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Returns from the Acceleration of Agricultural Research

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In September 1988 the Victorian Government released an economic strategy for agriculture which, amongst other things, provided an injection of funding in addition to existing departmental budget allocation to many agricultural research and extension projects. The benefit of the injection of funding is estimated in this paper for the *Production of High Quality Wheat for Victoria* project.

Two distinct estimation procedures are employed. Firstly, ABARE's computerised version of the Edwards and Freebairn economic surplus model was used to evaluate the magnitude and distribution of the benefits emanating from each of the research and development projects. A change framework was then applied since the timing of both the costs and benefits differs according to the funding scenario. The Net Present Value (NPV) of the research programs with the injection of funding was compared with the NPV without the injection of funding. The difference between the two reflects the earlier realisation of the benefits when the research programs are accelerated so that the adoption of research results is sooner rather than later. The total research costs (in real terms) and the adoption rate and level are assumed to be the same irrespective of the funding scenario.

I. INTRODUCTION

In September, 1988, the Victorian Government released an Economic Strategy for Agriculture (AS) which was directed at enhancing current competitive strengths and growth opportunities. The AS program provided resources in addition to the existing Department of Agriculture and Rural Affairs (DARA) budget expenditure on research. The additional resources were granted under the condition that the AS supported projects be formally evaluated in terms of management and financial performance

In this paper cost benefit analysis is used to assess the financial performance of the production of higher Quality Wheat for Victoria project. All benefits and costs are assessed from Victoria's viewpoint[1] (ie on a two region basis defined as Victoria and the rest of the world which includes the other states of Australia).

The structure of the paper is as follows. In Section 2 the general methods used to assess the project benefits and costs is described The economic surplus benefit estimation technique is detailed. Sections 3 details the benefit cost analysis for Production of High Quality Wheats for Victoria.

[1] Social cost benefit studies are traditionally from a national viewpoint

II. METHOD

Investment in agricultural research increases output through improvements to existing inputs, the development of new inputs, and through increased knowledge which enables producers and processors to select, combine and manage their inputs more efficiently. In this context, knowledge can be considered as part of the capital stock of the agricultural sector, just like other physical inputs. Like other forms of capital, knowledge must be created through investment, is subject to depreciation and its rate of utilisation (adoption) varies over time.

Evaluating the costs and benefits from agricultural research is not an easy task. Research costs are highly visible and occur, at points in time, well before any benefits start to flow. In addition, research, by its uncertain nature, is a high risk investment. Further, even if the research is successful a slow rate of adoption or utilisation (of new knowledge) can reduce benefits markedly.

A graphic description of the flow of research costs and benefits is shown in Figure 1. From the graph it can be seen that research investment initially shows an annual loss until industry begins to adopt the benefits. As time progresses the new knowledge is cumulatively utilised throughout the sector resulting in an increasing flow of benefits. Benefits will cease when it is no longer profitable to continue to use the technology, or when the innovation is superseded by improved technology.

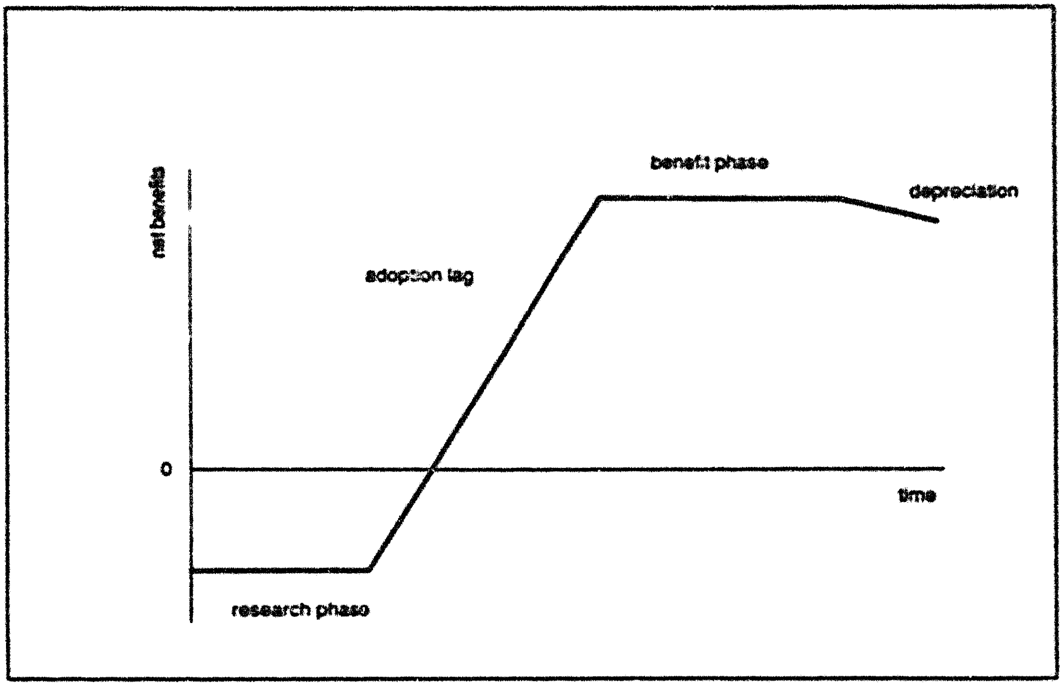


Figure 1 *Costs and Benefits of Research over Time*

This generalised graphic description of research cost and benefit flow applies equally well to specific AS projects. Net benefits are negative early in the project life but become positive when annual benefits are accumulated.

Research investment evaluation involves two distinct estimation procedures. First the benefits and costs need to be determined and secondly, the timing of the various costs and benefits need to be discounted to a common reference value. Each of these evaluation segments will be discussed separately.

A. The Effects of Research

A supply and demand framework can be used to estimate the effects of a research-induced productivity increase. A supply-enhancing change shifts the supply curve to the right, lowering unit costs. Such a shift permits more of that good to be produced at a lower price. A demand-enhancing change leads to an increase in product demand from factors such as promotion and advertising. This shifts the demand curve to the right and results in an increase in the price offered for that product.

Generally agricultural research is directed at reducing the costs of production, processing or marketing, thus, shifting the supply curve to the right. DARA has tended, in the past, to concentrate on farm level research aimed at reducing the costs of production through the adoption of new management techniques, crop varieties or input allocations. However, a number of the projects under the AS have a different focus.

The basic model used to determine the research benefits is shown in Figure 2. The graph shows a demand and supply schedule for a particular agricultural outp At point *e* and price *P*, markets clear and the supply of the good equals the demand of tha good. Any point on the demand curve represents what consumers are willing to pay for different quantities of commodity *Q*.

Investment in agricultural research which produces new knowledge then shifts the supply curve to the right (S2) by a unit cost reduction of R (equal to the new knowledge). The new cost reduction knowledge has lowered the equilibrium price *(g)* and increased the equilibrium quantity produced *(h)* (Figure 2).

