can be accessed and changed within the program. The menu commands that are used to maintain the information in the database are the **RECALL** and **RECORD** commands. They work in the same way whether they are being used on situations , soil types, fertilisers or strategies.

The RECALL command will retrieve a set of information from the database. (You will be asked to nominate which situation, soil type, fertiliser or strategy you wish to recall by pressing its associated alphanumeric key.) The information will be brought into the current screen, where you will be able to modify it by overwriting any data you wish to change. Any changes you have made will not remain unless you then RECORD the contents of the current screen, and associate them with an appropriate key.

The RECORD option lets you put the information on the currently active screen into the database, and associate it with an alphanumeric index key. If you specify a key that already has information of that sort associated with it, the old information associated with that key will be overwritten.

3.3 Inputs

This section describes the fields and menu options that you can access from the INPUTS screen. It assumes that you have read section 3.2 , 'The NPDECIDE database', and have some understanding of how this database is structured.

3.3.1 Paddock description

Name
This field is for the name of the farmer who is receiving the fertiliser advice. It is used in the header of any printed reports that are generated by the program. It is not essential and for many purposes you can leave this field empty, although it should be used for reference purposes when generating printed reports for farmers. It can be used to store any 30 characters of text information that you want to appear in the headers of the printed output.

Address
This field is for the address of the recipient of printed reports from the program. All the comments on the Name field (above) apply, to this field, except; that it consists of two lines of 30 characters rather than one.

Key
This displays the index key associated with the last situation that was recorded in or recalled from the internal database, ie. usually the current situation. See section 3.2, "The NPDECIDE database for more details.

Description
This field allows two lines of 50 characters for a brief verbal description of the current 'situation'. It is your responsibility to ensure that this verbal description matches the actual 'situation' that it is describing. (This reduces confusion when choosing situations and interpreting printed output.)

Soil
This field displays the name of the soil type that is currently selected. To select a different soil type, press the index key associated with that soil type, and its name will appear. When you leave the 'Soil' field or press the return or enter key, the information associated with that soil type will be recalled from the database. You can browse through the soil types available by picking through the alphanumeric keys until you find what you want. It is much more efficient, however, to refer to a printed list of available soil types, which you keep with your NPDECIDE

paperwork. NPDECIDE can print out such a list as part of its SOILS sub-menu. See section 3.5.2 for details.

Strategy
This field displays a verbal description of the fertiliser strategy that is currently selected. To select a different strategy, press the index key associated with that strategy, and its description will appear. When you leave the 'Strategy' field or press the return or enter key, the information associated with that strategy will be recalled from the database. You can browse through the strategies available by picking through the alphanumeric keys until you find what you want. It is much more efficient, however, to refer to a printed list of strategies, which you keep with your NPDECIDE paperwork. NPDECIDE can print out such a list as part of its MANAGEMENT sub-menu. See section 3.5.2 for details.

Potl yield
This field contains the potential grain yield (kg/ha) for the current situation. See sections 2.4 and 2.5 for more information on potential yield.

Take-all %
This field contains an estimate of the take all load in the paddock. This is expressed as the percentage of plants that have more than a quarter of the root system discoloured by the fungus.

3.3.2 Economics

Non-fertiliser costs
This field is for the total non-fertiliser costs ($/ha) that you want to account for when calculating the cash surplus achieved by growing the crop. Usually it includes the costs incurred by cultivation, seeding, pest control and harvesting, accounted for at harvest time. It can, however, be used for other purposes. For example, if the non-fertiliser costs are set to the level of profit that is achieved with no fertiliser, the resulting profit calculation becomes a calculation of the profit due to fertiliser, which may be of interest in some fertiliser decisions.

Fertiliser freight
This field is for the cost ($/t) of freighting fertiliser from the works to the farm. This is added to the fertiliser price for each fertiliser in the NPDECIDE database (price at the nearest works) when calculating profit, allowing convenient farm-to-farm adjustment of the farm-gate price of fertiliser. It could also include an application cost on a per tonne basis, if you wanted to account for application costs in this way. Fertiliser application costs can also be specified on a per hectare basis as part of the definition of a fertiliser strategy (see section *35.3)*, which is probably preferable.

