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The Environmental Impact of Arable Crop Production in the European Union:

Practical Options for Improvement

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The Environmental Impact of Arable Crop Production in the European Union:
Practical Options for Improvement

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EXECUTIVE SUMMARY

1. One of the five main objectives of the "Agenda 2000" reform of the Common Agricultural Policy (CAP) was the better integration of environmental goals into the CAP. Accordingly, member states are required to take appropriate measures, including general mandatory requirements, agri-environment measures and/or specific environmental conditions for direct payments ("cross-compliance"). This report considers the past and present environmental impact of arable agriculture, the likely impact of Agenda 2000, and describes potential measures for alleviating the impact. It was funded by the European Commission Directorate-General for the Environment, but the views set out are those of the authors and do not necessarily represent the views of the Commission or the Environment Directorate.

2. Although the coverage in pan-European, this report concentrates particularly on three member states representing the range of arable farming in the EU: The Netherlands, with the most intensive agriculture, the UK, representing the relatively intensive production typical of northern Europe, and Portugal, with mainly less intensive systems typical of southern Europe.

3. In **Section 1**, the arable sector in the European Union is briefly reviewed, particularly in relation to cereal, oilseed and protein crop (COPs), which accounted for 53.5m ha in 1996/7, or 90.5% of cultivated land in the European Community (excluding set-aside). 80% of EU cereal production is concentrated in five member states (France, Germany, Spain, Italy and the UK).

4. Cereal yields per hectare have increased at an average rate of 2.2% per annum since 1974, and this trend continues. Oilseed yields have also risen, though more slowly in recent years. Protein yields increased in the early years of the CAP but have recently declined.

   The increase in the use of fertilisers and pesticides has slowed in the 1990's and overall, use has declined though figures are variable between member states and between different measures of usage.

5. The number of holdings growing COPs has declined, while the area grown by a smaller number of specialist producers has increased. Very large individual farm cereal areas occur in UK, Denmark, Germany and France, whereas southern states still have much smaller areas per farm.

6. **Section 2** considers Environmental impacts of arable agriculture, under the headings of Soil, Water, Biodiversity, Landscape and Air.

7. Soils may be susceptible to erosion, loss of organic matter leading to poor structure, and pollution by pesticides and heavy metals. Soil erosion has effects external to the farm, through siltation of water courses and transport of pesticides and nutrients. The latter can also be conducted to water via leaching and sub-surface flow. Cultivation systems are

among the most important factors influencing soil properties.

8. Both ground and surface waters can be influenced by nutrient and pesticide pollution from arable land. This results in reduction in the quality of drinking water and necessitates expensive treatment. It also has ecological consequences for aquatic life. Intensification of farming systems, encouraged by economic support under the CAP has exacerbated these problems.

   Nutrients, especially phosphates cause eutrophication of water, which upsets the ecological balance and can result in undesirable effects such as fish death and algal blooms. Problems are greatest where farming is not intensive, and lower in southern Europe.

   Nitrates are particularly prone to leaching, and concerns over nitrates in water supplies have led to legislation in the form of the EU Nitrates Directive and the setting of limits in drinking water under the Drinking Water Directive.

9. Pesticides reach water via surface runoff, through soil cracks and drains. Permitted levels in drinking water are limited by the EU Drinking Water Directive, necessitating large treatment costs. Spray drift and acute pesticide pollution incidents can adversely affect aquatic organisms, as can the silt burden from eroded soil particles, which may also have phosphate and pesticides bond onto their surfaces.

   Inappropriate cropping and cultivation techniques can exacerbate these problems, but because the effects are externalised, they do not tend to play a large part in management decision-making.

10. Intensification of arable systems has led to a large decline in biodiversity on arable farmland. Loss of non-crop habitat and simplification of systems has disrupted food chains and caused declines in many species. Conversely, in southern Europe particularly, abandonment of arable management is also a problem.

    Declines are best quantified for birds, but there is also evidence for similar or greater levels of decline in mammals, plants and invertebrates. Important factors include the reduction in mixed farming, switch from spring to autumn sowing, reduced crop diversity, and increased use of pesticides and fertilisers. In the south, abandonment of fallows, intensification on the best soils and abandonment of the worst, and reduced habitat diversity through loss of traditional management systems in the Montado, Dehesa and Steppic landscapes have affected biodiversity. Drainage and irrigation also have also caused habitat degradation in many areas.

11. Landscapes have changed considerably as farming systems have changed. Landscape quality is partly subjective, but many valued features such as hedges, ditches, and stone walls have been lost in recent decades, fields have become larger and the landscape simpler.

    In southern states traditional montado and dehesa landscapes have come under threat through intensification, often supported by irrigation. This has led to a more uniform landscape, while elsewhere abandonment or afforestation has resulted in major landscape change.

12. Whilst arable agriculture itself is not a major source of air pollution, emission of greenhouse gasses (NO_2 and CO_2) and to a lesser extent pesticides, does occur. Problems are greatest in the Netherlands, though most of the greenhouse gases result from intensive livestock rather than arable farming. Long-distance transport of arable inputs and products also contributes to greenhouse gases and climate change.

13. **Section 3** attempts to forecast the effects of Agenda 2000 on arable systems and their environmental impacts. Forecasts of changes in cropping patterns are given based on SPEL, CAPA, INRA and FAL models. The area of set-aside is a crucial factor in determining both arable areas and environmental impacts. Models differ in their predictions, but there is general agreement that cereals, especially wheat, will increase in area and the area of oilseeds will fall.

14. Trends of increasing cereal yields, declining incomes and fewer larger, more specialised farms, especially in the north, will continue. The Environmental effects of arable farming will be similar under the new regime with minor variations as a result of even greater dominance of cereals, and the impact of new technologies such as precision farming and genetically modified varieties.

15. **Section 4** puts forward practical suggestions for alleviating the environmental effects of arable farming. These are presented separately for each of the three key member states in the study. For each country, proposed options are presented in two categories: cross compliance (i.e. measures which would provide conditions for arable area payments), and agri-environment measures, for which payments would be made. Cross-compliance conditions are intended to be compatible with “usual good farming practice”, as defined in article 28 of Commission Regulation 1750/1999, and to work towards both agricultural and environmental sustainability.

16. Management practices are proposed which address problems identified in Section 2 under the headings soil, water, air, biodiversity and landscape. It is important to avoid penalising farmers who already adopt good environmental practices. Integration of measures is necessary to maximise benefits, and whole farm plans can help here. The potential role of local marketing initiatives in maintaining regionally traditional production systems and minimising greenhouse gas emissions is emphasized. At the end of the section for each country, the environmental and agricultural benefits of the proposed measures are summarised in tables, and a further table summarises the degree to which cross-compliance measures meet criteria relating to impact on farming systems, cost, ease of monitoring and length of time needed for compliance.

17. Proposed UK cross-compliance measures are presented under the following headings: compliance with general mandatory regulations, soil erosion management plan, green stubbles and winter cover crops, contour strips, nutrient management plan, machinery maintenance, no autumn application of nitrogen, prevention of spray drift, prevention of

fertiliser drift, five metre buffer zones, no insecticides within 6 metres of field boundary, field pest threshold, one metre boundary strips, environmentally-managed habitat as percentage of eligible area, and minimum distance between non-crop habitats.

18. Proposed UK agri-environment options are: organic farming, arable conversion to grass, large riparian buffer zones, reedbed nutrient sinks, conservation headlands, conservation headlands with no fertiliser, wild bird cover crops, undersowing, grass leys, field boundary vegetation, hedges and shelterbelts, beetle banks, uncropped wildflower strips, hedge maintenance, stone walls and ditches, individual tree planting and integrated whole farm plans.

19. Netherlands cross-compliance conditions are classified in three sections (plus general mandatory regulations). Section A, procedural criteria, includes: erosion management plan, nutrient management plan, pesticide management plan, water management plan and nature management plan. Section B, technical conditions includes: general machinery maintenance, prevention of fertiliser drift and prevention of spray drift. Section C, physical conditions, includes: 2m field boundary strips and non-crop habitat as percentage of the farm.

20. Netherlands agri-environmental options are classified in two sections. Section A, flora and vegetation, includes: arable flora in *rotating* cereal crops without *herbicides* and fertiliser, arable flora in *rotating* cereals without *pesticides* and fertiliser *in any year*, arable flora in *permanent* cereal field (cereals five out of six years) without pesticides and low input of fertiliser, arable flora in cereal margins, and hedgerow management. Section B, fauna, includes: fauna margin, fauna fields, red list vertebrate management, and integrated whole farm plan.

21. Cross compliance conditions for Portugal include: contour ploughing, no stubble burning, winter cover crops, fallows as proportion of eligible area, buffer strips, and restricted fertiliser use within Nitrate Vulnerable Zones.

22. Agri-environment options proposed for Portugal include: restricted harvest dates, triticale erosion control, arable conversion to trees, extensive arable systems, montado, organic farming, polyculture, water points, wildlife crops, game management, shrub habitats and integrated whole farm plan. Issues and measures relating to afforestation of arable land in Portugal are considered in an appendix.

23. In **Section 5**, the criteria for distinguishing between measures which should be conditions for receiving direct payments and those for which additional payments shall be made are discussed. Crucial to these considerations is the achievement of environmental sustainability, both on and off the farm. We have interpreted the concept of good farming practice as including external impacts, which may not be given sufficient consideration by farmers left to their own devices.

24. Cross-compliance measures which are emphasized to ensure equity of contribution include managing a proportion of eligible area in an environmentally beneficial manner, and enforcing a minimum distance between non-crop habitats. The importance of

integrated whole farm plans is also stressed, with the desirability of achieving these for all farms as a long term aim. The need for baseline data to provide an inventory of existing status is highlighted.

25. The role and importance of cultivation systems is recognised, but in view of their complex nature and interaction with other factors, the best way forward may be through training and advice rather than implementation of general prescriptions.

    The benefits of local marketing initiatives as one way of conserving local traditions and environmentally benign production systems is emphasized.

26. The measures proposed in this study provide a first step in what will hopefully be a continuously evolving process towards an environmentally acceptable agriculture which also meets the wider needs of the population as a whole.

0.0 INTRODUCTION

The proposals for the reform of the common agricultural policy (CAP) known as Agenda 2000 included the better integration of environmental goals into the CAP as one of five main objectives (Commission of the European Communities 1997). However, with the main message of the reform being to increase competitivity, the European Commission "does not intend to undermine the competitive position of farmers by adding excessive environmental conditions beyond what is reasonable for farmers to provide" (Commission of the European Communities, 1999). The desired relationship between agriculture and the environment is described as "sustainable agriculture", sustainability being the key concept of the 5th Environmental Action Programme (Commission of the European Communities, 1992) defined as "development which meets the needs of the present without comprising the ability of future generations to meet their own needs"

In describing its approach to incorporating environmental considerations into Agenda 2000, the Commission stated "……it would be unfair to reward those farmers gaining an unfair competitive advantage by making excessive and damaging demands on environmental resources", and further, that "the farm sector needs to take account of the legitimate demands of society that agricultural activities should not pollute the environment, nor lead to severe erosion, nor destroy cultural landscape features valued particularly highly by society", (Commission of the European Communities, 1999).

To address these issues, it was proposed that "farmers should observe a minimum level of environmental practice as part-and-parcel of the support regimes, but that any additional environmental service, beyond the basic level of good agricultural practice…should be paid for by society through agri-environmental programmes".

Accordingly, under the so-called "Horizontal measures" (Council Regulation (EC) No. 1259/1999, 17 May 1999), member states were required from 1 January 2000 to take appropriate environmental measures, which could include general mandatory environmental requirements, support for agri-environment measures, or specific environmental requirements constituting a condition for direct payments. The last of these is commonly referred to as "cross compliance", which term will be used in this context throughout this report.

Although environmental measures are compulsory, their means of implementation is to some extent left to member states' discretion. The attachment of environmental conditions to direct payments (cross compliance) is itself discretionary, as is the reduction of direct payments by up to 20% according to various criteria ("modulation"), and the use of savings from either of these measures to increase support for rural development measures, including agri-environmental schemes.

Agri-environment schemes are provided for under the Rural Development Regulation (Council Regulation (EC) No 1257/1999, 17 May 1999), and the provision of Agri-Environment schemes is the only compulsory part of this regulation.

This report considers the implications of the Agenda 2000 reform for the integration of environmental considerations in the arable sector. It specifically addresses the past and current environmental impact of arable crop production in the European Union, and proposes practical measures to improve the environmental impact. The environmental measures are considered under the two headings of cross-compliance and measures appropriate for inclusion in agri-environment schemes.

Although the report is intended to be relevant to the European Community as a whole, the approach taken has been to select three member states which are broadly representative of the range of types and, particularly, intensities of arable agriculture in the European Union (EU). These are: the Netherlands (with the most intensive arable farming in Europe), the United Kingdom (relatively intensive arable agriculture representative of northern Europe) and Portugal (more extensive arable agriculture representative of southern Europe).

The report commences with a brief review of arable production in the EU (section 1) before considering the environmental impacts of arable farming in more depth (section 2). The likely impact of Agenda 2000 on arable crop production systems and their environmental impact are discussed in section 3, and finally section 4 outlines practical suggestions for improving environmental impact in the three selected member states, as cross-compliance and agri-environmental options. As far as possible these have been costed, or at least an indication of the likely cost given. Summary tables are given indicating the main impacts of the proposed measures on soil, water, biodiversity, landscape and air, and the cross-compliance measures are assessed according to various criteria set up to judge their acceptability.

The practical suggestions proposed are based on the experience of the report authors from the member states, and were selected:

(i) to address the impacts identified in section 2 under the headings of soil, water, biodiversity, landscape and air.
(ii) to provide workable solutions to environmental problems, as far as could be ascertained on the basis of current published literature and experience of the authors themselves.

Where further information is needed on a particular measure this is reported under its description, but this has not precluded the inclusion of measures thought to be particularly promising in addressing a particular environmental issue, or where there were, in the authors judgement, no realistic alternatives.

In conclusion, it is hoped that this report will make a useful contribution to the ongoing debate about the integration of environmental considerations into arable agriculture throughout the European Union under the Agenda 2000 reform of the CAP.

1.0 THE ARABLE SECTOR IN THE EU

For the purpose of this study, the arable crops under consideration are limited to cereal, oilseed and protein crops (known as COPs). These crops occupy approximately 32% of the EU's Utilised Agricultural Area (UAA) (Eurostat, 1998a) and contribute to approximately 11% of the EU's total agricultural output (EC, 1998).

This section examines the major trends in the EU's arable areas, yields, and farm structures since the last reform of 1992. It also identifies the major trends in the inputs applied to those crops. The environmental impacts arising from these trends is assessed in the next section.

1.1 COP Areas

The areas sown to COPs occupy some 53.5 million ha (in 1996/97). Areas for each Member State are broken down for the 1993/4 to 1996/7 period in Appendix 1.1. In summary, the area in food use includes:

- 47.6 m ha of cultivated land, of which:
  - 36.9 m ha (78%) is cereals (including for silage),
  - 4.8 m ha (10%) is oilseeds (rapeseed, sunflowerseed and soybeans),
  - 4.4 m ha (9%) is maize (mainly for silage),
  - 1.2 m ha (2.5%) are protein crops (field peas, beans and lupins),
  - 0.2 m ha (0.5%) is linseed;

  and
- 6 m ha of set-aside land, of which:
  - 3.7 m ha (62%) is compulsory (at 10%) growing some 0.7 m ha of non-food oilseeds,
  - 0.4 m ha (7%) is in the five year scheme, and
  - 1.9 m ha (31%) is voluntary set-aside (EC, 1997)

COP areas are limited by national base areas which are subdivided by (some) Member States into base regions. COP area payments cannot exceed the base area, limiting the growth of COPs grown with subsidies. A base area overshoot results in aid payment penalties and extra penalty set-aside (in theory, although not always adopted by Council in practice).

Nevertheless the take-up of the COP regime is increasing as a proportion of the base area eligible for payments, reaching 97.6% in 1997. The potential for further increases is therefore limited to some 2.4% of the base area (see Table 1 below)

Table 1.1. Proportion of base areas used as COPs

	1993	1994	1995	1996	1997
COP take-up (%)	92.2	95.4	96.1	97.2	97.6

Furthermore the areas of COP's grown are constrained by the annual rate of Set-aside adopted at Council. The Set-aside rate is complicated by the use of voluntary set-aside, guaranteed, rotational and non-rotational forms in 1994/5 and 1995/6 which leads to a higher effective average rate than the nominal rate (see Table 1.2 below).

Table 1.2. Set-aside data (EU-12 only*)

	1993/4*	1994/5*	1995/6	1996/7	1997/8	1998/9
Nominal rate (%)	15	15	12	10	5	10
Effective average (%)	15.5	18.0	18.5	15.8	na	na
Area (m ha)	6.3	7.3	7.5	6	na	na

Given the base area constaints on COP production, areas have not changed significantly since the 1992 reform. EU cereal areas have remained fairly static with 35.6 m ha grown in 1992 (27% of UAA in 1991) and 35.3 m ha grown in 1997 (25% of UAA in 1995) (see Appendices 1.2 & 1.3). However cereal production covered a greater area (nearly 40 m ha) pre-reform, after which there was a decline following the introduction of set-aside. Despite this overall reduction in cereal areas since the 1992 reform, the area of wheat and maize has been maintained while the area of other cereals (barley, oats and rye) has declined.

Oilseed areas have been constrained by a 5.482 m ha Maximum Guaranteed Area (MGA), agreed with the USA at Blair House, which has reduced the areas grown from 6.137 m ha in 1994/5 (4% of UAA) to 5.506 m ha in 1996/7 (see Appendices 1.4 & 1.5). The MGA has been exceeded over the last two years. The areas of proteins have appeared to decline slightly from 1.334 m ha in 1993/4 (1.3% of UAA) to 1.121 m ha in 1996/7 (see Appendices 1.6 &1.7).

1.2 Yields

1.2.1 Cereals

The production of cereals among the current Member States of the EU-15 has risen sharply since 1980. Despite the introduction of Set-aside in the 1992 reform, the rise in yields and the return of more normal weather to the Iberian peninsular after four years of drought (Spain is the fifth largest cereal producer in the EU) have resulted in record breaking levels of cereal production. Cereal yields (particularly for soft wheat) appear to break into new technical territory in 1978, 1984, 1991 and 1996. The recent introduction of strobilurin fungicides has led to further rises in yield in 1999 in some Member States, such as the UK.

Table 1.3. Average annual changes in yields, prices and values for EU-15 (%)

	YIELD		**REAL PRICE**		**REAL VALUE**		**CROP SHARE**	
	81/91	91/97	81/91	91/97	81/91	91/97	1981	1997
Cereals	+2.3	+2.1	-4.8	-7.2	-2.6	-5.3	12.0	9.5
Oilseeds	+11.9	+0.7	-6.2	-7.6	+5.0	-7.0	0.9	1.4

Cereal yields have increased at an average rate of 2.2% per annum since 1974. Pre-1992 wheat yields increased at a trend rate of 108 kg/ha/yr reaching 5.21 t/ha in 1992 while barley yields grew at a lower rate of 47 kg/ha/yr. An important consequence of these trend rates is that wheat yields overtook barley yields in the 1980's (barley yields were higher than wheat in the 1960's and 1970's).

Table 1.4: Cereal yields 1991-1996 (t/ha)

	1991/2	**1992/3**	**1993/4**	**1994/5**	**1995/6**	**1996/7**
Yield	5.00	4.69	5.09	5.01	4.94	5.46

This trend continues with wheat yields continuing to grow at 110 kg/ha/yr on average while barley yields are only growing at 40 kg/ha/yr since 1992. The evidence so far suggests that the 1992 CAP reform has not stood in the way of yield growth as a result of continuing technological advances (Eurostat, 1999).

The top three Member States for wheat yields (as an average of the three years 1995-1997) are:

- The Netherlands (8.45 t/ha)
- Ireland (8.32 t/ha)

- Belgium (8.02 t/ha)

EU cereal yields by Member State are shown at Appendix 1.8. Yield variations between the three EU Member States selected for this study are shown in Figure 1.2 below.

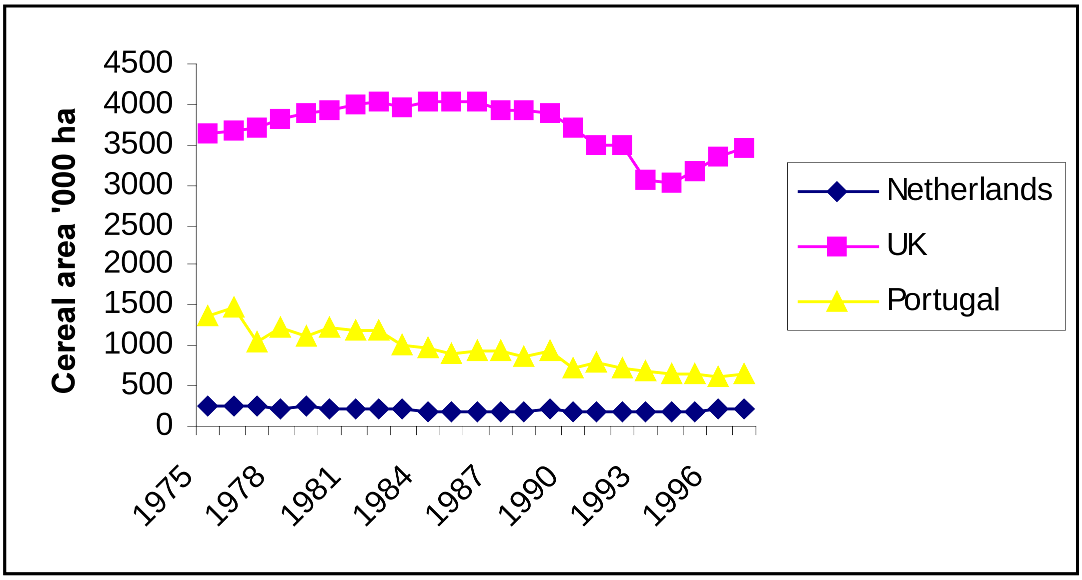

Figure 1.1 Cereal areas in the Netherlands, UK and Portugal, 1975-1997 (Agra-Europe)

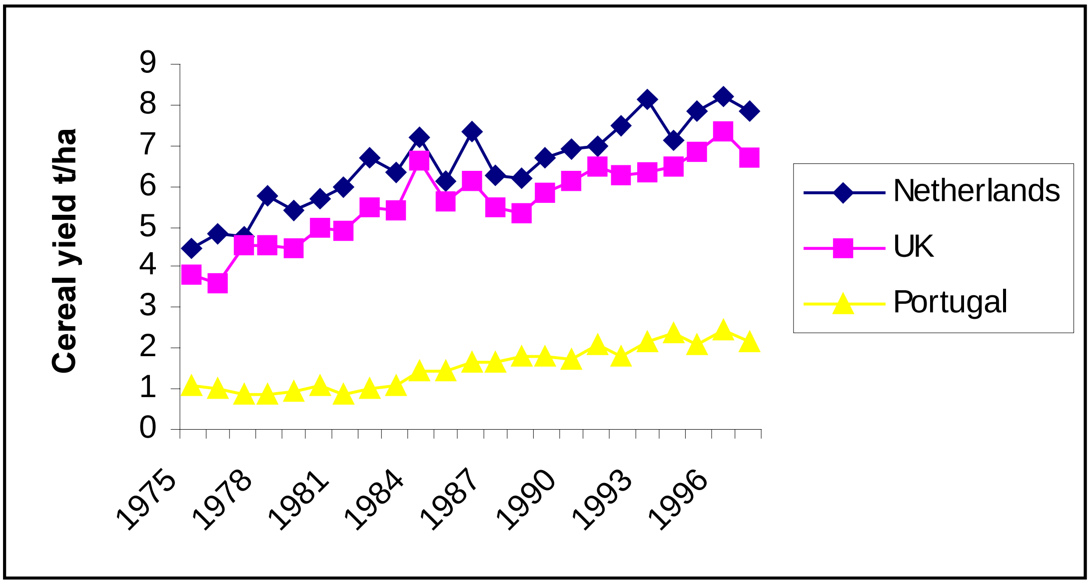

Figure 1.2 Cereal yields in the Netherlands, UK and Portugal, 1975-1997 (Agra-Europe)

1.2.2 Oilseed yields

The long-term trend in oilseed yields is for increases of 66 kg/ha/yr of rapeseed and sunflowerseed and double that for soyabeans. Since the 1992 reform, which decreased the internal price to the world market price, the rate of increase has slowed considerably.

Table 1.5. Oilseed yields 1992-6 (t/ha)

	AV 89-91	**1992/3**	**1993/4**	**1994/5**	**1995/6**	**1996/7**
Rapeseed	2.98	2.61	2.83	2.49	2.68	2.62
Sunflowerseed	1.67	1.49	1.09	1.53	1.48	1.65
Soyabeans	3.25	2.92	3.09	2.91	2.96	3.07

The development of non-food oilseeds on set-aside has diluted the yield figures somewhat. Appendix 1.9 shows the yields of rapeseed for food use only which, despite being higher than those in the table above, indicate no significant increase in yields since the 1992 reform.

1.2.3 Protein yields

Protein crop yields have shown increases on average of 162 kg/ha/yr since the introduction of the CAP but, since the 1992 reform, yields have declined from an average of 4.25 t/ha in 1993 to 3.74 t/ha in 1997 (see Appendix 1.10). Some of this yield decline can be accounted for by the change in cropping in Member States with less protein grown on fertile soils in France and UK and more grown in less fertile areas such as Spain and Germany (see Appendix 1.6).

1.3 Arable crop inputs

The use of both fertilisers and plant protection products has slowed in this decade compared to the 1980’s. There is, however, some discrepancy in the data since the amount of agrochemicals sold increased between 1991 and 1997 (Eurostat, 1998a) yet total amounts applied declined over that period (European Commission, 1999). The former records growth at a rate of 0.8% per annum between 1991 and 1997 which is considerably less than in the previous decade. Fertiliser use was already declining at a rate of 0.8% per year between 1981 and 1991 and that rate of decline has increased since.

Table 1.6. Average annual percentage changes in volumes, prices and values for EU-15

	VOLUME		**REAL PRICE**		**REAL VALUE**	
	81/91	91/97	81/91	91/97	81/91	91/97
Fertilisers	-0.8	-1.0	-4.3	-1.8	-5.1	-2.8
Plant protection products	+3.4	+0.8	-1.3	-1.5	+2.0	-0.7

The changes in fertiliser consumption have varied between Member States. In France the use of nitrogen fell by 10% between 1986 and 1994 in kg/ha, phosphates by 20% and potassium by 13%. The number of fungicide treatments fell by 5% but there was no change in insecticide use (Poiret, 1996). Taking the three Member States that form the case studies in this report, the UK, Netherlands and Portugal, it can be seen that total fertiliser use has decreased since 1985 in the Netherlands and the UK although in Portugal the trends are less obvious.

Table 1.7. Consumption of all commercial fertilisers ('000 t) (Eurostat, 1997)

	1980	**1985**	**1990**	**1994**
United Kingdom	2,054	2,524	2,413	2,219
Netherlands	679	701	558	534
Portugal	259	241	278	248

In terms of active ingredients the overall amount of pesticides used in arable systems has declined since the early 1990s although variations in the statistics are very much dependent on weather conditions and changes in crops grown. Between 1991 and 1996 the largest decreases in pesticide sales were seen in those countries which have specific policies on pesticide reduction ie Finland (-46%), the Netherlands (-43%), Denmark (-21%) and Sweden (-17%) (Eurostat, 1998b)

In 1996 there was an increase in sales volumes, particularly in Spain (+19%), France (+11%) and the UK (+6%) because of seasonal conditions such as weather and pest pressure. Sales were equally divided between fungicides (41%) and herbicides (39%) with insecticides (12%) and others (8%) making up the total.

In the Netherlands, surveys carried out in 1992 and 1995 show a decrease of consumption (measured by weight of active ingredient) of 5.4% with the total area on which pesticides were applied decreasing by nearly 2%. The crops with the highest pesticide use per ha in the Netherlands and Sweden in 1995 were in declining order:

- mushrooms,
- crops under glass,
- flowers,
- top fruit,
- potatoes and sugar beet, and
- cereals

although the absolute amount of active ingredient was greatest for cereals than for any other crop.

The total weight of pesticides used in the UK increased by 7% between 1994 and 1996 but the treated area of arable crops increased by 18% because of changes in the Set-aside obligations. The difference between the increase in the area treated and the weight of pesticides applied is due to reduced rates of application and the introduction of new products active at lower rates of application. Nonetheless the 30% decrease in Set-aside over this period led to an extra 1,432 tonnes of pesticides applied to 316,000 ha of cereals.The amount or pesticide applied per hectare of cereals increased slightly from 3.71 to 3.88 kg between 1994 and 1996, and from 1.98 to 2.23 kg for oilseed rape. The number of active ingredients applied to major cereal crops decreased slightly from 11.5 to 10.2 for wheat and 8.7 to 8.1 for winter barley (though it increased for oilseed rape from 5.1 to 6.4), but the number of applications remained constant at 4.9 for wheat, and increased from 3.5 to 4.1 for winter barley and from 3.2 to 4.1 for oilseed rape (Garthwaite *et al,* 1995; Thomas *et al*, 1997) As in the Netherlands, most pesticides are applied on wheat (9,500 tonnes in 1996) with a 14% increase in the amount applied per ha between 1994 and 1996.

Many factors have contributed to the overall reduction in pesticide volumes applied. These include:

1. weather conditions
2. seasonal conditions/pest pressure
3. pesticide prices
4. cropping/set-aside areas
5. lower doses & stronger active ingredients allowing lower doses
6. national policies eg taxes in some Member States
7. changes in survey techniques over the period

There is not sufficient data from Member States to distinguish between reductions resulting specifically from national pesticide reduction policies and other factors. For example farmers reacted to the introduction of a pesticide tax in Sweden in 1994 by increasing the amount of pesticide used by 50%. However the price cuts following the 1992 reform, and following the 1995 accessions for new entrants, contributed to the decline in growth rates of plant protection products applied between 1992-1996.

1.4 Geographical location of production

Three countries (France, Germany and Spain) account for some 60% of the cereal area in the EU-15. France and Germany are the major COP producers in the EU-15 followed by the UK, Spain and Italy. France, in particular, grows the most wheat, oilseeds and proteins of any Member State. This is perhaps not surprising given that France has the largest UAA and arable area in the EU-15.

Table 1.8. Concentration of arable and cereal production in EU-15, 1997 (Eurostat, 1998b)

1997	**ARABLE (HA)**	**ARABLE/ UAA (%)**	**CEREALS/ ARABLE (%)**	**CEREALS % OF PROD'N IN EU**
Belgium	841,000	61	36	1
Denmark	2,546,000	94	61	4
Germany	11,832,000	68	59	18
Greece	2,250,000	44	57	3
Spain	14,344,000	48	48	18
France	18,291,000	61	50	24
Ireland	1,100,000	24	28	1
Italy	8,105,000	52	48	11
Luxembourg	60,000	47	48	0
Netherlands	809,000	41	26	1
Portugal	2,278,000	57	29	2
UK	6,409,000	40	55	9
Austria	1,386,000	41	61	2
Finland	2,125,000	99	52	3
Sweden	2,746,000	86	46	3
EU-12	68,865,000	54	51	-
EU-15	75,122,000	55	51	100

Over half (51%) of the EU arable area grew cereals in 1997. The Nordic countries have the highest concentration of arable land, as a proportion of UAA, in the EU-15 with Denmark (and Austria) in particular having the highest share (61%) of their arable area devoted to cereals. Cereals also form a major (59%) contribution to the arable landscapes of Germany and Greece.