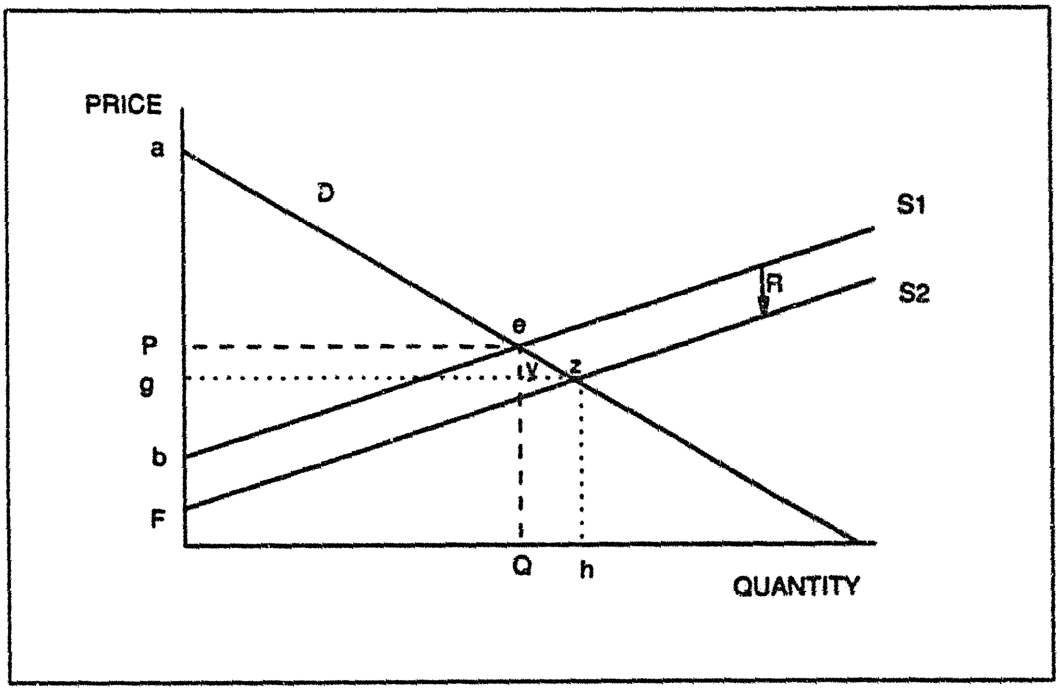


Figure 3 *Technology change*

To measure the benefits of a unit cost reduction (that is, a shift in the supply curve to the right) an economic technique known as economic surplus is employed. Economic surplus has been used extensively to evaluate the magnitude and the distribution of research benefits (Edwards and Freebairn 1981, Freebairn et al 1982, Alston and Freebairn 1986, and Alston and Mullen 1988).

An advantage of this benefit measuring technique is that it provides a greater emphasis on the price effects of research-induced change.

The methodology uses a partial equilibrium framework to examine the effect on consumer and producer surplus of a research-induced cost reduction (downward shift of the supply curve).

Consumer surplus is defined as the excess amount consumers are prepared to pay for a good (rather than go without it) over the amount they actually pay for it (Baxter and Rees 1983). This definition is graphically represented in Figure 3. Consumer Surplus is the area under the demand curve and above the equilibrium price level. It is a measure of the welfare that consumers derive from consuming good Q at price P in excess of the total purchase cost (P*Q).

Producer surplus is the excess of producers' total revenue, over the payment that would be required merely to induce him to continue to maintain his current level of supply. In Figure 3, the producer surplus is the area above the supply curve and below the equilibrium price line. Similarly, producer surplus is a measure of the welfare producers derive from the production of quantity of good Q and selling at price P.

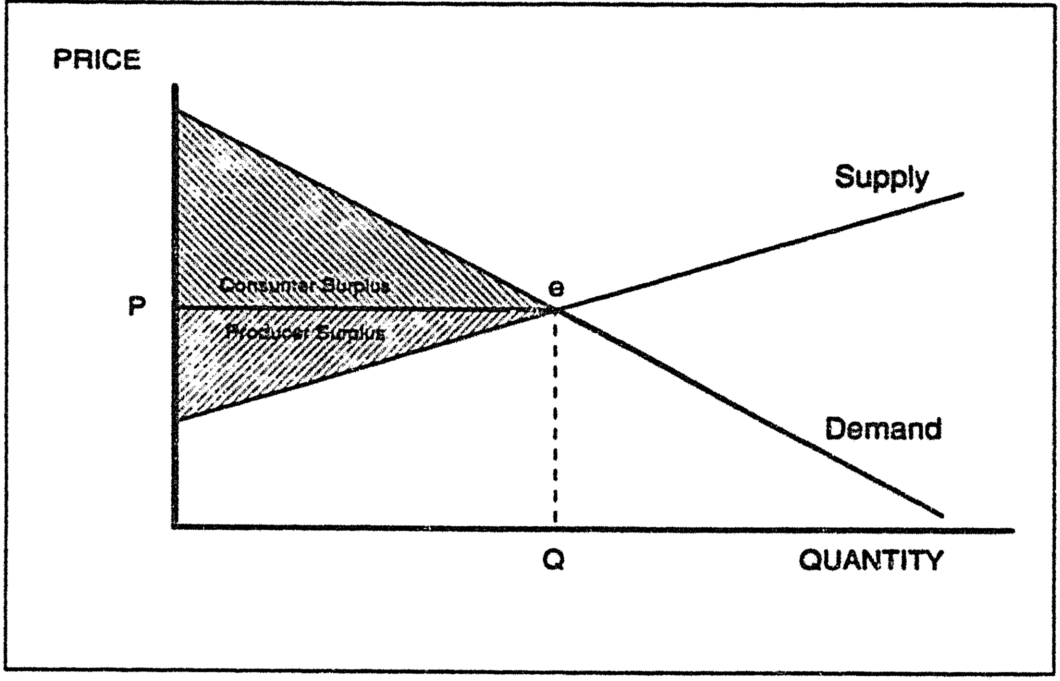


Figure 2 *Consumer and Producer Surplus*

Economic surplus is the total economy welfare derived from the consumption at price P and production at quantity Q. Thus, economic surplus is the sum of producer and consumer surplus.

Edwards and Freebairn (1981) used the economic surplus approach to measure the direct benefits of research. The Edwards and Freebairn model (EFM) estimates the welfare effects of changes in producers' and consumers' surplus arising from a technologically-induced shift in the supply function (Figure 2).

In Figure 2 consumer and producer surplus before the technological change is the area bounded by *aPe* and *bPe* respectively. The technological change reduces unit costs by R and shifts the supply curve to S2, lowering the price to *g* and increasing the quantity produced to *h*. The post innovation consumer and producer surplus is *agz* and *Fgz*. The change in economic surplus is the difference between the initial total surplus and the post-research total surplus, that is *(agz-aPe)+(Fgz-bPe) = Fbez*.

The EFM has been used to assess plant disease research in Australia (McLeish and Wonder 1982), is currently being applied in a major ABARE study evaluating the cost and benefits of all CSIRO research projects.

Past studies using the EFM framework identified three key factors which determined the magnitude of the benefits:

- extent and rate of adoption;
- size of industry of which the cost reduction is applicable;
- magnitude of cost reduction.

The Australian Bureau of Agricultural and Resource Economics (ABARE) computerised the EFM. The EFM adapted by ABARE has been used in this analysis to estimate (where appropriate) the benefits from research investment. Full details of the model are found in Edwards and Freebairn (1981, 1984).