Interest rate
This field lets you specify an interest rate (percent per growing season) which is charged against money spent on fertiliser use. This lets you account for the fertiliser costs, which are incurred at the start of the growing season, with the returns from the crop, which are expressed as their value at harvest time. This interest rate could be the real interest payable on money borrowed to

fertilise the crop, or the real rate of return that could be achieved by investing the fertiliser money elsewhere.

Wheat price
This is the farm gate value of a tonne of grain ($/t), nett of freight and tolls, at harvest time.

P future effect
This is a parameter that expresses the future benefits of phosphorus applied this year in terms of its value in the year of application. It has units of kg equivalents of freshly applied phosphorus per kg of phosphorus applied. A reasonable value for most situations in WA is 05, which implies that 1 kg of *phosphorus applied* in the current year has benefits into the future which, when summed up and discounted to harvest ties of the current year, amount to half of its value in the current year.

P replacement value
This provides a simple method for converting the future benefits of currently applied phosphorus, as calculated by using the phosphorus future effect parameter, into a monetary value. It values each kg phosphorus of residual benefits at the cheapest current replacement cost of freshly applied phosphorus, in units of $/kg phosphorus.

3.3.3 Phosphorus status

The entire purpose of the 'P HISTORY section of the input screen is to get an estimate of the phosphorus status of the paddock in question. To do this, it uses whatever soil test information is available from within the last five years, and a record of phosphorus applications over the last five years. The only figure that is actually used in the grain yield calculations is the adjusted soil test figure for the current year (in the bottom right corner of the table). Everything else in the table is used to calculate a reasonable estimate of this figure. If you want to override the calculations, you can type a soil test value straight into the field for current year's adjusted soil test, and this figure will be used, disregarding all the information in the rest of the table. The adjusted soil test field will be marked with a hash sign (#) to indicate that this has happened.

Previous history
This is the number of years between when phosphorus was first applied to the paddock and the first year in the phosphorus history table. This is used as an indicator whether the measured soil test values from the paddock are the result of a long history of phosphorus applications, or have been mainly built up recently. The length of time over which a soil test level has been built up affects the rate at which it declines with time. An approximation is all that is required, except for very young new land (a precision of plus or minus 20% is adequate).

Year
On each line of the phosphorus history table, the year refers to a particular crop, eg. the crop grown in 1989. The phosphorus-applied column refers to phosphorus applied to that crop, and the test column refers to a soil test taken before that crop.

P appl.

For each year in the phosphorus history table, you need to enter an estimate of the amount of phosphorus (kg elemental phosphorus/ha) that was applied to the paddock.

Test

This column is for the soil test level (ppm bicarbonate extractable phosphorus, Colwell) measured before the crop for each year in the table where one is available. There needs to be at least one soil test measurement in the table (ie. within the last five years). A zero in this column for a particular year indicates that there is no soil test measurement for that year (not a zero soil test level).

Adjusted

This column contains the estimated soil test level for each year in the table. NPDECIDE fits a model. of phosphorus soil test rundown (the P2ST model) to the information in the table. The soil test values generated by this model appear in the adjusted column. The adjusted figure for the current year is the estimate of soil test that is used by the rest of the program.

3.3.4 Nitrogen status

The nitrogen factors section of the input screen does three things. It sets the maximum nitrogen uptake, it sets the background level of organic nitrogen in the soil and it calculates the efficiency with which the organic and fertiliser sources of nitrogen are used. To do this, it combines information about the soil type and soil nitrogen transformations with the information on rainfall to estimate efficiency parameters for nitrogen from the soil organic matter and each source in the fertiliser strategy. See section 2.7 for more details on the NAVAIL model which is used to do this.