Approximately half of EU cereal production comes from 20 of the 127 regions of EU-15. These are:

- Denmark (classified as one region),
- Bayern, Niedersachsen and Nordrhein-Westfalen in Germany,
- Centre, Picardie, Champagne-Ardennes, Poitou-Charentes and Midi-Pyrenees in France,

- South-East in the UK, and
- Castilla-Leon and Castilla-la Mancha in Spain

The development of the individual cereal types has varied between Member States. Between 1974 and 1991, wheat areas grew in France (28%), the UK (77%) and Denmark (200%) and fell in Italy and Spain (-25%). The wheat area in Spain has largely been substituted by barley. Barley areas have declined generally in the EU with the increase in soft wheat in the five main cereal producing Member States and this has continued since the 1992 reform with further fall of between 10% and 20%, depending on the Member State (Eurostat, 1999).

1.5 Producer numbers and farm structures

A wide range of producers and holdings are involved in growing cereals, ranging from predominantly livestock producers for on-farm use to specialised combineable crop producers. But the proportion of holdings growing 'some' cereals has declined from 60% in 1975 to 43% in 1995 while the area grown by a smaller number of 'specialist' growers is increasing (5.5% of holdings growing some cereals now account for 41% of the area sown).

The overall decline in agricultural producers and holdings over time is well established. Between 1975 and 1995 the number of holdings fell by more than 1.4 million in EU-9 but the number of specialist crop growers increased by 47,000 (European Commission, 1999). It is hard to find data specific to COP holdings but trends in the average cereal area per holding can be established by combining the structural surveys (1993 & 1995) with IACS data (1997) in Appendix 11. At the start of the 1992 reform there were 3.4 m cereal holdings with an average cereal area of 10.4 ha. By 1997 the average area had increased to 14.2 ha. 'Professional' producers (in the 'general' scheme of support regime) numbered only 0.75 m in 1996/7 with an average COP area of 51 ha (see Appendix 1.12).

Examining the data on the COP schemes in more detail, it can be seen that the proportion of aid applications provided by 'professional' or 'general scheme' producers has increased from 70% in 1993/4 to 77% in 1996/7 (Appendix 1.13) while the number of 'small' producers within the simplified scheme has declined. This highlights the trend towards the concentration of cereal producers generally.

Wide variations appear between Member States with the UK and Denmark having the highest average cereals area (43 ha and 23 ha respectively in 1995) while Portugal and Greece only average 2.7 ha and 3.3 ha respectively. Very large and specialist cereal holdings can be found in the new German länder (averaging over 100 ha per farm) and in France. For example, between 1991 and 1995 the number of specialised cereal farms in France declined by 15% to 93,000 while the average size/farm increased 25% to 92 ha. Interestingly the share of the UAA devoted to COPs increased by 3 points to 83%, reflecting the increasing degree of specialisation of COP holdings.

The 1995 Survey found 857,000 'specialist' COP holdings, 12% of all holdings in the EU. Among Member States this proportion varied between a little over 1% in Ireland and the Netherlands to about 31% in Denmark. Of all the holdings growing some cereals in the EU, just over 25% were specialist COP holdings. This ratio was highest in Italy, the UK and Denmark at between 35% to 40%.

Survey data suggests that there is increasing specialisation over time among holdings growing some cereals in the EU. ‘Specialists’ rose from from 11% of holdings growing some cereals in 1975 (EU-9) to 18% in 1990 (EU-12). Furthermore COP ‘specialist’ holdings in the EU-15 are larger (34.7 ha) than either holdings growing some cereals (27.8 ha) or holdings as a whole (22.5 ha).

1.6 Conclusion

The total arable area, and the breakdown of crops within that area, has not changed significantly since the 1992 reform because of the straightjacket of arable base areas and maximum guaranteed areas (in the oilseed sector). The proportion of available ‘eligible’ land used by arable cropping is increasing. There is no evidence of any abandonment related specifically to the arable regimes. Nor are there significant changes in the amount of voluntary Set-aside claimed by farmers.

The largest fluctuations in arable areas have been caused by changes in the compulsory Set-aside rate. Approximately half of the EU’s arable area produces cereals but half of the EU’s cereal production is concentrated in 20 out the EU’s 127 regions. This concentration is particularly high in Denmark, Austria and Germany. The average cereal holding is becoming larger and the number of producers is becoming smaller. Within the COP scheme the number of ‘professional’ producers is growing while the number of ‘small’ producers is declining reflecting the increasing concentration of ‘professional’ cereal producers.

Given the finite limit to the base area which can receive support payments for producing arable crops, increases in EU arable production are a function of yield increases. Cereal yields, particularly wheat, have increased at a rate of approximately 0.1 t/ha/year as a result of genetic and technological advances. Yield increases in barley, oilseeds and pulses have been slower. The use of agrochemicals to protect crop yield has also grown on an annual basis although the rate of growth has slowed in this decade compared to the previous one. This is primarily a function of improvements in the efficacy of pesticides. Fertiliser use has been declining since 1981.

2. ENVIRONMENTAL IMPACTS

Arable farming is one of the oldest and most widespread forms of land use in Europe and supports a uniquely adapted and diverse fauna and flora. However, since the 1960s, concern has developed over the environmental impacts of arable farming, including impacts on wildlife and on the sustainability of arable systems themselves. With the widespread intensification of arable farming, environmental consequences have become apparent throughout the EU. Such environmental impacts include damage to, and removal of soil, thereby threatening agricultural sustainability, and the pollution of water sources which provide drinking water for a growing human population. Modern arable systems also impact upon biodiversity within the system itself, and in associated non-cropped habitats such as grassland, field boundaries and watercourses. The deterioration in arable ecosystems is also reflected in the aesthetic quality of the arable landscape. These costs to the community are externalised and, for the UK, have been estimated at €3.7 billion per year (€330/ha/yr; Pretty *et al*., in press).

There is a high degree of integration between these environmental impacts of arable management, but we have treated each separately as far as possible in the sections below, describing the environmental impacts of key management practices. Arable systems are also often highly integrated with livestock and forestry, and where this is the case we include these in our discussion of the arable system. There is a tendency for such multiple land use to be more sustainable, and to be associated with higher biodiversity and landscape value, than purely arable systems. The combination of price support and capital grants under CAP has encouraged abandonment of such integrated systems, as well as encouraging environmentally damaging practices through intensification within resulting simplified systems.

More recently, CAP reforms, including agri-environmental measures, have been introduced. These have experienced varying degrees of success in terms of their adoption by farmers, with inadequate funding, resistance to long-term obligations, and reluctance to abandon traditional practices being given as reasons for low adoption (Fay, 1998). Little evidence is available for the success, in terms of achieved objectives. While some success has been reported (Borralho et al., 1999), in other cases, conflicting objectives have led to detrimental consequences being observed (Wakeham-Dawson *et al*., 1998). There is some evidence for further intensification of management of arable crops and leys following CAP reform, and of loss of non-arable habitats to crops that are not eligible for arable area payments (Winter & Gaskell, 1998).

2.1 Soil

Soils have deteriorated during the life of the CAP, as a result of erosion, compaction, loss of organic matter and contamination with pesticides and, in some areas, heavy metals. The effects of these changes are usually externalised, being greater for society as a whole than for the farms on which they operate, and incentives to correct them are therefore largely lacking.

Arable soils are vulnerable to erosion by wind and water, compaction resulting from the use of heavy machinery, and declining organic matter resulting from frequent cultivations and use of synthetic fertilisers. These factors are highly integrated, and linked also with soil nutrient levels, themselves influenced by soil faunal activity. Inputs in the form of pesticides and organic and inorganic fertilisers also influence soil structure directly, and through their impact on the soil fauna.

During the life of the CAP, simplification of cropping systems, increases in field size and increased use of heavy machinery and pesticides have all contributed to higher levels of soil erosion than those occurring in the previous history of arable farming (Evans, 1996).

Half of the arable fields surveyed in England and Wales by Skinner & Chambers (1996) showed signs of soil erosion at least every other year. Evans (1996) reports mean annual rates of soil loss from arable land of 3.6 t/ha in Belgium and 6.1 t/ha and 5.1 t/ha in the English counties of Somerset and Hampshire respectively. DGXI estimates of mean annual soil loss across northern Europe (cited by Gardner, 1996) are higher, at 8 t/ha. Erosion rates are higher in southern Europe where 20 to 40 t/ha can be lost in a single storm (ECAF, undated).

2.1.1 Cultivation and physical structure

Sandy and peaty soils are particularly susceptible to erosion by wind and the peat area of the East Anglia (UK) arable area has declined considerably as a result of erosion, with the peat depth in remaining areas being substantially reduced. As these are underlain by clay and acid sulphate soils such erosion threatens the future cultivation of arable crops in this region. Erosion of cultivated soils resulting from the action of wind and water leads to loss of nutrients and crop rooting depth as well as pollution, eutrophication and sedimentation of aquatic habitats (Section 2). Off-farm costs of erosion resulting from damage to property, roads and communications, pollution of waterways and drinking water, sedimentation of reservoirs, and damage to fisheries are externalised to society and are considerably greater than on-farm costs incurred by farmers.

Organic matter is eroded from arable land to rivers disproportionately to its availability in the soil (Davies *et al*., 1993; Walling, 1990). Organic matter levels are higher in arable systems incorporating livestock or legume-based leys than conventional arable systems (Drinkwater *et al*., 1998) and Loveland (in press) recorded a decrease in mean soil organic carbon from arable ley sites of 0.49% over a 15 year period. ECAF (undated) suggests that in about 20 years of tillage, most agricultural soils lose 50% of organic carbon, making the soil more vulnerable to further erosion. Loss of organic matter can also lead to reduced water retention and consequent drought in dry regions, and to reduced drainage in wet ones (Benckiser, 1997). Organic matter also serves an important function in reducing leaching of pesticides to water through adsorption and higher microbial activity.

Shallow soils are associated with substantially lower cereal yields, owing to drought susceptibility (Loveland, in press). Evans (1981), cited in Loveland (in press), estimated that over the next 100 years the loss in yield would be around 2%, assuming annual erosion of 3 t/ha/yr. For erosion of 12 t/ha/yr yield loss was estimated at 8%. However, direct effects on yields in the shorter term are not felt unless soil organic carbon levels fall below 1%, a condition currently associated with only about 5% of UK arable land (Loveland, in press) (OC comprises 55% of total SOM (Persson & Kirchmann, 1994). Changes in soil are generally slight during the period of a farmer's life and environmental problems associated with erosion are externalised. The incentive for preventative action on the part of the farmer is therefore low.

Higher levels of erosion have resulted from an increased area of autumn cultivation, increases in field size and associated loss of hedges, and continuous arable cropping, all of which increase the exposure of soil to wind and water in space or time (Evans, 1996). Lack of crop cover and the presence of tramlines and wheelings increase erosion rates on arable land (Chambers *et al.*, 1992). Late harvested spring-sown crops such as maize (increasingly planted as a silage crop), sugar beet, potatoes and other vegetables also increase exposure of soils to erosion (Evans, 1996). Skinner & Chambers (1996) reported that 60% of erosion events occur on slopes of less than 7º and included hedge removal as a factor influencing erosion. However, rainfall, slope and soil type can all be major influences on erosion risk (MAFF, 1999a). Alström & Bergman (1990), working in Sweden, emphasised the influence of slope, slope length and area. Highest rates of soil erosion are associated with storm events (e.g. Boardman, 1990). However, on flat land with light soils (e.g. East Anglia, UK) wind erosion plays a greater role and shelter belts influence rates of soil erosion by wind.

Research by MEDALUS (Mediterranean Desertification and Land Use) in southern Europe, including the Portuguese Alentejo, clearly demonstrates the impact of arable cultivation on soils. Erosion rates differconsi derably between sites, from 1.2 t/ha/yr at Vale Formoso to 11.5 t/ha/yr at a site east of Mértola (Roxo, 1998). None of these rates is likely to be sustainable under Mediterranean conditions. Studies at the Vale Formoso site showed that soil erosion is higher under ploughed fields, wheat crops and bare soil than under naturally regenerated herbaceous plants or shrub (*Cistus spp*.) cover (Table 1.2, Roxo & Cortesão Casimiro, 1997). Slope and rainfall amount and intensity also influence erosion rates which are highest in ephemeral gullies (Imeson, 1998). Rainfall has declined since the 1930s (Roxo, 1998) and has become increasingly erratic, both within years and months (Bergkamp *et al*., 1997). Discharge into rivers is strongly related to rainfall. Most erosion is therefore associated with brief rainfall events, and could be exacerbated by sparser vegetation cover than in the past.

Table 2.1. Annual average soil erosion by land use in experimental erosion plots at Vale Formoso, Mértola, Portugal (t/ ha)

YEARS	BARE SOIL	WHEAT	STUBBLE	PLOUGH	PASTURE	*CISTUS*
1989-92	7.3	7.6	3.1	4.4	0.2	0.2

Source: Roxo & Cortesão Casimiro (1997)

Ploughing in Alentejo is often carried out in autumn and before the main rainfall period, and can account for a soil loss of 6 t/ha per tillage operation on slopes (Bergkamp *et al*., 1997). Ploughing of fallows continues through the spring in order to stimulate mineralisation of organic matter, prior to sowing the next crop. In Algarve where almost all arable land is no longer used for growing crops, small areas continue to be ploughed (probably to prevent scrub encroachment) but no data are available for erosion rates there. Barreiros *et al*. (1996a & 1996b) demonstrated that no-tillage systems can decrease runoff and increase soil bulk density, reducing erosion by 60% that of ploughed land. However, the applicability of such management will vary with soil type.

The use of heavy machinery and frequent passes with cultivating equipment can cause soil compaction, increasing runoff at the soil surface and creating a soil pan within the soil. The latter inhibits drainage, causing water-logging of crop plants on some soils and creating a physical barrier for their roots, making them more susceptible to drought in dry conditions. Soil compaction is a particular problem on soils with low organic matter where earthworm abundance and activity is low (Makeschin, 1997).

In soils which are not compacted and maintain high OM, earthworms play an important role in maintaining soil structure, improving aeration, crop root growth and drainage (Marinissen, 1992; Makeschin, 1997). In addition, the activities of worms distribute beneficial protozoa and mycorrhizal fungi (Makeschin, 1997), and can reduce leaching of nitrogen by increasing nitrification of soluble nitrates (Elliott et al., 1990). Soil compaction has been shown to reduce abundance of microfauna, especially in deep-tilled soils (Schrader & Lingnau, 1997) and to cause anaerobic conditions and changes in microbial community structure (Bamford, 1997).

Direct drilling favours the soil fauna responsible for breakdown and mineralisation of soil organic matter, especially deep burrowing worm species such as *Lumbricus terrestris* (Edwards, 1984). Shrader & Lingnau (1997) found higher earthworm densities in integrated (reduced cultivation, pesticide and mineral fertiliser applications) than in conventional arable systems. Conventional cultivation is especially damaging to soil fauna in semi-arid low OM soils (Bamford, 1997). However, direct drilling is associated with more crop pests such as wire worm (Elateridae), leatherjackets (Tipulidae) and slugs, the latter especially following rape crops.

2.1.2 Nutrients

Losses of phosphates from the soil are associated mainly with soil erosion. Leaching of nitrogen can result from applications of mineral fertiliser at very early stages in crop growth so that little is taken up by plants, or from the application of excessive amounts. However, much of the nitrogen lost from soil is now known to be associated with mineralisation of soil organic matter at a time when there is no crop cover to exploit the mineral nitrogen made available, normally the period following harvest (Bloem *et al*., 1994). Soil cultivation in warm wet conditions after harvest maximises mineralisation and loss of nitrate during the period before the following crop becomes established.

Organic matter reduces soil erosion, improves soil moisture retention and supports soil mesofauna that maintain appropriate soil structure for crop growth (Benckiser, 1997). Microbial activity, and therefore nutrient availability, are thought to be more synchronised with plant growth in ecofarming systems with minimal tillage and active management of organic matter (Bamford, 1997). Crop rotations which incorporate grass leys improve soil organic matter and reduce loss of nitrogen through leaching, but can be associated with high levels of leaching when they are ploughed (Young, 1986). The use of farmyard manure increases soil organic matter and releases nitrogen more gradually than an application of mineral fertiliser, but the mineralisation and subsequent availability of nitrogen does not necessarily match the requirements of the crop, with the result that leaching occurs (Laanbroek & Gerards, 1991). This is especially the case when organic fertilisers are applied in the autumn, as machinery and labour are often available at this time (Pain & Smith, 1993). Poultry manure is especially associated with excessive rates of mineralisation (Benckiser, 1997), while application of slurry from intensive livestock systems can be toxic to some earthworm species (Makeschin, 1997). However, nitrate leaching can be lower in arable systems incorporating livestock or legume-based leys than in conventional arable systems (Drinkwater *et al*., 1998).

In the Netherlands 'integrated' systems with reduced cultivation, and nitrogen and pesticide application were found to maintain organic matter (whereas this declined in conventional systems) and have crop yields which were 90% of those obtained from conventional systems (Lebbink, 1994). Most groups of organisms also had higher biomass in integrated than conventional systems (Zwart, 1994). Protozoa and nematodes were more abundant, and mineralisation of nitrogen was therefore higher in the integrated system, but excessively high in both after harvest (Bloem et al., 1994). Didden *et al*. (1994) reported that faunal mineralisation was 49% and 87% of the total mineralisation in conventional and integrated systems respectively.

Imports of food and fodder are estimated to increase regional production of sewage and manure by 20% (Benckiser, 1997). Sewage sludge applications to land are regulated by EC Directive 86/278/EEC. In 1999 42% of UK sewage production was applied to agricultural land, and the quantity used is likely to double by 2006, following the ban on sewage sludge disposal at sea in 1998 (Chambers, 1998). However, current useage represents less than 1% of British agricultural land (Chambers, 1997). In both northern and southern Europe, application of sewage sludge is associated with high soil phosphate accumulations and with problems of heavy metal accumulation in the soil (Ribeiro & Serrão, 1996; Benckiser, 1997). This reduces and changes the composition of the microfauna, hampering soil metabolism and reducing degradation of pesticides (Benckiser, 1997). Such residues can also inhibit clover-Rhizobium for many years following application (AFRC, 1990). In addition, the persistence and effects on soil microfauna of genetically manipulated microorganisms introduced with sewage could have severe environmental impacts, but this issue is poorly understood (Bamford, 1997; Benckiser, 1997). However, sludge cake applications supplying 250 kg/ha total N will typically provide about 4 t/ha of organic matter, and liquid sludge about 3 t/ha, to the soil, reducing erosion risk and increasing moisture retention (Chamber, 1998).

In the Netherlands approximately 25% of arable fields have high phosphate levels (RIVM, 1998) and 50% of applied phosphate is accumulated in the soil (CBS, 1997). Surplus nitrate is lost through runoff and denitrification.

In the Iberian Peninsula soil nutrients have become severely depleted since the beginning of the century following the adoption of cropping systems using little or no manure or fertiliser (Esselink & Vangilis, 1994), contributing to wide scale abandonment.

2.1.3 Pesticides and heavy metals

Pesticide use has been encouraged by increasing levels of support since the introduction of CAP regimes in 1971. Pesticides can influence soil structure and nutrient status through their action on soil fauna and flora, while some pesticides are themselves degraded by soil fauna (AFRC, 1990), with degradation rates varying both within and between active ingredients (Table 2.2). Although most herbicides are not toxic to soil fauna (Bamford, 1997), those that are include the triazines such as atrazine (Edwards, 1984). However, Edwards (1984) suggests that herbicides can indirectly reduce soil organic matter and the organisms associated with it by preventing the growth and eventual decay of weeds within the crop.

Insecticides have a greater effect on soil fauna (Bamford, 1997). Organophosphates have been shown to change the ratio of predatory mites to springtails, while carbamates are more persistent and have more broad-spectrum toxic and sublethal effects on soil organisms, including earthworms (Edwards, 1984; Makeschin, 1997). Of three pesticides tested by Krogh (1994) (pirimicarb, fenpropimorph and dimethoate), dimethoate was toxic to most soil fauna and Samsoe-Petersen et al. (1992) found that methiocarb was toxic to beetles (many of which perform a beneficial role) and deactivated earthworms. Metaldehyde had a lesser effect. Benzimidazole fungicides have also been shown to be toxic to earthworms and soil arthropods (Edwards, 1984).

In the Netherlands 123,000 kg of pesticide (active ingredient) reaches the soil in arable fields, mainly via droplet drift (MJP-G, 1997). On many arable fields the concentrations of heavy metals in the soil are higher than the target value (Dutch environmental standard) (CBS, 1997). Heavy metal residues (copper, cadmium and zinc) from artificial and natural fertiliser result in accumulation in the soil in some places (RIVM, 1998).

Contamination of soils by pesticides, heavy metals and nutrients in Spain varies with soil type, crop type and management practices, being highest under intensive irrigated systems (de la Rosa & Crompvoets, 1998). Copper-based fungicides have long been used in vineyards and Dias & Soveral-Dias, (1997) reported high levels of soil contamination by copper in ground previously occupied by vines and converted to arable use, with highest levels in soil from older vineyards. Copper is little used in arable systems, with the exception of organically grown potatoes, where it is recognised as a potential long-term environmental problem (Redman, 1992).

Table 2.2. Pesticide degradation rates in soil (data supplied by Pesticides Safety Directorate, York, UK.; F. Hutson, personal communication)

Active Ingredient	**Situation**	**Days (DT_{50})**	**Mean days**	**Source**
Atrazine	(laboratory)	41-146	81	EU Review
	(field)	5-60	29	EU Review
Isoproturon	(laboratory)	10-20		UK Review
	(field)	13-25		UK Review
Pirimicarb	(laboratory)	10-263		UK Review
	(field)	15-21		UK Review
Dimethoate	(laboratory)	4-16		UK Review
Metaldehyde	(laboratory)	1-7 (German soils)		UK Review
	(laboratory)	67-166 (US soils)		UK Review
Carbendazim	(laboratory)	20-365		EU Review
	(field)	100-180		EU Review

DT_{50} - time for 50% loss; half-life

2.2 Water

The impact of arable farming on water is closely related to that on soils as nutrient and pesticide pollution of water results from surface runoff and subsurface flow, often associated with soil particles which themselves have economic and ecological impacts. Nitrates and some pesticides also enter groundwater following leaching from arable land. Greatest impacts are associated with simplified, high input arable systems.

Large volumes of water are used annually in some regions for the irrigation of arable crops. The areas of crops irrigated in England, and the volumes of water used are given in Table 2.3 for 1995 (the most recent year for which data are available; MAFF, 1997). Watercourses and boreholes provide most of the water, with the greatest proportion being abstracted in the summer (Table 2.4). Although the proportion of total water use attributable to agriculture is relatively small, the fact that most of this water is used in the summer means that ecological impact can be considerable. There is in any case increasing concern about the sustainability of water use in England (Environment Agency, 1999). The problem is more accute in southern Europe where over-exploitation of groundwater for agriculture can lead to a decline in the quality and quantity of water, an increase in the economic cost, and an increase in water table depth (e.g. López-Bermúdez, 1998).

Table 2.3. Areas of irrigated arable crops in England in 1995 and the volume of water applied.

	Irrigated area (ha)	Volume of water applied (m^3)
Potatoes	62,110	83,800
Sugar beet	26,830	21,290
Cereals	13,440	5,620
Other crops grown in open	8,930	10,990

Table 2.4. Volume of water abstracted in England for agricultural use in 1995 by source.

	Summer		Winter	
	Volume	%	Volume	%
Total abstracted	148,310	90	15,760	10
Watercourse	66,470	40	10,290	6
Spring	3,860	2	670	0
Well	4,040	3	110	0
Deep borehole	52,730	32	980	1
Pond or lake	10.520	6	2,370	1
Mineral working	1,660	1	110	0
Public supply	4,160	2	280	0
Other source	4,930	3	960	1

Arable inputs such as pesticides and nutrients can enter ground and surface waters, seriously affecting the quality of drinking water, and the cost of its treatment. Their presence in surface water also can have serious consequences for aquatic life. Erosion of arable soils results in sedimentation of watercourses and deterioration in the quality of water and aquatic ecosystems. Economic support under CAP regimes for intensification of arable systems has increased the arable area, field sizes and fertiliser use, resulting in a deterioration in the quality of aquatic environments.

2.2.1 Nutrients

Nutrient pollutants from arable farming comprise mainly nitrogen and phosphate which reach water courses from the soil by leaching, surface run-off, sub-surface flow and soil erosion. Nitrate is soluble and enters water via leaching and run-off while phosphate molecules bind to eroded soil particles and enter water courses as run-off. Both nutrients can cause severe eutrophication of water, nitrates affecting mainly coastal waters such as the North Sea (Baldock *et al*., 1996) and Baltic (Saull, 1990) and phosphates affecting rivers and lakes, including those of conservation importance (e.g. Slapton Ley (Devon, England) (Tytherleigh, 1997). Eutrophication in both coastal and inland waters can result, through excessive growth of phytoplankton, in depletion of oxygen from water bodies, and subsequent death of fish and other aquatic animals. Blue-green algae associated with eutrophication produce toxins to which fish and terrestrial animals are susceptible. Changes in the composition of aquatic fauna resulting from eutrophication are to the detriment of species with high oxygen requirements and the invertebrate community becomes less diverse. Eutrophication of inland waters, as well as coastal waters, is an international problem. For example, discharge of phosphates from Spanish arable and industrial sources into the Guadiana river have resulted in phosphate concentrations of up to 5.36 mg/L and excessive growth of the water fern, *Azolla* in the Portuguese section of the river (Carrapi *et al*., 1996).

In Scotland eutrophication and changes in the fauna and flora of Loch Leven have been associated with high levels of phosphate derived from farmland (Castle *et al*., 1999). For Loch Leven in 1992, summer algal blooms were estimated to have cost the area up to £783,000 in lost business, and increased production costs to the downstream industries by £160,000 (Castle *et al*., 1999).

For the water supply industry, algal growth can result in blocked filters, reducing the efficiency and increasing the cost of cleaning drinking water (Evans, 1996). Such costs are rarely quantified (Harper, 1992), but the annual cost in 1982 of nitrate removal in the UK, including blending of sources, ion-exchange, and fertiliser use restrictions, were put at £10 million to £80 million (Anon, 1983 cited in Harper, 1992). Additional costs of removing algal growths resulting from eutrophication could be considerable (Magarara & Kunikane, 1986). The total U.K. costs of achieving the 50 mg NO_3 l^{-1} standard have been estimated at £199 M over the next 20 years Skinner *et al*., 1997). Pretty (1990) puts the cost of fertiliser use to U.K. water consumers at £3.70 per ha of farmland. Kraemer & Kahlenborn (1998) claim that encouraging farmers in Munich to adopt organic farming protects groundwater from nitrate leaching and (at DM 1 million) is cheaper than removing nitrates from drinking water.

Nitrates are particularly prone to leaching during the autumn when nitrate passes through the root zone faster than the crop is able to exploit it, and following ploughing of grassland, when organic nitrogen is mineralised (Young, 1986). Leaching is greater under cereals than under permanent grass (Croll & Hayes, 1988), but can also be high under rotational set-aside (Meissner *et al*., 1998). Drainage of heavy soils increases the rate at which nitrates and phosphates enter surface water (Parkinson, 1993). In a U.K. experiment nitrate lost from direct drilled land was 24% lower than from ploughed land, but still higher than the EC

Drinking Water limit (Skinner *et al*., 1997). The relative contribution to leached nitrate of nitrate from mineralisation of organic nitrogen and that from applied fertiliser is unclear, but the former is known to account for a substantial proportion of nitrate lost from cultivated and uncultivated soils (Addiscott *et al*., 1991; Sylvester-Bradley & Powlson, 1993). Although short-term responses to changes in fertiliser applications to cereal crops have also been reported (NRA, 1992), Addiscott et al., (1991) reported that only 6% of labelled fertiliser nitrogen applied to winter wheat was lost directly by leaching, and ploughing of grassland in the 1940s and 1950s is thought to have contributed to current high levels of nitrate in groundwater (Johnston, 1993).

Nitrates in potable water are limited by the EU Drinking Water Directive to 50 mg/l because of risks to human health such as methaemoglobinaemia (blue baby syndrome) (Cartwright *et al*., 1991) and gastric cancer resulting from nitrosamines (Skinner *et al*., 1997), but strong evidence for these is lacking. Within the UK water in many aquifers and surface waters exceeds the statutory limit for nitrates while in others nitrate levels have declined following changes in the management of arable crops (NRA, 1992). Nitrate levels remain highest in the south and east of England where rainfall and therefore dilution of nitrates, is lowest. The period between leaching and appearance in the saturated zone of the aquifer depends on geology and can exceed 40 years on sandstone and chalk but is considerably less than this on more pervious rocks such as limestone.

In the Netherlands application of nitrogen and phosphates to arable crops in the form of artificial fertiliser, manure and slurry has stayed more or less on the same (high) level in recent years (LEI-DLO, 1997). The total loss of nutrients to ground- and surface-water is declining but the critical load for groundwater nitrogen is still exceeded in large parts of the Netherlands and phosphate and nitrate concentrations in most large surface waters are still higher than the maximal tolerable concentrations (MTCs) (RIVM, 1998). The Dutch agricultural sector is responsible for approximately 64% of the N-load in surface waters, and 38% of the P-load (NMP-3, 1998). Legislation to control application rates, methods and timing, aims to reduce these environmental impacts. Other parts of Europe where similar problems occur include much of southern England, low-lying areas of Belgium and France, parts of Germany and the northern plains of Italy, but the greatest impact is often derived from intensive livestock, rather than arable systems (Gardner, 1996).

Phosphates enter surface water following periods of rain, when soil particles are eroded from exposed soil, especially where fields on slopes are ploughed. Phosphorus may enter water by surface runoff or by sub-surface flow through soil cracks and drains, and may be in the form of dissolved P or adsorbed to soil particles. Losses are greatest during storm events when transport through the soil is too fast for P to become adsorbed to stable particles within the soil. For example, Heathwaite (1997) recorded that particulate P formed the bulk of total P from sub-surface flow following a storm event. Readily drained sandy soils, and clay soils prone to cracking, especially those with field drains, are the most prone to loss of P in both dissolved and particulate form (Heathwaite, 1997). In Denmark, Kronvang (1990) found that 60% of annual P fluxes consisted of particulate P, with 70-90% resulting from short-term storm events. Studies in the UK suggest that farming is a major contributor of phosphates to surface water and that outputs from both agricultural and sewage treatment sources must be reduced if limiting levels of phosphate in water are not to be exceeded

(Johnes & O'Sullivan, 1989). Phosphate levels in water can also be influenced by the incorporation of pigs into arable systems, as exposed soil can increase loss of phosphate-laden particles and slurry can enter surface water.

