The Economics of No-Spray Zones

A Study of the Risks and Benefits of Pesticide No-Spray Restrictions

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R&D Technical Report P71

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Tel: 01454 624400 Fax: 01454 624409

Environment Agency's Publication Code: AN-07/97-0K-B-AYED

Dissemination Status
Internal: Released to Regions
External: Released to Public Domain

Statement of Use
The project is intended as a preliminary look at the economic implications of pesticide "no-spray" zones. Building on earlier agricultural studies, the report identifies the main factors influencing farm costs and environmental benefits, and gives an estimate of the total national costs of "no-spray" zones.

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EXECUTIVE SUMMARY

Of the 11,500 or so licensed pesticide products in the UK, approximately 120 fungicidal, 72 insecticidal and 129 herbicidal products require the provision of a no-spray zone for pesticide applications on land adjacent to watercourses. The status of such no-spray zones is currently being reviewed by the Buffer Zones Policy Group.

This study has been commissioned by the Environment Agency to provide a preliminary examination of the costs, risks and benefits associated with provisions for no-spray zones. The study timescale has been relatively short as the aim has been to provide timely information to the Buffer Zone Policy Group on the private costs to farmers arising from no-spray zones and of the changes in environmental risks and benefits associated with their use.

The private costs to farmers associated with no-spray zones have been assess in conjunction with a parallel study that the Consultants are undertaking for the Department of the Environment ("The Private Costs and Benefits of Pesticide Minimisation" - EPG:1./8/30). This study has involved additional work on the assessment of changes in environmental risk levels and ecological disturbance. This has involved the development of two-risk benefit models.

This report presents the results of the final stage of the study.

The analysis provides a variety of information regarding the effectiveness and cost of current restrictions. It also provides data on the influence of zone size and increases in the number of pesticides covered by restrictions on the effectiveness of no-spray zones as a whole.

In terms of estimating the costs to farmers associated with the implementation of no-spray zones, the implications of maintaining some (or all) production within zones are subject to considerable variation depending on locations, situation, etc. Consequently, a worst case approach based on the wholesale removal of zones from production has been used in this assessment.

It is estimated that, if farmers were to remove all 6m no-spray zones from production, the net national cost would be around £50m per year. Under the current restrictions it is estimated that the cost to farmers will be a maximum of around £m per year,

In a situation where all farmers received Countryside Stewardship Scheme (CSS) grants as compensation for removing no-spray zones from production, there would be a net national private benefit to farmers of around £20m per year (although there are obviously significant costs to the Exchequer with this level of compensation).

In terms of environmental risks, there are many difficulties associated with the expression of the 'actual' risks posed by spray drift. However, changes in risk levels have been expressed in relative terms for each of the scenarios under consideration.

Three scenarios have been selected:

- 'without' - where no pesticide applications are covered by no-spray zone restrictions;
- 'present' - where a number of identified pesticides carry 6m restrictions; and
- 'with' - where all pesticides carry 6m no-spray zone restrictions.

Terrestrial and aquatic risk scores have been derived for three representative crops under each of the scenarios using a combination of data including:

- pesticides and active ingredients used;
- area treated;
- concentration of active ingredients;
- degree of drift and deposition;
- persistence;
- mobility; and
- toxicity.

Bioassay mortality data have also been applied in a separate analysis to provide context to the changes in levels of environmental risk described above. This has been carried out for all scenarios.

The results of the study suggest that a 50% reduction in environmental risks is not possible under the current restrictions, regardless of the size of no-spray zone. The data suggests that the only means by which current restrictions could effect a 50% reduction in environmental risk with a 6m no-spray zone would be by significantly increasing the number of pesticides that are a 6m restriction. Under a situation where all pesticides were covered by no-spray restrictions, data suggests that a 50% reduction in risk would be achieved by a zone width of around 2m from the edge of the crop, equating to a distance of 4m from the water's edge.

Where all pesticides are covered by restrictions, the relationship between farmer's cost and levelof risk reduction suggests that an 80% reduction in risks provides an optimum level of investment. This is equivalent to a zone width to the edge of the crop of around 5.5-6m on all pesticides, witha net national cost of around £50m per year. It should be noted that such a zone would provide a distance of 7.5-8m from the water's edge.

The following recommenations have been made:

NSZ restrictions next to watercourses should be extended to cover all pesticides and the width of zone should reflect the level of risk reductions that is a) desirable; and b) cost-effective in terms of farmers' investment.

In order to reduce the costs to farmers associated with NSZ provisions, consideration should be given to an alteration in the current Arable Area Payment Rules to allow farmers to re-distribute setaside land to within field margins and NSZs. This would allow the operation of NSZs without significant costs to the farmer.

Consideration should be given to a scheme aimed at classifying those watercourses which would benefit most from a 'blanket' NSZ either in terms of the nature/quality of the watercourse or their geographical area.

The interim report for this study highlighted a possible anomaly between predicted and actual effects of drift and deposition. In light of the possible underestimation by modelled deposition, further research should be undertaken to identify more reliable estimates of drift/depostiion and its effection with distance. If possible, this should feed into decisions regarding the size of NSZs required to provide an adequate level of protection to both terrestrial and aquatic habitats.

KEY WORDS

pesticides; no-spray zones; buffer strips; economic appraisal

1. INTRODUCTION

1.1 Background to the Study

'No-spray zones' are a concept developed by the Ministry of Agriculture Fisheries and Food's Pesticide Safety Directorate (MAFF-PSD). Where specific pesticides are thought to pose 'serious' risks to the water environment, a limitation is placed on their use with respect to the provision of an area of land along the field edge to be left unsprayed where it is adjacent to a watercourse. This no-spray zone serves to protect the water environment from direct overspray and/or from the effects of spray drift and deposition.

The width of a required no-spray zone also varies according to the equipment being used. Where a tractor mounted hydraulic sprayer is used, the width of the no-spray zone is 6 metres. For hand-held sprayers and air-blast sprayers used on 'top-fruit' (e.g. orchards), these zones are 2m and 18m respectively.

Currently, all pesticides passing through either the 'first' approval or the 'review' of conditions of approval processes are assessed for the need for a no-spray zone. Those pesticides that were approved before no-spray zone provisions were introduced and have not yet been 'reviewed' are consequently not subject to no-spray requirements. There are currently around 120 fungicidal, 72 insecticidal and 129 herbicidal products covered by no-spray zone restrictions (around 20% of licensed products) covering around 15, 16 and 31 active ingredients respectively for fungicides, insecticides and herbicides[1].

The status of no-spray zones is currently 'under review' by the Buffer Zones Policy Group which comprises government and industry representatives.

1.2 Aims and Approach

This study has been commissioned by the Environment Agency to provide a preliminary examination of the costs, risks and benefits associated with provisions for no-spray zones for fields beside watercourses. The study timescale has been relatively short as the aim has been to provide timely information to the Buffer Zone Policy Group on the private costs to farmers arising from no-spray zones and of the changes in environmental risks and benefits associated with their use.

The approach to the study combines the use of qualitative information and the development of a quantitative risk-benefit model. This report provides a quantified assessment of likely changes in environmental risk and comparison to the net private costs to farmers.

With respect to the private costs to farmers, relevant information from a concurrent study on the Private Costs and Benefits of Pesticide Minimisation Techniques (DOE Contract:

[1] A list of product names and active ingredients subject to NSZ restrictions is provided in Annex 1.

EPG 1/8/30) is being fed into this assessment with the consent and approval of the Department of the Environment.

With respect to environmental risks and benefits, the study has been restricted to considering the influence of no-spray zones on risks of spray drift to the environments in and around surface waters. The changes in risks associated with overspray, leaching, etc. have therefore not been considered. Furthermore, the Environment Agency considers that 'terrestrial' bankside communities are part of the wider ditch, stream and river environments normally referred to as 'aquatic' environments. As such this study includes consideration of the risks to these communities. It should be noted that this may differ from the current MAFF-PSD standpoint in that no-spray zones are currently measured from the water's edge rather than the top of a bank.

1.3 Structure of the Draft Final Report

Section 2 of the report discusses the factors that influence the costs and benefits of no-spray zones to farmers. Section 2 also provides a summary of the problems that arise when predicting the changes in environmental risk from spray drift and deposition. Section 3 describes the methodologies that have been used to assess both private costs and changes in environmental risks given practical constraints and the additional constraints of budget and time.

Section 4 presents the results of the analyses and discusses some of the key findings, while Section 5 presents the conclusions and recommendations.

2. FACTORS INFLUENCING PRIVATE COSTS AND ENVIRONMENTAL RISK

2.1 The Impact of No-Spray Zones on Farm Budgets

2:1.1 Background

In financial terms, the costs associated with the operation of no-spray zones (NSZs) beside watercourses are largely restricted to the private costs to the farmer. Assessment of the private costs (and benefits) associated with the use of no-spray zones therefore requires consideration of the components of farm budgets which are affected by them.

There may also be costs to the Exchequer, however, where compensation is provided through agri-environment schemes such as the Countryside Stewardship Scheme.

2.1.2 The Farm Accounting System

A standard farm accounting system is in widespread use throughout the UK. This system requires that expenditure and revenue is allocated, where possible, to a specific crop or 'enterprise' in order to estimate 'gross margins'. The gross margin from an enterprise is its 'gross output' less 'variable costs'. Gross output consists of all the income earned by a farm and thus includes sales, any support payments due as a result of the Common Agricultural Policy (CAP) plus the value of any crop still in store and the value of any produce consumed on the farm by livestock. Variable costs are associated with crop-specific inputs such as seed, fertiliser, pesticides and contract or casual labour.

In order to estimate farm profit, 'fixed costs' are deducted from the total farm gross margin. These fixed costs are those which cannot be allocated to a particular enterprise and include regular labour, the capital and operating costs associated with machinery, building depreciation and repairs, other overheads, rent and finance charges.

2.1.3 The Effect of No-Spray Zones on Farm Costs

The requirement for NSZs for some pesticides has the potential to impact farm costs in a number of ways depending on whether or not the farmer chooses to remove the 'zone' from production. Given the manner in which NSZ restrictions have been 'allocated' (i.e. to 'first' approval and 'review' chemicals) many of the new, and perhaps more effective, products that enter the market have NSZs attached. As such, the farmer is either faced with using 'older' products on the whole field or 'newer' products on all areas except NSZs. In the latter case, any area of crop left untreated may harbour pests and diseases which may then spread to the rest of the crop, causing reductions in yield, quality, and in extreme cases, crop loss.

The decision as to whether to keep the NSZ in production is likely to be largely a reflection of the farmer's perception of the risks of yield and quality loss. In turn, the likelihood of these risks varies by crop. For example, with potatoes, the spread of blight from untreated areas presents a high risk of crop loss in a crop which is extremely 'valuable' in terms of gross farm output. In such circumstances, it is likely that the farmer would choose to remove the NSZ from productivity. On other crops, such as feed spring barley, the risk is not as severe and the crop is of less value. In such circumstances, the farmer may decide to keep the NSZ in production and accept the risks of reduced yield and quality.