Maximum N uptake

This is an estimate of the potential nitrogen uptake (kg nitrogen in the plant tops /ha). It is similar in concept to the idea of potential grain yield, and represents the maximum amount of nitrogen that could be taken up by the crop with no shortage of available nitrogen. In practice, it is not a familiar concept to most people, and NPDECIDE automatically sets a default value of 0.06 times the potential yield. In NPDECIDE; the relationship between the maximum nitrogen uptake and the potential yield mainly governs the way grain yield declines with increasing nitrogen application when nitrogen is in excess. In the region of economic rates of nitrogen, the shape of the response curve is fairly insensitive to the maximum nitrogen uptake, and the value of 0.06 time potential yield is good enough for most circumstances. However, it can become important when investigating high rates of nitrogen in situations where the main factors setting the potential yield are different to those setting the maximum nitrogen uptake (copper deficiency, or extremely harsh seasonal finishes). If you change the maximum nitrogen uptake figure value from its default of 0.06 times the potential yield, it will be marked with a hash(#).

Stable organic N

This is an estimate of the amount of nitrogen (kg/ha) held in the soil organic matter in stable forms with a low rate of turnover. This is mainly affected by soil type and location, and does not change much from year to year. In practice, we use total soil nitrogen as a reasonable estimate of the amount of nitrogen in this form, since most of the nitrogen in the topsoil at the time of soil sampling in WA is in this form. For most purposes, SON usually only needs to be estimated . with a precision of plus or minus a hundred kilograms, (a difference of 100 kg of SON makes a difference of about 2 kg of plant available nitrogen).

Residue organic N

This is an estimate of the amount of nitrogen (kg/ha) held in the soil organic matter in labile forms with a relatively high rate of turnover. This is mainly affected by recent additions of organic matter as a result of the paddock use over the last few years. We use a simple nitrogen budget based on recent paddock history to get an estimate of RON. In practice, we recommend you work out tables of RON values in advance, based on various paddock histories with levels of production applicable to recent seasons, and choose values of RON by educated guesswork with reference to those tables. The tables should be updated from year to year, and should relate fairly specifically to regions and soil types.

Leaching rain

This is an estimate of the amount of rainfall (mm) moving through the soil between seeding and 8 weeks after seeding. It is used to estimate the amount of nitrogen leaching that occurs, and its resultant effect on the availability of nitrogen from the various sources to the growing crop. It is obviously not known in advance, so an expected figure is usually used, except in situations where NPDECIDE is being used post-seeding to re-evaluate a fertiliser strategy in the light of an unexpected rainfall event.

Wetting depth at seeding

This is one of the parameters representing the soil water profile at seeding. NPDECIDE assumes a soil profile at seeding that is at field capacity from the surface down to the wetting depth (cm), and is at a fixed (low) water content below that.

Pre-seeding incubation

Varying soil moisture conditions over summer and autumn cause varying amounts of mineralisation of organic nitrogen pre-seeding. This parameter attempts to address this variation in a crude fashion, by running the soil nitrogen cycling model for a number of weeks before seeding at rates appropriate for the soil moisture and temperature conditions at seeding. This parameter, therefore, has units of equivalent weeks of mineralisation under growing season conditions. We do not know a great deal about the amount of mineralisation that occurs over summer, but have anecdotal evidence that it is quite variable, and can have a large effect on the nitrogen nutrition of the following crop in exceptional seasons. NPDECIDE has been calibrated with a value of 4 weeks pre-seeding incubation for most wheatbelt situations. On the south coast we suggest a larger value, about 10 weeks, and in seasons with unusually high amounts of summer rain (eg. cyclonic storms) we suggest a value of 12 weeks.

KN1, KN2, KRon, KSon

These are calculated indices of plant availability for nitrogen from the first and second fertiliser applications and RON and SON respectively. They are calculated by the NAVAIL sub-model of NPDECIDE from information about the soil types, fertilisers strategies and nitrogen cycling parameters in the NPDECIDE database in conjunction with the information given in the N section of the input screen. The Kn values are the summary parameters used by the rest of the program to generate yield and protein responses. You can override these calculated Kn values by typing in values directly into the relevant fields, which will then be marked with a hash (#) to indicate that the value may be inconsistent with the rest of the information on the screen. You may want to do this if you have Kn values that have been fitted directly to trial data, or want to quickly re-create an nitrogen response surface that has been generated by someone else's copy of NPDECIDE.