Rates of nitrogen and phosphate fertiliser application to crops in Portugal are considerably lower than those in northern Europe and nitrate levels in water are generally not a serious problem (de Sequeira, 1991; Ribeiro & Serrão, 1996). Eutrophication of inland waters is rare, but phosphorus accumulation can occur where sedimentation results from erosion of arable land (Soveral-Dias & Sequeira, 1992). Where intensively managed crops such as maize are grown (e.g. in the Ribatejo region (Ribeiro and Serrão (1996)) applications of 300 kg N and 140 kg P_2O_5 per hectare are common (Soveral-Dias & Sequeira, 1992). Here, levels of nitrate in groundwater have been found to exceed maximum acceptable concentrations defined by the European Community, with highest concentrations reflecting timing of crop irrigation (Cerejeira & Silva-Fernandes, 1995). Similar cases have been reported from the mainly horticultural regions of Algarve (Ribeiro and Serrão (1996) where saline intrusion is an additional problem.

Under Regulation 2078/92 some measures have been taken to reduce loss of nutrients from arable land to water, including in the UK, Nitrate Sensitive Areas and the Habitat Scheme, of which the latter makes provision for the establishment of riparian 'Buffer Zones' (Tytherleigh, 1997).

2.2.2 Pesticides and heavy metals

At least 40 pesticides have been found to be present in European ground or surface water at a concentration of at least 0.1 µg/litre, exceeding maximum admissible concentrations stipulated by the EC Drinking Water Directive (CEC, 1992). Pesticides enter surface water from point source contamination following spillage incidents (e.g. Anon, 1999a), and from diffuse sources following their application to crops. They can be toxic to aquatic organisms and some are potentially carcinogenic (Cartwright *et al*., 1991). Pesticides classed as List I under the EC Dangerous Substances Directive (76/464/EEC) are expected to be eliminated from groundwater under the EC Groundwater Directive (80/68/EEC), while those classed as List II are to be reduced. While 70% of the EU's drinking water is derived from groundwater sources, maximum permitted levels for pesticides are well below drinking water standards so as to reduce damage to aquatic invertebrate communities (Cartwright *et al*., 1991).

The presence of pesticides as pollutants of water depends on their mobility, solubility and rate of degradation. Highly persistent organochlorine pesticides are no longer used in arable systems, reducing the risks of pollution incidents resulting from arable operations. However, many modern pesticides are supplied in high concentrations of active ingredient and there is a high risk of pollution incidents resulting from spillages, inappropriate disposal and washing of sprayers.

Diffuse pollution of water by pesticides results mainly from surface run-off following spraying, rather than from pesticides entering aquifers. Isoproturon (IPU) is the most widely used herbicide in the UK and known to be susceptible to entering surface waters via runoff and movement through soil cracks (White & Hillier, 1997). In a Cambridgeshire (UK) study, levels of mecoprop and other herbicides were highest at times of high river flow (Hennings *et al*., 1990; *Clark et al*., 1991). These pesticides were carried in solution, rather than associated with particulates. Evans (1996) cites one study in which pesticide levels were up to 680 times higher during flood than under normal flow conditions. Croll (1988) found mecoprop in 35% of surface water samples from the English Anglian Region, with lindane and dimethoate (insecticides toxic to aquatic invertebrates) present in 16% and 14% respectively. Atrazine and simazine were the most frequently occurring pesticides (58% and 42% respectively) but these herbicides are extensively used in Britain by users other than arable farmers and the rate at which they enter leached or surface water varies with soil type, climate and cultivation methods (Hall *et al*., 1991). In a wider survey of 3500 sites in England and Wales, 100 of the 120 pesticides targeted were detected and five herbicides (atrazine, diuron, bentazone, isoproturon and mecoprop) regularly exceeded EC Drinking Water Directive limits (NRA, 1995). Pesticide application is associated with considerable costs to society in terms of water treatment. Pretty (1990) puts the cost to U.K. water consumers of pesticide application at between £19.39 and £22.10 per ha of farmland.

In the Po Valley of Northern Italy use of the herbicides atrazine and molinate on irrigated rice and maize over permeable gravel aquifers has resulted in the presence of these pesticides in the groundwater (Cartwright *et al*., 1991). For dryland crops drainage can increase movement of pesticides from field to surface water, by-passing the soil profile where such pesticides might otherwise be degraded (Cartwright *et al*., 1991).

In the Netherlands large quantities of pesticide reach ground and surface water as a result of drift, evaporation and runoff. In 1995, 46,000 kg (active ingredient) of pesticides (approximately 0.3% of estimated amount used) entered surface water by runoff, drift and rinsing of machines etc. 123,000 kg (active ingredient) was estimated to reach the soil *outside arable fields*, of which 26,000 kg entered groundwater by leaching. In a Dutch survey of large surface waters, all contained pesticides. For approximately 25% of the substances, the concentrations exceeded the MTC (RIZA, 1996). Some pesticides are found in groundwater in concentrations above EU standards for drinking water (CBS, 1997). Heavy metals have also been reported from groundwater below arable fields (CBS, 1997).

Rates of pesticide application to cereal crops in Portugal are generally considerably lower than those in northern Europe and pesticide levels in water are probably not a serious problem in most catchments. However, where intensively managed crops such as maize are grown, levels of atrazine in groundwater have been found to exceed MTC, with highest concentrations occurring following crop irrigation (Cerejeira *et al*., 1995). Nitrate levels are also high at this site and there is concern over the potential toxic effects of N-nitrosoatrazine which may be formed in the human stomach after joint ingestion of the two substances (Cerejeira *et al*., 1995).

In parts of north-east Europe levels of aluminium and heavy metal ions in soils are high, and acid rain resulting from industry and transport pollution to the air can cause increasing solubility and mobilisation of these metals, and their subsequent occurrence in groundwater (Bouma et al., 1998; Kraemer & Kahlenborn, 1998).

2.2.3 Cultivation

Soil erosion has increasing environmental consequences for aquatic habitats as well as for the soil itself. Preparing autumn seedbeds and late harvesting of crops such as maize, potatoes and sugar beet contribute to high silt loads in stream and rivers. However, early ploughing of rape residues can lead to high levels of nitrogen leaching (Powlson & Davies, 1993). Loss of soil to watercourses is greatest on sandy soils where infiltration capacity has been reduced by surface capping, and on clay soils where surface runoff is also high. Sub-soil fissures in clay soils during dry weather can lead to rapid movement of water and clay particles during subsequent rains. Subsoiling, mole ploughing and other drainage practices operate in a similar way, increasing movement of soil-derived sediment into watercourses and bypassing the natural filtering effect of undrained soils. Continuous cultivation of arable crops and removal of hedges are thought to have contributed to increased silt loads in British rivers (Skinner & Chambers, 1996). The associated economic costs could be considerable. In Britain, Evans (1996) estimated the annual cost of removing soil-derived impurities from drinking water at £3.6 - £30 million.

In Britain, ecological impacts of sedimentation in watercourses are best documented for salmonids (Theurer *et al*., 1998) but also affect other aquatic organisms and macrophytes. Salmonid eggs require a period of 60 – 180 days in gravel ‘redds’ on the river bed. Sedimentation into redds during this period rapidly reduces dissolved oxygen available in the water with the result that developing embryos are killed. This is thought to have been a major factor in the decline in numbers of economically important salmonids in British waters and to be closely linked with arable, rather than grassland systems. In the River Test (Hampshire, England), hatching rates of fry from redds in a section of the river fed by grassland streams was substantially higher than that where the river was fed by streams flowing through arable land (Anon, 1999b).

In Portugal, cultivation of arable land in autumn coincides with the main rainfall period. Rainfall is erratic and discharge of water into rivers, and erosion of soil, can be high during rainfall events (Bergkamp *et al*., 1997). Sedimentation of reservoirs can be considerable, reducing their capacity for water storage. D’Araújo (1974/6) reported sedimentation rates in an Alentejo reservoir, from a primarily arable catchment, of approximately 3.5 t/ha/yr. Annual rainfall has been declining since the 1930s (Bergkamp *et al*., 1997) with a decline in spring rainfall over the past decade (Bettencourt, 1999) and sedimentation in streams and rivers could be higher now than in the past. There appears to be no documentation of the impact of silt loads on aquatic life in Portugal.

Table 2.5. Positive and negative impacts of spring and autumn sowing of cereals in northern Europe.

	SPRING SOWING		AUTUMN SOWING	
	Positive	Negative	Positive	Negative
Soil	Uncultivated soil over winter is less susceptible to erosion, especially where crops are undersown.	Erosion is higher than autumn sowing if cultivation takes place, but lower if stubble left.	Erosion and nitrate leaching lower than bare plough (but higher than grass ley).	Loss of silt, phosphate and pesticides associated with erosion.
Water		Nitrate leaching can be high unless cover crops, undersowing or stubble regeneration are adopted.	Nitrate leaching similar to winter cover crop.	
Biodiversity	Often associated with cereal stubbles which provide food for birds in winter. Spring cultivation encourages rare spring-germinating arable plants. Lower herbicide use permits development of arable flora ecosystem. Compatible with undersowing which enables soil-dwelling invertebrates to over-winter.			Lower value for wildlife.

2.3 Biodiversity

Low intensity arable systems have evolved a characteristic and diverse fauna and flora. However, development of high input, simplified arable systems has been associated with a decline in biodiversity in arable ecosystems. Arable intensification has resulted in loss of non-crop habitats and simplification of plant and animal communities within crops, with consequent disruption to food chains and declines in many farmland species. Abandonment of arable management has also led to the replacement of such wildlife with more common and widespread species.

CAP regimes for arable crops since 1971 have coincided with the simplification of cropping systems, increased fertiliser and pesticide use, and the introduction of irrigation & drainage. Simplification of cropping systems results in reduced crop diversity and loss of non-crop habitats such as grassland, field boundaries, water-courses and trees, all of which can form an integral component of arable systems. These, and the loss of livestock from arable systems, have contributed to a decline in biodiversity. Within the cropping system, increased application of fertilisers and pesticides, often accompanying drainage and irrigation, has caused substantial damage to arable ecosystems, with consequent implications for biodiversity.

Birds provide good indicators of environmental change as they easily monitored, well researched, long-lived and high in the food chain (Furness & Greenwood, 1997). They can be relatively resistant to changes, for example in the supply of invertebrate food, although this is not universally true (Brickle & Harper, 1999). Changes in biodiversity are best quantified for birds. For example, percentage declines over 25 years in UK populations given by Crick *et al*. (1997) are grey partridge (86%), lapwing (55%), turtle dove (69%), skylark (62%), yellow wagtail (74%), song thrush (56%), tree sparrow (95%), reed bunting (60%) and corn bunting (80%). Similar declines in farmland species have been experienced across Europe, with 42% of declining species being affected by agricultural intensification (Tucker & Heath, 1994, Table 2.6). Such severe declines are not occurring for species associated with other habitats (figure 2.1) (Gibbons *et al*., 1993; Crick *et al*., 1997).

Of all European farmland species, specific causes are best demonstrated for grey partridge in Britain (Potts, 1986). For this species, reduced availability of invertebrates which form a key component of chick diet, has been identified as pivotal in population declines. Nestling survival of corn buntings, another severely declining species, has also been shown to be strongly related to invertebrate abundance, especially Symphyta and Lepidoptera (Brickle & Harper, in press), which occur at highest densities in relatively low-input arable systems incorporating undersown leys (Aebischer & Ward, 1997). This species is also strongly associated with low input arable systems in Portugal (Stoate *et al*, in press).

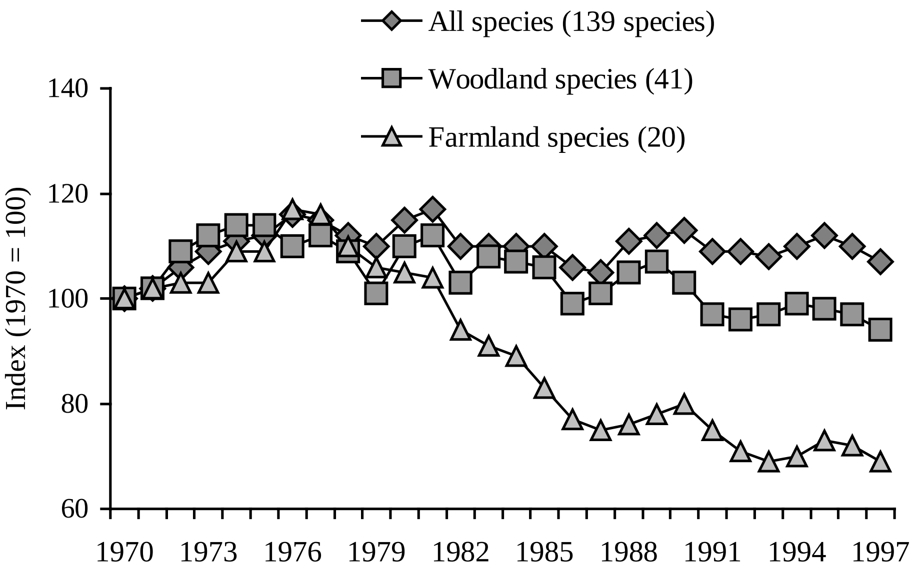

Figure 2.1 Changes in populations of farmland birds in the UK, compared with woodland species and all species. Source: "Sustainability Counts"[11]

In a report commissionsed by JNCC (1999), research carried out by The Game Conservancy Trust showed that the invertebrate groups which act as food for partridges and buntings are negatively related to insecticide use (especially spring and summer use), and some to fungicide use, especially Araneae and Opiliones. In addition, all five groups studied showed a decrease after insecticide use in the previous year, independently of crop type. Host-plants for phytophagous invertebrates are negatively related to dicotyledon-specific herbicide use. Contact-acting herbicides were linked more with the absence of weed taxa than herbicides with other modes of action. A decrease in weed abundance was linked particularly to the use of herbicides in spring and summer.

Agri-environmental measures introduced under Reg. 2078/92 have attempted to alleviate some of these adverse consequences of arable intensification. For example, in England the Countryside Stewardship Scheme provides opportunities to restore field boundary habitats, reduce pesticide inputs and maintain cereal stubbles through the winter, thereby improving breeding habitats, foraging habitats and winter food supplies for birds. Within a pilot Arable Stewardship Scheme additional opportunities exist for planting crop mixtures specifically designed for wildlife. Such incentives are intended to replace previously widespread arable habitats that have been lost through changes in cultivation, cropping patterns and arable inputs. Set-aside has been associated with some conservation benefits for birds (Wilson *et al*., 1995) but such benefits are well below those possible under more appropriate

[1] "*Sustainability Counts* and the populations of wild bird graph (DETR) are Crown copyright, reproduced with the permission of the Controller of Her Majesty's Stationary Office

management, as agricultural priorities have determined the management of set-aside (Winter & Gaskell, 1998).

Table 2.6. Changes in local populations of birds associated with arable environments (1970-1990) (Tucker & Heath, 1994). Species of global conservation concern are in bold.

ENGLISH NAME	SCIENTIFIC NAME	% POPULATIONS IN DECLINE	% POPULATIONS IN RAPID DECLINE
White Stork	*Ciconia ciconia*	52	38
Lesser Kestrel	***Falco naumanni***	**99**	**73**
Red-legged Partridge	*Alectoris rufa*	96	0
Grey Partridge	*Perdix perdix*	99	37
Quail	*Coturnix coturnix*	64	50
Crane	*Grus grus*	72	0
Great Bustard	***Otis tarda***	**61**	**5**
Little Bustard	*Tetrax tetrax*	80	6
Stone Curlew	*Burhinus oedicnemus*	74	1
Collared Pratincole	*Glareola pratincloa*	75	5
Black-bellied Sandgrouse	*Pterocles orientalis*	100	99
Pin-tailed Sandgrouse	*Pterocles alchata*	100	98
Short-toed Lark	*Calandrella brachydactyla*	90	0
Lesser Short-toed Lark	*Calandrella rufescens*	72	0
Thekla Lark	*Galerida theklae*	99	0
Woodlark	*Lullula arborea*	75	0
Skylark	*Alauda arvensis*	69	19
Tawny Pipit	*Anthus campetris*	86	0
Ortolan Bunting	*Emberiza hortulana*	49	41

2.3.1 Cultivation and crop rotation

Cropping systems have been simplified and become geographically polarised in Britain and The Netherlands (de Boer & Reyrink, 1989), with major consequences for biodiversity on farmland. High crop diversity is necessary to the ecological requirements of many species. For example, brown hares graze different crops at different times of year (Tapper & Barnes, 1986), while skylarks move breeding territories from one crop to another through the breeding season (Wilson *et al*., 1997), and yellowhammers switch from one crop to another as foraging habitats during the breeding season (Stoate *et al*., 1998). Lapwings require cereals in which to nest and adjacent pasture on which to feed newly hatched young (Tucker *et al*., 1994) while little bustard males and females have different habitat requirements during the breeding season (Salamolard & Moreau, 1999). As well as this, inter-species differences in habitat requirements result in higher numbers of species in landscapes with low intensity farming and high crop and structural diversity, as demonstrated for the Alentejo region of Portugal by Araújo, et al. (1996). Monitoring of a Zonal Programme introduced to this region under 2078/92 suggests that this measure is maintaining bird species diversity (Borralho *et al*., 1999).

Simplification of cropping systems in both northern and southern Europe has therefore had a negative effect on biodiversity. In Britain, geographical polarisation of arable and livestock farming has reduced the number of farms with high crop diversity. Pastures grazed by livestock are associated with large numbers of invertebrates which provide food for birds and other animals, and livestock feed sites in winter provide a source of food for seed-eating birds. The loss of livestock from farms in eastern Britain has removed these components from the arable landscape. Recent changes in the profitability of arable farming, relative to that of livestock, has resulted in conversion of former grassland to arable crops in other parts of the UK (Winter & Gaskell, 1998). For example, the grassland area in the English county of Leicestershire declined from 44% to 32% between 1969 and 1993, with arable grass leys declining from 13% to 9% over the same period (Loveland, 1999).

Intensification of grassland management and conversion of grass to arable cultivation resulted in a 92% decline in the area of 'unimproved' grassland in the UK between the 1930s and 1980s (Fuller, 1987), with a consequent decline in biodiversity, especially that of plants and invertebrates associated with semi-natural grasslands (Green, 1990). In the Netherlands, plants and invertebrates (especially dragonflies and butterflies) associated with semi-natural grassland and forest edges are also declining (IKC-NBLF, 1994) and desiccation of grasslands has resulted in declines of wading birds (Klumpers & Haartsen, 1998; Reyrink, 1989). Newbold (1989) reported losses or serious damage to 80% of British calcareous grassland between 1949 and 1984. Loss of diverse grassland ecosystems to arable crops in the UK has continued since then. Flax crops qualify for subsidies even when grown on land which is not eligible for arable area payments, and these subsidies exceed the value of payments for protection of grassland habitats. Previously uncultivated land is currently being lost to potato production, as disease-free and pesticide-free land is often required for this crop (CPRE, 1999). Production of potatoes is discouraged on arable land as this crop is not eligible for area payments.

Ironically, replacement of arable crops with grassland in order to limit cereal production and soil erosion and improve botanical composition in the South Downs ESA (England) had an adverse effect on skylarks and their food (Wakeham-Dawson *et al.*, 1998). In this study skylark breeding density was higher on arable, non-ESA fields than on those in the scheme, and grazing intensity was also often too high within ESA grassland for optimum availability of invertebrates. In winter, skylarks foraged mainly on cereal stubbles, reflecting the availability of broad-leaved weed seeds (Wakeham-Dawson & Aebischer, 1998).

In Portugal and other parts of southern Europe livestock plays an important ecological role in arable systems by grazing fallows and influencing their botanical and invertebrate composition. In particular, fallow periods of several years provide relatively stable habitats which contribute to the maintenance of plants, invertebrates and birds characteristic of steppic arable systems in Portugal (Beaufoy *et al*., 1994; Araújo, *et al*., 1996; Moreira & Leitão, 1996). The recently disturbed soil associated with first year fallow represents an important foraging habitat for many seed-eating birds in winter (Diaz & Telleria, 1994). Fallow periods vary with soil type, and this disparity has increased since the 1970s.

Intensification of arable cropping on the best soils has led to the complete abandonment of fallows, while cultivation has been abandoned in the least fertile areas. In the latter, the loss of crops and encroachment of scrub have resulted in the loss of fauna associated with the extensive arable landscapes, and in frequent cases land use converts to forestry (mainly *Pinus*) with financial support through EU regulation 2080/92. The area of Portuguese arable land converted to forestry under this regulation between 1994 and 1998 amounted to 138,715 ha (Portuguese Ministry of Agriculture, unpublished data). **Such abandonment and changes in land use are currently probably a greater threat to biodiversity of arable systems in southern Europe than the risk of intensification.**

Steppic arable landscapes support many of the most threatened species, and are therefore critical for maintaining species diversity at the national and European level. Such species include the globally threatened bird species, great bustard and lesser kestrel as well as many others of current conservation concern in Europe (Tucker & Heath, 1994). The loss of fallows and other consequences of arable intensification are a direct threat to these species (Peris *et al*., 1992). However, at the local level bird species diversity is higher in lightly wooded Montado (Portugal) and Dehesa (Spain) in which holm oak and cork oak have traditionally been managed as part of the arable system. This habitat has been threatened by wheat-growing campaigns (especially in Portugal) since the 1930s, increased mechanisation, reduced regeneration of trees due to increased livestock densities, and reduced demand for tree products (Yellachich, 1993; Diáz *et al*., 1997). Increasing use of plastic ‘corks’ in wine bottles could potentially damage the market for natural cork.

Livestock densities have also increased in steppic arable landscapes, resulting in destruction of the vegetation used by invertebrates and birds associated with fallows. Such stocking densities have been encouraged by headage payments on sheep and cattle, and by increased labour costs leading to replacement of traditional herders by wire fences. In some parts of Spain the loss of the predator control role of herders has resulted in unsustainable levels of nest predation for scarce breeding lark species (Suárez *et al*., 1993). Higher stocking densities on arable fallows are likely to reduce the Orthopteran food of bustards and other already threatened species (van Wingerden *et al*., 1997). Such livestock densities could also increase the area of cereals grown for fodder rather than grain.

Timing of the management of crops can also influence their suitability to invertebrate and bird species. Lapwings and skylarks breeding in northern Europe favour spring-sown cereals, in part because of their structure and less intensive management (Tucker *et al*., 1994; Odderskær *et al*., 1997). In Britain, spring-sown cereals are also historically associated with undersowing of grass leys, a management practice that encourages sawflies which over-winter as pupae in the undisturbed soil and whose larvae provide an important food sources for breeding birds such as grey partridge, skylark and corn bunting (JNCC, 1999). In Sussex (England) the distribution of breeding partridges and corn buntings is closely related to that of undersown arable leys (Potts, 1997; Aebischer & Ward, 1997) and availability of invertebrates such as sawflies is related to productivity of these species (Potts,1997; Brickle & Harper, in press).

Spring sowing on light soils in Britain is traditionally associated with the survival of cereal stubbles into the winter, thereby providing a food source for seed-eating birds. Modern machinery permits rapid harvesting and ploughing of land for subsequent crops, with the result that stubbles now remain available to wildlife for a very short period. This loss of stubbles has been associated with declines in numbers of many finches and buntings in northern Europe (Fuller *et al*., 1995). In the Netherlands the near extinction of hamsters is thought to be due to the short period in which this species may gather grain before hibernation (van Oorschot & van Mansvelt, 1998). Changes from spring- to autumn-sowing are also thought to have contributed to declines in many formerly common spring-germinating arable plants such as corn marigold and night-flowering catchfly (Wilson, 1994). Botanical composition of arable crops is also influenced by cultivation methods, with ploughing encouraging broad-leaved species which are important invertebrate and bird food, and minimal tillage encouraging grass weeds and cleavers.

Cultivation methods can also affect the composition of invertebrate communities in arable ecosystems. Ploughing is the most destructive, affecting invertebrate populations through physical destruction, desiccation, depletion of food and increased exposure to predators. Large carabid beetles are often more abundant in ploughed fields than minimal cultivation, with smaller species being more numerous in the latter (Baguette & Hance, 1997; Cárcamo, 1995), but these findings are not consistent across studies (Kendall *et al*., 1995). Effects of tillage methods on arthropods are currently the subject of research in Britain. Little is also known about the effects of minimal tillage on vertebrates, although Belmonte (1993) suggests that such methods might be beneficial to some birds in Spain.

2.3.2 Fertilisers

Modern crop varieties grow vigorously under high rates of fertiliser application, out-competing other arable plants, and increases in the use of fertilisers have contributed to a change in the arable flora (Wilson, 1994). The dense crop structure associated with high levels of fertiliser application is unsuitable for some birds as a habitat for nesting and foraging (Wilson *et al*., 1997). The increased use of mineral fertilisers has also influenced non-crop habitats associated with the arable system. Deposition of fertiliser in perennial vegetation at the field edge has contributed to a change in botanical composition towards annual weeds such as cleavers and barren brome (Boatman *et al*., 1994). Such changes encourage the perception among farmers of field boundaries as a source of weeds, leading to the further destruction of this habitat through deliberate or accidental use of herbicides, ploughing into the field edge, and in many cases complete removal (Boatman, 1989).

2.3.3 Pesticides

Direct effects of pesticides on vertebrates have been greatly reduced since the phasing out of organochlorines, although rodenticides continue to be a problem of secondary poisoning of barn owls in areas of Warfarin resistance (Shawyer, 1987). De Snoo *et al*. (1999) report few poisoning incidents resulting from arable use of pesticides in Europe but suggest that the efficacy of monitoring is uncertain and variable between countries.

Herbicides have continued to erode the arable flora throughout northern Europe, and increasingly, in the south. In Britain Wilson (1994), using 10km squares as sampling units, reported that the arable flora included 25 species that were recorded from fewer than 100 squares, at least 26 that were recorded from fewer than 15, and a further seven that had recently become extinct. Several of the rarest species no longer occur in arable habitats, but for others, the most suitable areas remain the calcareous and sandy soils of south and east England (Wilson, 1994). Similar declines in the arable flora have been reported from Germany (Agra Europe, 1991) and Denmark (Andreasen *et al*., 1996).

In the Netherlands formerly common species such as cuckoo flower, poppy species and cornflower have recently become scarce (Joenje & Kleijn, 1994). Both in Britain and The Netherlands arable flora are highly concentrated in field margins (Wilson, 1994; Joenje & Kleijn, 1994; De Snoo, 1997) where biomass, density and species diversity are reduced by herbicide use (Chiverton & Sotherton, 1991).

The effects of herbicides on vegetation have been demonstrated by various experiments with unsprayed field margins. At various sites in Europe it has been shown that leaving the outer few metres of a crop unsprayed with herbicide can have a positive effect on the presence and abundance of plant species (Schumacher, 1984; Chivertone & Sotherton, 1991; Hald *et al*., 1994; De Snoo, 1997). Also the diversity of adjacent ditch bank vegetation can increase as a result of unsprayed field margins (De Snoo & Van der Poll, 1999). Widespread adoption of set-aside contributes to a reduction in pesticide use on arable land, but an increase in the use of non-selective herbicides (especially glyphosate) which are known to affect field boundary vegetation and associated invertebrate communities (Haughton *et al*., 1999).

Although pesticide use in Portugal is well below that in northern Europe, declines in some arable plants have been reported following herbicide use, coupled with increased fertiliser use and abandonment of fallows (e.g. Évora, Alentejo (Moreira *et al*, 1996a)). Species threatened by such intensification include *Linaria ricardoi* and *Euphorbia transtagana*, both of which are included on the Directive 92/43/CEE (Conservation of natural habitats and wild fauna and flora).

Herbicide use in arable crops is known to have a negative impact on invertebrate abundance and species diversity (Chiverton & Sotherton, 1991; Moreby *et al*., 1994; Moreby, 1997). Direct effects of insecticides are a major influence on invertebrate communities (eg Moreby *et al*., 1994), although the effects differ between species, depending in part on their ecology (Grieg-Smith *et al*., 1992). Some fungicides have also been implicated in influencing invertebrate abundance (Sotherton *et al*., 1987; Reddersen *et al*., 1998).

In an analysis of a long-term monitoring project in Sussex (England) Ewald and Aebischer (1999) report a negative relationship between broad-leaved weed abundance and the use of dicotyledon-specific herbicides, and between grass weeds and broad-spectrum herbicides. Spring and summer use of herbicides was particularly effective at reducing broad-leaved weed abundance. Of the five invertebrate groups studied, all showed a negative relationship between abundance and the use of insecticides, and declines of four of them were associated with fungicide use. Particularly strong effects were noted for the pyrethroid and organophosphate insecticides, but none of the groups showed a negative relationship with use of the more selective insecticide, pirimicarb, suggesting that broad-spectrum insecticides are most damaging to cereal ecosystems. Broad-spectrum insecticides such as dimethoate continue to be the most widely used (Potts, 1997) and can cause substantial damage to populations of beneficial arable invertebrates and honeybees (Greig-Smith *et al*., 1995). Declines in British bumblebees have also been linked to use of arable pesticides (Williams, 1982).

Arable invertebrates are an essential component of the diet of many farmland birds during the breeding season and their decline has been linked most convincingly to the substantial decline in grey partridge numbers in Britain (Potts & Aebischer, 1991). In Sussex, partridge density was inversely related to the number of herbicide applications, and positively related to the number of weed taxa (Ewald & Aebischer, 1999). The abundance of corn buntings and skylarks was also inversely related to herbicide use, and that of corn buntings with fungicide use. All three species have declined substantially throughout their range in northern Europe (Tucker & Heath, 1994; Flade & Steiof, 1990; Fuller et al., 1995) and the Sussex results provide further correlative evidence for the impact of pesticides on the abundance of farmland birds as well as invertebrates.

Treated seeds may also pose a risk to seed-eating birds on arable fields. Even though the most hazardous pesticides have now been banned, small numbers of poisoning incidents continue to be associated with pesticide applications (Cooke, 1988; Hart & Clook, 1995; De Snoo *et al*., 1999).

Current use of herbicides and cropping practices combine to reduce production of weed seeds on arable land (Jones *et al*., 1997), and for some declining farmland seed-eaters a reduction in the area of weedy winter stubbles is thought to have contributed to increased winter mortality (Campbell *et al*., 1997). Where they still occur weedy winter stubbles are strongly favoured as a foraging habitat by finches and buntings such as cirl buntings (Evans & Smith, 1994) and corn buntings (Donald & Evans, 1994).

Herbicide tolerance in genetically modified (GM) arable crops could, in the near future, lead to increased use of very-broad spectrum herbicides, and more complete removal of arable plants and the other wildlife dependent on them. The use of broad-spectrum herbicides on such genetically modified crops could also result in even greater damage to adjacent habitats than is currently the case. There is also the danger that arable weeds could themselves acquire herbicide tolerance through hybridisation with GM crops. Insect resistance in GM crops could reduce the use of insecticides on arable land, with consequent benefits for other wildlife, but the impact of such GM crops on the natural predators of crop pests is not currently well understood. There is currently inadequate information available on the environmental impacts of GM crops.