The EFM assumes linear supply and demand curves and research-induced parallel shifts. That is, any reduction in costs affects all units by equal absolute amounts. The analysis requires the estimation of demand and supply elasticities and the measurement of a shift parameter (R). The approach itself is static in nature and does not incorporate the lags involved in the research process.

B. Research Costs

The research costs for the various projects are actual budget allocations for 1988 and 1989 and forecast expenditures for the life of the project. Full details of project costs are provided for each specific project.

All Figures in this study are expressed in 1989 dollars. The analyses are performed in real terms (inflation removed).

C. Cash Flow Analysis

In a cost benefit framework, there is a need to consider the fact that different stages of the research and development process occur at different points in time. Different costs may occur at different stages of the project life and adoption is spread over a number of years. Discounting procedures bring the estimated streams of costs and benefits to a common reference point. In this study the common reference point is 1989 dollar values.

The discounting technique known as net present value (NPV) is used to estimate the present value of the research projects. Discounting involves calculating today's (or the present) value of a sum of money spent or received in the future.

The formula for calculating the NPV is:

$$NPV = \sum_{t=1}^{n} \frac{Y_t - C_t}{(1+r)^t}$$

where Y_t = total benefits ($) incurred in year t
C_t = total costs ($) incurred in year t
r = discount rate
n = number years of the investment

Projects are classified as profitable if they have positive NPVs. That is the value of the research benefits expressed in today dollars exceeds the costs of the investment. In addition to NPV, the ratios of project benefits to costs (BCR) are presented.

D. Discount Rate

Cash flow analysis is very sensitive to the discount rate employed. As such a wide range of discount rates is found in the economic literature.

The Department of Management and Budget has determined that for the Victorian Government and semi government authorities the appropriate discount rate for new capital works is 4.0% real. ACIL (1989) using a weighted average cost of capital and the Capital Asset Pricing Model (to determine the supply price of equity capital) estimated the real cost of capital in the Victorian economy to be in the order of 8.0% real. The Commonwealth Treasury adopts a test discount rate of 10.0% real for evaluating public sector investment projects with sensitivity tests at 7.0% and 13.0%. The NSW Treasury requests evaluations to be undertaken using 7.0% with sensitivity tests at 4.0% and 10.0%.

A major cost benefit study into CSIRO division of entomology used real discount rates of 10.0% (Marsden *et al* 1980). Current ABARE studies estimating the returns to CSIRO research are also using real discount rates of 10%.

In accordance with the economic literature this analysis uses a real discount rate of 10.0%. This discount rate is more appropriate to the evaluation of research. As the Victorian Government requires a 4% real return, sensitivity is conducted at 6.0% and 12.0%.

E. The AS Evaluation Approach

The previous sections describe a general methodology to evaluate the costs and benefits of research investment. However, most of the projects funded through AS were projects already being researched by DARA. The additional AS resources effectively provided a stimulus to speed up the projects. The injection of AS funds boosted the existing projects thus allowing the stream of benefits to flow sooner rather than later.

Figure 4 shows the effects of the AS stimulus. The shaded area is the net benefit from speeding up the project. If the discounted cost for speeding up the project is less than the discounted benefit then it is profitable to increase the project speed. In this analysis, the shaded area in Figure 4 is the area which we intend to measure. The shaded area is a measure of the net benefits from speeding up the project. Therefore, the benefits of speeding up the project equate to the net benefit of the AS injection of funds.

In this analysis the AS project is assessed within a change framework. That is, the benefit of AS is determined by the difference in the returns of the 'with AS' to the 'without AS'. The total cost of the research is assumed to be the same in real terms (inflation removed) in both the 'with AS' and the 'without AS' scenarios. The only difference in costs appears in the timing of the respective cost flows. In the 'without AS' case the research would have proceeded, but at a much slower rate. The 'without AS' project would still have produced the benefits but it would occur at some time further in the future.

An advantage of evaluating the projects within a change framework is that any research costs that occurred prior to 1988 (commencement of AS) can be ignored. It would be virtually impossible to quantify the historical inputs stretching back over many years.

To account for the difference in timing of the flow of costs and benefits a discounted cash flow analysis is used. In terms of NPVs, the return to the injection of AS funds is equal to the NPV of the project with AS minus the NPV of the project without AS. If the difference is positive then the AS funds have been invested profitably.

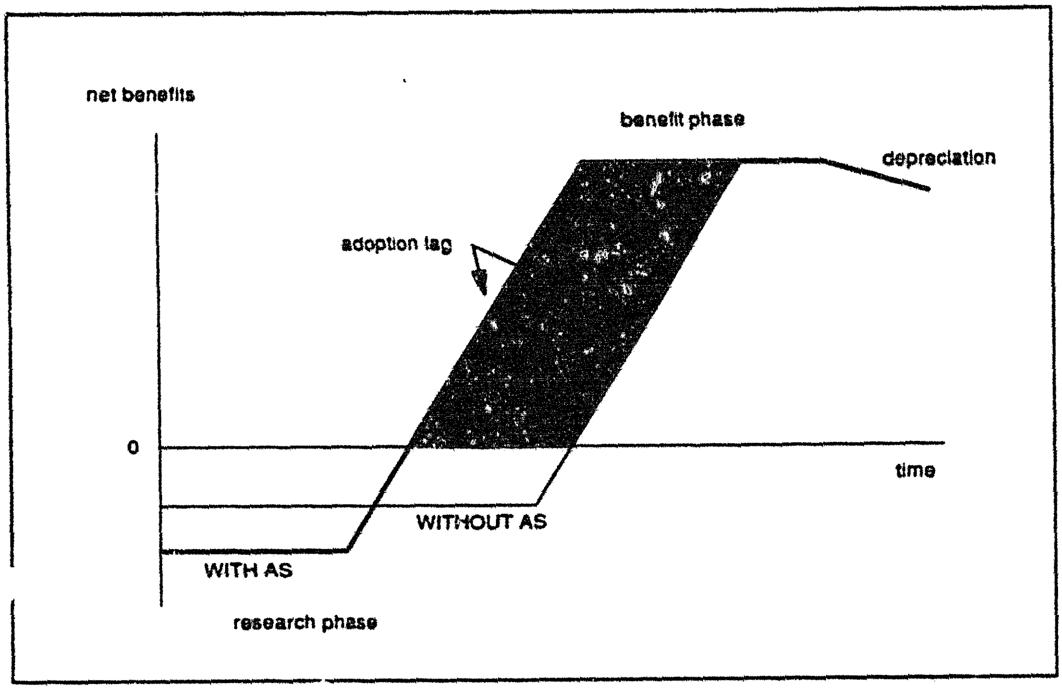


Figure 4 *A change approach*

III Production of High Quality Wheats for Victoria

Over the last few years the average protein content of Victorian ASW wheat has been following a downward trend. Except for the northern Mallee, the fall in wheat protein content is evident in all major cropping regions.

In an attempt to redress this decline DARA, in conjunction with the Australian Wheat Board (AWB), launched an extension program known as Protein Plus. The objective of the Protein Plus program (PPlus) is to increase the protein content of Victorian ASW wheat by encouraging growers to adopt improved cropping practices. The major strategy advocated by PPlus is to increase the legume component (both grain and pasture) of crop rotations.

It is well documented that increasing the legume component of crop rotations will directly increase soil nitrogen levels. Increased soil nitrogen aids crop growth and increases both grain yield and grain protein content.