In cases where the farmer does decide to remove a NSZ from production, the changes in farm costs will relate to the costs of removing this area of land from production. There are a number of cost components that will be affected by such a decision and the extent of these changes is governed by the nature of 'inputs' and 'outputs' of the crop under consideration. Thus, some of the cost components will increase while other will decrease. For example, whilst output will decrease because of a reduction in cropped area, so there will be reductions in fertiliser inputs, pesticide costs, seed costs and associated labour and machinery costs.

In situations where the farmer maintains the NSZ in production, the cost implications become more complex and varied. Risks of yield and quality loss are subject to a number of variable and unpredictable factors such as weather, nature and population of pests and diseases, etc. and the influence of these factors on risks of yield and quality loss varies by situation, location and year.

Table 2.1 summarises the key changes to each of the cost elements in a farm budget from the introduction of NSZs.

In addition to the direct effects of NSZ implementation on farm budget, the use of no-spray zones may have other costs and benefits which do not form part of the standard farm accounting system. For example, a NSZ may reduce the likelihood of a pollution incident and thus the likelihood of prosecution and the imposition of an associated fine. At the same time, in extreme cases where a farmer is cropping small fields bordered on three to four sides by water courses (or narrow fields as in the case of 'the fens'), the use of a NSZ may reduce the crop area to such an extent that the farm may no longer be viable and/or job losses may result. In terms of the effects of NSZs on potato and sugar beet growers in these areas, such crops must be grown in a rotation. In these circumstances potatoes and sugar beet often provide a large proportion of farm income such that, even if the farmer continued to grow cereals within the NSZ, the inability to crop a sufficient area of potatoes or sugar beet may make the business unviable or may require the farmer to re-schedule the rotation to reduce the costs to the degree possible.

Table 2.1 Changes in Cost Components of Farm Budgets Associated with No-Spray Zones

		Direction of Change*	Reason
Variable Costs	Seed	=/+	No change except where zone is left uncropped
	Pesticides	+	Reduced pesticide costs where no alternative is sought
	Fertiliser	=/+	No change except where zone is left uncropped
	Management	=/-	No change where zone is left uncropped; cost if 'tighter' management required to develop alternatives for a cropped zone
Fixed Costs	Labour	=/+/-	No change where area is left cropped and untreated; benefit where area is left uncropped; or cost where hand sprayer is used as a substitute.
	Machinery repairs	=/+	No change except where zone is left uncropped
	Energy	=/+	No change except where zone is left uncropped
	Contract charges	=/+	No change except where zone is left uncropped
Gross Output	Yield	=/-	No change except where zone is left uncropped or pest/weed problems reduce yield within zone
	Quality	=/-	No change except where pest/weed problems reduce quality within zone
Capital Costs	Capital purchases	=	No change
	Capital sales	=	No change

* Notes: = denotes no change in costs
+ denotes a 'benefit' in terms of reduced costs
- denotes a 'cost' in terms of increased costs

2.2 Environmental Risks and Benefits of No-Spray Zones

2.2.1 Background

The environmental benefits of NSZs will relate mainly to the avoidance of the risks associated with their use. As such, in order to assess the environmental benefits, it is necessary to make some estimation of the size and nature of the potential risks.

For this study, the nature of the risks avoided by the use of NSZs has been restricted to consideration of the reductions in spray drift and deposition. This requires some assessment to be made with regard to the effects of spray drift and deposition at various distances from spray applications.

2.2.2 The Factors which Affect the Degree of Drift

With any pesticide spraying operation, a proportion of the applied active ingredient will be carried beyond the area being targeted. The degree of such drift and deposition is dependant on a number of factors of varying degrees of complexity. In simple terms, at any given location, the most important factors governing the degree of drift and deposition during a spraying operation are likely to be:

- size of spray droplet;
- sprayer pressure;
- windspeed and direction; and
- maintenance and age of equipment.

Such factors represent the key physical components operating with respect to the two vectors, drift and deposition. However, the situation is made more complex by the interaction of these components with influences specific to each location and time. Such site and time-specific influences include:

- topography;
- presence of downwind vegetation;
- variations in height of downwind vegetation;
- nature of downwind vegetation in terms of canopy characteristics, leaf area, etc;
- season (for example, in terms of ground or plant cover); and
- presence of 'obstacles' such as hedgerows.

Such features 'interfere' with the drift and deposition process in a number of ways. For example, they may create eddy-currents, present more or less of a frictional barrier to wind carrying the drift, or cause air to rise and fall. These subtle changes in the movement of air and drift therefore promote or discourage deposition and interception depending on the nature of the interaction.

2.2.3 Sources of Data on the Biological Effects of Drift and Deposition with Distance

The biological and ecological effects of spray drift and deposition depend on the level of exposure of the individuals at risk, the type of pesticide being applied and the susceptibility of the individuals to the pesticide.

There are two sources of data relating to the assessment of environmental risks of spray drift and deposition: measured drift and deposition with distance; and bioassays of mortality with distance.

The level of environmental exposure to spray drift obviously depends on the extent of spray drift and deposition. As discussed in Section 2.2.2, the factors that influence this drift and deposition are both numerous and subject to a high degree of complexity. However, some studies have attempted to measure or model deposition of specific pesticides from standard spray equipment in order to establish general rules regarding deposition and hence risk.

An alternative to the measurement/modelling of drift and deposition is the 'direct' measurement of mortality of susceptible individuals at distance intervals from spraying operations. Such studies represent a direct, 'field' measurement of the biological effects of spray drift and are typically measured by comparing mortality of susceptible individuals of a species placed at intervals from the spraying operation with controls. From such measurements, mortality/distance functions can be calculated. A number of such 'bioassays' have been carried out. Appendices A and B provide a summary of the findings of two such bioassay surveys.

The study conducted on Cypermethrin by Davis *et al* (1993) (see Appendix A) highlights a possible anomaly between the 'actual' levels of mortality (as measured using bioassays) and measured deposition. Davis *et al's* measurement of distance versus invertebrate mortality was accompanied by deposition measurements using gas liquid chromatography and, despite the fact that over 50% insect mortality was still experienced at a distance of 5m, the presence of Cypermethrin could not be detected further than 1m from the source of the spray. There are two probable explanations for this difference:

- the 'direct' measurements of acute biological effects using bioassays are too sensitive; or

- the methods for collecting, analysing and modelling spray drift deposition are not sensitive enough.

This presents difficulties for the analysis because it is changes in the degree of drift and deposition (and associated risks) that provide the basis for the environmental assessment of NSZs.

3. THE METHODOLOGIES USED TO ASSESS COSTS AND RISKS

3.1 Estimation of Private Costs and Benefits to Farmers

3.1.1 The 'Worst' Case Approach

As discussed in Section 2.1.3, no-spray zones (NSZs) can effect farm budgets in a number of ways depending on whether (and in what circumstances) a farmer chooses to remove the zone from production. In general the farmer will incur greater costs by removing an area from production than by selectively using the zone for the production of certain, less susceptible, crops.

In terms of estimating the costs to farmers associated with the implementation of NSZs, the cost implications of maintaining some (or all) production within zones are subject to considerable variation depending on location, situation, etc. Consequently, a worst case approach based on the wholesale removal of NSZs from production has been used in this assessment. Best available estimates of the area potentially removed from production by the implementation of NSZs have been derived from the national Agrevo/NFU survey (pers. comm. 1996) of water courses/ditches adjacent to agricultural land, covering an area of approximately 48,000 ha, 245 farms and 5,257 fields.

3.1.2 Adjustments to the Gross Margin System

As previously noted, the methodology used to estimate costs has been based on that developed for the parallel study which the Consultants are undertaking for the Department of the Environment (entitled "The Private Costs and Benefits of Pesticide Minimisation Techniques"). The methodology has two steps:

1) **Crop-Specific Cost Estimates:** estimation of the costs and benefits of implementing NSZs on a representative selection of crops using standard cost data. This allows the differences in costs between crops to be taken into account;

2) **National Estimates of Costs and Benefits:** estimation of the national costs and benefits associated with implementing no-spray zones, based on the aggregation of crop-specific estimates identified in step 1.

Crop specific estimates of net incremental costs form the basis for the analysis being applicable to both farm level and national level. Given the widespread adoption of the gross margin system as a means of assessing farm profits, this forms an appropriate basis for estimating the costs and benefits of NSZs. However, for the purposes of this study, two key assumptions have been made:

- **Standard Base for Yields, Prices and Costs:** The variability of growing conditions throughout the UK results in many subtle variations in chemical combinations and practices which can further change with the growing conditions presented by a particular year. In addition, different farmers have different growing and marketing skills, all of which make definition of average scenarios a complex process. Given this, the costs and benefits of NSZs have been estimated using standard data for the key components of a farm budget. For example, for a reduction in the yields of Winter Wheat, the value of this loss has been costed using a figure for the average price per tonne.

- **Allocated Fixed Costs:** Whilst fixed costs are generally perceived to be more easily treated as a whole farm business cost, the marginal changes in fixed costs resulting from the implementation of NSZs are defined on a crop-specific basis.

There is a range of standard data sources including "The Farm Management Pocketbook" by John Nix of Wye College and the "Agricultural Budgeting and Costing Book" (ABC) by Agro Business Consultants. The ABC has been used to define standard costs for each of the crops and, where necessary, 'Nix' has been used to supplement standard information.

3.1.3 The Representative Crops

As is clear from the discussion above, the approach used in this analysis draws on crop specific estimates of changes in marginal cost to derive estimates of farm-level and national level costs. There is a very wide range of crops grown within the UK to which pesticides are applied to a greater or lesser extent. It has not been possible to consider the implementation of NSZs to all crops, thus the number of crops that have been chosen for detailed assessment has been rationalised. In making this rationalisation, a number of factors have been taken into account including:

- the extent to which the crops are grown within the UK;
- the similarity of pesticides and application technology used;
- the method of pesticide application; and
- the typical intensity of pesticide use on the particular crop.

The crops selected for detailed assessment are listed in Table 3.1 along with the crops for which they give indicative costs.

Table 3.1 The Representative Crops

Winter Wheat	Indicative of white strawed cereals sown in the autumn such as Winter Barley
Spring Barley	Indicative of white strawed cereals sown in spring
Winter Oilseed Rape	Indicative of all oilseeds sown winter or spring including Linseed
Sugar Beet & Potatoes	Both of these crops have been selected on the basis of the prevalence of fungicides and potential post harvest treatments on potatoes, and herbicides and insecticide use on sugar beet.

3.1.3 Aggregation to a National Level

As the crop specific estimates are calculated on the basis of changes to existing areas of crops, aggregation to the national level can be achieved by 'grossing up' the crop specific estimates to the area of the UK under production of each crop type.