3.3.5 Menu options

This section describes the options that are available from the main menu. The main menu appears on the right side of the screen, and is activated by pressing the slash key (/) while you are in the inputs screen. (See section 3.1.4). Pressing the slash key from within the menu will return you to the inputs screen.

Recall
In the main menu, this option lets you retrieve a set of information about a situation from your NPDECIDE database (See sections 3.2.4, 3.2.5).

Record
In the main menu, this option lets you save a set of information about a situation in your NPDECIDE database. (See sections 3.2.4, 3.25).

Fertilisers
This option lets you directly access the fertiliser information in your NPDECIDE database. Fertiliser information will appear in a window on the screen, and a sub-menu will appear below the main menu. See section 3.5 for more information

Management
The management option gives you direct access to the information about fertiliser strategies in your NPDECIDE database. See section 3.5.3 for more information.

Soils
This option gives you access to the information about soil types in your NPDECIDE database. See section 3.5.4.

N Params
This option lets you change the rate constants used by the simple nitrogen cycle model that is built into NPDECIDE. The model has been calibrated with these at certain settings, so if you want to play around with changing these rates, please jot down their values before changing them, so you can reset them to their original values when needed. See section 3.5.5.

List
The list option will print out a list of all the situations currently defined in your NPDECIDE database, indexed by their associated keys (See section 3.2.4). An up to date paper copy of this list should be kept with your NPDECIDE documentation. It saves a lot of mucking round if you

have this list on hand when using the program, because it is the fastest way of looking up this information.

Outputs
This option puts you into the output part of the program, which is described in the next section (3.4)

Quit
This option saves the current state of the NPDECIDE database on to disk, and gets you out of the program, as described in section 3.1.5.

3.4 Outputs

For a given fertiliser strategy, in a given situation, the outputs section of the program displays two-way tables of the predicted yield and profit responses to varying rates of the two fertilisers in the fertiliser strategy. An example of what an output screen looks like is shown in the quick reference guide that accompanies this manual.

3.4.1 Comparing situations and strategies

Situations
This field in the output screen lets you choose situations from those already set up in your NPDECIDE database, and see how they change the profit and yield response to a particular fertiliser strategy. While you are in the 'situation' . field, press the key associated with a situation you want to bring in to output screen. The verbal description of the situation will appear in this field as you press the key. The output table will be re-calculated for this new situation when you leave the situation field or press the carriage return key. When you first go into the output part of the program, it will ~e using a situation based on the contents of the INPUT screen at the time you moved to the output section.

Strategy
The strategy lets you choose fertiliser strategies from those already set up in your NPDECIDE database, and see how they perform in terms of yield and profit in the current situation. You select strategies in the same way as you do situations, as described above.

3.4.2 Changing the output table

Changing the output type
At present, the two-way table on the output screen can show yields, cash surplus or profits, corresponding to various combinations of rates of fertiliser in the current strategy. Types of output (in this case there are only three possibilities) are associated with numeric keys, (similarly to situations, fertilisers, strategies and soil types). However, you cannot change the way they are assigned. Yield is associated with the '1' key, cash surplus is associated with the '2' key and profit is associated with the '3' key. To change the content of the table, move to the field which describes the output type (ie. Yield, Cash Surplus or Profit) and press the key corresponding to the type of output you want in the table.