However, the exact transformation of soil nitrogen into yield and/or protein is quite complex. It is not a one-for-one relationship but rather soil nitrogen is divided amongst yield and/or protein. Generally, industry specialists believe soil nitrogen will be utilised in grain yield before grain protein.

It is the objective of PPlus to encourage growers to compare paddock protein to silo protein and thus get an indication of paddock performance[2]. If relative performance is low, growers are encouraged to adopt alternative cropping practices (such as increased legume percentages in rotations).

1. Measurement of Benefits

The benefits from PPlus stem from an increase in the profitability of wheat production. Profitability of wheat production is enhanced through increased yields and higher protein percentages which attract AWB premiums.

To calculate the benefits from PPlus, estimates are required of the profit increase (cost reduction), the adoption rate of PPlus and the project duration with and without Agricultural Strategy funding. To facilitate the estimation of the above parameters some key assumptions are required. Each key assumption and parameter is discussed separately.

a. Key Assumption 1 - Wheat Production Areas

Due to the wide diversity in conditions and farming practices for Victorian wheat production, yields and yield-protein relationships vary across the state. To reduce the impact of this array of production and management practices this analysis divides the state into three distinct cropping regions. The three regions *(denoted Mallee, Wimmera and North Central-East)* are defined to represent areas of similar production characteristics. Figure 7 shows the principal shires allocated to each region.

[2] Central to the PPlus extension program is the use of average protein content as an indicator of paddock performance. For example, a grower with a paddock showing an average protein content of 9.5 per cent compared to the silo average of 10.5 per cent will know that this paddock is performing below average. Currently, the AWB (or its licensed receivers) tests and records the average protein content of every delivery. Upon payment growers receive delivery details which list the protein contents of individual truck loads, together with summary statistics of the silo protein average.

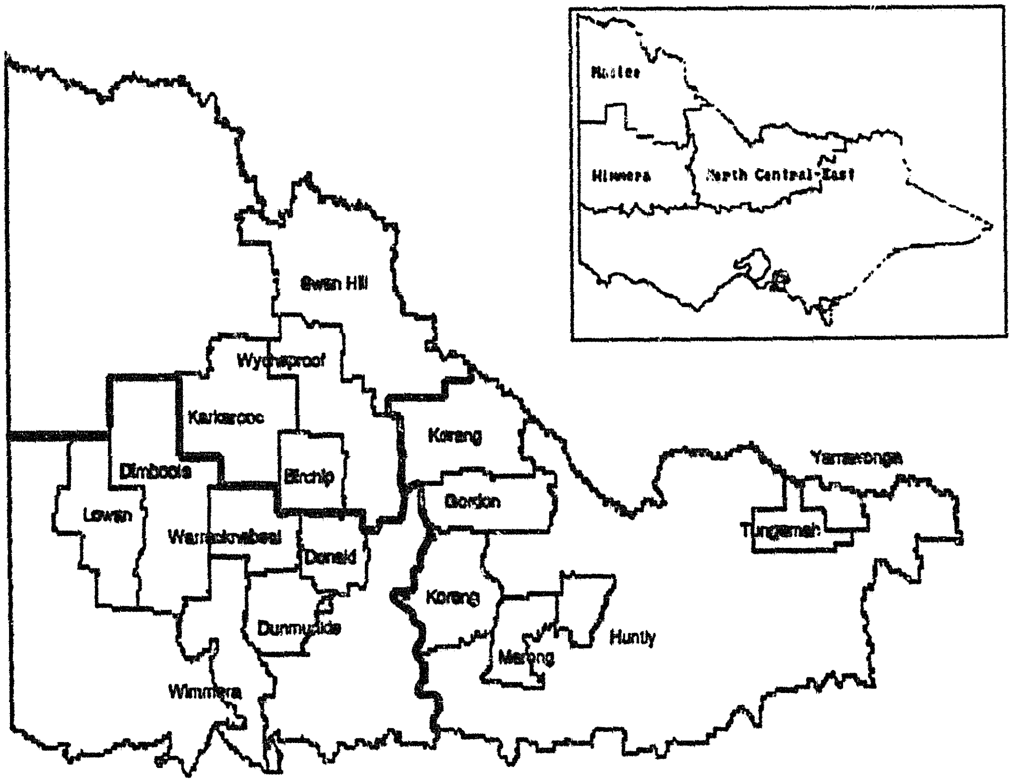


Figure 7 *Principal wheat growing shires selected for analysis*

The particular production characteristics used to select the above shires are:

- shires in which wheat production is a major enterprise; and
- shires which are predominantly under crop production.

Shires such as Walpeup and Mildura, although producing large amounts of wheat, were not included because they also contain large uncropped areas.

b. Key Assumption 2 - Crop Proportions

This analysis assumes the average proportion of crops represents the average agronomic profile of each region[3]. The crops or enterprises considered are wheat, barley, grain legumes, pasture legumes, other crops and fallow (Appendix A).

The total farmed area is assumed to equal the total area of wheat, barley, grain legumes, other crops, pasture legumes and fallow, as presented in Table 12. That is, the six enterprises are assumed to occupy 100 per cent of farmed land. The area of the different enterprises (expressed as a percentage) are averages for the three years 1985/86 to 1987/88. The fallow area percentages are DARA estimates[4]. DARA industry experts estimate the fallow area for the Wimmera and Mallee to be 84 per cent of the combined area of wheat and other crops. Due to the high percentage of

[3] Conducting the analysis this way avoids the problem of using 'average' or 'standard' rotations. Such generic rotations are meaningless at best.

[4] Australian Bureau of Statistics no longer collect statistics on farm area under fallow.

non-fallow crops in the North Central-East the estimate of fallow is set at 50 per cent of the area of wheat and other crops.

Table 12 *Adjusted percentages of major crops in the Wimmera, Mallee & North Central-East (1985/86 - 1987/88) - Current scenario.*

	Percentage of Total Area Cropped[1]					
	Wheat	Barley	Grain Legumes	Other Crops[2]	Pasture Legumes	Fallow[3]
WIMMERA	34	9	11	4	10	32
MALLEE	37	12	5	3	10	33
NORTH CENTRAL-EAST	32	4	6	11	30	17

1 The total area cropped for this analysis is assumed to be the sum total of wheat, barley, grain legumes, other crops, pasture legumes and fallow.
2 Crops other than wheat, barley and grain legume crops.
3 Fallow figures are DARA estimates as no statistics on fallow are collected by Australian Bureau of Statistics (ABS).

The objective of the PPlus program is to encourage a greater percentage of legumes in cropping rotations. For this objective to be met the project leaders believe that a legume (crop or pasture) needs to be included in the rotation at least every second or third year (Walters, 1990). This analysis assumes that a legume every second or third year represents the project outcome. A legume every second year implies that 50 per cent of the region area is sown to either pasture or grain legumes. Similarly, for the every third year scenario, 33 per cent of the region is sown to legumes. The 'every two year' and 'every three year' scenarios are named PP50 and PP33 respectively.

In the Wimmera it is believed that farmers will move more towards grain legumes rather than pasture legumes (Walters, 1990). It is therefore assumed that 75 per cent of total legumes are grain legumes and 25 per cent pasture legumes (Table 13). For example, Wimmera grain legume production for the PP33 scenario is 25 per cent of total area (75 per cent of the 33 per cent proportion).