3.2 Estimates of Changes in Environmental Risk

3.2.1 The Approach

As has been discussed in Section 2.2, there are many difficulties associated with the expression of the 'actual' risks posed by spray drift and deposition and hence the 'actual' changes in environmental impacts that are associated with the implementation of NSZs. In a small study such as this, the timescale is insufficient to overcome these difficulties in order to provide an assessment in terms of the level and nature of the impacts avoided. It should be noted that, for any future studies on the economics of NSZs in terms of environmental costs, such difficulties will need to be overcome in order to allow a 'value' to be placed on the environmental costs avoided by the implementation of NSZs.

However, it is the aim of this study to examine the changes in risks associated with the implementation of NSZs. As such, the expression of actual risk is unnecessary and changes in risk levels can be expressed in relative terms for each of the scenarios under consideration. A three stage approach has been developed to achieve this:

Stage 1: define crops and pesticides of interest;
Stage 2: define each scenario of interest; and
Stage 3: analyse the changes in risk levels associated with each crop and scenario.

3.2.2 Crops and Pesticides of Interest

The type and quantity of pesticides used in crop husbandry vary by crop type. In any examination of changes in agrochemical practise on farms, it is prudent to consider this variation in order to establish a representative picture of agrochemical usage.

As is discussed in detail later in this section, the methodology for assessing risk levels has been derived from a previous study by the Consultants for the Department of the Environment entitled 'The Risks and Benefits of Agrochemical Reduction'. Amongst other things, this study examined the changes in pesticide usage and risks associated with the use of Genetically Modified (GM) crops. In this case, two crops were selected for detailed analysis of changes in agrochemical usage, oilseed rape (OSR) and sugar beet (SB) and a risk based scoring and weighting system was developed for the analysis. However, the selection of these crops was on the basis that GM OSR and SB might soon be available to the farmer rather than on the basis of a representative sample of crops and agrochemical usage.

Therefore, it was decided that, for the examination of NSZs, the scoring and weighting system would be extended to cover winter wheat (WW) as a representative of white strawed cereals. This increased the coverage of the cropped are of the UK from 14% with OSR and SB to around 72% with the inclusion of WW.

3.2.3 'Risk' Scenarios of Interest

The original emphasis of the study was to examine the changes in risk levels associated with the removal of the current NSZ restriction. As discussed in Section 1, current restrictions relate to the use of a 6m NSZ for specific chemicals. In order to gauge the effectiveness of these restrictions on the reduction of risk levels, it was decided that the study would be extended to encompass a scenario where all pesticides have a 6m NSZ attached, i.e. a position where risks are reduced to a 'maximum' with the provision for a 6m zone. Thus the scenarios under consideration can be summarised as follows:

- 'without' any NSZ restrictions;
- 'present' situation where a number of identified chemicals have a NSZ attached; and
- 'with' all pesticides having a NSZ attached.

3.2.4 Changes in 'Terrestrial' and Aquatic Risk Levels

As mentioned in Section 3.2.2, the methodology for assessing risk levels has been drawn from a previous contract for the DoE. This methodology utilises a scoring and weighting system based on pesticide usage for each of the crops under consideration (OSR, SB and WW). For each of the crops, pesticide usage[2] is expressed in terms of:

- pesticides and active ingredients used;
- application rate;
- concentration of active ingredients; and
- percent area treated in an 'average' year in terms of weather conditions.

In terms of the 'terrestrial' risks of each application, crop-specific information on pesticide usage has been combined with data on the persistence, mobility, bioconcentration potential and toxicity of each active ingredient to provide a 'risk' score associated with overall pesticide usage on each crop.

Similarly, 'aquatic' risk scores have been developed on the basis of pesticide usage and toxicity of active ingredients. Aquatic scores differ from terrestrial scores in that, whilst both scores take account of toxicity, the exposure component of terrestrial risk scores is more complex than for aquatic scores.

In order to take account of the changes in risk associated with the introduction of NSZs, data on predicted deposition of pesticides with distance from standard tractor mounted sprayers has been incorporated into the scoring system. After discussion with the Steering

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2 Values for pesticide usage are for the cropping year 1995/96 giving up-to-date information on new products. Reference has been made to the 1993 and 1994 British Sugar Specific Crop Survey and the 1992 MAFF table for pesticide usage, with figures being extrapolated, in discussion with British Sugar and Morley Research Centre, to reflect the 1995/96 situation.

Group, it was decided that data from Ganzelmeier *et al* (1995) predictions of deposition should be used to give a guide to the likely 'drop-off' rate of deposition with distance.

In order to gauge the risks to both the 'banks' and the 'aquatic' environment itself, it was necessary to make some general assumptions concerning the width and distance of water bodies from the tractor mounted sprayer. As mentioned in Section 1.2, there may be some confusion over where a NSZ is measured from (e.g. water's edge, top of bank, or edge of crop). After discussion with the steering group, it was decided that the 6m zone would be measured from the edge of the crop.

In terms of the dimensions of the water bodies, it has been assumed that there would be a horizontal distance of 2m between the crop edge and the water's edge (1m of field margin/non-crop vegetative strip/sterile strip; and 1m of bankside vegetation). As such, in the analysis, the spraying operation actually occurs 8m from the water's edge. It has been assumed that the water body itself is 1m wide.

It should be stressed that all of these dimensions are horizontal. Because of the complexity of the factors that influence drift and deposition (as described in Section 2.2.2), it was agreed that the potential for eddy currents, etc. to increase or decrease deposition in the vicinity of water bodies could not be taken into account here. As such, a 'level ground' approach has been adopted for deposition modelling which ignores the effects of topography on drift/deposition.

'Without' NSZs Scenario

Calculation of risk levels for the 'without' scenario has involved a number of stages:

1) Average deposition onto 'near bank', 'far bank' and water surface was calculated from Ganzelmeier *et al* (1995) data with spray operations being conducted up to the edge of the crop (2m from the water's edge). Data expresses deposition in terms of the percentage of the applied rate of pesticide reaching the ground/ water surface.

2) Deposition data for 'near bank', 'far bank' and water surface (from stage 1) were incorporated into the risk-based scoring system described above. This provides terrestrial and aquatic risk scores for each pesticide used on each crop. The sum of all pesticide scores for each crop gives a total 'risk' score for each crop under a scenario where no NSZ are in existence.

3) The crop-specific risk scores calculated in stage 2 were combined to give an overall 'risk' score for the scenario. These combined scores take into account the contribution of each of the crops to the overall environmental risk associated with spray drift and deposition. This has been achieved by weighting each of the crop-specific risk scores on the basis of the percentage area of the UK under each crop. This gives weighted average scores for both terrestrial 'risk' on each bank and aquatic hazard potential for the water environment.

'Present' NSZ Scenario

As has already been discussed, current NSZ restrictions apply to specific chemicals. As such, some of the chemicals identified by the pesticide usage data for each crop are required to have a NSZ attached. Scores for the 'present' scenario were derived using the following steps:

1) Those pesticide products covered by NSZ restrictions were identified in the data.

2) Deposition values for 'near' bank, 'far' bank and water surface were re-calculated to take account of spray applications 6m from the edge of the crop (8m from the edge of the water) for the products identified in Step 1.

3) 'Risk' scores were calculated for each pesticide on each crop as for the 'without' scenario.

4) Total 'risk' scores for each crop were derived by summing the scores for each pesticide used on each crop.

5) Crop total 'risk' scores were combined to give an overall weighted average on the basis of the area of the UK under each crop.

Changes in both terrestrial risk scores and aquatic hazard potentials from the adoption of NSZs to certain pesticides therefore take account of the following factors:

- the environmental risk/hazard potential of the substances (on the basis of toxicity and, for terrestrial scores, persistence, bioconcentration, etc.);
- the quantities applied; and
- the 'popularity' of these pesticides in terms of percent area treated.

'With' NSZs Scenario

The methodology for calculating risk/hazard scores was the same as for the 'without' scenario except that deposition rates were re-calculated for all pesticides used on all crops to take account of the 6m 'retreat' of all spraying operations from the edge of the crop (8m from the water's edge). Combined scores were derived as before to allow direct comparison of all scenarios.

3.2.5 Estimates of Invertebrate and Seedling Mortality

In addition to the risk/hazard scores described above, an additional and entirely separate analysis was undertaken to provide some context to the level of impact reduced by the introduction of NSZs. The same scenarios were tested for this analysis as for the risk based scoring and weighting analysis.

Bioassay data (as described in Section 2.2) was used for both invertebrate mortality and seedling mortality with distance for both scenarios on 'near' bank, 'far' bank and water surface. The dimensions of the waterbodies were the same as for the scoring and weighting analysis described above, thus a 6m zone is measured from the edge of the crop, providing an overall distance of spraying operations from the water's edge of 8m.

It should be noted that the data produced from this part of the analysis is intended to act as a guide to the maximum level of disturbance to the ecological communities that make up ditch/watercourse ecosystems. The pesticides and test organisms used to derive bioassays often demonstrate the effects of a very toxic active ingredient on the most susceptible organisms and as such represent a 'worst case' scenario.

Crop Specific Estimates

In terms of ecological disturbance, the variation between crop husbandry practices for each of the crops OSR, SB and WW is related to the frequency of applications rather than the quantity of pesticides applied *per se*. Currently, bioassay data is only available for the effects of herbicides on vegetation and insecticides on invertebrates. So, by necessity, the analysis has been restricted to the consideration of insecticides and herbicides alone. The analysis of mortality for each of the scenarios is therefore not specific to individual pesticides, rather the type of application (insecticide or herbicide).

In this regard, the analysis of % mortality assumes that the effects of all agrochemical products are equal i.e. the innate variation in toxicity between products is immaterial. As described above, in this respect, the analysis of mortality may give a 'worst case' estimate. However, given the fact that the recommended application rate of pesticides given by manufacturers is based on their effectiveness or 'kill rate', it seems possible that this variation in toxicity between products may already be accounted for. By way of explanation, the application rate recommended by manufacturers is just sufficient to kill 100% of the target organisms. Thus, a highly toxic active ingredient will be effective at a lower concentration than a less toxic active ingredient. As such, the recommended application rate of a more 'toxic' substance is already reduced to compensate for its effectiveness (or toxicity) in terms of 'kill rate' of target (and therefore non-target) organisms.

Frequencies of application were derived for each of the crops using British Agrochemical Association data (BAA, 1996) for the cropping year 1995/96. This data was derived from areas of crop grown versus treated areas for each of the crops under consideration. An average weighted frequency was derived by application of the percentage of UK cropped area under each crop.

The bioassay data used for the invertebrate analysis has been derived from Davis *et al* (1993) as described in Appendix A and uses the mortality curve for Cypermethrin (showing less mortality with distance than for Triazophos). Seedling mortality bioassay data has been derived from Marrs *et al* (1993) as described in Appendix B and uses the curve for Glyphosate.

'Without' NSZs Scenario

Average invertebrate/seedling mortality was calculated for each application of herbicide/insecticide for the 'near' bank, 'far' bank and water surface using the distance-mortality curves described above. All spraying operations take place up to the crop edge (2m from the water's edge). A weighted average mortality was derived as before by applying the percentage area of the UK under each crop. Frequency of applications remains constant for all scenarios.