2.3.4 Drainage and irrigation

Large areas of grassland in northern Europe have been drained for conversion to arable crop production since the 1940s, but remaining wet grassland habitats have also been severely affected by drainage of adjacent arable land (Mountford & Sheail, 1984; Williams &

Bowers, 1987). As a result there have been substantial declines in abundance and diversity of birds, plants and invertebrates associated with wet grassland habitats in northern Europe (de Boer & Reyrink, 1989). Baldock (1990) highlights rapid changes to wet grassland habitats in France resulting from agricultural intensification.

In the Netherlands about 60% of the lowering of water tables is caused by draining of adjacent arable fields (RIVM, 1998). Most agricultural land in the Netherlands is drained to a depth of at least 0.5 metre so that plants requiring a high water table have become rare and replaced by more common species (Baldock *et al*., 1993).

In southern Europe the area of irrigated crops has increased considerably since the 1960s, taking the form of pivot irrigation in formerly dry areas, and flooded rice in low-lying areas (Suárez *et al*., 1997; Fasola & Ruíz, 1997). Pivot irrigation of crops such as maize is associated with increased fertiliser and pesticide applications and the environmental impacts of irrigation are therefore largely those of these inputs, including the loss of fallows in crop rotations. There is some evidence suggesting that electricity pylons installed to provide power for pivot irrigation are associated with increased mortality of large low-flying birds such as great bustard (Tucker, 1997), but the intensification of activity and inputs that are part of irrigated farming play a greater part in the elimination of such species from irrigated arable systems (Yanes, 1994). Drainage for irrigation has resulted directly in the local extinction of arable plants such as *Armeria arcuata* (Moreira et al., 1996b) and subsequent use of herbicides and fertilisers have a wider impact on the arable flora (Moreira et al., 1996a). Intensification associated with irrigation can also reduce invertebrate abundance, although Barranco & Pascual (1992) reported more Orthopteran species in irrigated than dryland cereals in Almeria. Stoate *et al*., (in press) found higher numbers of Orthoptera in Portuguese extensively managed cereals than in intensive systems.

In contrast, rice growing can increase the local diversity of birds and the aquatic invertebrates on which they feed (Fasola & Ruíz, 1997) if pesticide use is not high. Breeding abundance of six species of heron, as well as white stork, is related to area of flooded rice close to their breeding sites, and rice fields and the irrigation channels associated with them are favoured foraging areas in Portugal and elsewhere in southern Europe (Pain, 1994; Coelho, 1998). They can serve a particularly valuable role in the conservation of wetland wildlife, including breeding, wintering and migratory birds, where rice is grown close to estuary habitats, as is the case in the Ebro delta (Spain) (Pain, 1994).

Rice fields are often left dry during the winter, but when flooded to encourage ducks for hunting, they provide important feeding areas for wading birds (Pain, 1994; Fasola & Ruíz, 1997). In winter rice fields form an important part of wetland habitats in the Portuguese Tagus estuary which alone supports more than 20% of the north west Europe breeding population of black-tailed godwit and internationally important numbers of several other wader species (Pain, 1994). Rice fields potentially could be important in maintaining biodiversity in this area as drainage of natural wetlands, industrial occupation of agricultural land and tourism in riparian areas are current environmental threats (Ferriera, 1996). Substantial declines in the rice crop area, and a recent trend towards dry cultivation of rice in southern Europe could reduce the current ecological role of this crop (Fasola & Ruíz, 1997).

In Italy, the member state with the largest rice-growing area, the increasing scale of rice-growing operations has had substantial impacts on rice fields as a habitat for wildlife (Pain, 1994). Fields have been enlarged, reducing the habitat diversity and area of uncropped habitat, and the use of lasers enables farmers to produce level ground, lacking wet patches in which aquatic animals can survive when fields are drained. Such precision equipment also enables rice to be grown in shallower water which reaches higher temperatures and is less suitable for aquatic animals (Pain, 1994).

2.4 Cultural landscapes

Arable landscapes are valued by society beyond the farming community, but increased mechanisation and farm size, and simplification of crop rotations, have led to a reduction in landscape diversity. Non-crop features, as well as features within the cropping system have been lost during the life of the CAP. Traditional landscape features have also been lost through arable abandonment, especially in southern Europe.

Landscape changes throughout Europe have taken the form of a reduction in landscape diversity (Meeus, 1993), with a tendency for the most progressive farmers to create the simplest landscapes (Nassauer & Westmacott, 1987). In Britain, capital grants formerly available under the CAP have resulted in the loss of non-crop features such as hedges and ditches, and the replacement of traditional buildings with modern structures. Barr *et al*. (1993) reported a 1.7% annual rate of hedgerow loss in the 1984-1990 period, but this had reduced to 0.8% pa in the 1990-1993 period when the rate of hedge planting had increased from 0.4% pa to 1% pa. In the regions studied by Westmacott and Worthington (1997) 16,280 km of hedges were removed in the 1983-1994 period, compared with 3,225 km planted. Hedge removal had been greater in the period up to 1983. Field size in the 1983-1994 period increased by 19% in Cambridgeshire, 18% in Somerset and 17% in Warwickshire, but by only 2% in Huntingdonshire. Most recently changes have been more evident in the structure of hedges, resulting from abandonment, than in their removal. Barr *et al*. (1993) reported annual rates of 5.2% of hedges abandoned, compared with 1.3% restored, and perennial field boundary flora, perceived by many to be an attractive landscape feature, have been lost from most arable farms (Boatman, 1989). However, Westmacott and Worthington (1997) found an ‘improvement’ in hedge ‘quality’ in some areas. As with many landscape assessments, perceptions of ‘quality’ are likely to influence reported changes.

With farm amalgamation, farm size has increased and farms have become more specialised in their cropping systems, adopting simpler rotations than in the past. Mixed livestock and arable farms have been greatly reduced in number in many parts of Britain, creating a less diverse landscape. The occurrence of colourful arable weeds such as poppies has been reduced and some are close to extinction (see section 3).

Redman (1992) compared lowland arable landscape features on British organic farms with those on conventionally managed farms. Crop diversity was lower on organic farms and fields were smaller. Hedges were higher and less intensively managed than on conventional farms but of the farmers removing hedges, 43% were organic. However, of farmers actively ‘improving’ (or perceived by themselves or others to be doing so) only 11% were in conventional arable systems. Fifty per cent of conventional farmers claimed to have adopted measures to encourage wildlife, compared to 81% of organic farmers. However, such differences relate more to the attitudes of the farmers themselves than to the type of farming system (Redman, 1992). Chamberlain & Wilson (in press) found similar differences in hedge management between conventional and organic farms, but in their study, crop diversity was higher on organic farms.

In Portugal intensification of arable farming, often associated with the introduction of irrigation has led to the abandonment of fallows, creating a more uniform landscape lacking the flowering plants which are often abundant in fallows and low-input arable crops (Pineda & Montalvo, 1995). Such intensification is also associated with the presence of irrigation pivots and electricity pylons, both of which become prominent features in an otherwise open landscape.

Although once present throughout much of southern Europe, montado and dehesa are now largely confined to Portugal and Spain (Harrison, 1996). In Portugal the montado area has remained relatively stable at the national scale (Direcção-Geral das Florestas, 1998) but arable intensification, especially if accompanied by irrigation can result in the local loss of traditionally managed montado landscapes (Yellachich, 1993). Such an impact is currently anticipated as a result of irrigated agriculture in the area of the Alqueva Dam, a project funded by EC Cohesion Funds (Eden, 1996).

Because montados are a diverse and integrated system involving arable farming, sylviculture and livestock, restriction of current support measures to one component can result in the breakdown of the montado system with consequent damage to landscape features. Livestock headage payments contribute to abandonment of arable cultivation and to overgrazing of swards and the loss of regenerating trees in montados, resulting in an ageing oak tree population structure and susceptibility to disease (Eden, 1996). Another example of loss of habitat diversity through economic support comes from Spain where subsidies for almond cultivation are conditional on no more than 10% of the area being used for another crop (Pretty, 1998).

While intensification of arable farming can result in substantial landscape changes, abandonment has also had considerable consequences. Total abandonment for agriculture results in rapid development of shrub cover with the loss of the diverse flora associated with traditional arable rotations (Correira, 1993). While greater vegetative cover protects soil from erosion, the risk of fire is considerably increased, once again exposing the soil to erosion (Andreu *et al*., 1995). Such abandonment also results in the emigration of rural people, the loss of traditional skills and the deterioration or destruction of traditional farm buildings which themselves form landscape features. Land that ceases to be used for arable cultivation is frequently planted with *Pinus* species for pulp production, creating a uniform landscape which is poor in biodiversity and landscape features.

2.5 Air

Intensification of arable farming has been associated with pollution of air by pesticides, NO_2 and CO_2, while the loss of soil organic matter has reduced the system's ability to buffer the latter. Long distance transport of arable inputs and products associated with international trade also contributes to global warming.

Denitrification within arable systems can result in production of the greenhouse gasses NO and NO_2 (Benckiser, 1997). 70-80% of emitted nitrogen is deposited back onto the land resulting in eutrophication and acidification of some environments (Goulding et al., 1998). Deposition of atmospheric nitrogen can lead to eutrophication and acidification of semi-natural environments, resulting in reduction in botanical species diversity and changes to soil processes, as demonstrated at Rothamsted (UK) by Goulding *et al*. (1998). Similar changes in soil processes and botanical composition resulting from atmospheric nitrogen deposition have been reported in British upland heath and calcareous grassland (Lee & Capron, 1998), and in heathland in The Netherlands (Prins *et al*., 1991).

Soil denitrification varies with crop type, Svensson *et al*. (1991a) reporting higher rates in lucerne than grass, and higher rates in grass than barley, with this process accounting for between half and two thirds of nitrogen lost from the system. However, soil moisture and nitrate levels also influence rates of denitrification (Svensson *et al*., 1991b; Addiscott & Powlsen, 1992) and irrigated crops have been shown to increase NO_2 emissions (Armstrong-Brown *et al*., 1995). An estimated 3.2% of applied N is thought to be lost to the atmosphere as NO_2 (Armstrong-Brown *et al*., 1995).

Pearce & Mackenzie (1999) report increasing concentrations of some pesticides in rainwater in Europe and link these pesticides to an increasing incidence of cancers in Sweden.

In the Netherlands agriculture is responsible for 13% of the emission of greenhouse gasses (mainly CO_2, CH_4 and N_2O), but most is the result of dairy farming (CBS, 1997). Emissions of pesticides to the air are considerable in the Netherlands. Approximately 3.1 million kg (active ingredient) of pesticides were emitted to the air in 1995 (MJP-G, 1995). This is 24% of the total amount of pesticide used, and more than 90% of the total emissions to the environment. This is confirmed by measurements in wet and dry deposition which show concentrations of pesticides (Van Boom, 1993; Province Zuid-Holland, 1994; Hoogheemraadchap van Rijnland, 1993; Van der Pas, 1997).

Long distance transport of arable inputs and products contributes to emission of CO_2 and SO_2 to the atmosphere, contributing to climate change and acid rain and the environmental problems with which they are associated (Bealey et al., 1998). For example organic wheat is regularly imported from as far away as Australia. The agriculture sector world-wide accounts for about 5% of anthropogenic CO_2 emissions (ECAF, n.d.). Cultivation of arable soils is estimated to release 30 Mt yr^{-1} carbon to the atmosphere globally, through oxidation of carbon alone (Armstrong-Brown *et al*., 1995). However, SOM has considerable potential as a carbon sink for CO_2 emitted by arable operations (ECAF, n.d.; Armstrong-Brown *et al*., 1995). Pretty *et al.* (in press) estimates that air pollution and greenhouse gas emmisions arising from agriculture account for 48% of the industry’s externalised costs, even without including pollution associated with long-distance trade.

Table 2.7. Summary of effects of four European arable systems on soil, water, biodiversity, landscape and air

	SOIL				WATER			BIODIVERSITY		LANDSCAPE	AIR
	Erosion	Organic matter	Structure	Soil fauna	Nutrient pollution	Pesticide pollution	Sediment	Terrestrial	Aquatic		
Intensive	Ploughing aggravates erosion	OM levels low & often declining	Compaction common. Plough pans	Fewer worms. Impoverished micro fauna & flora	Pollution from fertilisers – leaching, drains & runoff	Pollution from spray drift, runoff & leaching	Surface erosion & drainage lead to sediment pollution	Simplified crop systems, high fertiliser & pesticide use reduce habitat diversity & food supply	Eutrophication, pesticide pollution & sedimentation	Larger fields, block cropping, less non-cropped land lead to homogeneous landscape	Pesticide pollution. Greater energy use from agrochemical manufacture & application
Organic	Ploughing less frequent unless stockless	Higher OM due to use of leys & organic manures	Leys & manure improve structure	Rotations & manures encourage microbes. No pesticides.	Ploughing of grass releases nitrates. May be aggravated with legumes	Few pesticides used	Surface erosion & drainage lead to sediment pollution	Greater crop & non-crop habitat diversity than intensive. Few pesticides. Mechanical weed control can be detrimental.	Little or no pesticide pollution. Mixed farming system may reduce sediment pollution. Nutrient pollution still occurs.	Mixed farming produces more diverse landscape. Higher proportion of non-crop features.	Low energy use. Possibly greater nitrate mineralisation
Integrated	Reduced cultivations reduce erosion	More OM than intensive?	Reduced cultivation improves soil structure	Reduced cultivation increases worm numbers. Reduced pesticide impact.	Lower, more targeted use of fertiliser reduces pollution	Reduced pesticide use	Reduced cultivations minimise erosion	Higher densities of some invertebrates. Limited evidence for other taxa	Pesticide, nutrient & sediment pollution likely to be reduced	Crop rotation may increase landscape diversity. May include grass margins etc.	Reduced cultivation & agrochemical use may reduce pollution?
Extensive (mainly southern Europe)	Erosion common due to ploughing	OM levels low & often declining	Probably poor	Reduced pesticide impact	Low rates of fertiliser use	Low pesticide impact	Frequent cultivations encourage erosion	Use of fallows & lower fertiliser & pesticide use lead to higher biodiversity and characteristic species not found in other systems	Limited evidence	Flowering plants in crops and fallows. Livestock graze fallows. Oaks actively maintained in some areas	Low energy use. Possibly greater nitrate mineralisation

3. POST-AGENDA 2000: FORECAST OF ARABLE CROP PRODUCTION SYSTEMS AND ENVIRONMENTAL IMPACTS

3.1 Introduction

In this section the study predicts future trends in arable areas, yields, producer numbers and regional concentration for the period 2000-2005. The cropping area forecast is a function of different models, including an evaluation by the University of Bonn using the SPEL/EU-MFSS model at the request of the Directorate-General for Agriculture. Forecasts of other variables are derived from extrapolations of the trends described in Section 1.

3.2 CAP Reform of March 1999

At the end of March 1999 the Heads of State agreed to a reform of the CAP at the European Council in Berlin. The Regulations[2] for the arable crop regimes, published in June 1999, show that the Council agreed to:

- Reduce cereal intervention prices by 15% in two annual steps from 1 July 2000 (to 101 €/t)
- Provide partial compensation with an increase in the cereal aid payment (63 € /t)
- Consider the need for a further reduction in intervention prices in 2002
- Reduce the set-aside aid payment to the cereal rate from 2000 onwards
- Reduce the protein payment to 72.5 €/t from 2000 onwards
- Reduce oilseeds and linseed aid payments over three years to the cereal rate
- Review oilseed prices and payments in 2003
- Set an obligatory Set-aside rate of 10% (in the absence of a Commission proposal varying from 10%)

Heads of State also gave Member States the discretion to:

- Increase the maximum amount of voluntary Set-aside from 50% to up to 100% of a holding
- Make the rules for Set-aside management more flexible to help the environment
- Maintain separate base areas for maize
- Extend arable payments to grass silage crops in Member States where there maize is not a ‘traditional crop’

[2] Council Regulations 1251/99 and 1253/99 published in OJ L160,1-14 & 18-20

3.3 Area effects (Set-aside)

The most significant single variable determining arable areas is the assumption about Set-aside – both compulsory and voluntary. Obligatory Set-aside is expected to remain at 10% in 2000 and in 2001 and voluntary Set-aside is expected to remain at around 0.5 m ha. Under those circumstances the cereal area is anticipated to stay at approximately 37.1 m ha. (European Commission, 1998a)

In 2002 we expect the Commission to take advantage of the provisions in the Berlin agreement to make further proposals to reduce cereal intervention prices by a further 5% or even 10%. In that event the Commission could reduce the compulsory Set-aside back to 0% as proposed initially in March 1998, though under Agenda 2000, set-aside rates are fixed at 10% unless the Commission proposes an alteration to the Council of Ministers. Under that scenario, total area under arable crops would expand by around 7% despite falls in revenue for arable crops. Cereals would be expected to benefit most from this expansion in harvested area with a total increase ranging for 6% to 11% depending on price developments. The proportion of cereal area accounted for by soft wheat is expected to grow while the area under coarse grains will fall. (European Commission, 1998b)

Alternatively, if no further price cuts are adopted at Council, Set-aside might have to climb to 17.5% to mitigate productivity increases while keeping subsidised exports within GATT Uruguay Round (and any WTO Millennium Round) agreements. Under that scenario we would expect the cereal area to reduce to 35.9 m ha.

Most of the models summarised below assume 10% Set-aside in 2000 and 2001 falling to 5% from 2002 onwards. Others have assumed that 10% throughout the period under review. Most assume an increase in voluntary Set-aside of between 300,000 to 700,000 ha.

3.4 Environmental impacts of set-aside area changes

Set-aside has a role to play in the alleviation of environmental impacts of arable farming identified in section 1. The incorporation of voluntary set-aside as a break in arable rotations could maintain levels of nitrate leaching unless set-aside is maintained over many years, when leaching could be reduced. Widespread adoption of voluntary set-aside, especially in southern Europe, could lead to a reduction in erosion and sedimentation of watercourses if vegetation is allowed to develop over a number of years.

Use of voluntary set-aside as a break in arable rotations would add to the diversity of crops available to wildlife, although as with soil conservation, its value would depend on the type of management adopted.

If voluntary set-aside was widely adopted in southern Europe, steppe habitats would be maintained, but the cereals that provide an important habitat for many endangered species would be lost, with severe detrimental consequences for European biodiversity, unless such set-aside is managed with environmental objectives. However, there are currently no indications that the voluntary set-aside area is likely to increase.

3.5 Model Forecasts

3.5.1 SPEL/EU-MFSS (Bonn University, 1999)

The SPEL/MFSS simulation assumes a constant 10% set-aside and compares the Agenda 2000 results with a 'reference' (Status quo or no reform) scenario run using 17.5% Set-aside. Under those circumstances, the changes in areas compared to the reference and also compared with the average areas for the 1992-1996 period are:

Table 3.1. Post-Agenda 2000: Overall percentage changes in crop areas (based on full implementation of the reform).

CROP	AGAINST REFERENCE	AGAINST 1992-1996 AVERAGE
Wheat	+ 2.63%	-2.3%
Barley	+2.19%	-4.6%
Proteins	+5.05%	+9.0%
Oilseeds	-0.33%	-5.8%

The changes in relative crop profitability following reform lead to an expansion of pulses and a contraction in oilseeds relative to cereals. Areas under oilseeds are expected to fall compared to both the status quo scenario and the average area grown since the 1992 reform.

3.5.2 CAPA model (BER, 1999)

This model assumes Set-aside rates of 10% in 2000 falling to 5% in 2001-2003. In general the area of soft wheat is forecast to increase by 9% from 14,040 ha in 1998 (when Set-aside was also 5%) to 15,340 ha in 2003. Rape falls from 2,126 ha to 1,908 ha and sunflowers from 2,551 ha to 1,796 ha over the same period.

There is no significant change in the areas of other cereals or maize. The run of the model which has been made available does not provide data for linseed, peas or beans. The overall area under oilseeds is expected to decrease by 20% from 5.0 m ha to 4.0 m ha in 2003 (excluding oilseeds planted on set-aside land).

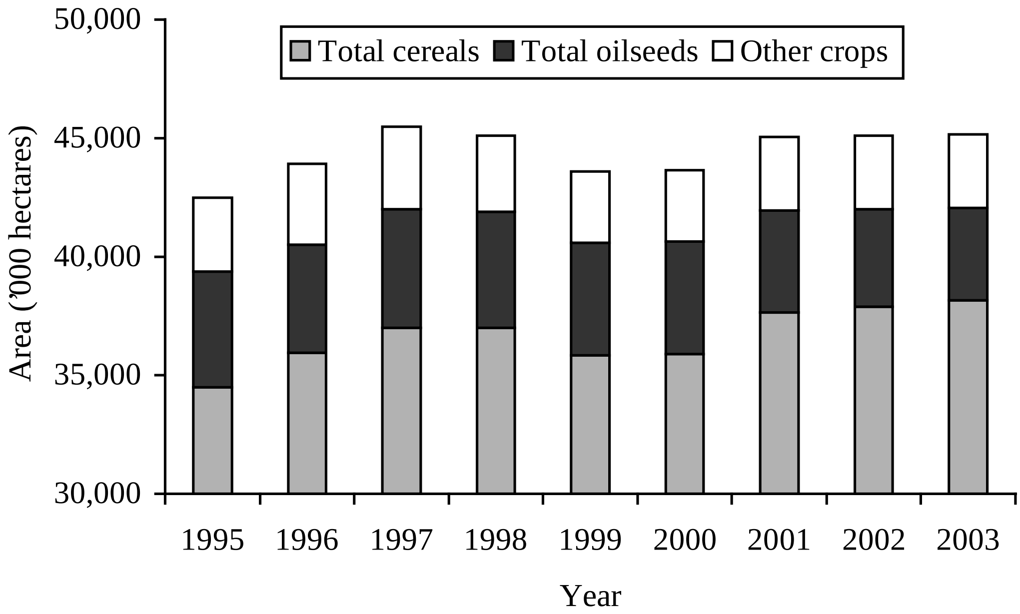

Figure 3.1. Total predicted area in cereals, oilseeds and other crops, 1995-2003

3.5.3 Institut National de la Recherche Agronomique (INRA)

The EU-12 oilseed area (excluding Sweden, Finland and Austria) is forecast to decline by 37% in 2005 compared to 1994 (Dow Jones, 1999). This fall in oilseed area is greater than the BER results because of the higher-weighting allocated to sunflower in the south resulting from the exclusion of the new entrants in INRA data. Sunflowers will not be a viable crop in unirrigated areas of the mediterranean Member States as a consequence of the reduction in aid payments.

3.5.4 German Federal Research Body for Agriculture (FAL)

This model ran under different cereal price scenarios in Germany. It predicted that cereals would increase by 12% to 28% and proteins by 8% to 30% depending on cereal prices. However oilseeds were expected to fall by a minimum of 40% with low cereal prices increasing to a 43% reduction at high cereal prices (Agra Focus, 1999).

3.5.5 Summary: All model forecasts

In general the models point to an increase in cereals at the expense of oilseeds. Most models show a stronger gain for wheat than coarse grains (barley, maize).

Table 3.2. Percentage change in 2005 compared to status quo (DG VI, 1999)

	SPEL	CAPA	FAPRI	USDA	OECD
Wheat	2.6%	9.0%	4.0%	6.4%	2.3%
Coarse grain	2.2%	0%	2.6%	4.5%	0.5%
Oilseeds	-0.3%	-20%	-2.8%	6.1%	-19.6%
Proteins	5.1%	na	na	na	na

Apart from the USDA, all the results show a decline in oilseeds areas, and specifically rapeseed areas, although SPEL forecasts an increase in both sunflower and soyabean areas. Both FAPRI and CAPA forecast a larger fall in sunflower than in rapeseed area. The differences in rape forecasts are a function of varying levels of oilseed prices in the model assumptions.

Total area under cereal and oilseeds is generally expected to increase slightly by 2%, due to the reduction in the rate of compulsory set-aside from 10% to 5% from 2002. However this reduction is not automatically offset by an increase in cropped area, because of a projected increase in voluntary set-aside of between 400,000 to 700,000 m ha.

3.6 Environmental impacts of crop area changes

Reductions in the areas of sunflower will reduce the area of arable land at risk from erosion by water, although the sunflower area will be concentrated in irrigated regions where severe erosion will continue.However, this deep-rooted crop may contribute to improvements in the soil nutrient status. A reduced oilseed rape area will contribute to reduced crop diversity, removing a foraging habitat for several bird species, but use of molluscicides in following cereal crops could be reduced (especially in wheat (Thomas *et al.,* 1996)) with consequent benefits to wildlife. The potato area remains relatively unchanged, with continuing risk of erosion and water pollution, especially in autumn and where the crop is irrigated.

Increased support for maize could increase the irrigated area in southern Europe, with associated intensification of crop management and negative effects for wildlife. Continuing irrigation will result in continued soil erosion and pollution of water by sediment, triazines, IPU and nitrates in both northern and southern Europe. A continued decline in the rice area would have negative consequences for aquatic birds and other animals, especially if dry cultivation of rice is adopted on the remaining area. Continuing soil erosion in southern Europe can be expected if there is no change in the cereal area, and more sustainable management practices are not adopted. The response of southern European countries to the United Nations Convention on Combating Desertification (UNCCD) will be crucial in this regard.

Attempts to reduce economic risk in the face of a more volatile market will lead to reduced crop diversity in favour of wheat. Recent development of fungicides against take-all in wheat (Löchel *et al*., 1998; Beale, *et al*., 1998), and herbicides for couch and bromes (Parrish et al., 1995) could contribute to the loss of break crops in these economic circumstance, with consequent reduced crop diversity. As wheat is one of the most intensively managed crops in terms of pesticide and nutrient use (Thomas *et al*., 1996) the increase in the area of this crops could potentially result in increasing arable intensification. Both reduced crop diversity and high use of inputs to the arable system would be detrimental to biodiversity, soil and water quality.

However, lower cereal prices may encourage farmers to reduce variable costs, including those of pesticides in some crops, and levels of input use will therefore depend on cereal prices. The reduction of intervention and market prices following the 1992 reform contributed to an increasing awareness of “precision farming” involving reduced volume applications and more sensitive management techniques. Pesticide applications (tonnes of active ingredient) have fallen since 1991, and despite rising again slightly in 1996, are still below 1991 levels (European Commission, 1999), though in the Netherlands, where cereals are generally treated as a “break” crop between high-value root crops (potatoes and sugar beet), the number of pesticide applidations increased between 1993 and 1997 on both “conventional” and “integrated” farms studied by Tamis *et al* (1999). It is anticipated that further reductions in cereal prices following the 1999 reform will contribute to a continuing trend of falling pesticide sales.

Under low-input management, wheat is known to provide a suitable habitat for many species. Conversely, low cereal prices are likely to encourage intensive livestock production with its associated risk of water pollution.

While the barley area as a whole is predicted to fall, the proportion of spring-sown barley is likely to increase, in order to achieve malting premium. This could have conservation benefits by reducing inputs (Thomas *et al*., 1996) and by restoring the potential for the establishment of undersown leys on mixed arable and livestock farms. In these circumstances, diversity and abundance of plants and invertebrates, and the vertebrates dependent on them, could be improved. An increase in undersown leys in mixed farming areas with light soils would reduce the risk of erosion in autumn. An increase in low input malting barley could also help to reduce water pollutants.

Genetically modified crops may increase herbicide use as herbicide tolerant crops permit use of broad-spectrum herbicides where this was not formerly possible, reducing weed abundance and diversity in crops. Adoption of genetically modified insect resistant crops could result in a decline in the use of insecticides, permitting the survival of arable invertebrates, but this would not be the case where invertebrate food plants had been eliminated in herbicide tolerant crops! The impact of insect resistant crops on natural predators of insect pests is not known. Genetic pollution from genetically modified crops to other arable plants, most notably (in northern Europe) from oilseed rape to wild turnip and black mustard could result in these species becoming serious arable weeds (Schiermeier, 1998).

Although continued cultivation and use of pesticides will result in some air pollution, increasing environmental awareness and an economic need to use inputs more efficiently are likely to result in the more widespread adoption of accurate application equipment and methods and lower emissions of pesticides and CO_2. However, continued emissions of CO_2, SO_2 and other pollutants will result from long distance transport of arable inputs and products associated with international trade, contributing to continued global warming and acid rain.

3.7 Yield effects

Cereal yields are expected to continue increasing at historic rates of 110 kg/ha for wheat, 20 kg/ha for barley and 140 kg/ha for maize. While it would seem logical that yield growth should slow in line with reductions in prices, lower future increases than past yields trends is unlikely because average yields in the past were often reduced by ‘restrictive’ practices (such as ‘stabilisers’). New yield-increasing chemistry in cereal fungicides will also boost yields.

Protein yields and oilseed yield increases have been very modest since the 1992 reform and are expected to stabilise in the medium term.

The positive trend in wheat yields, compared to the other supported crops, will be further encourage a swing to wheat stimulated by the re-orientation of aid payments in favour of cereals by the 1999 reform.

3.8 Farm structures

The 1999 reform will reduce arable crop incomes, compared to the pre-Agenda 2000 policy environment, assuming market prices stay at the levels experienced in 1999. This is because of the partial, rather than full, compensation for the cereal intervention price cuts and the real reductions in oilseed, pulse and set-aside payments. Even assuming a cyclic increase in commodity prices (as in the CAPA model) a real reduction of 0.3% in arable crop incomes is expected in 2003 compared to 1998.

A reduction in arable crop incomes will intensify the existing trends towards larger, more specialised holdings as smaller, less efficient producers are forced out of production. This trend is not exclusive to the arable crop sector but is perhaps most typical in ‘northern’ areas where the arable crop sector is concentrated. The ‘southern’ model of small holdings, run by older farmers, has shown less specialisation. Demographic trends with younger farmers expanding farm sizes will also be a factor.

Overall it is possible that there will be a further 15% fall in the number of holdings between 1993 and 2003 in the EU-12 with northern countries seeing the largest falls of around 30% (Netherlands, UK, Belgium) and southern countries showing smaller falls (Italy 6%, Greece 9%). (European Commission, 1997). By 2005 there will probably only be around 100,000 ‘professional’ decision-makers, farming areas in excess of 100 ha, in EU agriculture (AIGC, 1993).

The increasing specialisation of holdings will also lead to further regional concentration, particularly in the French North-East, the Midi-Pyrenees, the Eastern half of England, Sachsen-Anhalt and Thuringen (Germany), Marche (Italy) and Castilla-Leon (Spain).

Some have argued that increased geographical concentration in some areas may lead to abandonment in others. While this may be true in the context of EU agriculture generally, this is not the case with specific reference to the COP regimes. Trends show so far that farmers and Member States are increasing, rather than decreasing, their 'useage' of their arable base areas. It seems most unlikely that producers will forfeit aid payments (for voluntary Set-aside) by abandoning arable land altogether.

3.9 Environmental impacts of farm structure changes

The trend towards simplified crop rotations and larger farms is likely to continue, resulting in homogenisation of the arable landscape, for example, with the loss of colourful crops such as sunflower, linseed and rape, and the loss of small farms with their associated landscape features. Large fields, buildings, roads and other features are likely to predominate.

The continued loss of non-crop habitats, increases in field size, and decreases in crop diversity will combine to have substantial detrimental effects on biodiversity within arable ecosystems.

The future of current arable ecosystems will also be influenced very strongly by payments available for alternative land-uses. Afforestation would involve a total change of ownership and land-use, and the loss of arable steppe species. Livestock farming could be expanded by existing farmers but would be equally damaging to diverse arable ecosystems if cereals were abandoned. Incentives for land-uses other than arable farming, especially afforestation, would result in the loss of wildlife and open landscape features.