Due to the higher risk of producting grain legumes in low rainfall areas, Mallee farmers are expected to move towards medic production (Walters, 1990). To represent this preference a weighting of 75 per cent pasture legumes and 25 per cent grain legumes is used in the Mallee (Table 13).

The proportion of grain and pasture legumes is not varied for the North Central-East PP33 scenario as the proportion of legumes under the current scenario surpasses 33 per cent of the farmed area. Under the PP50 scenario the grain and pasture legume components were increased by two and eight per cent respectively thus maintaining their current relative proportions.

The proportion of non legume enterprises are assumed to have consistent relativities. That is, with increased legume percentages (after PPlus) wheat, barley, other crops and fallow areas are decreased in the same proportion.

Table 13 *Proportion of crops in Wimmera, Mallee and North Central-East with a 33 and 50 per cent legume component*

	Percentage of Total Cropped Area[1]					
	Wheat	Barley	Grain Legumes	Other Crops[2]	Pasture Legumes	Fallow
PP33						
WIMMERA	28	8	25	3	8	27
MALLEE	29	9	8	2	25	26
NORTH CENTRAL-EAST[3]	32	4	6	11	30	17
PP50						
WIMMERA	21	6	38	2	13	20
MALLEE	22	7	13	2	38	20
NORTH CENTRAL-EAST	25	3	8	8	42	13

1 The total area cropped for this analysis is assumed to be the sum total of wheat, barley, grain legumes, other crops, pasture legumes and fallow.

2 Crops other than wheat, barley and grain legume crops.

3 The combined proportion of legume crops and pastures in the North Central-East amounted to 36 per cent of total area under the current scenario and is therefore not adjusted for the 33 per cent legume scenario (PP33).

2. Cost Reduction - R Factor

As indicated earlier, the benefits from PPlus arise from increased wheat yields and higher protein premiums. To estimate the change in on-farm costs and returns involved in increasing legume production to the proportions shown in Table 13 a partial budget technique is applied.

a. Change in Costs

PPlus is primarily directed at increasing the legume (both pasture and grain) component of farm paddock rotations[5]. Obviously, such a change does not come without cost. The introduction of improved agronomic practices will require some additional costs to be met by individual farmers.

In this analysis, on-farm costs are estimated by calculating the total weighted variable cost for each region. Total weighted variable costs are determined by summing the weighted variable costs for all enterprises in each region. That is, the variable costs for each enterprise (from DARA gross margins) are weighted according to the proportion of the enterprise in each region and then added together to calculate a total weighted variable cost.

The total cost to producers of increasing grain and pasture legumes to PP33 and PP50 proportions are estimated by comparing the total weighted variable costs for the three scenarios (Table 14). The change from the current scenario to PP33 or PP50 increases the total weighted variable costs in the Wimmera by between seven and sixteen dollars per hectare, by three to seven dollars in the Mallee and by zero to seven dollars in the North Central-East (Table 14).

5 Alternative strategies, such as the application of nitrogen fertiliser, are also advocated by PPlus

Table 14 *Total Weighted Variable Costs for Wimmera, Mallee & North Central-East*[6]

	Cost Increase from Current Scenario ($/ha)	
	PP33	PP50
WIMMERA	7	16
MALLEE	3	7
NORTH CENTRAL-EAST	0	7

b. **Change in Returns**

A change in the returns received for wheat production are achieved through increases in wheat yield and protein. To estimate these increases specific yield/protein relationships for the period 1975-85 for each region are developed[7]. The relationships use average protein content of wheat delivered to silos in each region and the wheat yields as estimated from parish data collected by the ABS. These relationships are presented in Figures 3, 4 and 5 respectively.

In each region there is a negative linear relationship between yield and protein. That is, higher protein levels are more easily achieved at low yields than at high yields. PPlus is not attempting to alter the grain yield/protein relationship but rather to increase the total bank of soil nitrogen. The net effect of such a soil nitrogen increase will be a simultaneous increase in wheat yield and protein. Such an increase would be best represented by an upward parallel movement of the regression line[8].

For the purposes of this analysis it is assumed that PPlus will increase average protein by one percentage point. That is, at the farm level the protein content, at average yield, will be one per cent higher with PPlus than without PPlus. The partitioning of soil nitrogen between grain protein and grain yield is difficult to determine, however, it is considered increases in soil nitrogen will initially increase yield before protein content.

This analysis considers the costs and benefits for moving from producing wheat (current scenario) to wheat production of higher protein content and/or higher yield. A schematic representation of the changes considered in this analysis is presented in Figure 8. The current wheat protein and yield scenario in each region is represented as 'O' in Figure 8. This point was determined using the average wheat yield for each region (DARA estimate). The average protein content was calculated from the graph and roughly corresponds to AWB protein data. The upward parallel shift of the protein-yield relationship under PPlus is positioned such that at the average yield (O) the average protein content is one per cent higher.

Due to the complex nature of the protein/yield relationship of wheat (discussed above), three scenarios are examined: (A) one per cent protein increase with no yield increase; (B) no protein increase with full yield increase; and (C) 0.5 per cent protein increase with half the yield increase

[6] The weighted total variable costs have been developed to examine the difference in costs when changing the relative proportions of crops. These figures do not reflect average gross margins for each region and should not be compared.

[7] Protein data after 1985 is not considered due to the increased number of prime hard segregations and a change in the grower delivery patterns (the introduction of the central receival point system).

[8] Industry specialists suggest that higher protein contents are more achievable at lower yields and less achievable at higher yields. A parallel shift in the area of average yield is assumed and is considered to be a reasonable estimate, as this analysis is not concerned with the effects of Protein Plus outside the average yield region.

under (B). Points A and B represent the polar scenarios which may arise from PPlus, and point (C) represents the most likely outcome, being a mixture of both a yield increase and a protein increase (Figure 8).

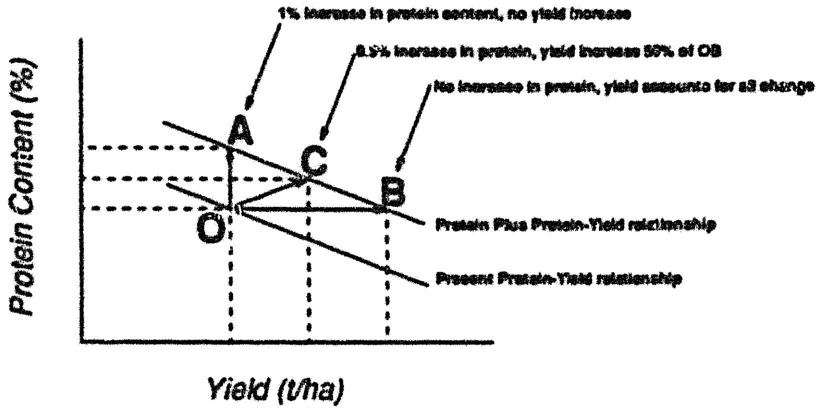


Figure 8 *Three scenarios for the effect of Protein Plus*

Using this approach the average yield and protein values are estimated for the Wimmera, Mallee and North Central-East from Figures 9, 10 and 11 respectively and are presented in Table 15.