'With' NSZs Scenario

Average invertebrate/seedling mortality was calculated as for the 'without' scenario except that account has been taken of the 6m 'retreat' of each spraying operation from the edge of the crop (8m from the water's edge).

'Present' NSZ Scenario

Within the 'present' scenario, seedling/invertebrate mortality is equivalent to a mixture of both 'with' and 'without' scenarios. Its position between the other two is a function of the percentage of applications that require a NSZ relative to those that do not. These percentages have been derived for each crop by calculating the percentage of insecticides/herbicides requiring a NSZ relative to the number used on each of the crops (using the pesticide usage data described in Section 3.2.4). Overall mortality has been calculated as before.

4. THE RESULTS OF THE ANALYSES

4.1 Private Costs and Benefits to Farmers

4.1.1 Results and Discussion

As discussed in Section 3.1, a 'worst case' scenario has been applied whereby all farmers remove no-spray zones (NSZs) from production. As such, all of the cost data presented below relates to the wholesale removal of NSZs from production, a situation that is unlikely to occur on a national scale under the present limitations (but might occur if all pesticides were covered by NSZ restrictions). The actual costs of the 'present' restrictions on NSZs are likely to be considerably lower. This difference in the level of costs between the 'present' situation and a situation where all pesticides are covered by NSZ restrictions has been addressed in the discussion below.

The marginal changes to farm costs that result from removing all 6m NSZs from production are related to a 3.1% reduction in cropped area for each of the crops under investigation (using the Agrevo/NFU data mentioned in Section 3.1.1). Because of differences in the inputs and outputs of the various crops, the effects of this reduction in cropped area vary from crop to crop. It should be noted that arable area payments have not been included in the analysis as these vary from year to year. However, Countryside Stewardship Scheme (CSS) grants, which, in theory, are available to farmers who remove strips of marginal land from production, have been considered. In the analysis of private costs to farmers, marginal changes in costs have covered both 'with' CSS payment and 'without' CSS payment situations as it is possible that, in circumstances where all farmers attempt to claim CSS payments, the status of payments might be reviewed. This enables examination of how the current level of CSS payments (at £0.35 per metre of 6m strip) serves as compensation to farmers for lost cropping area (and the potential costs to the Exchequer associated with their award).

Crop-Specific Estimates

Table 4.1 summarises the effects of losses of cropped area relative to standard costs with all values being in terms of £ change per hectare per year for each of the crops under consideration.

As might be expected, there is an overall reduction in farm income per hectare for all of the crops under consideration where CSS grants are not available. Reduction in income from sugar beet is most severe, with a reduction of around £38 per hectare. This figure is largely attributable to the reduction in yields associated with leaving the NSZ out of production for what is a valuable crop. Savings in seed, pesticide, fertiliser and transport costs from reductions in cropped area are relatively insignificant compared with the reduction in output.

A fairly large reduction in income is also experienced on potatoes. Here reduction in output is even more severe but is compensated by reductions in the 'fixed' cost elements: storage treatments, storage, etc.

The reduction in farm income on spring barley is the least severe of the crops examined because of the relatively low yields from spring crops and the smaller premium for barley.

Penalties in output on winter wheat are more severe than on spring barley owing to the greater yield loss from more developed winter crops. Savings in the variable cost elements are 30% higher for winter wheat than spring barley.

Oilseed rape experiences a reduction of around £11 in overall farm income per hectare by the removal of NSZs from production.

Table 4.1 **Crop Specific Estimates for Removal of 6m NSZs from Production**
(i.e. where all pesticides have a NSZ restriction)

		Change Var. Costs (£/ha/yr)	Change in Fixed Costs (£/ha/yr)	Change in Output (£/ha/yr)	Change in Income (£/ha/yr)
Winter Wheat	+ CSS payments	£-9.67	£-20.59	£-24.03	**£6.23**
	- CSS payments	£-9.67	£-2.51	£-24.03	**£-11.85**
Spring Barley	+ CSS payments	£-6.01	£-20.00	£-16.12	**£9.90**
	- CSS payments	£-6.01	£-1.92	£-16.12	**£-8.18**
Oilseed Rape	+ CSS payments	£-7.53	£-20.48	£-20.65	**£7.36**
	- CSS payments	£-7.53	£-2.40	£-20.65	**£-10.72**
Sugar Beet	+ CSS payments	£-11.56	£-24.90	£-55.61	**£-20.14**
	- CSS payments	£-11.56	£-6.82	£-55.61	**£-38.22**
Potatoes	+ CSS payments	£-40.11	£-66.97	£-110.67	**£-3.59**
	- CSS payments	£-40.11	£-48.89	£-110.67	**£-21.67**
Notes		where a '-' is a benefit		where a '-' is a cost	

In terms of the inclusion of CSS payments in the analysis (which appear under the changes in fixed costs), it is interesting to note that there is a fairly sizable benefit to all combinable crops (winter wheat, spring barley and oilseed rape). In contrast, both sugar beet and potatoes still experience a loss in farm income. This is because of the high value of these crops. CSS payments are thus insufficient to compensate these losses in income. However, as both sugar beet and potatoes must be grown in a rotation, increases in income on the intervening crops may result in no overall change in farm costs if CSS payments are included.

National Estimates

Crop-specific estimates of cost changes have been aggregated to the national level by combining them with the area of the UK under different crops. These area figures have been derived from official Scottish Office, MAFF and Department of Agriculture for Northern Ireland farm censuses. In all cases these relate to the 1995 cropping year, except for N. Ireland which uses 1996 data.

Table 4.2 presents the estimates of the national costs to farmers from the removal of 6m NSZs from production. As with crop-specific estimates, the national estimates examine the inclusion of CSS grants and their effects on overall net costs to farmers.

As can be seen from Table 4.2, the greatest cost is incurred by growers of winter cereals, where the large areas under this crop contribute to a net national cost of around £31m per year. Costs to other crops are smaller in comparison. Under this 'worst case' scenario, it is estimated that the national cost of removing NSZs from production is around £50m per year.

However, as discussed at the beginning of this section, it is unlikely that all farmers will remove crops from production under the present restrictions. A more realistic figure can be estimated if it is assumed that growers of cereals continue to use NSZs for producing crops without significant yield penalties and all other growers remove their crops from production (which is still unlikely). Using these assumptions, we arrive at a national cost of around £15m per year for the implementation of the current restrictions regarding NSZs.

Under a situation where all NSZ are removed from production on all crops but CSS payments are provided to allow some compensation, there is a net benefit on all combinable crops. A small cost of around £0.6m per year is incurred on potatoes and a larger cost of around £4m to sugar beet growers, but there is an overall net benefit of around £20m to farmers from the removal of NSZs from production.

Table 4.2 National Estimates (£m) of Cost of Implementation

	National Cost of Implementation with CSS Payments (£m/year)	National Cost of Implementation without CSS Payments (£m/year)
Winter Cereals	-16.21	30.79
Spring Cereals	-5.52	4.56
Oilseeds	-2.6	3.79
Sugar Beet	3.95	7.49
Potatoes	0.61	3.7
Total	**-19.77**	**50.33**

Notes: Where a 'negative' value denotes a benefit

4.2 Environmental 'Risk' Changes

4.2.1 Introduction

Results and analysis are presented below for both the examination of changes in risk/hazard levels and mortality under each of the NSZ scenarios.

As described above, Agrevo/NFU data has been used to estimate the % area of crop land lost by removing 6m NSZs from production. This same data has been used to estimate the length of watercourses/ditches adjoining arable land by combining the information with the area of the UK under arable land. In making this estimate, it has been conservatively assumed that all watercourses/ditches are surrounded on both sides by arable land (where it is likely that some watercourses will actually be adjacent to roads, meadows, etc.). Using these assumptions, it is estimated that there are approximately 117,000km of watercourses/ditches adjacent to agricultural land in the UK. Assuming an average horizontal width of 3m for each watercourse and associated banks, this is roughly equivalent to 35,000ha of bankside vegetation and water surface (an area corresponding to two thirds the size of the Norfolk Broads National Park).

It should be noted that, whilst the above estimate of the length/area of land and water assumes that watercourses are surrounded on both sides by agricultural land, the results presented below only take account of the effects of spray deposition from one side of the watercourse.

4.2.2 Changes in Risk/Hazard Potential

Table 4.3 presents the calculated changes in risk levels associated with each of the crops and scenarios under consideration.

As can be seen in Table 4.3, there is considerable variation between the levels of risk associated with each crop, with sugar beet posing almost twice the 'terrestrial' risk compared with oilseed rape because of the nature, type and frequency of applications of agrochemicals on this crop. Winter wheat is even higher than sugar beet for the same reasons and, given the larger area of the UK under winter cereals, pulls the weighted average up to a fairly high hazard potential.

In terms of variations between crop aquatic hazard potentials, applications to sugar beet pose three times the aquatic hazard potential as applications to oilseed rape. Winter wheat applications pose a similar aquatic hazard potential as for sugar beet. Differences between the terrestrial and aquatic scores can be explained by the fact that the aquatic index is based on use and toxicity of active ingredients, where the terrestrial scores take consideration of use and toxicity of active ingredients as well as a number of other factors including persistence and bioconcentration. As such, it is important to note that the aquatic and terrestrial indices are not comparable with one another.

Table 4.3 Changes in Risk/Hazard Levels for Each of the NSZ Scenarios

Environment	Crop	'Without' NSZ	'Present' NSZ	'With' all NSZ
'Near' Bank	OSR	31.84	30.78	4.00
	SB	68.85	68.45	8.64
	WW	91.66	66.49	11.51
	Weighted Average	**84.54**	**63.02**	**10.61**
'Far' Bank	OSR	10.48	10.19	2.97
	SB	22.65	22.55	6.41
	WW	30.16	23.37	8.54
	Weighted Average	**27.81**	**22.01**	**7.88**
'Water'	OSR	4.49	4.39	0.95
(Aquatic Hazard Potential)	SB	12.77	12.64	2.70
	WW	12.59	9.16	2.66
	Weighted Average	**11.79**	**8.85**	**2.50**

Notes: Where all NSZs measured as 6m from the crop edge, equivalent to 8m from the water's edge

Table 4.4 presents data on the percentage reduction in risk levels achieved under each of the scenarios and crops. As such, the 'without' situation (where there are no NSZs in operation and spray applications are thus 2m from the water's edge) represents the maximum degree of risk for each of the crops, and the baseline against which the other scenarios are compared. The larger the percentage reduction in average risk levels associated with a NSZ scenario, the more effective the scenario is at reducing the overall environmental risks of pesticide spray drift and deposition. For example, under the present NSZ scenario (where 6m NSZ restrictions apply to specific pesticide products only)[3] there is an overall reduction in aquatic risks of around 25% relative to the situation where there are no NSZ in existence. In contrast, under a scenario where all pesticides are covered by 6m NSZ restrictions, the degree of risk reduction is around three times higher than the 'present' scenario.