3.10 Conclusion

The increasing market orientation of the COP regime following the Berlin agreement will force the concept of comparative advantage on EU agriculture. Climatically the northern EU-15 (and north-western Europe in a future EU-20) is suitable for low cost, low quality cereal production. Oils and proteins are currently grown at lowest cost in the Americas. It is inevitable that not only will there be increased concentration of cereal production in northern Europe within the EU-15, but given the substitution of coarse grains and oilseeds by wheat, that there will be a greater concentration of the world's feed (soft) wheat production within the EU. In southern Europe, abandonment or afforestation of arable farms is likely to continue.

At farm level, oilseeds (but not linseed) and proteins will still exist in arable rotations but areas will in the main fall and will fluctuate depending on wheat: oilseed: protein commodity price ratios. Production of COPs will also become ever more specialised, with larger units leading to a loss of crop diversity and a reduction in semi-natural habitats.

4. PRACTICAL SUGGESTIONS FOR ALLEVIATING ENVIRONMENTAL IMPACTS OF ARABLE FARMING

4.1 Introduction

In this section each of the three key countries is treated separately, as geographical factors, such as climate, geology, topography and culture, demand different approaches in each country. Such factors will also operate within countries, requiring environmentally appropriate designation of administrative regions. Practical suggestions are divided into cross-compliance conditions and agri-environment options.

Cross-compliance conditions incorporate and develop current “Good Agricultural Practices”, requiring additional input from the farmer and some modification of the farming system to reduce environmental impacts of arable farming. Area payments would be conditional on carrying out these practices and farmers would undertake to adopt these conditions when signing the IACS agreement. They comprise a package of management practices that are intended to ensure sustainability, in so far as this is possible at current levels of knowledge and practical within existing structural frameworks. They should be considered as “good farming practice”, as defined in Commission Regulation No. 1750/1999 on support for rural deveopment, article 28. Criteria for selection of cross-compliance conditions include:

- minimal interference with the farming system
- relatively low cost
- ability to be monitored and followed through to a legally enforceable conclusion
- timescale compatible with IACS submissions.

Agri-environment options are voluntary additional practices designed to have positive environmental impacts to counter long-term environmental problems. These options are designed to address problems that farmers can not realistically be expected to approach under cross-compliance and have an additional cost to the farmer who would be compensated accordingly. However, this should not rule out the possibility that some agri-environment options could be incorporated into the cross-compliance conditions at a later date, as systems change and our knowledge of what is and what is not sustainable increases.

Where possible, we have selected management practices that address more than one environmental problem. For example, agri-environment options intended to restore soil organic matter are expected to reduce erosion rates by increasing infiltration rates, increase breakdown of pesticides by increasing microbial activity and act as a sink for atmospheric carbon. The environmental problems addressed by each condition or option are indicated by symbols representing benefits to soil (■), water (♒), air (☂), biodiversity (🕷) and cultural landscape (⛰). Where symbols appear in grey, environmental benefits are expected to be relatively small. In southern Europe, afforestation of formerly arable land in order to reduce soil erosion, creates a mosaic of forest within an arable landscape. Such forest can have negative environmental consequences and we make recommendations for the appropriate management of this feature separately (Appendix 3).

Environmental measures must avoid penalising farmers already adopting good environmental practices (e.g farms with high hedge density and small field size) and rewarding those who do not. They should also avoid perverse effects such as piping watercourses to avoid adoption of buffer zones adjacent to them. An inventory of current habitats would help to prevent this. While each measure is intended to alleviate past or present environmental problems, based on the latest research available to us, greatest environmental benefits are likely to result from an integration of a number of measures, according to local conditions. We include an agri-environment option for the provision of advice to enable farmers to integrate fully the relevant measures, in order to maximise the environmental benefits and to accommodate compatible marketing of agricultural produce. Environmental benefits of maintaining or restoring the integration of livestock or sylviculture into arable systems can be as great as, or greater than, modification of practices within either livestock, forestry or arable systems, and environmental measures must be sufficiently flexible to accommodate this approach. Whole farm plans are useful in this regard (see Agri-Environment Option 17). A local scale approach promotes the integration of measures in order to achieve environmental, social and nature conservation objectives.

Opportunities exist, especially in the longer term, for offsetting costs of support for environmental measures by exploiting marketing opportunities such as premia for ‘regional’ products and food from environmentally benign production systems. For example, Serpa sheep cheese is produced in the predominantly arable Alentejo region of Portugal. Iberian pigs and the production of ham and other regional pork products are directly linked to holm oak montados. Promotion of sylvicultural products such as cork and charcoal could also be encouraged within Alentejo arable systems.

Demand for organic produce has increased substantially, most recently in the U.K, but 75% of organic food consumed in the U.K. is currently imported (Soil Association, 1999) and environmental costs associated with transport are externalised. Consumption of locally produced food has environmental benefits in terms of reducing air pollution associated with transport, and increasing habitat diversity, as well as restoring social integration of rural communities (Pretty, 1998). Such local marketing is occasionally applied to arable products (e.g. Wookey, 1987), but is more generally associated with horticultural and livestock products, either within, or independently of, arable systems. It is exemplified by box schemes and farmers’ markets (Pretty, 1998). The following practical suggestions will have greatest and most efficient environmental benefits if adopted within the context of this wider policy.

4.2 United Kingdom practical suggestions

4.2.1 UK Cross-compliance

1. Compliance with general mandatory regulations

Description:

Farmers must comply with EU Directives and member states' legislation to protect the environment.

Environmental benefit:

Minimisation of environmental impacts relating to nutrient and pesticide use.

Guidelines:

Compliance with EC Nitrates Directive and UK Control of Pesticides Regulations, Environmental Protection Act (1990) and Food and Environment Protection Act (1985). These regulations require product use according to pesticide label instructions in order to minimise contamination of aquatic and terrestrial non-crop habitats by pesticides and nutrients. Details are given in MAFF (1991) and MAFF (1999b).

Agricultural implications:

None, as farmers should already be complying by law.

2. Soil erosion management plan ■ ♒

Description:

Assessment of erosion risk for whole farm, and development and implementation of appropriate soil management.

Environmental benefit:

Reduced soil erosion benefits for aquatic environments by reducing sedimentation and phosphate deposition.

Guidelines:

Soil erosion risk should be assessed for all cultivated parts of the farm, based on soil texture, slope and annual rainfall (Table 4.1). Attention should be given to changes in soil and slope within fields and additional influences such as erosion history, soil organic matter, length of slope, hedges along contours, gateways etc.

Action should be taken to minimise erosion across the whole farm, with special attention being directed to the most vulnerable areas. A minimum soil organic carbon level should be set at 2%, and action taken to exceed this level wherever possible (Current mean soil organic carbon for arable/ley soils is 2.8%; Loveland, in press). Other soil management should be adopted according to erosion risk. Where erosion risk is 'moderate' or 'high' (Table 4.1), practices should include green stubbles (or winter cover crops), contour strips, rough seedbeds, minimum cultivation, adoption of grass leys, strategic positioning of set-aside and other appropriate cropping. Where erosion risk is 'very high' a change in landuse should be considered (MAFF, 1999a).

Cost:

Time spent mapping erosion risk and drawing up plan. There may be further costs of implementation if high or very high risk areas are identified.

Agricultural implications:

Restrictions on previous cropping and cultivation practices.

Table 4.1. Erosion risk in relation to rainfall, soil type and slope.

	AVERAGE RAINFALL > 800MM				AVERAGE RAINFALL < 800MM			
Soil Texture	Steep slopes >7°	Moderate slopes 3-7°	Gentle slopes 2-3°	Level ground <2°	Steep slopes >7°	Moderate slopes 3-7°	Gentle slopes 2-3°	Level ground <2°
Sand	Very high	High	Moderate	Slight	High	Moderate	Lower	Slight
Loamy sand	Very high	High	Moderate	Slight	High	Moderate	Lower	Slight
Sandy loam	Very high	High	Moderate	Slight	High	Moderate	Lower	Slight
Sandy silt loam	Very high	High	Moderate	Slight	High	Moderate	Lower	Slight
Silt loam	Very high	High	Moderate	Slight	High	Moderate	Lower	Slight
Silty clay loam	High	Moderate	Lower	Slight	Moderate	Moderate	lower	Slight
Other mineral soils	Lower	Slight	Slight	Slight	Lower	Slight	Slight	Slight

Source: MAFF, 1999a

3. Green stubbles and winter cover crops ■ ♒ 🕷

Description:

Natural regeneration of stubbles or establishment of fast growing crops such as rye and mustard on ploughed land following harvest of previous crop, where a spring-sown crop is to follow, and the previous crop is harvested before 1 October.

Environmental benefit:

Cereal stubbles (except maize) help to reduce erosion (MAFF, 1999c) and leaching (Hewitt et al., 1992) if a green cover of volunteers and weeds is allowed to establish soon after harvest. Stubbles can also provide a food source for seed-eating birds in winter where weeds are present (Wilson et al., 1996). Spring-sown crops following over-wintered stubbles are associated with arable plants and birds that are not found in autumn-sown crops (O'Connor & Shrubb, 1986; Wilson, 1994). Winter cover crops can help control of both water and wind erosion on sensitive soils (MAFF, 1999a). If established quickly following ploughing, they can also reduce nitrate leaching and contribute to SOM when ploughed in (McCracken et al., 1994), although there is some evidence to suggest that nitrogen is not readily available to the following crop and long-term accumulation of organic matter may result (Harrison & Peal, 1996).

Guidelines:

Where stubbles are maintained, a green cover must be established by permitting growth of weeds and volunteers from the previous crop. A 55% *increase* in nitrate leaching can result if green vegetation in not established in stubbles (Meissner et al., 1998). If stubbles are to be ploughed prior to drilling the next crop, this must not take place before 15 February. On clay soils where cultivation is difficult at this time of year, direct drilling should be adopted. If vegetated cereal stubbles are not retained through the winter, green cover must be provided by cover crops where it is not intended to sow the following crop before 1 January. Crops such as rye or mustard should be sown in late summer or early autumn and ploughed in before drilling in spring. Rapid establishment following harvest of the previous crop is essential for effective reduction of leaching. Mustard can be established by broadcasting onto bare plough or into preceeding crop just before harvest without seedbed preparation.

Cost:

Seed costs are about €42.56/ha for rye and €22.40/ha for mustard, plus €7.68/ha for broadcasting (Nix, 1998). An additional cost of €10.24/ha may be incurred for spraying off prior to sowing cover crops.

Agricultural implications:

Increased need for fungicide use where volunteers in stubbles form a 'green bridge' between crops for fungal diseases. Volunteers may also harbour crop pests. The need to establish cover crops early competes for time with harvesting.

4. Contour strips ■ ♒

Description:

5 metre (minimum width) vegetated strips across field slopes.

Environmental benefit:

Reduced erosion and loss of soil, pesticides and nutrients to water (MAFF, 1999a). 5 metre wide grass strips can reduce sediment transport by 80%, but steep slopes and the incidence of concentrated flow reduce their effectiveness (Dillaha & Inamdar, 1997). Contour strips increase habitat diversity for wildlife, especially if strips are planted with appropriate species.

Guidelines:

Contour strips must be a minimum of 5 metres wide and at intervals of 200 metres wherever erosion risk assessments suggest that erosion risk is moderate or higher (see condition 2). Where erosion risk is high, there is a benefit to adopting wider strips (see Agri-Environment Option 2). Contour strips must be sown with perennial grasses (at least 3 species) and may include a 'beetle bank' (see above) or a hedge on a low bank. A ditch with a grass strip along the up-slope side further prevents runoff (MAFF, 1999a). To ensure adequate vegetative cover during winter, and to provide conservation benefits, the vegetation should ideally not be cut, but if it is cut, this should only be between 15 July and 15 August. The strips should not be used by vehicles.

Cost:

€38.40/ha for standard grass seed mix, plus €7.68/ha drilling costs. Loss of crop from land under strip at approximately £580/ha/yr (Loddington data, 1998).

Agricultural implications:

If cultivations continue across the contours increased turning will result, increasing cultivation time and reducing yield (through soil compaction and damage to crop).

5. Nutrient management plan

Description:

Regular testing of soil nutrient status and adjustment of organic and inorganic nutrient applications in accordance with this, residues from previous crops, and nutrient demands of current crops (MAFF, 1994). Timing, as well as amounts of applications are considered. Similar measures are already adopted in North America (e.g. Sharpley & Rekolainen, 1997) and some European countries (e.g. Denmark; Agra Focus, 1999b).

Environmental benefit:

Planned use of nutrient inputs, according to soil nutrient status, can have environmental benefits as well as economic benefits for the farmer (e.g. Poulton et al., 1997). Reduction in fertiliser lost to water and other non-target habitats, with consequent reduction in eutrophication of watercourses, and in loss of botanical diversity in non-cropped habitats (Boatman et al., 1994; Tsiouris & Marshall, 1998).

Guidelines:

On-farm testing of manure and soil nitrogen, with laboratory testing of other nutrients where necessary. Such data can be used with computer-based decision support systems such as 'MANNER' to predict appropriate levels of nitrogen application (MAFF, 1999c). Records of soil tests and applications to be kept and available for inspection if required. Some flexibility to take account of unpredictable rainfall patterns will be required. Maximum effectiveness would result from GIS-based mapping.

Cost:

Soil sampling costs.

Agricultural implications:

Improved efficiency of fertiliser application and utilisation of organic manures and existing soil nutrient status.

6. Machinery maintenance. ♒ ☂ 🕷

Description:

Biennial testing and servicing of farm machinery, including tractors, grain driers, sprayers and nozzles, fertiliser distributors and border discs etc.

Environmental benefit:

Reduced emissions of CO_2, SO_2 and other atmospheric pollutants. Reduced fertiliser and pesticide input to water and other non-target habitats. This condition is already in operation in some member states.

Guidelines:

Machinery must be tested and certified as functional and correctly calibrated by an approved service provider. Certificates must be kept and be available for inspection.

Cost:

Testing and servicing costs

Agricultural implications:

Improved efficiency of fuel, fertiliser and pesticide use, with consequent economic benefits for farmers.

7. No autumn application of nitrogen. ♒ 🕷

Description:

Fertiliser must not be applied to cereal crops in autumn when the crop's nutrient requirements can be met by residual nutrients and uptake by the crop is minimal (MAFF, 1994).

Environmental benefit:

Reduced nutrient to water and other non-target habitats.

Guidelines:

See description

Cost:

Nothing – a saving to the farmer.

Agricultural implications:

Autumn nitrogen application to rape is thought to reduce pigeon damage to the crop, but uptake of nitrogen by other crops in autumn is low and agricultural implications are therefore small.

8. Prevention of fertiliser drift ♒ 🕷

Description:

Use of pneumatic or liquid applicators, or fitting of deflector plates, border discs or tilting spreaders.

Environmental benefit:

A reduction in amount of nutrients entering watercourses, reducing the risk of eutrophication and declines in aquatic biodiversity. A reduction in the application of fertiliser to other non-target habitats maintains botanical diversity in field boundaries (Boatman et al., 1994; Tsiouris & Marshall, 1998).

Guidelines:

Farmers should be obliged to take appropriate precautions to prevent fertiliser misplacement. Twin disc spreaders can be fitted with border discs or have tilting hoppers. Single disc and oscillating spout spreaders can have deflector plates fitted. Pneumatic and liquid fertiliser spreaders do not need special fittings as they do not work on an overlap principle like spinning disc and oscillating spout spreaders. Information on appropriate equipment and its use should be made readily available to farmers by government advisory organisations, with restrictions on the sale of equipment that cannot be modified to restrict fertiliser distribution outside the cropped area.

Cost:

Example: Cost of border disc €57.6, offset by savings in fertiliser of €0.19 per 100m or €1.92 for a 6ha field.

Agricultural implications:

Improved efficiency of fertiliser application and consequent economic benefits.

9. Prevention of spray drift

Description:

Adoption of appropriate spraying equipment and practices.

Environmental benefit:

Reduced pesticide impact on water and other non-target habitats and organisms. Drift of pesticides into field boundaries alters the composition of plant communities (Cooke, 1993) and can also affect invertebrate communities both directly (Longley et al., 1997), and by altering vegetation structure (Haughton et al., 1999) and abundance of food plants. Pesticide drift reduction can also benefit other non-crop habitats such as heath, pasture and woodland (Cooke, 1993).

Guidelines:

Equipment used must be designed to reduce drift (e.g. lowdrift nozzles, sleeve boom and twin fluid sprayer (Holterman & Van de Zande, 1996, Miller 1999). Spraying must not be carried out in winds above force 3 on the Beaufort Scale (Table 4.2).

Table 4.2. Wind speed guide

APPROX. AIR SPEED AT BOOM HEIGHT	BEAUFORT SCALE (AT HEIGHT OF 10M)	DESCRIPTION	VISIBLE SIGNS	SPRAYING
Less than 2 km.h	Force 0	Calm	Smoke rises vertically	Use only ‘medium’ or ‘coarse’ spray quality
2 - 3.2 km/h	Force 1	Light air	Direction shown by smoke drift	Acceptable spraying conditions
3.2 – 6.5 km/h	Force 2	Light breeze	Leaves rustle, wind felt on face	Ideal spraying conditions
6.5 – 9.6 km/h	Force 3	Gentle breeze	Leaves and twigs in constant motion	Increased risk of spray drift; take special care
9.6 – 14.5 km/h	Force 4	Moderate breeze	Small branches moved, raises dust or loose paper	Spraying inadvisable

Source: MAFF (1999b)

Cost:

Equipment (e.g. low drift nozzles; €9.6 for 6, tilt jets €14.08-€16 for 6)

Agricultural implications:

Improved efficiency of pesticide application. Potential limitations in the number of spray occasions must be taken into account when planning spray programmes (Spackman, 1983).

10. Five metre Buffer zones

Description:

5 metre width belts beside permanent watercourses, and sown to perennial grasses.

Environmental benefit:

Buffer zones reduce loss of soil, pesticides and nutrients from arable fields to waterways, with strips of just 5 metres width reducing sediment transport by at least 50% and pesticide transport by at least 45% (Davies, 1999). Wider buffer zones have greater benefits and flexibility (see agri-environment options). Vegetation traps water-borne silt, and associated phosphate and pesticides, soluble nutrients and pesticides being absorbed or broken down following infiltration. Additional steps to reduce the loss of pollutants should be taken simultaneously at the source in arable fields, such as conservation tillage, contour ploughing, controlled grazing densities etc (Davies, 1999; Dillaha & Inamdar, 1997) (see cross-compliance condition 2).

Guidelines:

5 metre riparian strips are sown to perennial grasses to establish a dense sward which should persist through the winter when transport of pollutants is greatest. Vegetation should be sufficient to encourage sedimentation within the buffer zone under normal erosion rates. If this is not achieved preventative action, such as land use change, should be taken at the erosion source. Set-aside can be used to extend the buffer zone width to 10 metres.

To reduce nutrient accumulation, herbaceous vegetation could be cut and removed between mid-July and mid-August, although such action conflicts with some conservation objectives (e.g. removal of harvest mouse habitat) and could reduce the efficacy of vegetation to remove silt over-winter. Further research is needed on this issue.

Concentrated flow can reduce the effectiveness of buffers by reducing the area over which surface flow takes place. Where this occurs, water bars should be constructed within the buffer, and perpendicular to its length, at 15-30 metre intervals to intercept runoff (Dillaha & Inamdar, 1997).

Cost:

Costs associated with sowing grasses (c. €38.4/ha for standard mix) and land lost from production (€371.2/ha/yr, see condition 4).

Agricultural impacts:

Land lost to arable production.

11. No insecticides within 6 metres of field boundary

Description:

No insecticides must be applied to the outer 6m of arable crops.

Environmental benefit:

Maintenance of beneficial arable invertebrates in the field edge. This is the favoured foraging area for gamebirds and songbirds which will benefit from the presence of arable invertebrates. Reduced insecticide applied to water and other non-target habitats and organisms. Drift of insecticides into field boundaries directly affects arthropod communities (Longley et al., 1997). A six metre buffer zone can encourage more rapid recolonisation by arthropods (Holland *et al*, 1999). Monitoring of this condition could be difficult, but the practice is already applied under LERAP (Local Environment Risk Assessments for Pesticides; MAFF, 1999d), and stipulated on some product labels (e.g. dimethoate labels reads 'do not treat cereals after 1 April within 6m of edge of crop').

Guidelines:

Autumn applications of insecticide are permitted across the whole field, but summer applications must not be made to the outer 6 metres of cereal fields. Crop walking and observations of changes in aphid abundance can optimise use of insecticides where their use is permitted (Oakly & Walters, 1994).

Cost:

Yield reduction resulting from reduced insecticide use is generally slight and gross margins can even increase slightly (MAFF, 1999b; Oakley, 1997).

Agricultural implications:

Possible minor reductions in yield/quality of crop – unlikely to be economically significant. Need to plan applications to allow for witholding insecticide from outer 6 m (e.g. when using tank mix of fungicide and insecticide).

12. Field pest threshold

Description:

No application of insecticides to arable crops when pest thresholds are below the recognised thresholds where these exist (Oakley & Walters, 1994). For some problems e.g. aphids in autumn giving rise to barley yellow dwarf virus, thresholds are not yet available.

Environmental benefit:

Strict adherence to threshold, rather than prophylactic application of insecticides will reduce the number of applications, benefiting arable invertebrates and the larger animals that are dependent on them as a food source. Numbers of invertebrate pest predators of aphids and other crop pests are also likely to benefit from fewer applications of pesticides.

Guidelines:

Aphid abundance can be higher at field edges than in the main crop (Winder et al., 1998) and observations of changes in aphid numbers in headlands should be used as a basis for threshold assessment and subsequent spraying decisions (Oakley et al., 1994). An obligation to phone an inspectorate before spraying should be stipulated to provide an option to inspect pest thresholds in headlands. Such inspections should be conducted very soon after spraying as aphid numbers can increase rapidly.

Monitoring would be difficult but could be achieved with a rapid-reaction inspectorate checking a small proportion of cases. A list of pest thresholds would be required.

Cost:

Time spent examining crops. Possible extra pass with sprayer if insecticides are not used in tank mix with fungicides.

Agricultural implications:

Possible effects on timeliness of other operations. Monitoring and extra spraying time.

13. One metre field boundary strips

Description:

1 metre strip of perennial herbaceous vegetation in field boundaries. In the UK, grants are already payable under Agri-Environment Schemes such as the Countryside Stewardship Scheme for two metre wide grass strips, so requiring a wider strip as a cross compliance measure would conflict with this well established scheme. Also, under current EU regulations, farmers have to exclude their field boundaries from their Arable Area aid claims when the distance from the centre of the boundary to the crop is more than two metres. In the Netherlands, where field boundaries usually consist of ditches, a two metre strip is preferred (see below).

Environmental benefit:

Perennial herbaceous vegetation in field boundaries provides a wintering habitat for predatory invertebrates which control cereal pests in the spring (Wratten & Thomas, 1990). Broad-leaved perennial plants provide food for adult and larval butterflies and moths, and hoverflies and bumble bees (Osborne & Corbet, 1994). This herbaceous vegetation is also used by small mammals such as harvest mice (Bence, 1999). It also provides a nesting habitat for gamebirds and songbirds and influences breeding numbers of some of these species (Rands, 1987; Stoate, 1999).

Guidelines:

A strip of land adjacent to an arable crop is established by natural regeneration or sowing with perennial grasses and managed to create a tussocky sward. The sward should be cut in the first year. It should not be cut in subsequent years unless there is evidence of suckering of shrub species, when no more than one cut should be made outside the nesting season (March –July). Pesticides and fertilisers may not be used on the strip.

Cost:

Lost arable production. Chaney et al. (1999) estimate gross margin forgone from the outer 1 metre of a cereal field (assuming grain at €44.8/t) at €273/ha.

Agricultural implications:

Establishment of a perennial sward reduces the incidence of annual weeds in field boundaries and adjacent crops and provides habitat for beneficial predatory invertebrates which may help reduce numbers of crop pests.

14. Environmentally-managed habitat as percentage of eligible area

Description:

Environmentally-managed habitat should represent at least 5% of the eligible arable area, to include hedges, ditches, grass strips, beetle banks and wild bird cover. Conservation headlands and undersowing within the cropped area could also be included. A menu of appropriate habitats would be available for farmers to choose from. Farms with less than 5% of the eligible area represented as environmentally-managed habitats are not eligible for agri-environmental options. A similar scheme already exists in Switzerland where the statutory non-crop area was increased from 5% to 9% (Marshall, 1998). However, 9% is likely to be too high for the UK.

Environmental benefit:

By stipulating a proportion of land to be managed with environmental benefits across all farms, this condition ensures that farmers who have maintained such areas are not penalised, while those who have destroyed habitat features are obliged to replace them or provide alternative habitats. Economic pressures on farmers with conservation interests to remove existing habitats are therefore reduced, while improvements in environmental management are encouraged on a wide scale. In many cases, environmentally conscious farmers will qualify to receive area payments without the need for additional measures.

Guidelines:

Environmentally managed habitats must comprise at least 5% of the eligible arable area, and also comply with condition 15. Where the percentage is less than 5%, additional non-crop habitat must be created under appropriate guidelines. A maximum field boundary width of 16m (to allow for watercourses with buffer strips) should be permissible within the eligible area.

Cost:

Where non-crop habitat needs to be increased arable land is lost from production and seed and planting costs are incurred. No cost to farmers with existing requirement of non-crop habitat.

Agricultural implications:

Reduced field size on some farms.

15. Minimum distance between non-crop habitats ■ ♒ 🕷

Description:

Maximum distance of 400 metres between adjacent pieces of non-crop habitat. Minimum width of non-crop habitat 4metres

Environmental benefits:

As 14. Allows adequate dispersal of invertebrates through fields and provides network of corridors for non-crop fauna and flora.

Guidelines:

Field boundary width must be 4 metres per 400 metres of arable field. If sown, field boundary vegetation must comprise at least three perennial grass species (excluding ryegrass) and must not be used for frequent vehicle access. No fertiliser use is permitted. Vegetation may only be cut once every 3 years between 15 July and 15 August.

Cost:

Where non-crop habitat needs to be increased, arable land would be lost from production and seed and planting costs incurred. No cost to farmers with existing requirement of non-crop habitat.

Agricultural implications:

Reduced field size on some farms.

4.2.2 UK agri-environment options

1. Organic farming

Description:

Adoption of organic standards of production according to the requirements of the United Kingdom Register of Organic Food (UKROFS).

Environmental benefit:

Organic farming systems can be associated with the accumulation of soil organic matter, with its associated environmental benefits (El Titi & Landes, 1990, cited in Pretty, 1998). Persson & Kirchmann (1994) showed that addition of organic manure to arable land was the most effective method of restoring organic carbon, showing an increase from 1.5% to approximately 2.2% between 1956 and 1983 in Swedish arable soils. Reduced leaching of nutrients (Stopes et al., 1996), higher landscape diversity (Chamberlain & Wilson, in press) and higher biodiversity (Moreby et al., 1994; Chamberlain & Wilson, in press) may result. However, these benefits are associated as much with a change of attitude in farmers adopting organic systems as with the agricultural systems themselves (Countryside Commission, 1995). Recent studies indicate that some benefits e.g. for birds, may be equally obtainable on conventional farms if appropriate habitat management is carried out (Boatman & Stoate, 1999; Chamberlain & Wilson, in press, Potts, 1999).

Guidelines:

As defined by Reg. 2092/91.

Cost:

Complex

Agricultural impacts:

Major changes to farming system and farmers' approach to it.

Suggested payment:

Current Organic Aid payments for conversion in the UK start at €144/ha/yr and fall to €12.8/ha/yr in year five (MAFF, 1999e). In the UK one private water company (Wessex Water) has started a pilot €25.6/ha/yr payment (above the Organic Aid payment) to farmers who adopt organic systems in an attempt to reduce water treatment costs, In Germany, similar schemes are in place, with rates of payment varying according to water company region and farm-scale environmental objectives (Bernd Hoermann, pers.comm.).

2. Arable conversion to grass ■

Description:

Planting of permanent grassland on slopes or other areas susceptible to soil erosion by wind or water.

Environmental benefit:

Prevention of soil erosion from the most susceptible arable areas. Reduction in leaching of nitrate to water, and build up of soil organic matter as CO_2 sink. Possible increase in crop diversity in some arable areas, with consequent benefits for wildlife and landscape. Loss of soil, pesticides and nutrients to water is also lower under non-arable land use than under arable crops.

Guidelines:

Sowing of grass cover comprising at least 3 perennial grass species. Additional payments could be made available for establishing more botanically diverse swards. Grazing or cutting are permitted but grazing densities must be restricted as high densities can increase the risk of soil erosion (Heathwaite et al., 1990). No fertiliser application. Herbicides may only be used as spot treatments for the control of notifiable weeds.

Cost:

The difference between arable and extensive livestock gross margins (e.g. €179/ha/yr based on Loddington data, although some fertiliser is used at Loddington).

Agricultural impacts:

May involve introduction of livestock to previously all arable farm.

Suggested payment:

Current Countryside Stewardship payment is €179/ha/yr.

3. Large riparian buffer zones ♒

Description:

Up to 30 metre width belts beside streams and rivers, and sown to perennial grasses, and possibly including trees.

Environmental benefit:

Buffer zones reduce loss of soil, pesticides and nutrients from arable fields to waterways. Wide buffer zones increase their capacity to reduce loss of silt, phosphorus and pesticides to water from sub-surface flow through field drains and cracks. Increased width also contributes to the alleviation of problems associated with concentrated flow where buffer zones are not level (Dillaha & Inamdar, 1997). Vegetation traps water-borne silt, and associated phosphate and pesticides, soluble nutrients and pesticides being absorbed or broken down following infiltration. The presence of trees increases the effectiveness of buffer strips in removing surplus nutrients (Davies, 1999; Dillaha & Inamdar, 1997; Correll, 1997). Buffer zones may not be appropriate where the groundwater passes deep beneath the buffer, or where the watercourse is a considerable depth below the level of the buffer (Correll, 1997).

Guidelines:

30 metre riparian strips are sown to perennial grasses to establish a dense sward which should persist through the winter when transport of pollutants is greatest. Willow, poplar and/or alder trees can be planted at 10 metre minimum distance from waterways, to reduce shading and leaf-fall. Vegetation must be removed periodically to avoid nutrient accumulation. Trees should be harvested at up to 12-15 year intervals and removed from the site (Mander et al., 1997). Herbaceous vegetation should be cut and removed between mid-July and mid-August. Where field drains are present in adjacent arable fields, these must be broken into a ditch or pond.

It is important that additional steps to reduce the loss of pollutants such as sediment, pesticides and nutrients should be taken simultaneously at the source in arable fields, such as conservation tillage, contour ploughing, controlled grazing etc (Davies, 1999; Dillaha & Inamdar, 1997).

Concentrated flow can reduce the effectiveness of buffers by reducing the area over which surface flow takes place. Where this occurs, water bars should be constructed within the buffer, and perpendicular to its length, at 15-30 metre intervals to intercept runoff (Dillaha & Inamdar, 1997).

Cost:

Costs associated with sowing grasses, planting trees and breaking field drains.