Table 15 *Yield and Protein relationships tested to measure benefits*

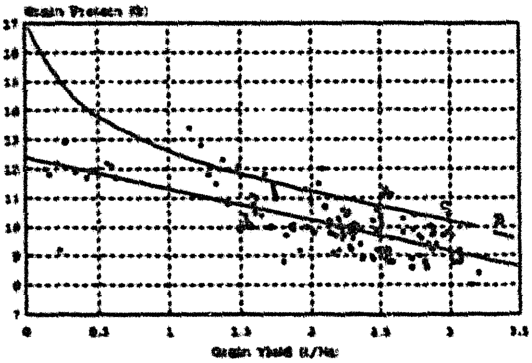
	Yield-Protein Scenarios							
	O[1]		A		B		C	
	Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein
WIMMERA	2.5	9.7	2.5	10.7	3.4	9.7	2.9	10.3
MALLEE	1.6	11.9	1.6	12.9	2.4	11.9	2.0	12.4
NORTH CENTRAL-EAST	2.0	10.0	2.0	11.0	3.0	10.0	2.5	10.5

1 'O' represents the average yield and protein level for each of the three regions (Figure 5).

The protein and yield levels from Table 15 are used to calculate gross margins for each region (Appendix B)[9]. Changes in profit ($/tonne) for the three scenarios (A, B, and C) for PP33 and PP50 were then calculated from the gross margins for each region[10]. The weighted average increase in profit resulting from PPlus range from -$2.19 per tonne for PP50 to $47.15 per tonne for PP33 (Table 16).

9 In each case, the yield-related variable costs were incorporated where yield increased. Premiums for higher protein were also included.

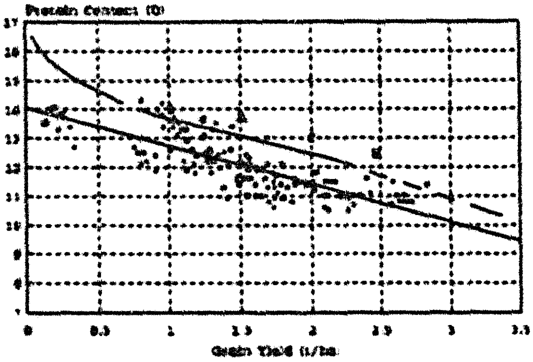
10 The change in profit for each region represent the gross margin for wheat taking into account variable costs for barley, grain legumes, other crops, pasture and fallow weighted according to the area proportion of each crop in each region. The changes in profit are then weighted according to the amount of wheat production in each region.



Protein Plus[11]: Protein = 13.10 - 1.08 * Yield

Present Trend: Protein = 12.10 - 1.08 * Yield (R^2=0.53)

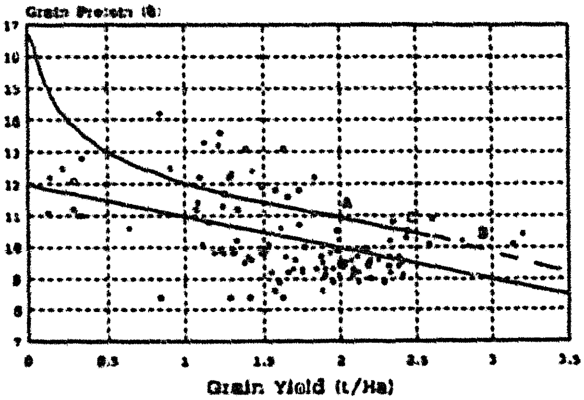
Figure 9 *Protein and yield relationship for the Wimmera*



Protein Plus[14]: Protein = 14.76 - 1.32 * Yield

Present Trend: Protein = 13.76 - 1.32 * Yield (R^2=0.65)

Figure 10 *Protein and yield relationships for the Mallee*



Protein Plus[11]: Protein = 12.67 - Yield

Present Trend: Protein = 11.67 - Yield (R^2=0.23)

Figure 11 *Protein and yield relationships for the North Central-East*

[11] N.B. The curved and dashed lines representing the change are outsid he region in which we are concerned.

Table 16 *Benefits from PPlus for the Wimmera, Mallee and North Central-East*

	Increase in Profit ($/tonne)		
	A	B	C
PP33			
Wimmera	0	40	21
Mallee	0	51	31
North Central-East	2	53	33
Weighted average[1]	0.86	47.15	27.91
PP50			
Wimmera	-3	38	18
Mallee	-2	50	29
North Central-East	-1	51	31
Weighted average[1]	-2.19	45.37	25.38

[1] The average increase in profit is weighted in terms of percentage production from each region. The Wimmera, Mallee and North Central-East regions produce 38.11, 38.42 and 23.47 per cent of Victoria's wheat crop respectively

3. The Adoption Rate

As discussed earlier, PPlus is primarily an extension program designed to disseminate agronomic information on more profitable farming practices. Although the PPlus package will be extended to all wheat growers, the main group of farmers which will be targeted are farmers who deliver wheat of a protein content lower than their respective si o average. Under this strategy the evaluation team, in consultation with PPlus researchers, as umed that only 20 per cent of wheat farmers will adopt the new knowledge. Total adoption (considered to be 20 per cent) is assumed to occur linearly over a seven year period following an initial three year lag phase. The lag phase represents the time required for the benefits of a change in rotation to be translated into a change in yield and protein percentages. This adoption rate is conservative and is considered by the team as plausible.

4. Speeding up the Project

Like other AS funded projects, the net effect of the additional funds is to accelerate the extension programs and thus the adoption of the new technology. The inflow of Agricultural Strategy (AS) money will allow the completion of the PPlus extension package in four years. Without AS funds, members of the PPlus team estimate that the project would require a further two years to be completed. That is, the injection of AS funds has accelerated or shifted the flow of benefits back by two years.

Both the 'with AS' and 'without AS' scenarios are assumed to have seven years of benefit flow following a three year lag phase. A schematic representation of the effect of AS funds is shown in Figure 6.

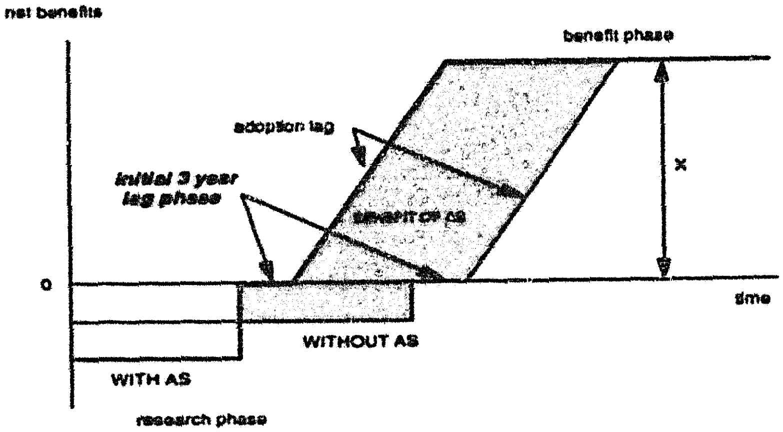


Figure 12 *The benefits from Protein Plus under a change approach (not to scale)*

In this analysis acceleration of the PPlus program by two years is assumed to be the optimistic scenario. Acceleration by one year is assumed to represent the pessimistic scenario.

The variables used in the Edwards Freebairn Model are listed in Table 17. The variables are the same for both the 'with AS' and 'without AS' scenarios, except for the length of the project phase. The two cases for the cost reduction of the project are also investigated (PP33 and PP50 scenarios).