There is an obvious difference in the degree of risk reduction achieved by current restrictions on each of the crops under consideration. From Table 4.4 it can be seen that the level of overall aquatic risk reduction achieved on winter wheat under these restrictions is 27.2%, where on OSR and SB, reductions are 2.2% and 1.0% respectively. This is because both a larger number and a greater weight of the more popular pesticides are subject to restrictions under winter wheat than the other crops.

[3] Thus some applications take place 8m from the water's edge

Table 4.4 % Reduction in Risk Levels by the Implementation of NSZs

Environment	Crop	'Present' NSZ	'With' all NSZ
'Near' Bank	OSR	3.3	87.4
	SB	0.6	87.4
	WW	27.5	87.4
	Weighted Average	**25.5**	**87.4**
'Far' Bank	OSR	2.7	71.7
	SB	0.5	71.7
	WW	22.5	71.7
	Weighted Average	**20.9**	**71.7**
'Water' (Aquatic Hazard Potential)	OSR	2.2	78.8
	SB	1.0	78.8
	WW	27.2	78.8
	Weighted Average	**24.9**	**78.8**

Notes: Where all NSZs measured as 6m from the crop edge, equivalent to 8m from the water's edge

4.2.3 Changes in the Level of Ecological Disturbance

As described in Section 3.2.5, an attempt has been made to provide some context to the changes in risk levels described above. This has been achieved by the use of bioassay mortality/distance relationships to provide some estimate of levels and frequencies of invertebrate and seedling mortality under each of the three NSZ scenarios.

Table 4.5 provides estimates of the % mortality of invertebrate populations for each application of insecticide under the different NSZ scenarios. These estimates are given for populations residing on both 'near' and 'far' banks and the water surface itself. For example, in a situation where no NSZs are in existence, there is a predicted average invertebrate mortality of 96% on the 'near' bank for each application of insecticides. Under the 'present' situation, this is reduced to 52% mortality. In addition, the average frequency of such losses is estimated at 1.1 times a year (based on BAA [1996] data on the average number of hectares treated for each crop). Placing NSZ restrictions on all insecticide applications is likely to reduce invertebrate mortality to 18% on the 'near' bank.

As can be seen from Table 4.5, only under the 'present' situation is there any variation between mortality data for each crop. This variation reflects the proportion of chemicals used on each crop that are covered by NSZ restrictions (and hence the number of insecticide applications that take place 6m from the edge of the crop). Invertebrate mortality is greatest (and most frequent) on SB under the present NSZ restrictions.

Table 4.5 % Mortality of Invertebrates (% per Application)

Environment	Crop	'Without' NSZ	'Present' NSZ	'With' all NSZ	Frequency (per Year)
'Near' Bank	OSR	96	57	18	1.3
	SB	"	79	"	1.5
	WW	"	49	"	1.0
	Weighted Average	**96**	**52**	**18**	**1.1**
'Far' Bank	OSR	80	44	7	1.3
	SB	"	64	"	1.5
	WW	"	36	"	1.0
	Weighted Average	**80**	**39**	**7**	**1.1**
'Water' Surface	OSR	88	49	11	1.3
	SB	"	71	"	1.5
	WW	"	42	"	1.0
	Weighted Average	**88**	**44**	**11**	**1.1**

Notes: Where all NSZs measured as 6m from the crop edge, equivalent to 8m from the water's edge

Table 4.6 shows similar information on seedling mortality. Information on emergent and floating vegetation is included as a guide of relative effects rather than actual effects.

In terms of levels of ecological disturbance, seedling mortalities give an indication of the influence of herbicide spray drift and deposition on the age structure of plant communities under each of the three NSZ scenarios. Given the variation in susceptibility of different plants to herbicides (and the selective nature of herbicides used on most crops), in a situation where no NSZs are in existence, it is likely that herbicide spray drift and deposition is a very significant ecological factor, determining both community age structure and community type. Mortality of susceptible species here is around 65% on the 'near' bank with a frequency of 2.6 times a year.

The level of disturbance to (primary) plant communities is nearly halved by the introduction of the present restrictions on NSZ and is halved again by the introduction of 6m NSZ to all herbicides.

In terms of disturbance to invertebrate communities, a similar relationship is found by the introduction of each of the NSZ scenarios.

Table 4.6 % Mortality of Seedlings (% per Application)

Environment	Crop	'Without' NSZ	'Present' NSZ	'With' all NSZ	Frequency (per Year)
'Near' Bank	OSR	65	42	18	1.6
	SB	"	55	"	5.7
	WW	"	37	"	2.5
	Weighted Average	**65**	**38**	**18**	**2.6**
'Far' Bank	OSR	42	27	11	1.6
	SB	"	36	"	5.7
	WW	"	24	"	2.5
	Weighted Average	**42**	**25**	**11**	**2.6**
Emergent and Floating Vegetation	OSR	53	33	14	1.6
	SB	"	44	"	5.7
	WW	"	30	"	2.5
	Weighted Average	**53**	**31**	**14**	**2.6**

Notes: Where all NSZs measured as 6m from the crop edge, equivalent to 8m from the water's edge

4.3 Effectiveness of No-Spray Zone Restrictions

4.3.1 Introduction

In addition to providing an assessment of changes in private costs, risk levels and ecological disturbance, it has been possible to conduct an assessment of how risk levels and private costs change with the size of no spray zone. The results of this analysis are described below.

4.3.2 Determining the Optimum Size of a NSZ

Figure 4.1 shows the relationship between the width of NSZ and the reduction in aquatic risks achieved under both the 'present' scenario (where NSZ are attached to specific pesticides) and a situation where all pesticides have a NSZ attached. As such, the larger the % reduction in risk, the greater the effectiveness of the NSZ provisions for each zone width. It should be noted that, as for the rest of the analysis, the NSZ is measured from the edge of the crop. As such, a NSZ of 2m in Figure 4.1 reflects a distance of 4m between spray application and water's edge and a NSZ of 20m reflects a distance of 22m from the water's edge.

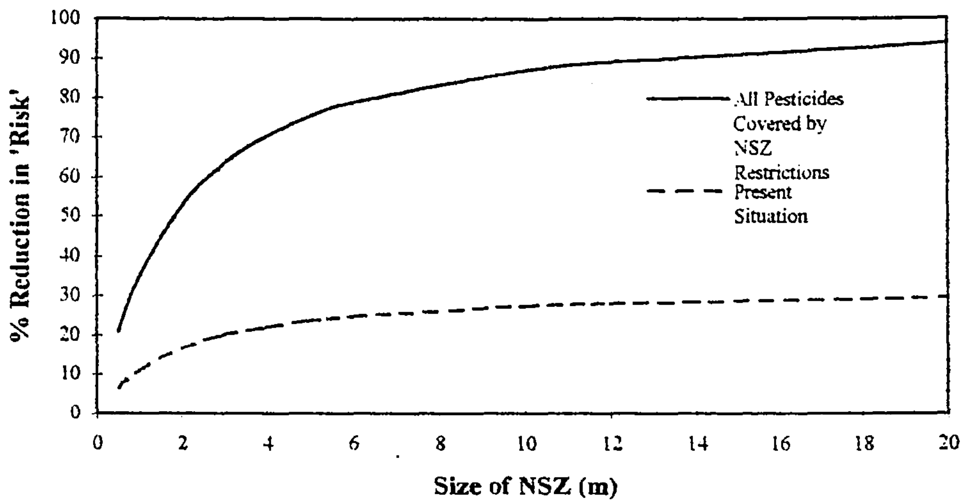

Figure 4.1: % Reduction in Environmental Risks by Increasing NSZ

As can be seen from this graph, even with a small zone, NSZ provisions on all pesticides provide an effective means of reducing environmental risks. Indeed, the data suggest that a 50% reduction in risk is achieved by a zone width of around 2m (4m separation between application and water's edge) and a 70% reduction is achieved at around 4m (6m from water's edge). Increasing the size of zone from 4m (6m from water's edge) up to the (current) width of 6m (8m from waters edge) only achieves a further 10% decrease in environmental risks.

In terms of the current restrictions, the reduction in risks achieved by increasing the size of zone is fairly poor. Indeed, at the current width of 6m (8m from water's edge), the data suggest that the same overall level of risk reduction could be achieved with a smaller zone of around 1m (3m from waters edge) if all pesticides are covered by NSZ restrictions.

A 50% reduction in environmental risks is not possible under the current restrictions, regardless of the size of NSZ. The data suggest that the only means by which current restrictions could achieve a 50% reduction in environmental risk with a 6m NSZ would be by significantly increasing the number of pesticides that are covered by a 6m restriction.

Figure 4.2 builds on Figure 4.1 and shows the relationship between width of zone to crop edge and both the overall level of risk reduction achieved and the national costs to farmers associated with placing NSZ restrictions on all pesticides (ignoring CSS payments and assuming that farmer's remove the land from production).

As can be seen from Figure 4.2, the costs associated with a 50% reduction in environmental risk from pesticide spray drift are around £17m per year in the absence of CSS payments (this being achieved by the use of a 2m NSZ on all pesticides, i.e. a distance of 4m from the water's edge). Reducing risks by a further 20% (providing an overall reduction of 70%) would double the costs to the farmer.

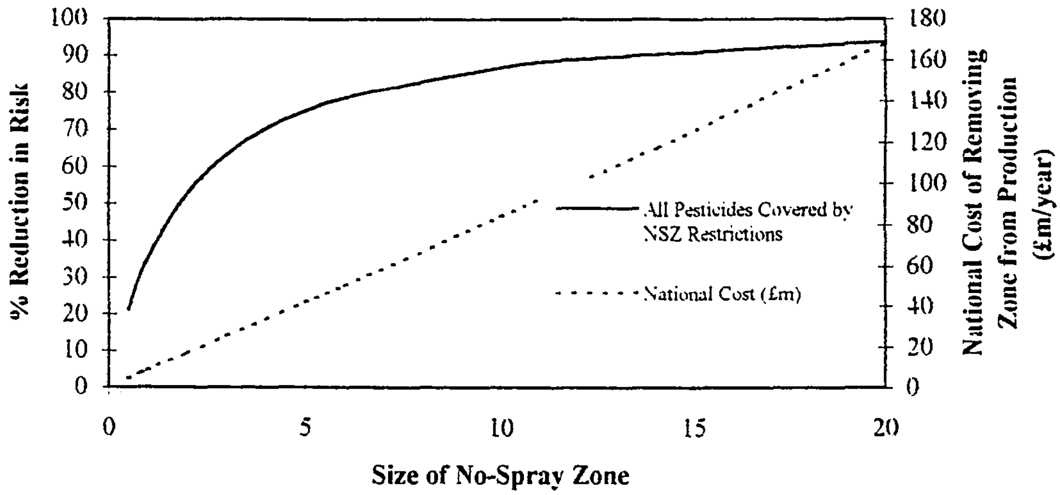

Figure 4.2: % Reduction in Environmental Risks and National Costs of Removing NSZs from Production with Increasing Size of Zone

The relationship between costs and level of risk reduction is plotted graphically in Figure 4.3. As can be seen from this graph, costs per unit risk reduction begin to increase fairly rapidly after an 80% reduction in risks, suggesting that this could be taken as an optimum (or maximum) level of expenditure for a risk reduction strategy. This risk reduction strategy is equivalent to the placing of 5.5-6m NSZ restrictions on all pesticides[4], where costs are calculated on the basis that the farmer's response to these restrictions is to remove the zones from production in all cases. As discussed earlier, it is unlikely that all farmers will remove crops from production within NSZs. Consequently, this is still likely to be an optimum but the costs will be lower.