Changing the rates in the fertiliser table

The top and left margins of the output table control the fertiliser rates of that are used in the table. These rates can be specified either in terms of kilograms of fertiliser per hectare, or dollars of expenditure per hectare. The expenditure field refers to expenditure up to the time of fertiliser application, ie., the cost of the fertiliser and the cost of fertiliser application. It does not include the interest rate described in 3.3.2, which is subsequently taken into account in the profit and cash surplus calculations. On the output screen, there is a field for each rate, and you can change a particular rate by moving to its corresponding field and typing in. the new value. If you enter the rate in the kilograms per hectare field, the program calculates the appropriate value for the expenditure field, and vice versa. Although any rates can be put into the table, in any order, it usually makes sense to set up the table to include a zero rate of each fertiliser, followed by a range of rates (in numerical order) that contain the region of the response surface that you are interested in, in terms of profit and expenditure. If you change fertiliser strategies, the program keeps the rates of expenditure the same, and re-calculates the amounts of the new fertilisers that can be applied for those rates of expenditure.

3.4.3 Interpreting the output table

The output table in NPDECIDE is simply an estimate of the response surfaces corresponding to the inputs that it is given. In itself, this is not a fertiliser recommendation.

The combination of rates that gives highest current cash surplus

Regardless of what sort of output you are looking at (yield, cash surplus, profit), one of the combinations of rates in the output tables will be marked _ with a '<' sign, and will possibly be highlighted on the screen in some way (depending on how your copy of NPDECIDE is configured to your computer's screen). Of all the combinations of fertiliser rates on the table, this is the one that gives the largest cash surplus in the current year. IT IS NOT A FERTILIZER RECOMMENDATION. It is there to help you choose a relevant range of rates in the output table.

Most profitable combination of rates

In each output table, the combination of rates that gives the highest profit (which includes the future benefits of applied phosphorus) is marked with a '<<'symbol. The same comments apply to this as apply to the combination of rates that gives the highest cash surplus. IT IS NOT A FERTILIZER RECOMMENDATION.

Imposing constraints on expenditure

One of the things you can do with the output tables is to investigate the best way of spending a given amount on a particular fertiliser strategy. If the rates in the output table are set up in fixed increments of dollars expenditure, then elements in the table that are on the same diagonal are examples of different ways of distributing the same total expenditure across the two fertilisers in the strategy. This is illustrated below.

3.4.4 Menu options

Report

The report option prints out a one-page output summary for the current fertiliser strategy and situation, using the combination of rates in the output table currently on the screen.

This report has four parts:

1. A report header, which contains all the information needed to recreate the response surface at a later date, if needed. Because spare is limited, and the detailed information is not needed very often, much of the information is in a fairly cryptic summary form, which is not self-explanatory. The quick reference guide contains a key to the detailed information in the report heading.
2. The current two-way table of yield response
3. The cash surplus table
4. The profit table

Input

Selecting this option returns you to the INPUT screen.

3.5 Fertilisers, management, soils and nitrogen parameters.

This section explains the type of information about fertilisers, fertiliser strategies, soils and nitrogen cycling parameters that are contained in the NPDECIDE database, and how to manipulate them. In each case, you gain access to this information via the appropriate menu option from the main menu in the INPUTS part of the program. A window will appear in the middle of the screen, which will have a number of fields in it relating to the current fertiliser, fertiliser strategy, soil type or set of N cycle parameters. You move around this screen in the same way you do the INPUT or OUTPUT screen, and make changes to the information on the screen as you see fit. The slash key (/) switches control between the screen and the sub-menu that appears on the right side of the screen.

3.5.1 Sub-menu options

For soils, fertilisers or fertiliser strategies, the sub menus do the same sorts of things. They let you recall information from and record information into your NPDECIDE database about soil types, fertilisers and strategies, they let you make a list of this information for future reference, and they let you return back to the INPUTS section of the program.

Recall

While the recall option is active, you can retrieve the information concerning a particular soil type, fertiliser or management strategy by pressing the key associated with it. The relevant information will be displayed in the sub-window in the middle of the screen. This lets you browse through the contents of the database, or, by using the slash key (/) to move onto the active screen and change this information.

Record

The record option lets you put the information currently on the active screen into the database, associated with a particular alphanumeric key. Simply press the key that you want the information associated with and the information on the screen will overwrite the information in the database currently associated with that key (if any).