Table 17 *Variables for PPlus used in Edwards Freebairn Model*

Variable		Assumptions	Source
Commodity price ($/tonne)		140	ABARE[1] (1990)
Cost saving ($/tonne)	PP33	27.91	From gross margins
	PP50	25.38	From gross margins
Quantity produced in Victoria (tonnes)		2,230,000	AWB (1985-90)
Quantity produced in ROW[2] (tonnes)		514,800,000	ABARE (1989)
Quantity consumed in Victoria (tonnes)		332,000	AWB (1985-90)
Elasticity of supply for Victoria		1	DARA estimate
Elasticity of supply ROW[2]		1	DARA estimate
Elasticity of demand for Victoria		-0.35	DARA estimate
Elasticity of demand ROW[2]		-20	DARA estimate

1 ABARE estimated forecast price for medium term
2 ROW = Rest of World (i.e. all other countries and the rest of Australia)

5. Project Costs

The costs for the PPlus project have been calculated over a three year period from 1988-89 to 1990-91. To account for the extra year required to complete the project, the average annual expenditure for the first three years is assumed to equal the fourth year of funding. The total project cost adopted accounts for the expenditure for the 'with AS' scenario. The same total project cost is assumed for the 'without AS' scenario but is distributed equally over the estimated six year project phase. Agricultural Strategy, DARA and industry funds associated with the PPlus project are listed in Table 18.

Table 18 *Costs for the PPlus project*

FUNDING SOURCE	1988/89 (Actual) $ ('000s)	1988/89 (Allocated) $ ('000s)	1990/91 (Estimated) $ ('000s)
AGRICULTURAL STRATEGY			
Salary	20.5	34.8	34.9
Travel	5.8	10.2	10.2
Operating	17	2.6	2.7
Capital	0	0	0
Subtotal	43.4	47.8	47.8
DARA			
Salary	36.8	73.6	73.6
Salary (on-cost)[1]	31.1	58.9	58.9
Operating (overheads)[2]	0	0	0
Salary (on-cost)[3]	0	0	0
Subtotal	14.8	29.6	29.6
OTHER[4]	10	0	40
TOTAL	149.9	235.9	275.9

1 cash outlays and infrastructure contribution on-costs include both Agricultural Strategy and State salary components (55% of base salary)
2 estimated to be $10,000 per full time staff member per annum (including electricity, phone, heating, rent, depreciation, insurance, etc.)
3 long term government contribution to salary on-cost for provision of long service leave and superannuation (24% of base salary)
4 other funding sources including industry and Commonwealth Government funding

6. Results

The benefits for speeding up the adoption of increased legume use in cropping rotations are summarised in Table 19. The benefits are expressed as Net Present Value (1989 dollars), and calculated using a discount rate of 10 per cent. The NPVs for speeding up the project by one year (pessimistic scenario) and two years (optimistic scenario) are presented for the adoption of a legume in rotation every three years (PP33) and a legume in rotation every two years (PP50).

Table 19 *Net Present Value for the PPlus Project*

	1989 Dollars (Discount Rate = 0.10)		
	A	**C**	**B**
PP33			
Speed up project by 1 year *(pessimistic)*	0.07m	3.3m	6.0m
Speed up project by 2 years *(optimistic)*	0.1m	6.3m	11.4m
PP50			
Speed up project by 1 year *(pessimistic)*	(0.3m)[1]	3.0m	5.7m
Speed up project by 2 years *(optimistic)*	(0.5m)[1]	5.7m	10.9m

1 A decrease in revenue of $2.19 per tonne results if all the increased soil nitrogen due to PPlus is utilised in increasing protein only. Consequently the NPVs are negative.

The benefits flowing from the project range from a pessimistic loss of $0.5m to an optimistic $11.4m. The most pessimistic case is the scenario A (PP50) which represents a one per cent increase in protein content with no increase in yield (two years acceleration of the project). The most optimistic scenario for the change due to PPlus is case B (PP33 and the project accelerated by two years). In this case the benefits are attributed to a yield increase with no change in protein content. The most likely scenario (half a percentage point increase in protein content with half the increase in yield achieved at point B, and the project accelerated by two years) returned NPVs of $6.3m and $5.7m for PP33 and PP50 respectively.

From Table 19 it is evident the time over which the AS funds accelerate the project have a large effect on the magnitude of the benefits. That is, if the project is only accelerated by one year instead of two years (expected), the benefits would be reduced by nearly 50 per cent in all cases.

The high producer surplus to consumer surplus (PSCS) ratio indicated that producers will capture the large majority of benefits generated from PPlus. The PSCS ratios for PP33 and PP50 are 7156 and 7097 respectively. That is, for every dollar of benefit captured by consumers, producers receive over $7000.

The results suggest that the major potential benefits from the PPlus project flow from an increase in yield. If PPlus results in an increase in protein content only, the benefits from the PPlus program will be quite small, and even negative (for the PP50 scenario). That is, if the benefits from PPlus are defined in terms of protein increases alone the PPlus campaign is uneconomic. Obviously, this analysis is based on the current AWB premiums. If higher premiums are offered a shift in protein may become economic. The most likely outcome from PPlus (an increase in protein content combined with an increase in yield - point C) should return benefits in the order of seven to eight times the cost of the project.

It should be noted that this analysis only answered the on-farm costs and benefits of PPlus. It was assumed that no extra costs were incurred in sampling, testing and administering the payment for protein scheme. If these costs are included the benefits from the program will be significantly reduced.

7. Sensitivity Analysis

Sensitivity analyses were performed on some of the key variables (details are shown in Appendix C).

The results are extremely sensitive to the choice of R factor used in the analysis. The size of the benefits from the PPlus project are highly sensitive to whether the soil fertility improvements achieved through increased use of grain and pasture legumes are utilised in increased protein content or increased yield. If the improvement in soil fertility results purely in an increase in protein content the benefits from AS funds may be as low as $0.1m for PP33 and a loss of over $0.5m for PP50. Conversely, if the improved fertility is consumed in increased yield (considered to be the most probable outcome) benefits from the project could be as large as $10.9m for PP50 and $11.4m for PP33.

As shown in Table 19, the benefits are very sensitive to the time over which the project is accelerated (that is, the number of years over which the project is speeded up). If the project is accelerated by only one year the benefits from PPlus are reduced by approximately 50 per cent for all scenarios.

The benefits from PPlus are relatively sensitive to a change in the discount rate. Decreasing the discount rate from ten per cent to six per cent increased the benefits by five per cent. An increase in the discount rate to twelve per cent decreased the benefits by eight per cent.

The results were relatively insensitive to the other variables used in the model. For example, sensitivity on the elasticity of supply (±50%) only showed a variation in the result of less than five per cent for all scenarios.