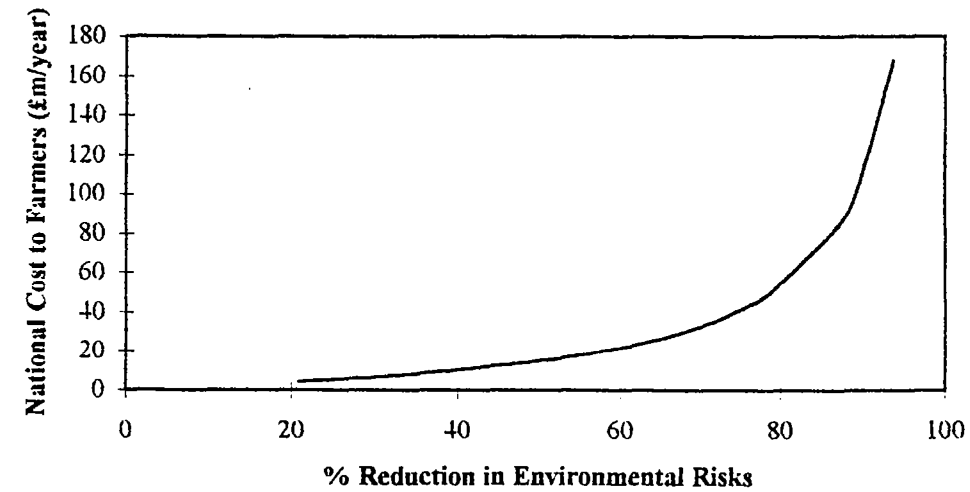

Figure 4.3: Cost per Unit Risk Reduction

[4] Providing a separation between application and water's edge of 7.5-8m.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Private Costs to Farmers Associated with No-Spray Zone Restrictions

It is estimated that, if farmers were to remove all 6m no-spray zones (NSZ) from production, the net national cost would be around £50m per year. However, under the current restrictions it is unlikely that all farmers would respond by removing all crops from production within these zones. As such, it is estimated that current restrictions cost farmers a maximum of around £15m per year (assuming that NSZs are used only for the production of cereals but all other enterprises are removed from production within these areas).

In addition, in a situation where all crops are removed from production and all farmers receive Countryside Stewardship Scheme (CSS) grants as compensation, there would be a net national private benefit to farmers of around £20m per year. This benefit is comprised of a £24m per year benefit on all combinable crops but a cost of around £4m per year on potatoes and sugar beet. It should be noted that, under this scenario, the Exchequer would incur costs of around £50m per year in the operation of agri-environment schemes providing farmers with full compensation.

On a crop specific basis, the effects of removing production within NSZs are felt most on sugar beet, with a reduction in annual farm income of around £38.22 per hectare currently grown. Potatoes are also adversely effected with an expected reduction of £21.67 per hectare per year, whilst losses in farm income to combinable crops are around half this cost.

5.1.2 The Level of Risk Reduction Achieved through No-Spray Zone Restrictions

Risk Changes

Overall terrestrial and aquatic risks are reduced by around 25% under the current restrictions (where these changes are relative to the situation where no NSZs are in existence). This compares with a predicted reduction of around 80% under a situation where all pesticides are covered by a 6m NSZ restriction (thus applications take place 8m from water's edge). As such, placing 6m NSZs on all pesticides would be three times more effective at reducing environmental risks than the current restrictions.

It should be noted that these % reductions in risk apply to an overall average level of risk. As such, they do not take account of specific sites and situations where, for example, all of the pesticides selected for use by a particular farmer are covered by NSZ limitations. In this (albeit unlikely) situation, the current restrictions will obviously perform as well as 6m restrictions on all pesticides. Comments of the Draft Final Report have highlighted this point as a criticism of the 'overall risk' approach. However, the same logic applies to the reverse (and perhaps more likely) situation where a farmer preferentially selects pesticides that are not subject to NSZs. In this situation the current restrictions will fail completely to reduce environmental risks on a given stretch of watercourse. However, this criticism of the approach taken in the analysis does add weight to the idea of developing a classification-based system whereby NSZ restrictions apply to watercourses of a particular type, quality or geographical area.

Ecological Disturbance

In terms of invertebrate mortality, it is estimated that, under a situation where no NSZs exist, mortality levels of (at worst) 96%, 80% and 88% would be experienced on the 'near bank', 'far' bank and water surfaces respectively each time an insecticide was applied. As such, under such circumstances pesticide spray drift and deposition is a significant factor influencing the population dynamics of invertebrate communities. The present restrictions reduce mortality by around 50% on average. However, extending 6m NSZ restrictions to cover all pesticides reduces mortality by between 80% and 90% depending on proximity of the environment to the spraying operation.

Seedling mortality predictions have been made to examine the effects of herbicide NSZ restrictions on levels of disturbance to plant communities. In the absence of NSZs, it is estimated that expected mortality is (at worst) around 65% on the 'near' bank for every application (on average 2.6 applications per year). This indicates that under such circumstances herbicide drift is an important factor governing both the age structure and the species composition of vegetation adjacent to spraying activities. Present NSZ restrictions reduce this expected mortality to 38% while extension of NSZs to cover all herbicides reduces mortality to 18%.

5.1.3 The Cost Effectiveness of No-Spray Zone Restrictions

A 50% reduction in environmental risks is not possible under the current restrictions, regardless of the size of NSZ. The data suggests that the only means by which current restrictions could effect an overall 50% reduction in environmental risk with a 6m NSZ would be by significantly increasing the number of pesticides that are covered by a 6m restriction. Under a situation where all pesticides were covered by NSZ restrictions, data suggest that a 50% reduction in risk would be achieved by a zone width of around 2m (4m from water's edge). Increasing zone width to 4m (6m from water's edge) would effect a 70% reduction.

The analysis presented in this report suggests that the overall level of aquatic risk reduction that is achieved under the present restrictions could be accomplished by placing a 1m NSZ restriction on all pesticides (where this has the effect of separating applications and water's edge by a distance of 3m). However, it should be noted such estimates are dependant on the accuracy of modelled/measured drift deposition rates which, as noted in the Interim Report, may underestimate the degree of drift and deposition of pesticides from tractor mounted sprayers.

With respect to a situation where all pesticides are covered by NSZ restrictions, the relationship between farmers' costs and level of risk reduction suggests that an 80% reduction in risks provides an optimum (or maximum) level of investment. This is equivalent to a zone width of around 5.5-6m on all pesticides, with a net national cost of around £50m per year (ignoring CSS payments).

5.2 Recommendations

Given the above discussion, the following recommendations are made:

NSZ restrictions next to watercourses should be extended to cover all pesticides and the width of zone should reflect the level of risk reduction that is a) desirable; and b) cost-effective in terms of farmers' investment.

In order to reduce the costs to farmers associated with NSZ provisions, consideration should be given to an alteration in the current Arable Area Payment Rules to allow farmers to re-distribute setaside land to within field margins and NSZs. This would allow the operation of NSZs without significant costs to the farmer[5].

Consideration should be given to a scheme aimed at classifying those watercourses which would benefit most from a 'blanket' NSZ either in terms of the nature/quality of the watercourse or their geographical area.

The interim report for this study highlighted a possible anomaly between predicted and actual effects of drift and deposition. In light of the possible underestimation by modelled deposition, further research should be undertaken to identify more reliable estimates of drift/deposition and its effects with distance. If possible, this should feed into decisions regarding the size of NSZs required to provide an adequate level of protection to both terrestrial and aquatic habitats.

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5 It should be noted that current Arable Area Payment rules stipulate a minimum width of 20m for setaside to allow the operation of a satellite 'policing' system. As such, MAFF's application to the EC to reduce this minium width has already been rejected on this basis. However, a general prohibition on crop husbandry within a certain distance from watercourses would be relatively easy to 'police' separately under the setaside rules.

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CONSULTEES

Specific to this Study

Agrevo
English Nature
Environment Agency, Anglian Region
Environment Agency, Southwest Region
Environment Agency, Thames Region
Farming and Wildlife Advisory Group (FWAG)
National Farmers Union (NFU)
Pesticide Safety Directorate
Professor RH Marrs, Ness Botanical Gardens, Liverpool University
MAFF, Cereals and Setaside Division
MAFF, Anglian Region

As part of DoE Contract: EPG 1/8/30 - Private Costs and Benefits of Pesticide Minimisation

Agricultural Engineers Association
British Agrochemicals Association (BAA)
British Crop Protection Council
British Retail Consortium
British Society of Plant Breeders
C & G Wilmots
Co-operative Wholesale Society
Country Landowners Association
English Nature
Environment Agency
Farmers Link
Farming and Wildlife Advisory Group (FWAG)
Focus on Farming Practice (FoFP)
Game Conservancy Trust
Henry Doubleday Institute
Institute of Grassland and Environmental Research (IGER)
Koppert Biological Systems
Linking Environment And Farming (LEAF)
Less Intensive Farming and the Environment Project (LIFE - IACR)
MAFF Economics Division
MAFF Environmental Protection Division
MAFF LINK/IACR
National Farmers Union (NFU)
Pesticide Safety Directorate
Pesticides Trust
Rhône Poulenc
Soil Association
UK Agricultural Supply Trade Association
University of Aberystwyth
University of Southampton Department of Agricultural Economics
Women's Farming Union
World Wide Fund for Nature (WWF)
Wye College

Appendix A: Davis, BK *et al* (1993): *Insecticide Drift from Ground-Based Hydraulic Spraying of Peas and Brussels Sprouts: Bioassays for Determining Buffer Zones*, Agric. Ecosyst. Environ, Vol 43, 2, pp93-108.

Davis *et al* (1993) used a bioassay methodology to establish the size of buffer zone that would be required to protect invertebrates outside the sprayed crop. 'Target' lepidoptera larvae (*P.brassicae*) were set out in replicates perpendicular to the downwind field edge at a number of distances up to 25m. Six sites were assessed and details such as windspeed and direction, height of vegetation, crop type, spray pressure, etc. were measured. After treatment, mortality was assessed over a period of three days.

At the same time, deposition of each of the insecticides was measured using paper collection analysed by image processing. Cypermethrin deposition was measured using aluminium mesh cylinders and a gas liquid chromatograph.