List
This option will print out an indexed list of all the sets o' fertiliser, fertiliser strategy or soil type information currently assigned to keys in your NPDECIDE database. We suggest that you keep an up to date printed copy of these lists with your documentation at all times.

Inputs
This option will return you to the usual INPUTS screen.

3.5.2 Fertilisers

Fertiliser
This field is for the name of the fertiliser, (up to 30 characters long).

Key
This field shows the alphanumeric key that the fertiliser information currently on the screen was last associated with.

%N03
This field is for the percentage nitrogen, in the form of nitrate, in the fertiliser (by weight).

%NH4
This field is for the percentage nitrogen, in the form of ammonium, in the fertiliser (by weight)

%Urea
This field is for the percentage nitrogen, in the form of urea, in the fertiliser (by weight).This field is for the percentage phosphorus in the fertiliser (by weight)

Nrate
This field is for the nitrification rate (fraction remaining/week) of ammonium produced by the fertiliser source (if applicable). It varies between fertilisers because of the different local pH effects caused by the fertilisers.

TAeff
This is a parameter relating to the effect of the fertiliser source in suppressing the take-all fungus. Values of parameter for the common nitrogen fertilisers have been obtained from analysis of data from Gordon MacNish's work. Again, it varies between fertilisers probably because of the different local pH effects caused by the fertilisers.

Price
This is the price of the fertiliser ($/t). We suggest setting it at the appropriate works price, because freight and transport costs can be accounted for separately in the input screen.

3.5.3 Management

Key

This field shows the alphanumeric key that the fertiliser strategy currently on the screen was last associated with.

Appl, App2

Each fertiliser strategy can consist of two fertiliser types or applications. Therefore for each strategy there are two sets of parameters, one for each possible application. The words Appl and App2 are just abbreviated headings in the management sub window screen, referring to the two possible applications.

Fertiliser

For each application in the strategy, this field lets you specify the fertiliser used. It stores the index key for the appropriate fertiliser in the database but displays the name of the fertiliser that is assigned to that key. You specify a particular fertiliser by typing in its appropriate index key.

Descriptor

This is just some brief verbal shorthand (up to 20 characters) which helps describe the application time and method of the fertiliser in each application. The program combines the descriptions and names of each fertiliser to make up a verbal title for the strategy as a whole, eg.' Super drilled + Urea at 4 weeks'

ReP

This figure expresses the relative effectiveness of the phosphorus in the fertiliser, as affected by the application method, compared to that of superphosphate drilled at seeding. For example, super topdressed before seeding might only be half as effective for plant growth in the current season as super drilled at seeding, therefore ReP is 05 for this circumstance. However, in another circumstance, deep-banded phosphorus might be expected to be more effective than drilled super, and therefore ReP should be greater than one.

TAp

This field refers to the time of application of the fertiliser (weeks after seeding). In NPDECIDE, it is only relevant to sources of nitrogen.

ApCost

This is for any additional ($/ha) cost that is incurred by the fertiliser application. For example, this may be an estimate of the fixed costs involved in the fertiliser application, a contract spreading charge, or an opportunity cost charged against an operation at an inconvenient time.

3.5.4 Soils

Soil name

This is for the name given to the soil type (up to 30 characters).

Key

This field shows the alphanumeric key that the soil type currently on the screen was last associated with.

Kp

This parameter determines the curvature of the response to currently applied P It has units of kg grain/kg P and represents the theoretical maximum efficiency of grain production per unit P for wheat on that soil type.

Cst

This parameter calibrates the Colwell soil test against percentage yield, determining the curvature of the yield response to levels of soil test. It has units of fraction of potential yield per ppm soil test, and represents the maximum efficiency of grain production per ppm soil test.

P2ST

This parameter represents the effect of an application of P on the following year's soil test. It has units of ppm P per kg P and accounts for losses in the first year after application, soil bulk density, and other soil processes that have their biggest effect in the first season after application.

WC, WHC .

The simple soil water model used by NPDECIDE assumes a soil profile that is wet to a certain water holding capacity from the soil surface down to a wetting depth, and at another (lower) water content below this. WHC is the water holding capacity and IWC is the initial water content at depth. Both are expressed as a percentage of the soil volume.