Appendix A: Percentage o; Crops in Statistical Shires: Average of three years 1985/86 - 1987/88

	Percentage of total area[1]					
	Wheat	Barley	Grain Legumes	Other Crops[2]	Pasture Legumes	Fallow
WIMMERA						
Dimboola (S)	24.91	13.23	8.85	1.42	15.50	22.12
Donald (S)	25.76	6.76	8.01	3.92	13.57	24.93
Dunmunkle (S)	24.78	5.20	11.88	3.70	16.82	23.92
Lowan (S)	19.83	6.76	6.07	2.46	30.21	18.72
Warracknabeal (S)	32.85	5.83	7.44	2.06	12.73	29.33
Wimmera (S)	25.22	4.35	9.61	4.24	25.36	24.75
Average	25.56	7.02	8.64	2.97	19.03	23.96
MALLEE						
Birchip (S)	29.[illegible]	10.95	4.47	0.89	16.00	25.55
Karkarooc (S)	26.95	9.40	3.76	1.48	24.24	23.88
Swan Hill (S)	25.73	7.11	3.31	3.83	22.26	24.83
Wycheproof (S)	30.66	7.55	4.01	1.95	14.78	27.39
Average	28.22	8.75	3.89	2.04	19.32	25.41
NORTH CENTRAL-EAST						
Gordon (S)	14.42	4.60	3.44	4.45	36.94	9.44
Huntly (S) - Pt B	17.49	1.52	1.99	6.52	43.39	12.01
Korong (S)	14.02	2.18	1.44	5.65	41.12	9.83
Marong (S) - Pt B	15.69	1.75	1.04	6.16	45.97	10.92
Tungamah (S)	18.65	1.86	4.54	8.00	46.11	13.33
Yarrawonga (S)	21.24	1.00	3.53	6.82	42.12	14.03
Kerang (S)	20.60	4.03	5.31	4.10	27.94	12.35
Average	17.44	2.42	3.04	5.96	40.51	11.70

1 Total area is calculated as the total area of wheat, barley, grain legumes, other crops, pasture legumes and fallow

2 Crops other than wheat, barley and grain legume crops.

Appendix B: Wheat production gross margins for each region for PP33 and PP50 under three scenarios (A, B and C)[1]

	Present	PP33			PP50		
	'O'	A	B	C	A	B	C
Gross Margins for Wimmera							
Yield (t/ha)	2.5	2.5	3.4	2.9	2.5	3.4	2.9
Variable Costs ($/Ha)[2]	57	64	67	65	72	75	74
Farm Price ($/t)	158	158	158	158	158	158	158
Protein content (%)	9.40	10.40	9.43	9.97	10.40	9.43	9.97
Protein payment ($)	10.50	18.25	14.57	17.12	18.25	14.57	17.12
Gross Income ($/Ha)	406	413	552	475	413	552	475
Gross Margin ($/Ha)	349	349	485	410	341	476	402
Gross Margins for Mallee							
Yield (t/ha)	1.6	1.6	2.4	2.0	1.6	2.4	2.0
Variable Costs ($/Ha)[2]	46	49	51	50	53	56	54
Farm Price ($/t)	158	158	158	158	158	158	158
Protein content (%)	11.65	12.65	11.66	12.15	12.65	11.66	12.15
Protein payment ($)	15.67	18.87	23.07	21.37	18.87	23.07	21.37
Gross Income ($/Ha)	268	272	394	334	272	394	334
Gross Margin ($/Ha)	222	223	343	284	218	339	280
Gross Margins for North Central-East							
Yield (t/ha)	2.0	2.0	3.0	2.5	2.0	3.0	2.5
Variable Costs ($/Ha)[2]	68	68	72	70	75	78	76
Farm Price ($/t)	158	158	158	158	158	158	158
Protein content (%)	9.67	10.67	9.67	10.17	10.67	9.67	10.17
Protein payment ($)	10.02	15.68	15.03	16.28	15.68	15.03	16.28
Gross Income ($/Ha)	326	332	489	411	332	489	411
Gross Margin ($/Ha)	258	263	417	341	257	411	335

1 To incorporate the increase in profit due to PPlus into the EFM the increase in gross margins are converted to dollars per tonne.

2 Total weighted variable costs across all enterprises

Appendix C: Sensitivity Analyses

Table 1 *Net Present Benefits (NPVs) with Varying Discount Rates and R factors (PP33)*

PP33	1989 Dollars		
	A	C	B
FPlus Program Scenario		***Discount rate = 0.06***	
Speed up project by 1 year *(pessimistic)*	0.08m	3.4m	6.1m
Speed up project by 2 years *(optimistic)*	0.2	6.6m	11.9m
		Discount Rate = 0.10	
Speed up project by 1 year *(pessimistic)*	0.07m	3.3m	6.0m
Speed up project by 2 years *(optimistic)*	0.1m	6.3m	11.4m
		Discount Rate = 0.12	
Speed up project by 1 year *(pessimistic)*	0.06m	3.0m	5.5m
Speed up project by 2 years *(optimistic)*	0.1m	5.8m	10.5m

Table 2 *Net Present Benefits (NPVs) with Varying Discount Rates and R factors (PP50)*

PP50	Increase in Profit ($/tonne)		
	A[1]	C	B
PPlus Program Scenario	*Discount rate = 0.05*		
Speed up project by 1 year *(pessimistic)*	(0.3m)	3.1m	5.9m
Speed up project by 2 years *(optimistic)*	(0.5m)	6.0m	11.4m
	Discount Rate = 0.10		
Speed up project by 1 year *(pessimistic)*	(0.3m)	3.0m	5.7m
Speed up project by 2 years *(optimistic)*	(0.5m)	5.7m	10.9m
	Discount Rate = 0.12		
Speed up project by 1 year *(pessimistic)*	(0.2m)	2.8m	5.3m
Speed up project by 2 years *(optimistic)*	(0.5m)	5.2m	10.0m

1 A decrease in revenue of $2 19 per tonne results if all the increased soil nitrogen due to PPlus is utilised in increasing protein only Consequently the NPVs are negative.

Table 3 *Selected NPVs for the two scenarios PP33 and PP50 with research accelerated by two years*

	NPV (1989 dollars)	
	PP33	PP50
Variable Sensitivity Tested		
Base Case	**6.3m**	**5.7m**
Medium term Price of Wheat		
154	6.3m	5.7m
126	6.4m	5.7m
Reduction in Costs Rest of World		
-5.58	6.3m	5.6m
-11.16	6.2m	5.6m
Elasticity of supply		
0.5	6.0m	5.5m
1.5	6.6m	5.9m
Elasticity of Demand		
0.18	6.3m	5.7m
0.52	6.3m	5.7m
Elasticity of Supply Rest of World		
0.5	6.3m	5.7m
1.5	6.3m	5.7m
Elasticity of Demand Rest of World		
10	6.3m	5.7m
30	6.3m	5.7m

Table 4 *Selected NPVs for the two scenarios PP33 and PP50 with research accelerated by one year*

	NPV (1989 dollars)	
	PP33	**PP50**
Variable Sensitivity Tested		
Base Case	**3.3m**	**3.0m**
Medium term Price of Wheat		
154	3.3m	3.0m
126	3.4m	3.0m
Reduction in Costs Rest of World		
-5.58	3.3m	3.0m
-11.16	3.3m	3.0m
Elasticity of supply		
0.5	3.2m	3.0m
1.5	3.5m	3.1m
Elasticity of Demand		
0.18	3.3m	3.0m
0.52	3.3m	3.0m
Elasticity of Supply Rest of World		
0.5	3.3m	3.0m
1.5	3.3m	3.0m
Elasticity of Demand Rest of World		
10	3.3m	3.0m
30	3.3m	3.0m

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