The results varied by site and pesticide used. In the case of Cypermethrin, using a standard application rate of 25 g active ingredient/ha, the following ranges in distances to 50%, 20% and 10% mortality were found:

50% mortality at between <1 and 14m
20% mortality at between 7.3(±1.2) and 21.6m
10% mortality at between 18.6 and 24m

A relationship was fitted to percentage mortality (P) and distance (d) for Cypermethrin:

$$P = 107-73/[1 + \exp(0.618d-3.034)]$$

The calculation of a similar curve for Triazophos(with Dimethoate) gave a move 'convex' curve over the first 10m with the relationship between P and d being:

$$P = 101.95/[1 + \exp(0.582d-4.759)]$$

The authors note that mortality at the edge of the current 6m no-spray zone would be of the order of 24-75% depending on conditions but that drift over a crop would be less than over an uncropped area.

Appendix B: Marrs RH *et al* (1993): *Determination of Buffer Zones to Protect Seedlings of Non-target Plants from the Effects of Glyphosate Spray Drift*, <u>Agric. Ecosyst. Environ.</u>, Vol 45, 3-4, pp283-293.

Marrs *et al* note that the impact of lower doses of herbicides encountered from spray drift has received relatively little attention. In this study, Marrs *et al* examined the effects of spray drift on seedlings of *L. flos-cuculi* and a mixture of 15 species of plant in trays positioned at various distances from a 2 bar tractor mounted sprayer applying Glyphosate at the rate of 2.2 kg ai/ha.

After exposure, seedling health was monitored and classified into healthy or dead. Where appropriate, regression models were fitted to give equations of mortality with distance for *L. flos-cuculi*. Results varied between experiments, the first experiment showing a large percentage of seedlings damaged or destroyed within the first 10m with 30% mortality at the 10m point. In the second experiment, mortality declined rapidly to 10% over the first 10m and after 20m declined to levels equivalent to controls. Experiment 3 showed similar results. The relationship between distance (d) and % mortality (P) for the second experiment can be summarised as:

$$P = 0.64 + 5227/1 + \exp(0.22(d + 18.38))$$

With the multi-species experiments, the responses varied by species. The shortest distance to P=50 was between 0 and 5m and the greatest distance being 15-20m with detectable mortality up to 40m away. Response curves for all species indicated that there was little mortality after 20m.

Marrs *et al* reports that, in contrast to seedlings, no significant effects on a range of performance indicators have been established beyond 8m for established perennial plants. This difference may be explained in terms of both efficiency of interception of drift by, and the increased susceptibility of, seedlings.

The difference in results between each of the three experiments was concluded to have been because of very subtle differences in conditions influencing drift interception, fallout and vegetational 'eddies'.

The authors report that the original estimates for the size of no-spray zone to protect vegetation from herbicides were 6-10m based on studies of perennials. In light of the regeneration effects of herbicides with distance, an increase of this zone to 20m seems appropriate adjacent to communities where seedling regeneration is of great importance and 6-10m where such regeneration is not so important to community structure.

ANNEX 1

PESTICIDE PRODUCTS AND ACTIVE INGREDIENTS

SUBJECT TO NO-SPRAY ZONE RESTRICTIONS

List of Products Which Have One Or More on-Label Approvals Which Are Subject to the 'Buffer Zone' Restriction for the Use of Certain Pesticides Near Surface Waters (As At 11 September 1996)						
	Product Name	**Act. Ingredient A**	**Act. Ingredient B**	**Act. Ingredient C**		Type
			FUNGICIDES			
149	Fisons Turfclear	Carbendazim				F
150	Fisons Turfclear WDG	Carbendazim				F
68	Bravocarb	Carbendazim	Chlorotholanil			F
160	Greenshield	Carbendazim	Chlorotholanil			F
161	Greenshield	Carbendazim	Chlorotholanil			F
245	Retro	Carbendazim	Chlorotholanil			F
34	Ashlade Mancarb Plus	Carbendazim	Chlorotholanil	Maneb		F
312	Tripart Victor	Carbendazim	Chlorotholanil	Maneb		F
49	Barclay Corrib	Chlorotholanil				F
50	Barclay Corrib 500	Chlorotholanil				F
56	Baton SC	Chlorotholanil				F
57	Baton WG	Chlorotholanil				F
60	BB Chlorotholanil	Chlorotholanil				F
63	Bombadier	Chlorotholanil				F
64	Bombadier FL	Chlorotholanil				F
65	Bravo 500	Chlorotholanil				F
66	Bravo 500	Chlorotholanil				F
67	Bravo 720	Chlorotholanil				F
78	Chiltern Chlorotholanil 500	Chlorotholanil				F
83	Clayton Turret	Chlorotholanil				F
84	Clortosip	Chlorotholanil				F
94	Contact 75	Chlorotholanil				F
106	Daconil Turf	Chlorotholanil				F
107	Daconil Turf	Chlorotholanil				F
108	Daconil Turf	Chlorotholanil				F
129	Duomo	Chlorotholanil				F
177	ISK 375	Chlorotholanil				F
181	Jupital	Chlorotholanil				F
184	Landgold Chorotholanil 50	Chlorotholanil				F
185	Landgold Chorotholanil FL	Chlorotholanil				F
202	Mainstay	Chlorotholanil				F
211	Miros DF	Chlorotholanil				F
242	Repulse	Chlorotholanil				F
243	Repulse	Chlorotholanil				F
244	Repulse	Chlorotholanil				F
250	Rover DF	Chlorotholanil				F
267	Sipcam UK Rover 500	Chlorotholanil				F
275	Standon Chlorotholanil 50	Chlorotholanil				F
305	Top Farm Chlorotholanil 500	Chlorotholanil				F
310	Tripart Faber	Chlorotholanil				F
311	Tripart Faber	Chlorotholanil				F
314	Ultrafaber	Chlorotholanil				F
31	Ashlade Cyclops	Chlorotholanil	Cymoxanil			F
99	Cyclops	Chlorotholanil	Cymoxanil			F
126	DUK 44	Chlorotholanil	Cymoxanil			F
162	Guardian	Chlorotholanil	Cymoxanil			F
163	Guardian	Chlorotholanil	Cymoxanil			F
23	Alto Elite	Chlorotholanil	Cyproconazole			F
222	Octolan	Chlorotholanil	Cyproconazole			F
255	SAN 703	Chlorotholanil	Cypropiconazole			F
52	BAS 438	Chlorotholanil	Fenpropimorph			F
96	Corbel CL	Chlorotholanil	Fenpropimorph			F
167	Halo 300	Chlorotholanil	Flurtriafol			F
171	Impact Excel	Chlorotholanil	Flurtriafol			F

172	Impact Excel	Chlorotholanil	Flurtriafol			F
173	Impact Excel 375	Chlorotholanil	Flurtriafol			F
165	Halo	Chlorotholanil	Flutriafol			F
166	Halo	Chlorotholanil	Flutriafol			F
233	PP 375	Chlorotholanil	Flutriafol			F
237	PROSPA	Chlorotholanil	Flutriafol			F
121	Dreadnought Flo	Chlorotholanil	Mancozeb			F
122	Dreadnought Flo	Chlorotholanil	Mancozeb			F
268	SIPCM Flo	Chlorotholanil	Mancozeb			F
151	Folio 575 SC	Chlorotholanil	Metalaxyl			F
210	Merlin	Chlorotholanil	Propamocarb hydrochloride			F
296	Tatoo C	Chlorotholanil	Propamocarb hydrochloride			F
253	Sambarin 312.5 SC	Chlorotholanil	Propiconazole			F
254	Sambarin TP	Chlorotholanil	Propiconazole			F
6	Adagio	Chlorthalonil	Mancozeb			F
213	Moot	Cyproconazole	Tridemorph			F
256	SAN 735	Cyproconazole	Tridemorph			F
231	Plover	Difenoconazole				F
4	Acrobat	Dimethomorph				F
5	Acrobat MZ	Dimethomorph	Mancozeb			F
175	Invader	Dimethomorph	Mancozeb			F
258	Saracen	Dimethomorph	Mancozeb			F
182	Karathane Liquid	Dinocap				F
183	Karathane WP	Dinocap				F
81	Clayton Epoxicon	Epoxyconazole				F
141	Epic	Epoxyconazole				F
134	Eclipse	Epoxyconazole	Fenpropimorph			F
140	Ensign	Epoxyconazole	Tridemorph			F
224	Opus	Epoyconazole				F
226	Opus Team	Epoyconazole	Fenpropimorph			F
225	Opus Plus	Epoyconazole	Tridemorph			F
77	Cherokee 318.EC	Fenbuconazole	Fenpropimorph			F
174	Indar Must	Fenbuconazole	Fenpropimorph			F
220	Myriad	Fenbuconazole	Fenpropimorph			F
203	Mallard	Fenpropidin				F
204	Mallard 750 EC	Fenpropidin				F
227	Patrol	Fenpropidin				F
228	Patrol	Fenpropidin				F
301	Tern	Fenpropidin				F
302	Tern 750 EC	Fenpropidin				F
9	Agrys	Fenpropidin	Fenpropimorph			F
251	SA 722	Fenpropidin	Prochloraz			F
269	SL 501	Fenpropidin	Prochloraz			F
270	SL 522A	Fenpropidin	Prochloraz			F
273	Sponsor	Fenpropidin	Prochloraz			F
192	Legend	Fenpropidin	Propiconazole			F
223	Opal	Fenpropidin	Propiconazole			F
236	Prophet 500C	Fenpropidin	Propiconazole			F
261	Sheen	Fenpropidin	Propiconazole			F
326	Zulu	Fenpropidin	Propiconazole			F
212	Monicle	Fenpropidin	Tebuconazole			F
271	SL 556 500 EC	Fenpropidin	Tebuconazole			F
148	FD 4058	Fluazinam				F
153	Frowncide	Fluazinam				F
187	Langold Fluazinam	Fluazinam				F
191	Legacy	Fluazinam				F

252	Salvo	Fluazinam				F
262	Shirlan	Fluazinam				F
306	Top farm Fluazinam	Fluazinam				F
86	Cogito	Propiconazole	Tebuconazole			F
139	Endeavour	Propiconazole	Tebuconazole			F
54	Basilex	Tolclofos-methyl				F
55	Basilex Soluble Sachets	Tolclofos-methyl				F
247	Rizolex 50 WP	Tolclofos-methyl				F
248	Rizolex 50 WP in Soluble Sachets	Tolclofos-methyl				F
138	Elvaron M	Tolyfluanid				F