3.5.5 Nitrogen cycle parameters

There is only one set of N cycling parameters in the NPDECIDE database. Generally, these should not be changed, because the model has been calibrated with these parameters set at certain values. However, there may be some uses where people may want to play with these parameter settings. All the rates are expressed as a proportion of the remaining N of that type per week. For example, a RON ammonification rate of 0.04 implies that 4 percent of the nitrogen in the form of RON is converted through to ammonium in a week.

SON ammon. rate

This is the rate at which SON is converted-through to ammonium

RON ammon. Rate

This is the rate at which SON is converted through to ammonium.

O.M. nitrif. Rate

This is the rate at which ammonium originating from SON and RON is converted through to nitrate.

Urea hydrol. Rate

This the rate at which urea is hydrolysed to ammonium

Nitrate immob. Rate
This is rate at which nitrate is immobilised by the soil biomass

Immob. return rate
This is the rate at which temporarily immobilised nitrogen is released back as ammonium.

3.6 Changing the screen and printer settings

NPDECIDE uses extremely simple screen and printer commands, and so is quite adaptable to different machines, although a bit Spartan looking. There are, however, a number of simple changes that can be made to enhance. the way its output looks on your screen and printer. The information about what text colors and attributes to use, what size paper is in the printer and what type styles to use on the printer is held in your NPDECIDE database. To change any of these, you make a text file containing the new set-up information, and start the program up by typing

NPDECIDE A FILENAME.STP ↵

Where filename.stp is a the name of the text file containing the set-up information eg. NPDCOLOR.STP.

This changes the screen and printer information in the NPDECIDE database, and the next time you start the program, the program will be set up as specified. You only need to specify a steep file when you wish to change the current set-up, not in the normal use of the program.

Normal text	7
Background	0
highlight	15
HP color	143
HP back	5
CS color	0
Cs back	5
LPP	70
Boldon	27 69
Boldoff	27 70
Italon	-1
Italoff	-1

Figure 3-1 Contents of a typical .stp file

Black	0
Blue	1
Green	2
Cyan	3
Red	4
Magenta	5
Brown	6
Light Grey	7
Dark Grey	8
Light Blue	9
Light Green	10
Light Cyan	11
Light Red	12
Light Magenta	13
Yellow	14
White	15

Figure 3-2 Numeric codes for screen colours

An example of the contents of a typical set-up file is shown below. The order of the parameter settings is important. In fact, the text decriptor at the start of the line is ignored by the program; it only reads the numeric values and relies on there being one per line, in the order shown. The text is just there for us humans to see which is which. The best thing to do if you want to change the setup is to edit an existing set-up file, and change the settings where needed.

The first 7 parameters are the numeric codes for the colour is used to display various types of text on the screen. An index to these codes is shown in table 3.6.2. To make text blink, add 128 to the code value. Monochrome monitors relate these colours to levels of brightness. The last four parameters are for printer control strings to control the typestyles used on printed output. You need to consult your printer manual to find out what these codes are for your printer. A description of the meaning of the parameters is given below.

Normal text
This is the colour used for the normal text on the screen

Background
The normal background colour

Highlight
The colour used on highlit text

HP color
The colour used to mark the text of the combination of rates on the output table that give the highest profit.

HP back

The colour used to mark the background of the combination of rates on the output table that give the highest profit.

CS colour

The coir used to mark the text of the combination of rates on the output table that give the highest cash surplus in the current year.

Cs back

The colour used to mark the background of the combination of rates on the output table that give the highest cash surplus in the current year.

Boldon

This can be a list of up to four numbers, which represent the decimal values of the ASCII characters in a printer control string which turns bold print on. A negative value disables this ability. These comments apply to all the printer options (below).

Boldoff

This can be a string of up to four decimal values which turns bold printing off.

Italian

This can be a string of up to four decimal values that turn italic printing on.

Italoff

This can be a string of up to four decimal values that turn italic printing on.