Agricultural impacts:

Land lost to arable production. On drained land, some water-logging at the within-field slope base could occur on shallow slopes.

Suggested payment:

Compensation for lost groos margin (e.g. €371/ha, Loddington average gross margin, 1998). The Arable Stewardship Scheme payment for similar prescriptions is €373/ha/yr.

4. Reedbed nutrient sinks ♒

Description:

Reedbeds and other marginal vegetation in enlarged ditches, especially where they enter watercourses.

Environmental benefit:

Removal of nutrients from drainage water, reducing their transport to watercourses. The mechanisms by which reedbed nutrient sinks operate are not fully understood, but the technique has been widely and successfully used in relation to high nutrient status waste water, for example from sewage treatment (Hawke & José, 1996). More research is needed into the design of this management practice for arable systems.

Guidelines:

Marginal vegetation is encouraged along ditches draining from arable fields. Ditches are widened and deepened where they enter watercourses and planted with reeds. In order to minimise phosphate accumulation, reeds would probably need to be harvested, but research into this is needed.

Cost:

Land lost to arable production. Cost of digging (see option 3) and planting reeds.

Agricultural impacts:

None.

Suggested payment:

5. Conservation headlands

Description:

Selectively sprayed cereal field headlands.

Environmental benefit:

Selective use of herbicides permits the development of an arable plant community that supports high invertebrate abundance and diversity (Sotherton, 1991). These invertebrates, in turn, provide food for breeding gamebirds, increasing chick survival and autumn populations (Rands, 1985, 1986; Sotherton & Robertson, 1990). Conservation headlands are also used for foraging by breeding songbirds (De Snoo, et al., 1994), butterflies (Dover, et al., 1990; Dover, 1997; De Snoo et al., 1998) and small mammals (Tew et al., 1992), and permit the survival of rare and endangered arable plants (Wilson, 1994). Conservation headlands also protect non-crop vegetation in field boundaries from pesticide drift (Longley & Sotherton, 1997; Longley et al., 1997).

Guidelines:

Pesticide use on the outer 6m of cereal fields is restricted according to the guidelines presented in table 4.3.

Table 4.3. Guidelines for selective use of pesticides on conservation headlands in UK cereal fields (Sotherton, 1998).

	AUTUMN SPRAYING	SPRING SPRAYING
Insecticides	Yes (avoiding drift)	No (Only up to 15 March)
Fungicides	Yes	Yes
Growth regulators	Yes	Yes
Grass weed herbicides	Yes (but only compounds	Yes (but only compounds
Broadleaf weed	No (except compounds	No (except compounds

More specific guidelines, including recommended selective herbicides and cultural hints, are published by The Game Conservancy Trust (Anon, 1998). These are used as the basis for agreements under British Agri-Environment Schemes.

Cost:

A field-scale yield loss of up to 0.5%, according to field size, can be expected (Boatman & Sotherton, 1988; Boatman et al., 1999). Selective herbicides used may be more expensive than broad-spectrum herbicides used on the rest of the field, and additional application costs are involved in applying selective products to the headlands. Table 4.4 shows the costs calculated for the Alerton Research and Educational Trust's farm at Loddington in Leicestershire, U.K. for 1997 and 1998 (Boatman et al., 1999).

Table 4.4 Profit forgone per hectare of conservation headland at Loddington, 1997 and 1998.

	1997	1998*
Extra herbicide	€8.05	€27.62
Extra application	€8.64	€17.30
Yield forgone	€17.09	€19.76
Total	€33.78	€64.68

* Herbicide costs were higher in 1998 because tri-allate was applied in October and four extra passes with herbicide were required in spring, compared with two in 1997.

Agricultural implications:

Reduced yield in field headlands. Weed problems can develop if conservation headlands are adopted in the same field for more than two consecutive years. For this reason it is recommended that conservation headlands are rotated around the farm. A different complement of pesticides may be required for conservation headlands and the main crop, requiring purchase of additional pesticides and additional spray applications. Weeds may cause problems at harvest in some instances; this can be solved by the application of glyphosate pre-harvest.

Suggested payment:

€64/ha. A payment of €64/hectare is currently made under the Scottish Countryside Premium Scheme and the pilot Arable Stewardship Scheme in England, whilst payments in Environmentally Sensitive Areas range from £38.4 to £64 per hectare.

6. Conservation headlands with no fertiliser

Description: As for conservation headlands, but with no nitrogen fertiliser applied.

Environmental benefit: All benefits noted under conservation headlands apply, but the reduced competition from the crop allows less competitive plants to survive and promotes a more diverse flora (Grundy et al., 1991). This option is particularly appropriate for the conservation of rare arable flora, where such species are known to occur, as many are unable to compete with crops at high nitrogen levels (Wilson, 1999).

Guidelines: As above

Cost: Substantial reductions in crop yield, up to 50%.

Agricultural implications: As for conservation headlands, but much greater reduction in crop yield. Nitrophilous weeds e.g. *Galium ararine* are less of a problem.

Suggested payment: The current payment of €96/ha in the pilot Arable Stewardship Scheme is considered too low. A more realistic payment would be €192/ha.

7. Wild Bird Cover crops

Description:

Unharvested crops (normally grown as crop mixtures) specifically to meet the ecological requirements of birds in the breeding season, or during winter.

Environmental benefit:

Two main forms of WBC are currently in use (Sotherton, 1998). One, based on cereals, provides invertebrate-rich foraging habitat for birds in the breeding season and also provides food for certain seed-eating birds if left over the following winter. The other provides annual or biennial seed-bearing crops as a food source for seed-eating birds in winter (Stoate & Szczur, 1997), but flowers of biennials also provide a food source for declining bumble bees (Osborne & Corbet, 1994). Butterflies are amongst the other invertebrates to benefit from WBC management (Boatman & Stoate, 1999) and these crops can also provide nesting habitat for some songbirds, and cover for gamebirds and hares.

Guidelines:

Cereal-based mixtures: Sow wheat, triticale & linseed in autumn on heavy soils, and in autumn or spring on light soils. Addition of legumes (e.g red clover, birdsfoot trefoil) beneficial if early autumn or spring sowing (will not establish if sown after early September in autumn).

Kale-based mixtures: Sow kale and quinoa or millet for seed in first year. Evening primrose or teasel can be added to maintain a mixture in the second year and prolong the flowering season. For insects add lucerne, chicory, phacelia etc.

Cost:

The cost has been estimated at €173/ha (Boatman & Stoate, 1999) but this could be reduced considerably if simple, readily available crop mixtures are used. Land lost to arable production (but can be done on set-aside).

Agricultural implications:

Could be source of weeds if not managed appropriately.

Suggested payment:

€448/ha to compensate for lost arable production (if not on set-aside), seed and sowing costs. Although the payment is high, biodiversity benefits are also high per unit area, maintaining value for money.

8. Undersowing

Description:

Grass/clover ley undersown into spring-sown cereal.

Environmental benefit:

Undersown grass encourages soil invertebrates and sawflies which over-winter in the soil. These provide food for birds. In particular, there is a strong link between sawflies and survival of the Biodiversity Action Plan species, grey partridge (Potts, 1991). Spring-sowing encourages some of the rarer arable plants, while reduced use of herbicides in grass/clover swards maintains the presence of these and other broad-leaved plants, and the invertebrates associated with them. Undersowing also results in less nitrate leaching during ley establishment (Philipps & Woodward, 1998; Philipps et al., 1998). Organic ley/arable systems have been shown to have lower nitrate leaching rates than conventional farms in NSAs (Stopes et al., 1996). Arable systems incorporating a three-year ley have been shown to have 25% more organic carbon than rotations comprising only annual crops and have greater potential for soil stability and mitigating CO_2 emissions than other modern arable systems (Paustian et al., 1997).

Guidelines:

Spring-sown cereal, undersown with a grass/legume seed mix, is established between 14 February and 20 April. The cereal should be sown at a seed rate of not more than 100 kg/ha. The seed mix should be sown at a seed rate of at least 12kg/ha, including at least either 25% white clover or 33% red clover (by weight). The undersown ley must not be destroyed until 15 July of the following year. Herbicides used must be compatible with a grass/clover sward. No nitrogen should be applied, but clover should be encouraged as a source of nitrogen, and Potassium, Phosphorus and lime may be used.

Cost:

Yield reduction associated with spring cereals, plus additional yield reduction due to low seed rate and competition from grasses.

Agricultural implications:

Yield reduction associated with spring cereals. May involve introduction of livestock to arable only system. Fencing and water may be required where not already present.

Suggested Payment:

A payment of €115/ha is currently made for undersowing under the pilot Arable Stewardship Scheme, or €384/ha over two years if followed by a grass ley.

9. Grass leys

Description:

Premium for grass leys up to 25% of arable area (with advice for establishment of crops following leys). This option is intended to maintain leys and livestock in otherwise arable systems.

Environmental benefit:

Increased soil organic matter resulting from ley establishment improves soil structural stability, with consequent reductions in soil erosion (Evans, 1996; Skinner & Chambers, 1996) and increases in moisture retention. Organic arable ley systems are encouraged in Germany where they have shown a 1.2-1.7% increase in SOM between 1979 and 1986, with cereal yields 115% of conventional crops (El Titi & Landes, 1990 cited in Pretty, 1998). Similar results were recorded in Sweden (Persson & Kirchmann, 1994). The capacity of soil organic matter to act as a sink for CO_2 mitigates impacts of emissions from the use of machinery on farms and transport of arable inputs and products. Arable systems incorporating a three-year ley have been shown to have 25% more organic carbon than rotations comprising only annual crops and have greater potential for mitigating CO_2 emissions than other modern arable systems (Paustian et al., 1997). Nitrate leaching to water is also considerably lower under arable systems incorporating leys than arable systems without them (Stopes et al., 1996). Mixed farming is also associated with higher crop diversity, with considerable benefits for wildlife, and increased landscape diversity.

Guidelines:

Grass/legume leys can lead to increased nitrate leaching when ploughed but, if managed appropriately, can show less leaching than systems without leys, while increasing soil organic matter (Drinkwater et al., 1998). The period between ploughing and sowing the following crop should be kept to a minimum by delaying the timing of ley cultivation prior to sowing a winter cereal (Stopes et al., 1997). Arable grass leys must remain for a minimum of three years. No nitrogen should be applied, but clover should be encouraged as a source of nitrogen, and Potassium, Phosphorus and lime may be used.

Cost:

Less than undersowing. If replacing arable, difference in gross margin between arable and livestock enterprise. If replacing permanent pasture, costs of establishment and IACS implications as only arable land is eligible for IACS payments. May involve introduction of livestock to arable only system. Fencing and water may be required where not already present.

Agricultural implications:

Only applicable to mixed arable and livestock farms, or arable farms with potential, for introduction of livestock.

Suggested payment:

€179/ha/yr

10. Field boundary vegetation

Description:

Strips of perennial grasses, with or without broad-leaved plants, in field boundaries. Payments are made for strips of 2 or 6 metres.

Environmental benefit:

Perennial herbaceous vegetation in field boundaries provides over-wintering habitat for invertebrate predators of crop pests (Wratten & Thomas, 1990), nesting habitat for gamebirds and songbirds (Rands, 1987, Stoate, 1999), and a habitat for small mammals such as harvest mouse (Bence, 1999). Many broad-leaved perennials are used by butterflies and beneficial insects such as hoverflies and bumble bees (Osborne & Corbet, 1994). Invertebrates in this habitat provide food for breeding birds. Establishment of a perennial sward reduces the incidence of annual weeds in field boundaries and adjacent crops.

Guidelines:

A strip of land adjacent to an arable crop is established by natural regeneration or sowing with perennial grasses and managed to create a tussocky sward. The sward should be cut in the first year. It should not be cut in subsequent years unless there is evidence of suckering of shrub species, when no more than one cut can be made outside the nesting season (March-July inclusive). Pesticides and fertilisers may not be used on the strip.

Cost:

Chaney et al. (1999) estimated gross margin forgone from the outer 2 metres of a cereal field (assuming grain at €44.8/t) at €291/ha, and from the outer 6 metres at €332/ha.

Agricultural implications:

Land lost to arable production. However, yields at field edges are lower than further towards the field centre, so lost gross margin is less (Chaney *et al.*, 1999).

Suggested payment:

This option is currently available within the Countryside Stewardship Scheme at €22.4/100m/year for 6 metre strips, and €9.6/100m/year for 2 metre strips. However, these payments are thought to be too high, particularly those for 2m strips. Payments should more accurately reflect gross margin foregone, with possible allowance for cost of seed and sowing in the first year.

11. Hedges and shelterbelts

Description:

Hedges and shelterbelts

Environmental benefit:

Hedges and shelterbelts provide breeding and winter habitats for a wide range of wildlife, including birds, mammals and invertebrates. As linear features they are also thought to provide links between otherwise isolated areas of shrubby habitat, aiding dispersal of wildlife (Dawson, 1994). When planted along contours they help reduce soil erosion from arable land.

Guidelines:

Native shrub and tree must be used, wherever possible obtained from local sources. Alien tree species may be used as a temporary nurse component of shelterbelts. Hedges should be planted along contours wherever possible.

Cost:

€2.3 per metre for plants, guards and canes at 6 plants per metre. If contract labour is employed, add €1.28 per metre for planting. If rabbit fenced (no guards) €1.92 per metre. Fencing by a contractor is €1.6 per metre.

Agricultural implications:

Land lost to arable production. Shading of adjacent crops by trees. Some shelter provided by hedgerow – may help to prevent erosion.

Suggested payment:

A payment of €1.28/m is currently made for hedge planting or restoration under the Countryside Stewardship Scheme, with supplements for guards and fencing where used (e.g. €0.13 for spiral rabbit guard, €0.38/m for rabbit or sheep netting).

12. Beetle banks

Description:

Low mid-field banks of perennial grasses.

Environmental benefit:

Beetle banks provide an over-wintering habitat for many invertebrate predators of crops pests such as aphids (Thomas et al., 1992). They also provide nesting habitat for skylarks, and for small mammals such as harvest mouse and field vole which support predatory birds.

Guidelines:

During normal autumn cultivation create a ridge of earth bank approximately 0.4 metres high and 1.5 to 2 metres wide by two-directional ploughing. A 25 metre gap should be left between each end and the field boundary. Beetle banks are sown with with a mixture of perennial grasses such as cocksfoot, timothy and red fescue. The banks can be cut in the first year to control annual weeds, but should not be cut in subsequent years. Perennial weeds such as thistle and dock can be removed by spot treatment with herbicide.

Cost:

Cost is approximately €4.48/100m (€1.92 for ploughing, €0.64 for seed, €1.92 for broadcasting by hand). A cost of €5.67 – 6.4/100m/yr must be added for lost gross margin, unless on set-aside.

Agricultural implications:

Improved biological control reduces need for insecticides.

Suggested payment:

A payment of €9.6/100m (€480/ha) is currently made under the Countryside Stewardship Scheme. This is probably too high; a payment of €4.48/100m in year one, followed by an annual payment of €3.84/100m in subsequent years, would be more realistic.

13. Uncropped wildflower strips 🕷

Description:

A cultivated but uncropped strip of land at the field edge.

Environmental benefit:

These strips encourage rare annual and biennial arable plants in field margins (Wilson, 1994). They are therefore most likely to be of conservation benefit where such plants are known to be represented by seeds in the seed bank. However, such strips also provide foraging habitats for other wildlife throughout the year.

Guidelines:

The strip must be cultivated once every year, or once every other year, in the spring or autumn. Herbicide application must be limited to the use of a weed wiper or spot treatment for the control of spear thistle, creeping thistle, field thistle, curled dock, broad-leaved dock and ragwort. No other pesticides or fertilsers may be used.

Cost:

Gross margin forgone (approximately €288-320/ha) plus cultivation costs of approximately €10.90/ha.

Agricultural implications:

Possible source of weeds to infest neighbouring crops.

Suggested payment:

A payment of €22.4/100m is currently made under the Countryside Stewardship Scheme (€373/ha).

14. Hedge maintenance

Description:

Maintenance of hedges in accordance with regional tradition.

Environmental benefit:

Hedges provide a historically important and valued landscape feature in many parts of lowland farmland. They also provide habitat for many wildlife species including nesting birds, small mammals and a variety of invertebrates.

Guidelines:

Management of hedges may include coppicing, laying, protection from livestock or gapping up as appropriate to the cultural values of the region.

Cost:

Laying €1.92 – 3.2/m, coppicing €2.00/m, livestock fencing €1.28/m plus €1.60/m labour. For gapping up see hedge planting (above).

Agricultural implications:

More hedge cutting. Laying or coppicing of tall hedges may reduce shading of nearby crops.

Suggested payment:

A payment of €1.28/m (with supplements) is currently made for hedge restoration under the Countryside Stewardship Scheme.

15. Stone walls and ditches

Description:

Maintenance of stone walls and ditches, and building new walls where appropriate.

Environmental benefit:

Stone walls and ditches provide a historically important and valued landscape feature in many parts of lowland farmland.

Guidelines:

Major rebuilding following collapse, or to prevent collapse of stone walls forming prominent landscape features.

Cost:

Dry stone walling €8/m^2

Agricultural implications:

Boundary more stock-proof.

Suggested payment:

A payment of €7.68/m is available for stone wall restoration under the Countryside Stewardship Scheme. Support could also be made available for capital works that do not impinge on the environment.

16. Individual tree planting

Description:

Standard native trees

Environmental benefit:

Trees provide a historically important and valued feature in many parts of lowland farmland and provide an additional habitat for animal communities in field boundaries.

Guidelines:

Planting of native species from local seed if possible. Guard against livestock if necessary, protect from weeds for 2-3 years. Planting should enhance existing landscape and should be avoided in traditionally open landscapes.

Cost:

Small transplants and guards etc €1.12 plus cost of labour (at about €0.64 per tree). Larger trees are more expensive.

Agricultural implications:

Shading of neighbouring crops.

Suggested payment:

A payment of €1 per tree, plus €0.32 for a protective tube is available under the Countryside Stewardship Scheme.

17. Integrated whole farm plan ■ 〰 ⛰ 🕷 ☔

Description:

Integration of management options and cross-compliance conditions, in order to maximise environmental benefits in terms of management of soil, water, air, biodiversity and landscape.

Environmental benefit:

This option aims to maximise the environmental benefits of other agri-environment options and cross-compliance conditions. Full integration of environmental and agricultural management practices is likely to result in more economically and ecologically sustainable management of the farm, with emphasis on long-term benefits (two or three generations) as well as more immediate returns.

Guidelines:

In the UK guidance for integrated whole farm plans are provided by the LEAF (Linking Environment and Farming) and EMA audits which enable farmers to assess the sustainability of their own farming operation. Equivalent guidance targeted primarily at biodiversity conservation is provided by the Farming and Wildlife Advisory Group's (FWAG) Landwise Plan. The aim would be to enable the farmer, with professional advice, to formulate a package of management practices which would best suit the environmental, economic and cultural circumstances of each farm. The farmer would be encouraged to consider marketing opportunities arising from farm management changes resulting from the plan (e.g. regional or organic produce), or supplementary activities likely to benefit from it, such as shooting (Boatman & Brockless, 1998), fishing (Westcountry Rivers Trust, 1999) or tourism (e.g. Woodcraft & Woodcraft, 1998). Such opportunities would reduce dependence on financial support.

Cost:

Professional help with formulating integrated plan.

Agricultural implications:

Improved sustainability and, possibly, profitability of management system.

Suggested payment:

A payment of €192 for professional help in drawing up a management plan is available under the Countryside Stewardship Scheme in England.

Table 4.5. Summary of environmental and agricultural benefits of cross-compliance conditions in the UK.

	SOIL	WATER	AIR	BIODIVERSITY	LANDSCAPE	IMMEDIATE AGRICULTURAL	LONG-TERM AGRICULTURAL
Compliance with general mandatory regulations	Less erosion	Less nutrient loss to water	Less pollution	Less pollution			
Erosion management plan	Less erosion	Less sedimentation & eutrophication					Soil quality maintained
Contour strips	Less erosion	Less soil & nutrient loss to water		Potential wildlife habitats			Soil quality maintained
Winter cover crops or green stubbles	Less erosion & higher soil organic matter	Less leaching		Winter bird food. Spring-germinating annual plants			
Nutrient management		Less nutrient pollution		Less pollution of aquatic & other habitats		More efficient fertiliser use	
Prevention of fertiliser drift		Less nutrient pollution		Less pollution of aquatic & other habitats		More efficient fertiliser use	
Prevention of pesticide drift		Less pesticide pollution		Less pollution of aquatic & other habitats		More efficient pesticide use	
5m buffer zones		Less loss of soil, nutrient & pesticide to water		Less pollution of aquatic & other habitats. Wildlife habitats	Increased landscape diversity		
No insecticide in 6m field margin				Benefits arable inverts. & prey. More beneficial inverts.			Beneficial invert. population established
Headland insecticide threshold				Benefits arable inverts. & prey. More beneficial inverts.			Beneficial invert. population established
1m field boundary strips				Benefits beneficial inverts, plants, birds etc	Flowering plants & wildlife in field boundaries		Beneficial invert. population established
Machinery maintenance			Less CO_2, SO_2 & pesticide pollution	Less pesticide & nutrient pollution		More efficient use of inputs	More efficient use of inputs
Non-crop habitat as % of eligible area				Permanent wildlife habitats	Increased landscape diveristy		

Table 4.6. Summary of environmental and agricultural benefits of agri-environment options in the UK.

	SOIL	WATER	AIR	BIODIVERSITY	LANDSCAPE	IMMEDIATE AGRICULTURAL	LONG-TERM AGRICULTURAL
Organic farming	Improved SOM	Reduced loss of soil, nutrients & pesticides to water	SOM as CO_2 sink	Increased habitat diversity, weed & invert abundance	Increased landscape diversity	Economic premium on products	Improved sustainability
Arable conversion to grass	Considerably improved SOM	Reduced loss of soil, nutrients & pesticides to water	SOM as CO_2 sink	Increased habitat diversity	Increased landscape diversity		Soil conservation
Arable leys	Considerably improved SOM	Reduced loss of soil, nutrients & pesticides to water	SOM as CO_2 sink	Increased habitat diversity	Increased landscape diversity		Soil conservation
30m riparian buffer zones		Reduced loss of soil, nutrients & pesticides to water		Potential wildlife habitats			
Reedbed nutrient sinks		Reduced eutrophication					
Conservation headlands				Benefits to range of arable wildlife			
Conservation headlands with no fertiliser				Benefits to range of arable wildlife, especially plants			
Wild bird cover crops	Potential to reduce erosion			Benefits to range of arable wildlife, esp. birds in winter	Increased landscape diversity		
Undersowing	Reduced erosion	Reduced leaching		Benefits to range of arable wildlife	Increased landscape diversity		
Hedges & shelterbelts	Potential to reduce erosion			Permanent habitat for birds & other wildlife	Traditional landscape feature		
Beetle banks	Potential to reduce erosion			Wildlife habitat			
Uncropped wildflower strips	Potential to reduce erosion			Plant & invert. habitat	Landscape feature		
Hedge maintenance				Benefits to some wildlife	Traditional landscape feature		
Stone walls				Potential wildlife habitat	Traditional landscape feature		
Tree planting				Benefits to some wildlife	Landscape feature		
Integrated whole farm plan	Optimum application of options to soil management	Optimum application of options to reduce water pollution	Optimum application of options to reduce air pollution	Optimum application of options to improve biodiversity	Optimum application of options to improve biodiversity	Optimum application of options to farm profitability	Optimum application of options to long-term sustainability

Table 4.7. Summary of criteria met by cross-compliance conditions in the UK..

	IMPACT ON FARMING SYSTEM	COST	EASE OF MONITORING	LENGTH OF TIME NEEDED FOR COMPLIANCE
Compliance with general mandatory regulations	Small	Low	Difficult	Short
Erosion management plan	Small	Low	Moderate	Long
Contour strips	Moderate	High	Easy	Short
Winter cover crops or green stubbles	High	High	Easy	Short
Nutrient management	Small	Low	Moderate	Short
Prevention of fertiliser drift	Small	Low	Moderate	Short
Prevention of pesticide drift	Small	Low	Moderate	Short
5m buffer zones	Moderate	Moderate	Easy	Short
No insecticide in 6m field margin	Moderate	Low	Difficult	Short
Headland insecticide threshold	Moderate	Low	Difficult	Short
1m field boundary strips	Small	Low	Easy	Short
Machinery maintenance	Small	Moderate	Easy	Short
Non-crop habitat as % of eligible area	Dependent on farm	Dependent on farm	Easy	Moderate

4.3 Netherlands practical suggestions

4.3.1 Netherlands Cross-compliance

1. Compliance with general mandatory regulations

See under UK cross-compliance.

SECTION A: PROCEDURAL CRITERIA

2. Erosion management plan ■

Description:

Assessment of erosion risk for whole farm, and development and implementation of appropriate soil management. Most relevant for erosion sensitive areas, such as the southern part of the Netherlands, and in areas where fields are surrounded by waterways such as ditches.

Environmental benefit:

Reduced soil erosion benefits aquatic environments by reducing sedimentation and nutrient deposition.

Guidelines:

Soil erosion risk should be assessed for all cultivated parts of the farm, based on soil texture, slope and annual rainfall. Attention should be given to changes in soil and slope within fields and on the edges of the fields (ditch banks). Additional attention should be given to influences such as erosion history, soil organic matter, length of slope, hedges along contours, gateways etc.

Action should be taken to minimise erosion across the whole farm, with special attention being directed to the most vulnerable areas. Soil management should be adopted according to erosion risk including practices such as winter cover crops or green stubbles (where appropriate), contour strips and appropriate cropping.

Costs:

Low, depending on the measures necessary (see UK)

Agricultural implications:

Improved soil management in specific areas in erosion sensitive regions such as the southern part of the Netherlands. More sustainable ditch banks along water ways.

3. Nutrient management plan ♒ 🕷

Description:

Mineral book keeping system on the farm for inorganic and organic nutrient application *cf*. MINAS system as required in the Netherlands in 1999 for arable farms with an input of more than 100 kg phosphate and for all farms in 2001 (MINAS, 1989, information Dutch Min. Agriculture, November 1999). The system includes regular testing of soil nutrient status and adjustment of organic and inorganic nutrient applications in accordance with this, residues from previous crops, and nutrient demands of current crops. Timing is considered, as well as amounts of applications. Recently, proposals have been made for the MINAS standards to be tightened up to ensure compliance with the Nitrates Directive (Brinkhorst & Pronk, 1999) Similar measures are already adopted in other countries (see also UK, Sharpley & Rekolainen, 1997).

Environmental benefit:

Planned use of nutrient inputs, according to soil nutrient status, can have environmental benefits as well as economic benefits for the farmer (e.g. Poulton et al., 1997). Reduction in fertiliser lost to water and other non-target habitats, with consequent reduction in eutrophication of watercourses, and in loss of botanical diversity in non-cropped habitats (Boatman et al., 1994; Tsiouris & Marshall, 1998; Kleijn, 1996). Finally farmers' attitudes will be changed, by reflection on their own management.

Guidelines:

Cf. MINAS bookkeeping system (input, supply nutrients, manure quality certificates etc). Records of soil tests and applications to be kept and available for inspection if required. Some flexibility to take account of unpredictable rainfall patterns will be required. Maximum effectiveness would result from GIS-based mapping.

Cost:

Low costs for MINAS system and soil sampling costs.

Agricultural implications:

Improved efficiency of fertiliser application.

4. Pesticide management plan ■ ♒ 🕷 ☔

Description:

Pesticide book keeping system on the farm for use of all type of pesticides (herbicides, insecticides, fungicides etc.). The amount per hectare of active ingredient and formulation in kg/ha in the different crops is recorded in the system and also the application method (spraying equipment, nozzle types etc.), the sprayed area, day of application and target disease, pest or weed (*cf.* CBS, 1997). The system takes account not only of the amount of active ingredient applied, but also the potential environmental damage for aquatic organisms, soil organisms and ground water based on the Environmental Yardstick for pesticides of CLM (CLM, 1997).

Environmental benefit:

Optimisation of pesticide use can have major environmental benefits to biodiversity (non-target organisms) and non-target areas such as ditches etc. (De Snoo, 1995, De Snoo & De Wit, 1998, De Snoo & Van der Poll, 1999). Potential environmental damage is hardly considered by farmers when choosing which pesticide to use (cf. De Snoo et al., 1997). Farmers' attitudes will be changed, by reflection on their own management (*cf.* De Snoo & De Jong, 1999). In the longer term environmental bench marking between farmers can be promoted.

Guidelines:

Records of pesticide use to be kept and available for inspection if required. Maximum effectiveness would result from computer system and GIS-based mapping.

Cost:

Low, depending on the facilities already available on the farm

Agricultural implications:

Improved efficiency of pesticide application.

5. Water management plan

Description:

Assessment of hydrological changes for whole farm due to increased drainage, lowering ground water level etc. and development and implementation of appropriate water management.

Environmental benefit:

Higher ground water level benefits biodiversity, especially in nature reserves, woodland etc. due, not only changes in water level, but also to changes in soil aeration, mineralization, eutrophication etc. (Runhaar, 1999). Also, the runoff of surface water into rivers and extraction of ground water could be reduced.

Guidelines:

Measurement of ground water level and water level in the ditches, and nett. water balance etc. (cf. Bleumink & Buys, 1996). Water book-keeping system for all cultivated parts of the farm. Attention should be given to the water management on the farm, such as the amount and period of irrigation etc. After the assessment, prevention measures could be taken in terms of decreasing water extraction, decreasing crop evaporation measures etc. Farmers' attitudes will be changed, by reflection on their own water management.

Costs:

Low, water measurements of ground water and ditches.

Agricultural implications:

Improved water management, especially irrigation.

6. Nature management plan

Description:

Development of a nature management plan for the whole farm. Methodology should conform to the Natuurprotocol of Smeding/DLV. (Smeding, 1995, Smeding & Joenje, 1999). An inventory should be made of all non-cultivated habitats on the farm such as ditches, ditch banks, hedgerows etc., and the surroundings of the farm in landscape terms should be taken into account. The ecological infrastructure on the farm should be measured, mapped and assessed for quality. An analysis of potential improvements ecological infrastructure is then carried out.

Environmental benefit:

Enhancement of biodiversity on the farm, in the non-cultivated areas as well as species which also live partly in the crops like invertebrates which can play a role in biological control of pests. Positive change of farmers' attitudes regarding biodiversity on their farms.

Guidelines:

Inventory, mapping and quality assessment according to the Natuurprotocol (Smeding, 1995). Maximum effectiveness would result from GIS-based mapping.

Cost:

Low, 2 days of work for inventory. Costs of follow up depending of the assessment.

Agricultural implications:

Improved biological control of pests is possible.

7. General machinery maintenance

Description:

Regular servicing of farm machinery, including tractors, grain driers etc. Fertiliser distributors must be calibrated and tested every two years and a certificate of their suitability issued. Pesticide sprayers must be calibrated and tested every two years and a certificate of their suitability issued (For field sprayers this is already mandatory in the Netherlands).

Environmental benefit:

Reduced emissions of CO_2, SO_2 and other atmospheric pollutants.
Reduced fertiliser applied to water and other non-target habitats and organisms. Reduced pesticide applied to water and other non-target habitats and organisms. This condition is already in operation in some other member states.