HERBICIDES						
21	Alpha Simazol	Amitrole	Simazine			H
22	Alpha Simazol T	Amitrole	Simazine			H
13	Alpha Atrazine 50 SC	Atrazine				H
14	Alpha Atrazine 50 WP	Atrazine				H
36	Atlas Atrazine	Atrazine				H
37	Atlas Atrazine	Atrazine				H
45	Atrazol	Atrazine				H
109	Dapt Atrazine 50 SC	Atrazine				H
157	Gesprim 500 SC	Atrazine				H
214	MSS Atrazine 50 FL	Atrazine				H
215	MSS Atrazine 80 WP	Atrazine				H
315	Unicrop Atrazine 50	Atrazine				H
316	Unicrop Atrazine FFL	Atrazine				H
317	Unicrop Flowable Atrazine	Atrazine				H
318	Unicrop Flowable Atrazine	Atrazine				H
40	Atlas Minerva	Bromoxynil	Dichloroprop	Ionycil + MCPA		H
72	Capture	Bromoxynil	Diflufenican	Ionycil		H
264	Sickle	Bromoxynil	Fluoroxypyr			H
15	Alpha Briotrol Plus 19/19	Bromoxynil	Ioxynil			H
116	Deloxil	Bromoxynil	Ioxynil			H
117	Deloxil	Bromoxynil	Ioxynil			H
118	Deloxil	Bromoxynil	Ioxynil			H
285	Stellox 380 EC	Bromoxynil	Ioxynil			H
286	Stellox 60WG	Bromoxynil	Ioxynil			H
292	Swipe 560 EC	Bromoxynil	Ioxynil	Mecoprop		H
293	Swipe P	Bromoxynil	Ioxynil	Mecoprop-P		H
297	Teal	Bromoxynil	Ioxynil	Triasulfuron		H
298	Teal G	Bromoxynil	Ioxynil	Triasulfuron		H
299	Teal M	Bromoxynil	Ioxynil	Triasulfuron		H
235	Profalon	Chloropropham	Linuron			H
1	Accord	Dicamba	Triasulfuron			H
2	Accord	Dicamba	Triasulfuron			H
47	Banvel T	Dicamba	Triasulfuron			H
152	Framolene	Dicamba	Triasulfuron			H
272	Soltair	Diquat	Paraquat	Simazine		H
287	Stexal	Fluoroxypyr	Ioxynil			H
136	EF 1166	Fluoroxypyr	Metosulam			H
87	Complete 20	Fluroglycofen-ethyl				H
88	Colpete 5	Fluroglycofen-ethyl				H
89	Complete Forte	Fluroglycofen-ethyl	Isoproturon			H
92	Competitor	Fluroglycofen-ethyl	Isoproturon			H
93	Competitor	Fluroglycofen-ethyl	Isoproturon			H
137	Effect	Fluroglycofen-ethyl	Isoproturon			H
90	Complete Mix 20 PVA	Fluroglycofen-ethyl	Mecoprop-P			H
142	Estrad	Fluroglycofen-ethyl	Mecoprop-P			H
143	Estrad Duplo	Fluroglycofen-ethyl	Mecoprop-P			H
91	Complete Mix A	Fluroglycofen-ethyl	Triasulfuron			H
259	Satis 15 WP	Fluroglycofen-ethyl	Triasulfuron			H
120	DP 353	Fluroxypyr	Thifensulfuron-methyl	Tribenuron-methyl		H
280	Starane Super	Fluroxypyr	Thifensulfuron-methyl	Tribenuron-methyl		H
27	Arsenal	Imazapyr				H
28	Arsenal	Imazapyr				H
29	Arsenal 50	Imazapyr				H
30	Arsenal 50	Imazapyr				H
168	Harlequin 500 SC	Isoproturon	Simazine			H

234	Premiere Granuales	Isoxaben	Trifluralin			H
190	Lanslide	Lenacil	Linuron			H
7	Afalon	Linuron				H
8	Afalon EC	Linuron				H
16	Alpha Linuron 50 SC	Linuron				H
17	Alpha Linuron 50 WP	Linuron				H
33	Ashlade Linuron FL	Linuron				H
38	Atlas Linuron	Linuron				H
39	Atlas Linuron	Linuron				H
110	Dapt Linuron 50 SC	Linuron				H
195	Linurex 50 SC	Linuron				H
196	Linuron Flowable	Linuron				H
216	MSS Linuron 50	Linuron				H
217	MSS Mirlin	Linuron				H
249	Rotalin	Linuron				H
284	Stefes Linuron	Linuron				H
323	UPL Linuron 45% Flowable	Linuron				H
10	Alistell	Linuron	2,4-DB	MCPA		H
85	Clovacorn Extra	Linuron	2,4-DB	MCPA		H
300	Tempo	Linuron	Terbutryn			H
69	Bronox	Linuron	Trietazine			H
176	Ipicombi TL	Linuron	Trifluralin			H
313	Triplen Combi	Linuron	Trifluralin			H
71	Campbell's Trifluron	Linuron	Trifuralin			H
75	Chandor	Linuron	Trifuralin			H
194	Linnet	Linuron	Trifuralin			H
221	Neminfest	Linuron	Trifuralin			H
309	Trifluron	Linuron	Trifuralin			H
123	Duet	Mecoprop-P	Thifensulfuron-methyl			H
240	Raven	Mecoprop-P	Triasulfuron			H
135	EF 1077	Metosulam				H
11	Ally	Metsulfuron-methyl				H
12	Ally WSB	Metsulfuron-methyl				H
82	Clayton Metsulphuron	Metsulfuron-methyl				H
178	Jubilee	Metsulfuron-methyl				H
179	Jubilee 20 DF	Metsulfuron-methyl				H
180	Jubilee 20 DF	Metsulfuron-methyl				H
189	Landgold Metsulfuron	Metsulfuron-methyl				H
198	Lorate 20DF	Metsulfuron-methyl				H
279	Standon Metsulfuron	Metsulfuron-methyl				H
169	Harmony M	Metsulfuron-methyl	Thifensulfuron-methyl			H
119	Deuce	Pendimethalin	Simazine			H
209	Merit	Pendimethalin	Simazine			H
145	Falcon	Propaquizafop				H
263	Shogun 100 EC	Propaquizafop				H
18	Alpha Simazine 50 SC	Simazine				H
19	Alpha Simazine 50 WP	Simazine				H
20	Alpha Simazine 80 WP	Simazine				H
35	Ashlade Simazine 50 FL	Simazine				H
41	Atlas Simazine	Simazine				H
42	Atlas Simazine	Simazine				H
158	Gesatop 50 WP	Simazine				H
159	Gesatop 500 SC	Simazine				H
218	MSS Simazine 50 FL	Simazine				H
265	Simazine SC	Simazine				H
266	Sipcam Simazine Flowable	Simazine				H

319	Unicrop FlowableSimazine	Simazine				H
320	Unicrop FlowableSimazine	Simazine				H
321	Unicrop Simazine 50	Simazine				H
322	Unicrop Simazine FL	Simazine				H
325	Weedex S 2 FG	Simazine				H
46	Aventox SC	Simazine	Trietazine			H
241	Remtel SC	Simazine	Trietazine			H
97	Crackshot	Thifensulfuron-methyl				H
98	Crackshot	Thifensulfuron-methyl				H
125	DUK 118	Thifensulfuron-methyl				H
238	Prospect	Thifensulfuron-methyl				H
70	Calibre	Thifensulfuron-methyl	Tribenuron-methyl			H
124	DUK 110	Thifensulfuron-methyl	Tribenuron-methyl			H
197	Lo-Gran 20 WG	Triasulfuron				H
111	Debut	Triflusulfuron-methyl				H
112	Debut WSB	Triflusulfuron-methyl				H
127	DUK 440	Triflusulfuron-methyl				H
128	DUK 550	Triflusulfuron-methyl				H

INSECTICIDES						
3	Acquit	Alphacypermethrin				I
26	Apex	Alphacypermethrin				I
79	Clayton Alpha-Cyper	Alphacypermethrin				I
95	Contest	Alphacypermethrin				I
146	Fastac	Alphacypermethrin				I
147	Fastac	Alphacypermethrin				I
281	Stefes Alphacypermethrin	Alphacypermethrin				I
294	Talstar	Bifenthrin				I/A
295	Talstar	Bifenthrin				I/A
61	Birlane 24	Chlorfenvinphos				I
62	Birlane 24	Chlorfenvinphos				I
257	Sapecron 240 EC	Chlorfenvinphos				I
48	Barclay Clinch	Chlorpyyrifos				I/A
130	Dursban 4	Chlorpyyrifos				I/A
131	Dursban 4	Chlorpyyrifos				I/A
199	Lorsban T	Chlorpyyrifos				I/A
200	Lorsban T	Chlorpyyrifos				I/A
274	Standon Chlorpyriphos	Chlorpyyrifos				I/A
59	Baythroid	Cyfluthrin				I
24	Ambush C	Cypermethrin				I
25	Ambush C	Cypermethrin				I
32	Ashlade Cypermethrin 10 EC	Cypermethrin				I
51	Barclay Cypersect XL	Cypermethrin				I
76	Chemtech Cypermethrin 10 EC	Cypermethrin				I
80	Clayton Cyperten	Cypermethrin				I
100	Cymbush	Cypermethrin				I
101	Cymbush	Cypermethrin				I
102	Cyperkill 10	Cypermethrin				I
103	Cyperkill 25	Cypermethrin				I
104	Cyperkill 5	Cypermethrin				I
105	Cypertox	Cypermethrin				I
201	Luxan Cypermethrin	Cypermethrin				I
229	Permasect C	Cypermethrin				I
239	Quadrange Cyper 10	Cypermethrin				I
246	Ripcord	Cypermethrin				I
276	Standon Cypermethrin	Cypermethrin				I
282	Stefes Cypermethrin	Cypermethrin				I
283	Stefes Cypermethrin 2	Cypermethrin				I
307	Toppel 10	Cypermethrin				I
308	Toppel 10	Cypermethrin				I
324	Vassgro Cypermethrin Insecticide	Cypermethrin				I
113	Decis	Deltamethrin				I
114	Decis	Deltamethrin				I
186	Landgold Deltaland	Deltamethrin				I
277	Standon Deltamethrin	Deltamethrin				I
115	Decisquick	Deltamethrin	Heptenophos			I
144	Evidence	Deltamethrin	Pirimicarb			I
288	Sumi-Alpha	Esfenvalerate				I
289	Sumi-Alpha	Esfenvalerate				I
207	Meothrin	Fenpropathrin				I/A
208	Meothrin	Fenpropathrin				I/A
290	Sumicidin	Fenvalerate				I
291	Sumicidin	Fenvalerate				I
164	Hallmark	Lamda cylohathrin				I
170	Hero	Lamda cylohathrin				I
188	Langold Lamda-C	Lamda cylohathrin				I
232	PP 321	Lamda cylohathrin				I

278	Standon Lamda-C	Lamda cylohathrin				I
43	Atlas Steward	Lindane				I
44	Atlas Steward	Lindane				I
154	Gamma-Col Turf	Lindane				I
155	Gamma-Col Turf	Lindane				I
156	Gamma-Col Turf	Lindane				I
193	Lindane Flowable	Lindane				I
73	Castaway Plus	Lindane	Thiophanate-methyl			I/LUM
74	CDA Castaway Plus	Lindane	Thiophanate-methyl			I/LUM
230	Permit	Permethrin				I
53	BASF Phorate	Phorate				I
219	MTM Phorate	Phorate				I
260	Savall	Quinalphos				I
303	Tombel	Quinalphos	Thiometon			I
304	Tombel	Quinalphos	Thiometon			I