Guidelines:

Testing of sprayers according to the Stichting Keuring Landbouwspuiten. Test of fertiliser distributors can be based on different current tests available in the Netherlands. Tests to be standardised for field edge application of sprayers and fertiliser distributors (See also Melman, 1991).

Cost:

Low - testing and servicing costs

Agricultural implications:

Improved efficiency of fuel, fertiliser and pesticide use, with consequent economic benefits for farmers.

8. Prevention of fertiliser drift

Description:

Use of pneumatic or liquid applicators, or fitting of deflector plates, border discs or tilting spreaders.

Environmental benefit:

Reduced fertiliser lost to water and other non-target habitats (Boatman et al., 1994; Tsiouris & Marshall, 1998, Melman, 1991).

Guidelines:

See description

Cost:

Low, equipment

Agricultural implications:

Improved efficiency of fertiliser application.

9. Prevention of spray drift ♒ 🕷

Description:

Equipment used must be designed to reduce drift (e.g. low drift nozzles, sleeve boom, anti-drift additives, twin fluid sprayer). Spraying must not be carried out in winds exceeding 3 m/s.

Environmental benefit:

Reduced pesticide deposition into water and other non-target habitats. (De Snoo & De Wit, 1993, 1999; Van der Zande, 1995; Jepson & Sotherton, 1998). Benefits biodiversity

Guidelines:

Spraying not be carried out in winds exceeding 3 m/s. Use of specific anti drift nozzles for field sprayers and a spray shield for knapsack sprayers used on the field edge.

Cost:

Low, equipment

Agricultural implications:

Improved efficiency of pesticide application.

SECTION C: PHYSICAL CONDITIONS:

10. 2m field boundary strips

Description:

2 metre strip of perennial herbaceous vegetation in field boundaries throughout the farm between the crops and non-cultivated elements such as ditches, hedgerows etc.

Environmental benefit:

Perennial herbaceous vegetation in field boundaries provides a wintering habitat for biodiversity (See De Snoo & Chaney, 1999) such as predatory invertebrates which control cereal pests in the spring (Wratten & Thomas, 1990). Broad-leaved perennial plants provide food for adult and larval butterflies and moths, and hoverflies and bumble bees (Osborne & Corbet, 1994). This herbaceous vegetation is also used by small mammals such as harvest mice (Bence, 1999; Remmelswaal & Voslamber, 1996). It also provides a nesting habitat for gamebirds and songbirds and influences breeding numbers of some of these species (Rands, 1987, Stoate, 1999).

Guidelines:

A strip of land adjacent to an arable crop is established by natural regeneration or sowing with perennial grasses and managed to create a tussocky sward. The sward should be cut in the first year, if necessary. It should not be cut in subsequent years unless there is evidence of suckering of shrub species, when no more than one cut can be made, between 1 July and 15 August. Pesticides and fertilisers may not be used on the strip. No tillage is allowed. N.B. When the strip is used for intensive machinery, a 2.5 m field boundary width is required.

Cost:

High, depends on the crops grown on the farm involved (see also UK). In the Netherlands in 2000 a crop free strip between a waterway and crop is mandatory. In most arable crops it should be 50 cm wide. In cereals 0,25 cm and in potatoes 1,5 m (ontwerp-Lozingenbesluit WVO open teelt en veehouderij, 1999).

Agricultural implications:

Lost arable production. Establishment of a perennial sward reduces the incidence of annual weeds in field boundaries and adjacent crops.

11. Non-crop habitat as percentage of the farm

Description:

Non-crop habitat representing at least 5% (see Smeding, 1995, De Snoo & van de Ven, 1999, Vereijken, 1995) of the farm area, including field boundaries and the 2m wide grass strip (see condition no. 9). Also conservation headlands (see UK) can be part of the 5% area. Farms with less than 5% represented as non-crop habitats would not be eligible for agri-environmental options.

Environmental benefit:

Non-crop habitats increase landscape diversity and increase habitat diversity for wildlife. Perennial vegetation is important to many wildlife species associated with arable landscapes. Also the drift of agrochemicals to surroundings of arable field would be reduced.

Guidelines:

See Protocal natuurplan (Smeding, 1995).

Cost:

High for farmers who have removed all their hedges, ditches and other habitats. Nothing for those who have not.

Agricultural implications:

Lost arable production, opportunities for biological control.

4.3.2 Netherlands Agri-Environmental Options

SECTION A: FLORA AND VEGETATION

1. Arable flora in *rotating* cereal crops without *herbicides* and fertiliser

Description:

Unfertilised rotational cereal crop (other than maize) where no herbicides and mechanical weed control is applied to promote arable flora.

Environmental benefits:

Promotion of biodiversity, especially arable flora during the growing season (Schumacher, 1984, De Snoo, 1997). Enhancement of (rare) weed species which can also be important for the rest of the agro-ecosystem (De Snoo & Chaney, 1999). In the sixth year there should be at least 20 indigenous plant species per 25 m^2 in the field section with a standing cereal crop.

Guidelines

(*cf*. Management category 20A concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV): The management unit is used as arable land and has an area of at least 0.5 hectare, of which at least 50% is cropped annually with a cereal other than maize. No fertilisers or herbicides may be used on the field section with the cereal crop. Creeping thistle, common sorrel and cleavers may be locally controlled. There may be no mechanical weed control in the section with the cereal crop between 1 April and harvest.

Agricultural impacts:

Yield losses in the management unit

Suggested payment:

cf. concept-Regeling Agrarisch Natuurbeheer, 1999, Min. LNV: Conservation subsidy per ha per year, including monitoring subsidy and ‘mountain farmer support’: €427.

2. Arable flora in *rotating* cereals without *pesticides* (herbicides, insecticides etc.) and fertiliser *in any year* 🕷

Description:

Unsprayed and unfertilised rotational cereal crop (other than maize) where no mechanical weed control is applied to promote arable flora.

Environmental benefits:

Promotion of biodiversity especially arable flora during the growing season (Schumacher, 1984, De Snoo, 1997). Enhancement of (rare) weed species which can also be important for the rest of the agro-ecosystem (De Snoo & Chaney, 1999). In the sixth year the management unit should have at least 20 indigenous plant species per 25 m^2.

Guidelines

(cf. Management category 20B concept-regeling agrarisch natuurbeheer, 1999, min. LNV):The management unit is used as arable land and is cropped with a cereal other than maize at least three in every six years. In the sixth year the management unit is cropped with a cereal other than maize.. The management unit has an area of at least 0.5 hectare. No crop protection chemicals or fertilisers may be used in any year. There may be no mechanical weed control in the section with the cereal crop between 1 April and harvest.

Agricultural impacts:

Yield losses in the management unit

Suggested payment:

cf. Management category 20A concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV: Conservation subsidy per ha per year, including monitoring subsidy and mountain farmer support: €590.

3. Arable flora in *permanent* cereal fields (cereals five out of six years), without pesticides and low input of fertiliser

Description:

Unsprayed cereal crop (other than maize) where no mechanical weed control is applied to promote arable flora.

Environmental benefits:

Promotion of biodiversity, especially arable flora during the growing season (Schumacher, 1984, De Snoo, 1997). Enhancement of (rare) weed species which can also be important for the rest of the agro-ecosystem (De Snoo & Chaney, 1999). In the sixth year the management unit should have at least 25 indigenous plant species per 25 m^2. On sandy soils with groundwater level VI or VII there are at least 15 species per 25 m^2, including at least two of the following three: lamb's succory, annual vernal grass, *Aphanes microcarpa.*

Guidelines

(*cf*. Management category 22A concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV): The management unit is used as arable land, and is cropped with a cereal other than corn at least five in every six years, including the sixth year. In years with a cereal crop, from sowing through to harvest there may be no mechanical weed control nor any use of pesticides other than for local control of creeping thistle, common sorrel or cleavers. No fertilisers may be used, except for application of farmyard manure (up to two years in six).

Agricultural impacts:

Yield losses in the management unit

Suggested payment:

cf. Management category 22A concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV: Conservation subsidy per ha per year, including monitoring subsidy and mountain farmer support: €576.

4. Arable flora in cereal margins

Description:

Unsprayed and unfertilised cereal crop margin (other than maize) where no mechanical weed control is applied, to promote arable flora.

Environmental benefits:

Promotion of biodiversity, especially arable flora during the growing season (Schumacher, 1984, De Snoo, 1997). Enhancement of (rare) weed species which can also be important for the rest of the agro-ecosystem (De Snoo & Chaney, 1999). In the sixth year the management unit should have at least 25 indigenous plant species per 25 m^2. On sandy soils with groundwater level VI or VII there should be at least 15 species per 25 m^2, including at least two of the following three: lamb's succory, annual vernal grass, *Aphanes microcarpa.*

Guidelines

(*cf*. Management category 22B concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV): The management unit is between 3 and 12 metres wide and.cropped every year with a cereal other than maize. From sowing through to harvest there may be no mechanical weed control nor any use of pesticides other than for local control of creeping thistle, common sorrel or cleavers. No fertilisers may be employed on the management unit.

Agricultural impacts:

Yield losses in the management unit

Suggested payment: cf. Management category 22B concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV: Conservation subsidy per ha per year, including monitoring subsidy and mountain farmer support: €563.

5. Hedgerow management

Description:

Hedgerow preservation in the landscape

Environmental benefits:

Promotion of biodiversity specially flora and fauna related to hedgerows.

Guidelines

(*cf.* Management category 34 concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV): No actions to be undertaken that change the landscape element in any way other than for the purpose of its preservation; no use of pesticides or fertilisers; no fires in or in the direct vicinity of the hedgerow. The element is located in the 'sand' or 'coastal' landscape category. It is linear and has standing vegetation on a raised bedding, is at least 50 metres long and no more than 10 metres wide and the raised bedding is at least 0.5 metre high. The element has at least 40 indigenous trees (see Annex 50) per hectare, no more than 20 of which are standards. The diameter of the main trunks (of trees other than standards) is no more than 0.12 metre at 1.30 metres above grade. Overhanging branches and shoots are to be removed. All sawing is to be carried out at a height of between 0.15 and 0.50 metre above grade.

Agricultural impacts:

Management costs of the hedgerow.

Suggested payment:

Costs: intermediate, compensation cf. Management category 34 concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV: Conservation subsidy:
€ per year per hectare of hedged land with 100% cover.
€ per year per hectare of hedged land with between 75% and 100% cover.
€ per year per hectare of hedged land with between 50% and 75% cover.

6. Fauna margin 🕷

Description:

Unsprayed and unfertilised field edges with cereals (other than maize) or grasses to promote arable fauna.

Environmental benefits:

Promotion of biodiversity, especially arable fauna during the whole year (food and cover) in field margins. Enhancement of invertebrates (epigeic soil fauna such as carabids), vertebrates such as mice and breeding birds (Remmelszwaal & Voslamber, 1996; Thomas et al., 1991; De Snoo, 1995; De Snoo & Chaney, 1999).

Guidelines

(*cf*. Management category 19 concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV): The management unit is between 3 and 12 metres wide and is cropped with a cereal other than maize or set to grass between 1 May and the following 1 November. The prescription is designed for clay soil used as arable land. Any change in the position of the field margin is reported to LASER (Service of the Ministry of Agriculture). The vegetation of the management unit may be cut between 1 July and the following 15 August, but no more than twice. The second cut should be restricted to half the management unit. No use of pesticides nor any mechanical weeding may be used other than for local control of creeping thistle, common sorrel or cleavers.

Agricultural impacts:

Large loss of yield in the management unit when a cereal crop is growing, no yield when grass is cultivated. Costs of (partly) mowing.

Suggested payment:

cf. concept-Regeling Agrarisch Natuurbeheer, 1999, Min. LNV: Conservation subsidies per ha per year: Basic grant: €1688, including ‘mountain farmer support’, for the basic management unit with a rotating fauna margin, the location of which is reported annually.

a) Plus: €1089 extra for allowing the vegetation of a seasonal margin to stand in the winter, at least until 1 March, following a complete cycle from 1 May to the following 1 November.

b) Plus: €717 extra for each subsequent cycle from 1 May to the following 1 November that the fauna margin remains in the same position.

b) Plus: €136 extra for sowing a flower mixture in the margin or managing it as set-aside.

7. Fauna fields

Description:

Unsprayed and unfertilised fields with cereals (not maize) or grasses to promote arable fauna on arable fields.

Environmental benefits:

Promotion of biodiversity, especially arable fauna and flora. Enhancement of invertebrates (epigeic soil fauna such as carabids), vertebrates such as mice and breeding birds (Remmelszwaal & Voslamber, 1996, Thomas et al., 1991, De Snoo & Chaney, 1999). In the sixth year the management unit should have at least 20 indigenous plant species per 25 m^2

Guidelines

(*cf*. Management category 21 concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV): The management unit is used as arable land, and has an area of at least 0.5 hectare. It is cropped with a cereal other than maize at least five in every six years, including the sixth year. In years with a cereal crop no pesticides may be used. Creeping thistle, common sorrel and cleavers may be locally controlled. There may be no mechanical weed control or tillage between 1 April and harvest.

Agricultural impacts:

Yield losses in the management unit

Suggested payment:

cf. Management category 20A concept-Regeling Agrarisch Natuurbeheer, 1999, min. LNV: Conservation subsidy per ha per year, including monitoring subsidy and mountain farmer support: €585.

8. Red list vertebrate management

Description:

Enhancement of specific vertebrate species of high nature conservation interest (selected red list species) on arable land. No threatening agricultural operations may be undertaken in the management unit from the moment red list species settled and discovered (breeding etc.) until the young have become independent.

Environmental benefits:

Promotion of biodiversity especially rare vertebrates on arable land

Guidelines

The management unit is used as arable land, and selected red species (such as ortolan bunting, hamster etc.) are settled on the land (nestling, breeding, territories etc.). All such settlements must be reported to LASER (min. Agriculture). No threatening agricultural operations (pesticide spraying etc.) may be undertaken in the management unit from the moment the settlement of the species is discovered until off spring has grown up.

Agricultural impacts:

No yield in the management unit

Suggested payment:

High, depending on the species and area involved

9. Integrated whole farm plan

Description:

Integration of management options and cross-compliance conditions, in order to maximise environmental benefits in terms of management of soil, water, air, biodiversity and landscape (environmental company certification).

Environmental benefit:

This option aims to maximise the environmental benefits of other agri-environment options and cross-compliance conditions. Full integration of environmental and agricultural management practices is likely to result in more economically and ecologically sustainable management of the farm, with emphasis on long-term benefits as well as more immediate returns.

Guidelines:

In the UK guidance for integrated whole farm plans are provided by the LEAF (Linking Environment and Farming) and EMA audits which enable farmers to assess the sustainability of their own farming operation. Equivalent guidance targeted primarily at biodiversity conservation is provided by the Farming and Wildlife Advisory Group's (FWAG) Landwise Plan. The aim would be to enable the farmer, with professional advice, to formulate a package of management practices which would best suit the environmental, economic and cultural circumstances of each farm. In the Netherlands procedures, indicators and thresholds are being developed to establish a system of environmental company certification of arable farms (*cf*. Udo de Haes & De Snoo, 1996; 1997).

Cost:

Low, costs for assessment of environmental company certification.

Agricultural implications:

Improved sustainability and possibly profitability of management system.

Table 4.8 Summary of environmental and agricultural benefits of cross-compliance conditions in the Netherlands.

	Soil	Water	Air	Biodiversity	Landscape	Immediate agricultural	Long-term agricultural
SECTION A: PROCEDURAL CRITERIA							
1. Erosion management plan	Less erosion	Less sedimentation & eutrophication				Stable ditch banks	Soil quality maintained
2. Nutrient management plan	Less nutrient leaching and pollution terrestrial habitats	Less nutrient deposition	Less nutrient evaporation			More efficient fertiliser use	
3. Pesticide management plan	Less pesticide leaching and pollution terrestrial habitats	Less pesticide deposition	Less pesticide evaporation			More efficient pesticide use	
4. Water management plan		Promote water quality and quantity	Less water evaporation	Increased biodiversity	Benefits forests/nature reserves	More efficient water use	
5. Nature management plan				Increased biodiversity	Increased landscape diversity	Promotion biological control	
SECTION B: TECHNICAL CONDITIONS							
6. Machinery maintenance		Less pesticide & nutrient pollution	Less CO_2, SO_2 & pesticide pollution			More efficient use of inputs	More efficient use of inputs
7. Prevention of fertiliser drift	Less pollution terrestrial habitats	Less nutrient pollution				More efficient fertiliser use	
8. Prevention of spray drift	Less pollution terrestrial habitats	Less pesticide drift				More efficient pesticide use	
SECTION C: PHYSICAL CONDITIONS							
9. 2m field boundary strips	Less erosion, nutrient and pesticide drift	Less nutrient and pesticide drift		Increased biodiversity	Increase landscape diversity	Promotion biological control	
10. Non-crop habitat as % of the farm				Increased biodiversity	Increase landscape diversity	Promotion biological control	

Table 4.9. Summary of environmental and agricultural benefits of agri-environment options in the Netherlands

	Soil	Water	Air	Biodiversity	Landscape	Immediate agricultural	Long-term agricultural
SECTION A: FLORA AND VEGETATION							
1 Rotating cereal crop without herbicides and fertiliser				Enhancement of arable flora			
2 Rotating cereals without pesticides and fertiliser in any year				Enhancement of arable flora			
3 Permanent cereal fields without pesticides and low fertiliser input				Enhancement of arable flora			
4 Arable flora in cereal margins				Enhancement of arable flora			
5 Hedgerow management				Enhancement of hedgerow vegetation	Increased landscape diversity		
SECTION B: FAUNA							
6 Fauna margins				Enhancement of arable fauna			
7 Specific bird breeding colonies and/or territories (fauna sanctuary)				Enhancement of arable fauna			
8 Red list vertebrate management				Enhancement of red last vertebrates			
9 Integrated whole plan	Optimum application of options to soil management	Optimum application of options to reduce water pollution	Optimum application of options to reduce air pollution	Optimum application of options to improve biodiversity	Optimum application of options to landscape improvement	Optimum application of options to farm profitability	Optimum application of options to long-term farming sustainability

Table 4.10. Summary of criteria met by cross compliance conditions in The Netherlands.

	Impact on farming system	Cost	Ease of monitoring	Length of time needed for compliance
SECTION A: PROCEDURAL CRITERIA				
11. Erosion manageme nt plan	Small	Low	Easy	Short
12. Nutrient manageme nt plan	Small	Low	Easy	Short
13. Pesticide manageme nt plan	Small	Low	Easy	Short
14. Water manageme nt plan	Small	Low	Intermediate	Short
15. Nature manageme nt plan	Small	Low	Easy	Short
SECTION B: TECHNICAL CONDITIONS				
16. Machinery maintenanc e	Small	Low	Easy	Short
17. Prevention of fertiliser drift	Small	Low	Easy	Short
18. Prevention of spray drift	Small	Low	Easy	Short
SECTION C: PHYSICAL CONDITIONS				
19. 2m field boundary strips	Large	High	Easy	Intermediate
20. Non-crop habitat as % of the farm	Large	High	Difficult	Long

4.4 Portugal practical suggestions

4.4.1 Portugal cross-compliance conditions

1. Contour ploughing ■ ≋

Description:

Desertification control – Cultivations along contours on slopes >8%.

Environmental benefit:

Erosion control. This measure is suggested in ONACCD, 1997 (the national organisation for desertification control) to control erosion in forestry and agriculture cultivations.

Guidelines:

Same as description. Applied to all cultivations.

Cost:

Costs of simplified topographic works and increase in machine power to work in contours. Cost depends on slope and the type of cultivation. If we consider a 30% increase in costs they can vary from €15/ha in a 8% slope ploughing to €250/ ha in high slope terrain preparation for forest plantation.

Agricultural implications:

Minimal

2. No stubble burning ■ ☂ 🕷

Description:

No stubble burning (or restricted burning)

Environmental benefits:

Stubble burning continues to be widely practised in Portugal, except in the Castro Verde Zonal Plan. No stubble burning would increase botanical diversity and invertebrate abundance, providing food for other wildlife. Incorporation of unburned crop residues increases soil organic matter.

Guidelines:

No, or restricted stubble burning.

Cost:

Increased cost of preparing land for subsequent crops.

Agricultural implications:

Accelerated mineralisation and control of crop diseases are perceived benefits of current stubble burning practice.

3. Winter cover crops ■ ♒ 🕷

Description:

Legumes or cereal/legume mixtures as winter soil cover for cropping or green manure where bare ploughed land would otherwise exceed 25% of arable area in winter.

Environmental benefits:

Reduced soil erosion and nitrate leaching, and increased soil organic matter. Legumes (and to a lesser extent cereals) provide food for birds over winter and grain and other seeds are also available in the following stubbles if the crop is allowed to mature. Cover cops would be particularly beneficial in irrigated areas where fallows are not present to maintain organic matter, and where surface runoff can be higher than in rain-fed systems.

Guidelines:

Sowing should be as early as practicable (Sept/Oct) to get early germination and rooting while soil is warm, and to avoid erosion and leaching in autumn. Suitable legumes include chickpea, field beans, lupins, vetches, clovers etc. Cereals include oats, triticale and soft wheat. Minimal cultivations and fertiliser use. Can be direct drilled. This practice can be applied to inter-row olive groves and can be grazed, harvested, sprayed off or green manured in the spring.

Cost:

Seed and sowing costs, €75-150 /ha.

Agricultural implications:

Improves soil organic matter and structure for following crops. Good water filtration and retention, especially if the crop is harvested or manured before dry weather starts (March/April).

4. Fallows as proportion of eligible area. ■

Description:

Minimum fallow area defined as a proportion of the eligible area by region (soil type). Only in applicable zonal plan areas.

Environmental benefits:

Fallows reduce soil erosion (Bergkemp *et al* 1997) and provide breeding nesting habitat for arable fauna.

Guidelines:

See description.

Cost:

Agricultural implications:

5. Buffer strips ■

Description:

Buffer strips on arable land with pivot irrigation schemes

Environmental benefits:

Reduced deposition of sediment, nutrients and pesticides in watercourses (Davies, 1999). Non-cropped habitat for wildlife.

Guidelines:

Buffer strips can be positioned along watercourses or along contours within cropped areas (contour strips) and should comprise unmanaged perennial vegetation.

Cost:

Cost of lost arable production varies considerably with location.

Agricultural implications:

Land lost to arable production, but soil loss reduced.

6. Restricted fertiliser use within Nitrate Vulnerable Zones ♒

Description:

Restriction on the use of organic and inorganic fertilisers on arable land within NVZs, an obligation within the Nitrates Directive.

Environmental benefits:

Minimisation of loss of nitrates to surface and ground water

Guidelines:

Fertiliser application forbidden when soil is saturated following rain. Application of nitrogen to be determined by soil fertility analysis. Maximum amounts of N/ha, depending on crops and zones (e.g. for maize 260 Kg/ha in zone 1 and 260kg/ha in zone 2).

Manure application forbidden between December and January. Organic nitrogen application limited to 210 Kg/ha/yr. Incorporation of manure into soil. Restrictions on irrigation rates.

Cost:

Reduced input costs, with possible yield loss in some circumstances

Agricultural implications:

May be some effect on profitability

4.4.2 Portugal agri-environment options

1. Restricted harvest dates

Description:

Indicated dates for cutting forage crops and harvesting grain cereals (Only in applicable zonal plan areas, due to administration constraints).

Environmental benefits:

Reduced destruction of bird nests and disturbance of chicks (e.g. great bustard, little bustard, Montagu's harrier, red-legged partridge. Granivorous species could also benefit from fallen grain.

Guidelines:

A local committee comprising bird experts and farmers (e.g. local farmers' association) decide the date when operations can be done. This can be forecast well in advance through experience, depending on climatic conditions.

It is also possible to grow forage crops with a structure that is not attractive to nesting birds. These could be cut at an earlier date.

Cost:

Varies with decided date, depending on the difference between this and the optimum harvesting date.

Forage crops – loss of feed at 0.5 t/ha. €62.5/ha
Cereal crops – loss of grain at 0.5t/ha. €62.5/ha

Agricultural implications:

Delayed harvesting results in a decline in forage quality and grain yield.

Suggested payment:

62.5 euros/ha/yr

2. Tritcale erosion control ■ ♒ 🕷

Description:

Sowing triticale for grazing and grain, straw and stubbles.

Environmental benefits:

Reduced soil erosion. Stubbles provide invertebrate and seed food for birds in winter.

Guidelines:

Triticale should be sown in October with minimal cultivations and fertiliser use. New varieties (e.g “Fronteira”) have been developed specifically for this purpose in southern Iberian Peninsular. They have improved tillering and are late-maturing.

Agricultural implications:

Can be grazed by cattle, sheep or goats during the difficult winter months of December and January and then recovers to produce grain and straw, as well as stubbles that can be grazed in late summer when alternative food is also scarce.

Cost:

Seed at €75/ha, Fertiliser at €25/ha and sowing costs at €50/ha = €150/ha.

Suggested payment:

Due to benefits to livestock payment should be less than cost, say €75/ha.

3. Arable conversion to trees ■

Description:

Arable conversion to trees (in accordance with the forest component of Reg. 1257/99 (Rural Development).

Environmental benefits:

Reduced soil erosion (Bergkamp et al., 1997). Increased local biodiversity, but potential loss of steppe habitats supporting nationally and globally endangered species (Araújo et al., 1996).

Guidelines:

Avoid areas associated with arable steppe habitats of conservation importance. Target slopes on land susceptible to erosion. Follow 2080/92 measures which suggest species to be planted in different zones within Portugal. Contour planting and good follow-up management is essential for effective establishment.

In the centre and north, pines and oaks would be planted for timber production. In the south, cork or holm oak or stone pine would be planted to increase (or re-establish) the area of montado where livestock can be grazed when the trees have established (10-20 years).

Cost:

Long-term investment with no income in early years, especially in montado.

Agricultural implications:

Land lost to arable production, but only that where gross margins from arable farming are currently very low.

Suggested payment:

Current payments are €184/ha/yr over 20 years for oak species, and €175/ha/yr for Pine.

4. Extensive arable systems

Description:

Management of extensive dryland arable systems (rotation of one or two years cereals followed by 1 – 4 years fallow, depending on soil type).

Environmental benefits:

Fallows reduce soil erosion (Bergkamp et al., 1997). Extensive arable systems are important habitat for endangered species such as great bustard, little bustard, Montagu’s harrier, stone curlew, calandra larks etc (Araújo et al., 1996). The systems also support high botanical diversity and abundance of invertebrates such as Orthoptera (Stoate et al., in press).

Guidelines:

Avoid cultivating slopes susceptible to erosion. Minimal tillage, with cultivations along contours. Restricted use of fertiliser and herbicides. Adoption of cereal varieties that are adapted to low input systems and are late-maturing. No cultivation of slopes >12%.

Cost:

Costs are lower than more intensive production systems.

Agricultural implications:

Requires close integration of livestock and arable systems.

5. Montado ■ ♒ ☂ 🕷 ⛰

Description:

Low density montado of holm oak, cork oak or Pyrenean oak.

Environmental benefits:

Montados are associated with high landscape diversity and biodiversity (Araújo et al., 1996) and trees and other perennial vegetation associated with them contribute to reduced soil erosion (Bergkamp et al., 1997).

Guidelines:

Minimal cultivations to avoid damage to tree roots and to prevent erosion on slopes. Protection of small trees from machinery and livestock damage, especially during scrub clearance. Some scrub cover should be retained for wildlife and erosion control. Pruning of trees should be done only by trained people. Livestock densities should be restricted to 2 LU/ha to prevent over-grazing (damages flora and soil) and damage to regenerating saplings.

Cost:

Loss of income from lower livestock densities and increased costs of scrub control.

Agricultural implications:

Winter pruning of oaks can be reserved for years of acute drought and used for cattle and goat feed.

Suggested payment:

€100/ha

6. Organic farming ■ ⩨ ☂ ✱ ⛰

Description:

Organic farming according to existing Reg 2078/92 guidelines (Ministéro de Agricultura, 1998; Agrobio, 1998).

Environmental benefits:

Reduced pesticide pollution of soil and water and improved SOM and soil structure.

Guidelines:

2-3 year conversion from conventional to organic system administered by ECOCERT. Equivalent rules for organic certification of livestock are currently being developed.

Cost:

Costs vary considerably, according to the agricultural system being converted.

Agricultural implications:

Lower yields during conversion and early post-conversion periods. Organic farms increased from 200 to 600 (18,000ha) between 1994 and 1998.

Suggested payment:

Under 2078/92 maximum payments (with modulation for larger areas) are:

AGRICULTURAL SYSTEM	PAYMENT (€/HA)
Annual dryland crops	181 (up to 25ha)
Annual irrigated crops	301 (up to 25ha)

7. Polyculture ■ ♒ 🕷 ⛰

Description:

Maintenance of extensive agriculture incorporating livestock, trees (fruit, vines, olives etc) and annual cropping according to existing Reg. 2078/92 guidelines (Ministéro de Agricultura, 1998).

Environmental benefit:

Conservation of biodiversity and cultural landscapes (e.g Dennis, 1998; Pretty, 1998). Changes in agricultural practices in European arable steppes can have significant impacts on bird populations of high conservation value. The maintenance of the mosaic within the agricultural system is essential for preserving biodiversity. For example, the fact that different species have different habitat requirements through the year is an important feature of bird communities in agricultural landscapes. Consequently, the maintenance of habitat diversity in traditional mixed farmland is of high conservation significance (Delgado & Moreira, in press). For example, cereal fields are selected mostly by species preferring tall and dense vegetation (e.g corn buntings (Cramp, 1988, Moreira & Leitão, 1996)), whereas other species as the little bustard , may have similar densities in cereal fields and fallows (Delgado & Moreira, in press). On the other hand, bare ground or grazed vegetation favour species like calandra larks. In the near future, the implementation of a package of scientifically based agri-environmental measures could represent a unique opportunity for the conservation of European farmland birds (Potts 1997, Borralho *et al.*, in press).

The benefits referred above for bird species will benefit a wide range of other species. These measures will have, in general, positive effects on the habitats and ecological niches of several other species.

Guidelines:

Conservation and promotion of biodiversity through the maintenance and improvement of environmentally-friendly extensive agricultural practices, simultaneously raising the farmers' income. Namely, the maintenance of the traditional arable systems that promote the maintenance of a large number of different habitats. They consist on an integration of cereal crops with alternating ploughs and fallows, co-existing with livestock and forest.

Maintain stocking density below 2 LU/ha forage area and maintain any existing system of traditional irrigation, terraces, trees and forest land. Optimise use of animal manure and restrict use of fertiliser and pesticides.

Cost:

In most cases the agricultural implications are centred on the costs related to the intervention and maintenance of non-profitable cultures. About 50 000 ha of extensive cereal land should be held in production in the traditional extensive rotations with an approximate cost of M€7.5/year.

Agricultural implications:

Dependent on specific zonal plan. This option prevents abandonment in areas where there is no alternative/supporting employment. The system is relatively labour-intensive, maintaining rural communities.

Suggested payment:

€300/ha/year

Under 2078/92 payments received are:

AREA	PAYMENT (€/HA)
Up to 5ha	217
5-10ha	173
More than 10ha	130

8. Water points 🕷

Description:

Water points management.

Environmental benefit:

Water availability has been shown to affect the survival (Degen, 1985), reproduction (Koerth & Guthery, 1991), population dynamics (Rice *et al.*, 1993), and distribution and habitat use (Brennan *et al*., 1987; Borralho *et al.*, 1998) of several bird species. The provision of summer water points is often suggested as a management tool for the improvement of red-legged partridge habitat (Otero, 1990). These water points can be reservoirs, small dams, small ponds, springs and wells with fauna accessibility. It is important to guarantee the sustainability of these water sources. In some drier regions this sustainability is only possible on managed areas, above all with game management. A recent study, concerning the summer distribution of red-legged partridge in relation to water availability on Mediterranean farmland, carried out on Southern Portugal, showed that water points significantly affected partridge distribution during the dry Mediterranean Summer. On average, the coveys were almost twice as close to water as would have been expected (Borralho *et al.*, 1998). Water points provide not only drinking water but also succulent food, such as green vegetation and arthropods, which possibly enhances the survival of adults and young (Degen, *et al.* 1984). It is possible that water availability acts seasonally as a limiting factor on life-history parameters of some species in the Mediterranean region, particularly in years of drought. Some studies found that during the summer months in hot and dry areas, phasianids are concentrated around water sources; except for areas where succulent vegetation remains abundant during the dry periods of the year (see for example, Rito & Borralho, 1997).

Guidelines:

Increase availability of water by means of maintenance of water supply in dry periods, cleaning and installation of water points.

Cost:

In the southern dry regions of Portugal more than 10 000 water points were needed to obtain regional scale effects, this results in a cost of about M€1.5/year.

Agricultural implications:

none.

Suggested payment:

€150\water point/year.

9. Wildlife crops ■ ☂ 🕷

Description:

Crops designed to provide food and cover for farmland wildlife

Environmental benefit:

The planting of game crops is a management measure often recommended to improve habitat quality for game species, in particular, resident small game. These crops can provide additional food at critical times of year, nesting cover, protection from predators, shade, invertebrates and green vegetation as a source of water in dry areas. Crop planting must be done according to the species that is(are) intended to benefit from the management. Legumes provide food for birds in the form of leaves in winter and invertebrates and seeds in summer. They can also be strategically placed to reduce soil erosion and increase SOM.

Guidelines:

Use of several game crops such as triticale, buckwheat, vetch and lupin Fences may be placed for the protection of the game crops from rabbits. The sowing period depends on the season during which it is intended to take advantage of the crop.

Early sowing (late September-early October) to have well established crops by late autumn. Small applications of P & K may be required, with nitrogen to aid establishment. Minimal cultivations or direct drilling are preferred. This option should be associated with other management such as provision of water points and fencing restrictions.

Cost:

Lost gross margin plus seed and sowing costs. Considering the amount of about 5000 ha of wildlife crops, the cost will be about M€1\year.

Agricultural implications:

Provides an alternative use for land abandoned by the cereal system. Contributes to soil structure and nutrient status for following crops if plots are moved from year to year.

Suggested payment:

€200\ha\year

10. Game management

Description:

Game management as a conservation measure and improvement of the income generated by agriculture.

Environmental benefit:

Game management is likely to have a significant impact on diversity. Game management can induce managers to adopt more ecologically beneficial practices on areas of intensive agriculture. These factors could contribute to a higher biodiversity and abundance on managed areas (Borralho *et al.*, subm.). Some measures as predator control could promote higher abundance and occurrence of game and non-game non-predatory species (Stahl and Migot, 1993). In a study carried out in Portugal on both game-managed farms and unmanaged farms, a higher number of species of European conservation concern was recorded on the adjacent game-managed areas. Guild diversity was also higher on managed sites (Borralho *et al.*, subm).

Guidelines:

Provide an incentive to farms with game management plans officially approved by the Ministry of Agriculture. Opportunities for training (perhaps conditional on receiving payments) should be made available to potential game managers to maximise broad environmental benefits and minimise negative impacts.

Cost:

Regarding the 2 650 000 ha of game managed zones we can estimate the cost of this measure at M€13.25\year

Agricultural implications:

The game management plans must adapt to the local conditions of agriculture production.

Suggested payment:

€5\ha\year

11. Shrub habitats ■ 🕷

Description:

Natural regeneration of woody vegetation in field boundaries.

Environmental benefit:

Many birds and other wildlife require shrubby habitats which have been removed from modern arable landscapes. Regeneration is currently prevented by more intensive grazing and more frequent cropping than in the past. Shrub strips could be sited along contours to minimise erosion.

Guidelines:

Install fencing parallel to field boundaries to create 10m wide strips of shrub vegetation by natural regeneration.

Cost:

Fencing costs and land lost to arable production.

Sheep fencing: 1 m height, 3xZn galvanized wire fence with a barbed wire top line, wood posts, applied in place: €2.99/ m.
cow fencing: 1.4 m height, 3xZn galvanized wire fence with a barbed wire top line, wood posts, applied in place: €5.38/ m.

Agricultural implications:

Land lost to arable production

Suggested payment:

€

12. Integrated whole farm plan

Description:

Integration of management options and cross-compliance conditions, in order to maximise environmental benefits in terms of management of soil, water, air, biodiversity and landscape.

Environmental benefit:

This option aims to maximise the environmental benefits of other agri-environment options and cross-compliance conditions. Full integration of environmental and agricultural management practices is likely to result in more economically and ecologically sustainable management of the farm, with emphasis on long-term benefits (two or three generations) as well as more immediate returns.

Guidelines:

The aim would be to enable the farmer, with professional advice, to formulate a package of management practices which would best suit the environmental, economic and cultural circumstances of each farm. The farmer would be encouraged to consider marketing opportunities arising from farm management changes resulting from the plan (e.g. regional or organic produce), or supplementary activities likely to benefit from it, such as shooting or tourism. Such opportunities would reduce dependence on financial support.

Cost:

Professional help with formulating integrated plan.

Agricultural implications:

Improved sustainability and, possibly, profitability of management system.

Suggested payment:

Table 4.11. Summary of environmental and agricultural benefits of cross-compliance conditions in Portugal.

	SOIL	WATER	AIR	BIODIVERSITY	LANDSCAPE	IMMEDIATE AGRICULTURAL	LONG-TERM AGRICULTURAL
Compliance with general mandatory regulations	Minimise pollution	Minimise pollution	Minimise pollution	Minimise pollution			
Forest landscapes	Minimise erosion	Minimise surface drainage	CO_2 sink	Increase plant diversity	Increase scenic quality of landscape		
Contour ploughing	Minimise erosion	Minimise surface drainage				Increased cultivation costs	Soil quality maintained
No stubble burning	Increase soil organic matter			Stubble use by wildlife			Soil quality maintained
Winter cover crops	Minimise erosion and nitrate leaching			Use of cover crops by wildlife			Soil quality maintained
Fallows as proportion of eligible area	Minimise erosion			Use of fallows by wildlife			
Buffer strips		Minimise sedimentation and loss of pesticides and nutrients to watercourses		Use of non-cropped habitat by wildlife			
Restricted fertiliser use in NVZs		Minimise loss of nutrients to watercourses					

Table 4.12. Summary of environmental and agricultural benefits of agri-environment options in Portugal.

	SOIL	WATER	AIR	BIODIVERSITY	LANDSCAPE	IMMEDIATE AGRICULTURAL	LONG-TERM AGRICULTURAL
Restricted harvest dates				Conservation of species breeding in cereals		Potential loss of cereal production	
Triticale erosion control	Minimise soil erosion			Stubbles provide invertebrate & seed food for birds in winter		Positive effects on cattle production	
Arable conversion to trees	Minimise soil erosion		CO_2 sink	Increased habitat and species diversity			Increased land value and forestry potential
Extensive arable systems				Important habitat for endangered species. High Botanical diversity		Requires close integration of livestock and arable systems	
Montado	Improved soil organic matter		CO_2 sink	Increased biodiversity	Promotes landscape diversity		
Organic farming	Improved soil organic matter	Reduced loss of soil, nutrients & pesticides to water	Organic matter as CO_2 sink	Increased habitat diversity	Increased landscape diversity	Economic premium on products	Improved sustainability
Polyculture				Increased habitat diversity	Increased landscape diversity	Limits on cattle stocking densities	
Water points				Increased species diversity			
Wildlife crops	Improved soil organic matter			Increased species diversity			
Game management				Increased species diversity		Maintenance of agricultural systems through diversification	
Pine & Eucalyptus plantations	Improved soil organic matter	Minimise surface drainage		Increased habitat diversity	Increased landscape diversity		
Shrub habitats		Reduced erosion on slopes		Increased habitat & species diversity			

*Table 4.13. Summary of criteria met by cross-compliance conditions in Portugal. Star rating selected so that **** represents favourable, and * represents unfavourable compatibility with criteria.*

	IMPACT ON FARMING SYSTEM	COST	EASE OF MONITORING	LENGTH OF TIME NEEDED FOR COMPLIANCE
Compliance with general mandatory regulations	Small	Low	Difficult	Short
Contour ploughing	Small	Low	Easy	Short
No stubble burning	Moderate	Low	Easy	Short
Winter cover crops	Moderate	High	Easy	Short
Fallows as proportion of eligible area	Small	Moderate	Easy	Short
Buffer strips	Small	Moderate	Easy	Short
Restricted fertiliser use in NVZs	Small	Moderate	Difficult	Short
Non-crop habitat as % of the farm	Dependent on farm	Dependent on farm	Easy	Moderate

5.0 DISCUSSION AND CONCLUSION

This report has attempted to identify the environmental impacts, both positive and negative, of current arable agriculture in the EU and how these are likely to change over the next few years. The intensification of arable production over the last few decades, whilst it has brought many benefits, has also resulted in negative effects on the environment, which now need to be addressed to fulfil the Agenda 2000 aim of better integrating environmental goals into the CAP.

Environmental impacts can be addressed by measures at three levels, (i) statutory conditions, (ii) conditions for receipt of direct subsidy payments (cross-compliance), and (iii) voluntary options for which additional payments are made under the Agri-Environment provisions of the Rural Development Regulation. This report is primarily concerned with (ii) and (iii) above.

One of the most difficult considerations with which we have had to contend is the dividing line between cross-compliance conditions, for which the farmer receives no additional reward, and agri-environment measures for which a payment is made. We accept that opinions will differ on where this boundary should be drawn. Our criteria for cross-compliance conditions are set out in section 4.1, but it is recognised that it is not possible to address all the problems identified in Section 2 with measures which fulfil all the criteria completely, and some level of compromise will be needed.

Our aim in developing the set of suggestions for cross-compliance has been the development of arable farming which is both *agriculturally and environmentally sustainable.* However, it has become clear that in a number of areas there is insufficient information available at the current time to determine what is, and what is not, sustainable in the medium to long term, for example in terms of levels of water abstraction. It is expected that there will therefore be an evolution of environmental measures to better address the issue of sustainability as further research is carried out in this area.

In drawing the distinction between cross-compliance and agri-environment proposals, we have been guided by the statements that "Agri –environmental commitments shall involve more than the application of good farming practice" (Council Regulation No 1257/1999, Article 23, paragraph 2), and "…..usual good farming practice is the standard of farming which a reasonable farmer would follow in the region concerned" (Commission Regulation No. 1750/1999, Article 28). We have considered that good farming practice should be sustainable. However, although reasonable farmers would be expected to be concerned with the agricultural sustainability of their management practices, and should also be concerned with their environmental sustainability on their own land, many of the environmental effects of arable farming are partly or completely externalised (e.g. pollution of watercourses), and so are of greater concern to society as a whole than the farmer himself. This externalisation of impacts gives rise to the need for cross-compliance conditions, under the assumption that farmers should accept their responsibility for the effect of agriculture on the environment as a whole, not just within the boundaries of their farms.

Cross-compliance conditions, then, should aim to bring all farmers up to a level which is acceptable to the rest of society. It is important that in this process the contribution of those who are already above average is recognised, and measures such as requiring all farmers to manage a proportion of their eligible area in a environmentally beneficial manner, and setting a minimum distance between non-crop habitats, will ensure that the burden falls on those who do not currently make their share of the contribution.

In order to judge whether farmers have complied with their obligations, an inventory providing baseline data on the current status of farm structure, features etc. would be invaluable. Some of the necessary information is already collected under the IACS system, and this could be extended to provide the further information needed.

One management practice which can have a considerable influence on environmental impacts and sustainability is cultivation system. Inappropriate cultivations can lead to considerable ecological and environmental damage, and there is considerable scope for improving systems both in terms of such impacts and also in terms of improving farm profitability. However, cultivation machinery and practices vary widely and interact in complex ways with farm type and size, soil type and condition as well as cropping system, and we did not feel it appropriate therefore to suggest prescriptions for cultivation techniques. Improvements in cultivation practices are probably better pursued through advice and training based on a continuing research programme, and the recent initiation of ECAF (European Conservation Agriculture Federation) is a major step forward in this regard.

Benefits of environmental measures are likely to be maximised by a holistic approach, and emphasis has been placed on integrated whole farm plans by contributors from all three key countries in this study. Ideally, a long term aim would be for all farms to have such a plan, but for most this would require professional help and so a considerable funding commitment would be needed.

The European Union contains a large range of farming systems, landscapes and traditions. Many of the aspects which are most valued by society, and most environmentally important are a product of regional or local systems which have developed over long periods of time. Inevitably, centralisation of decision making promotes uniformity, and this trend must be constantly monitored and, where necessary, resisted if the cultural and ecological diversity within rural Europe is not to be irreparably damaged. One way of supporting regional traditions is through local marketing strategies incorporating premia for food produced in a traditional and environmentally benign manner. Such approaches also help to reduce unnecessary transport, thus reducing the environmental footprint of food production in terms of energy consumption and air pollution. The measures suggested in this report will have the greatest benefits if implemented within such a framework.

In conclusion, the measures proposed in this report are seen as a start in the process of transferring the emphasis of agriculture from purely food production to environmentally sustainable production in a way which provides other services such as unpolluted air and soil, a diverse landscape incorporating abundant biodiversity, and a thriving rural culture. In the longer term, further adjustment of the agriculture support system will be needed to ensure that this aim is fully achieved.

Endnote

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Appendix 1. Data on the EU Arable Sector

Appendix 1.1: Total COP areas ('000 ha)

	1993/4	1994/5	1995/6	1996/7
B/Lux	521	522	514	524
Denmark	1779	1720	1754	1819
Germany	8696	8692	8640	8962
Greece	1362	1346	1225	1302
Spain	8830	8252	8191	8296
France	12108	11873	11921	12506
Ireland	296	278	281	294
Italy	4746	4789	4998	5181
Netherlands	425	436	434	434
Portugal	855	828	750	764
UK	3854	3813	3881	4020
Austria			1032	1055
Finland			1068	1143
Sweden			1199	1275
EU-12	43472	42548	42589	44102
EU-15			45888	47575

Appendix 1.2: EU Cereal Areas ('000 ha)

	1992	1993	1994	1995	1996	1997
B/Lux	340	342	339	338	325	333
Denmark	1612	1438	1415	1454	1545	1555
Germany	6514	6224	6235	6527	6707	7014
Greece	1407	1374	1307	1235	1300	1304
Spain	7404	6426	6486	6693	6770	6977
France	9345	8543	8168	8292	8839	9204
Ireland	300	285	270	274	293	310
Italy	4225	4073	4117	4225	4262	4150
Netherlands	183	187	194	198	206	207
Portugal	753	712	688	689	670	703
UK	3489	3031	3042	3181	3357	3514
Austria	838	825	821	754	810	848
Finland	917	923	945	978	1075	1112
Sweden	1168	1153	1173	1104	1209	1268
EU-12	35573	32632	32262	33105	34276	35271
EU-15	38496	35534	35201	35941	37371	38500

Source: Crop Production Quarterly Statistics, 1992-1998 (Eurostat)

Appendix 1.3: Cereal area as % of utilized agricultural area

	1991	1993	1994	1995
Belgium	22.5	22.6	22.7	22.6
Denmark	56.5	54.1	51.9	53.3
Germany	37.1	37.7	36.1	37.6
Greece	25.8	25.0	25.6	30.5
Spain	29.3	29.3	22.2	22.2
France	30.2	30.7	26.8	27.5
Ireland	6.8	6.8	6.1	6.2
Italy	24.4	25.3	23.1	23.8
Luxembourg	24.6	23.6	23.4	22.7
Netherlands	9.0	9.2	9.9	10.0
Portugal	18.2	16.8	16.5	16.8
UK	19.0	19.7	19.1	20.1
Austria			23.9	23.5
Finland			37.3	45.2
Sweden			32.7	35.4
EU-12	26.9	27.2	24.7	25.5
EU-15			25.2	26.0

Appendix 1.4: Oilseed areas ('000 ha)

	1993/4	1994/5	1995/6	1996/7
B/Lux	8	15	11	8
Denmark	161	171	154	107
Germany	1151	1288	1051	923
Greece	17	21	21	24
Spain	2080	1408	1169	1213
France	1401	1823	1916	1863
Ireland	2	6	5	3
Italy	276	418	468	594
Netherlands	1	1	2	2
Portugal	98	130	69	107
UK	422	506	445	430
Austria		155	140	104
Finland		67	86	61
Sweden		128	109	67
EU-12	5617	5787	5311	5274
EU-15		6137	5646	5506

Appendix 1.5: Oilseed area as % of utilized agricultural area

	1991	1992	1994	1995
Belgium	0.5	0.4	1.3	1.3
Denmark	10.1	6.1	6.3	6.0
Germany	5.5	5.1	7.4	
Greece	0.0	5.2	0.4	0.6
Spain	4.4	4.4	5.1	4.2
France	6.2	5.6	5.9	6.5
Ireland	0.1	0.1		0.1
Italy	3.0	2.8	2.7	2.8
Luxembourg	2.4	1.2	1.4	2.1
Netherlands	0.3	0.2	0.2	0.2
Portugal	0.0	1.7	3.3	2.4
UK	2.4	3.3	3.6	
Austria				4.6
Finland				4.0
Sweden			4.6	3.5
EU-12	4.0	3.7	4.7	
EU-15				

Appendix 1.6: Protein crop areas ('000 ha)

	1993/4	1994/5	1995/6	1996/7
B/Lux	9	6	5	2
Denmark	121	106	78	69
Germany	89	75	120	150
Greece	5	4	3	2
Spain	29	98	108	113
France	750	672	580	547
Ireland	6	5	2	
Italy	90	84	42	59
Netherlands	4	4	2	1
Portugal	17	1	5	4
UK	214	229	191	174
Austria		55	26	35
Finland		6	5	5
Sweden		10	13	18
EU-12	1334	1283	1137	1121
EU-15		1353	1181	1179

Appendix 1.7: Protein area as % of utilised agricultural area

	1991	1992	1994	1995
Belgium	0.4	0.3	0.4	0.2
Denmark	3.6	4.0	3.8	
Germany	0.3	0.4	0.6	0.7
Greece	0.0	0.6	0.4	0.5
Spain	1.1	1.1	1.4	1.9
France	2.3	2.4	2.3	1.9
Ireland	0.1	0.1	0.1	0.1
Italy	0.9	0.9	0.6	0.6
Luxembourg	0.8	0.6	0.5	0.4
Netherlands	0.7	0.5	0.3	0.2
Portugal	5.6	5.8	1.2	1.2
UK	1.6	1.2	1.4	1.2
Austria			1.4	0.8
Finland			0.4	0.3
Sweden				
EU-12	1.0	1.5	1.3	
EU-15				0.5

Appendix 1.8: EU Cereal Average Yields (t/ha)

	1993/4	1994/5	1995/6	1996/7
B/Lux	6.72	6.57	6.67	7.54
Denmark	5.7	5.54	6.16	5.82
Germany	5.71	5.83	6.11	6.19
Greece	3.19	4.03	3.42	3.24
Spain	2.69	2.31	1.69	3.1
France	6.52	6.55	6.45	6.95
Ireland	5.8	6.08	6.4	7.02
Italy	4.8	4.61	4.3	4.70
Netherlands	7.9	7.03	7.64	8.33
Portugal	1.97	2.3	1.79	2.44
UK	6.43	6.55	6.84	7.3
Austria		5.39	5.54	5.13
Finland		3.6	3.4	3.47
Sweden		3.84	4.43	4.82
EU-12	5.13	5.08	4.99	5.55
EU-15		5.01	4.94	5.46

Appendix 1.9: Average Rapeseed yields - food use (t/ha)

	1993/4	1994/5	1995/6	1996/7	1997/8
B/Lux	3.00	3.00	3.00	3.00	
Denmark	2.54	2.15	2.18	2.25	
Germany	2.83	2.63	3.2	2.35	
Greece					
Spain	1.23	0.81	0.66	1.50	
France	2.85	2.63	3.21	3.31	
Ireland	3.30	3.31	3.30	3.30	
Italy	2.00	2.09	2.44	1.80	
Netherlands	3.30	3.30	3.30	3.30	
Portugal			1.20	1.20	
UK	2.98	2.54	2.80	3.30	
Austria		2.85	2.85	2.10	
Finland		2.16	1.50	1.60	
Sweden		1.88	1.89	2.40	
EU-12	2.83	2.52	2.92	2.79	
EU-15		2.49	2.81	2.72	

Appendix 1.10: Average Protein crop yields (t/ha)

	1993/4	1994/5	1995/6	1996/7	1997/8
B/Lux	4.47	4.41	4.48	4.52	
Denmark	3.76	3.60	3.60	3.90	
Germany	3.26	3.20	3.21	3.28	
Greece	2.11	2.00	2.00	2.00	
Spain	1.13	1.00	0.56	0.93	
France	5.07	5.10	4.79	4.80	
Ireland	4.86	4.87	4.79		
Italy	1.57	1.56	1.70	1.84	
Netherlands	4.71	4.63	3.00	3.00	
Portugal	0.82	0.80	0.80	0.80	
UK	3.88	3.17	3.18	3.60	
Austria		3.10	3.26	3.33	
Finland		2.24	1.00	1.00	
Sweden		4.08	2.63	2.50	
EU-12	4.25	3.96	3.72	3.79	
EU-15		3.92	3.69	3.74	

Appendix 1.11: Average cereal area/holding (ha)

	1993/4	1995/6	1996/7*
Belgium	8.7	8.7	10.0
Denmark	21.7	23.2	25.6
Germany	15.1	17.2	21.9
Greece	3.3	3.3	4.1
Spain	13.5	13.5	17.7
France	17.8	19.4	24.3
Ireland	13.8	13.8	15.4
Italy	4.4	4.4	5.9
Luxembourg	13.1	13.8	16.6
Netherlands	9.7	9.7	8.0
Portugal	2.5	2.7	4.3
UK	40.8	42.6	52.0
Austria	6.7	6.7	7.8
Finland	12.3	12.3	13.1
Sweden	19.1	19.1	20.3
EU-12	10.1	10.8	14.4
EU-15	10.4	10.8	14.2

Appendix 1.12: Average aided area per farm (general scheme) (ha)

	1993/4	1994/5	1995/6	1996/7
Belgium	44	41	42	42
Denmark	50	51	52	53
Germany	72	67	64	64
Greece	13	15	13	14
Spain	66	61	52	48
France	57	57	58	60
Ireland	59	53	52	54
Italy	29	23	23	21
Luxembourg	36	39	40	45
Netherlands	47	36	38	38
Portugal	121	111	100	85
UK	116	115	114	114
Austria			23	22
Finland			24	26
Sweden			45	45
EU-12	62	59	56	54
EU-15			52	51

Appendix 1.13: General scheme arable aid applications (areas) as a proportion of total (%)

	1993/4	1994/5	1995/6	1996/7
Belgium	30.7	36.6	36.2	37.0
Denmark	73.4	79.5	82.0	83.8
Germany	74.9	79.1	80.3	82.4
Greece	7.3	10.8	9.1	8.9
Spain	68.1	75.0	79.4	82.2
France	80.6	83.4	84.0	85.2
Ireland	60.4	68.9	68.9	67.9
Italy	32.9	35.7	38.4	43.0
Luxembourg	31.3	35.5	38.3	40.6
Netherlands	15.4	22.4	21.6	22.3
Portugal	63.0	58.0	58.8	54.7
UK	92.3	93.4	93.5	94.0
Austria			61.9	65.4
Finland			68.0	65.1
Sweden			83.0	83.2
EU-12	70.1	73.7	75.1	76.9
EU-15			74.9	76.5

Appendix 2. List of species mentioned in the text

English Name	Scientific Name
Plants	
Almond	*Prunus communis*
Annual vernal grass	*Anthoxanthum puelii*
Barley	*Hordeum distichum*
Barren brome	*Bromus sterilis*
Birdsfoot trefoil	*Lotus corniculatus*
Black mustard	*Brassica nigra*
Broad-leaved dock	*Rumex obtusifolius*
Buckwheat	*Fagopyrum esculentum*
Chickpea	*Cicer arietinum*
Cleavers	*Galium aparine*
Cocksfoot	*Dactylis glomerata*
Common sorrel	*Rumex acetosa*
Cork oak	*Quercus suber*
Cornflower	*Centaurea cyanus*
Corn marigold	*Chrysanthemum segetum*
Creeping thistle	*Cirsium arvense*
Cuckoo flower	*Cardamine pratensis*
Curled dock	*Rumex crispus*
Evening primrose	*Oenothera biennis*
Field beans	*Vicia faba*
Holm oak	*Quercus rotundifolia*
Kale	*Brassica oleracea acephala*
Lamb's succory	*Arnoseris minima*
Linseed	*Linum usitatissimum*
Lucerne	*Medicago sativa*
Lupin	*Lupinus luteus*
Maize	*Zea mays*
Maritime pine	*Pinus pinaster*
Millet	*Panicum miliaceum*
Mustard	*Sinapis alba*
Night-flowering catchfly	*Silene noctiflora*
Oats	*Avena spp.*
Olive	*Olea europea*
Phacelia	*Phacelia tanacetifolia*
Potato	*Solanum tuberosum*
Quinoa	*Chenopodium quinoa*
Ragwort	*Senecio jacobaea*
Red clover	*Trifolium pratense*

Red fescue	*Festuca rubra*
Reed	*Phragmites australis*
Rye	*Secale cereale*
Ryegrass	*Lolium perene*
Spear thistle	*Cirsium vulgare*
Stone pine	*Pinus sylvestris*
Sugar beet	*Beta vulgaris*
Teasel	*Dipsacus fullonum*
Timothy	*Phleum pratense*
Trticale	*Triticum x Secale*
Umbrella pine	*Pinus pinea*
Vetch	*Vicia spp.*
Wheat	*Triticum aestivum*
Wild turnip	*Brassica rapa*

Invertebrates

Wire worm	*Agriotes lineatus (larvae)*
Leatherjacket	*Tipula sp. (larvae)*

Birds

Avocet	*Recurvirostra avosetta*
Barn owl	*Tyto alba*
Black-headed gull	*Larus ridibundus*
Black-tailed godwit	*Limosa limosa*
Calandra lark	*Melanocorypha calandra*
Cirl bunting	*Emberiza cirlus*
Corncrake	*Crx crex*
Common tern	*Sternahirundo*
Corn bunting	*Miliaria calandra*
Great bustard	*Otis tarda*
Grey partridge	*Perdix perdix*
Lapwing	*Vanellus vanellus*
Lesser kestrel	*Falco naummanni*
Little bustard	*Tetrax tetrax*
Marsh harrier	*Circus aeruginosus*
Montagu’s harrier	*Circus pygargus*
Ortolan bunting	*Emberiza hortulana*
Red-legged partridge	*Alectoris rufa*
Reed bunting	*Emberiza schoeniclus*
Short-eared owl	*Asio flammeus*
Skylark	*Alauda arvensis*
Song thrush	*Turdus philomelos*
Stone curlew	*Burhinus oedicnemus*
Tree sparrow	*Passer montanus*
Turtle dove	*Streptopelia turtur*

White stork	*Ciconia ciconia*
Yellowhammer	*Emberiza citrinella*
Yellow wagtail	*Motacilla flava*

Mammals

Brown hare	*Lepus capensis*
Cattle	*Bos taurus*
Hamster	*Crisetus crisetus*
Harvest mouse	*Micromys minutus*
Pig	*Sus scrofa*
Rabbit	*Oryctolagus cuniculus*
Sheep	*Ovis aries*

Appendix 3. Afforestation of arable land in Portugal in the 1990s

In 1989 the total area of arable land in Portugal was estimated as 2 330 365 ha (RGA, 1989). During the last decade two major global change tendencies were registered in arable land: (1) an increase in fallow area in direct response to changes in CAP market policies and (2) the transformation of arable land to forest in response to market policies, forest measures (Reg 2080/92) and specific national forest programs during the period 1994-1999 (PAMAF –PDF).

The forest measures (Reg 2080/92) were specifically directed at afforestation of agricultural land and were almost all applied to the afforestation of arable land. Despite the relatively low intensity of the two programmes, the results of the first four years of application (1994-1998) show that the rate of conversion of arable land to forest is substantial. If the year of 1989[3] is taken for reference, in the last four years about 6% of the total arable land was planted with forest whithin the scope of Reg 2080/92 (MADRP, *não publicado*). If the forest plantation carried out whithin PDF is considered, the total afforestation undertaken during the same period represents about 8.2% of the arable land present in 1989.

Table 1 Area of forest planted (ha) (Reg 2080/92 and PDF) during the 1994-1998 period *(MADRP, não publicado)*

SPECIES	REG 2080/92	PDF	TOTAL
Maritime pine (*Pinus pinaster*)	4465	31492	35957
Umbrella pine (*Pinus pine*a)	26280	3682	29962
Cork oak (*Quecus suber*)	55138	8806	63944
Holm oak (*Quercus rotundifoli*a)	22005	1011	23016
Others	24756	14164	38920
Total	132644	59155	191799

The dynamics of arable land in Portugal are strongly linked with forest. The process of afforestation of arable land is promoted by the EU (Reg 1257/99), providing reasons to believe that its intensity will increase in the 1999-2006 period. The suggestions regarding environmental impacts of agriculture in Portugal must consider the dynamics of change in arable land and anticipate the major impacts of afforestation. We therefore recommend that the following be adopted as an agri-environment measure, in addition to those listed in section 4.4.2.

Pine and Eucalyptus plantations

[3] The last agriculture census operation was done in 1989, a new operation is currently in the fieldwork phase. The new census results, probably available in late 2000 will reflect the changes described above.

Description:

Vegetation management in Pine and Eucalyptus stands.

Environmental benefit:

Arable land has been replaced by pine and eucalyptus plantations in many areas so that forest plantations are now present within arable landscapes (Appendix 2). All forests should have conservation goals among their management objectives, including separate conservation areas. The importance of these comes from the fact that most of them are permanent, unlike the rest of the productive forest which changes dramatically, particularly at the end of each rotation. Such features provide permanent bird habitat and retain representative sections of the original vegetation (Hill, 1983), providing a refuge for sedentary animals such as amphibians, reptiles and small mammals during the closed-canopy stage (Petty & Avery, 1990). Promoting a greater structural diversity along edges between wooded and open areas creates a more gradual transition between them (Forestry Commission, 1993). For example, habitat structure and botanical composition have an important role in the structure of bird communities. Their management can therefore be a useful conservation tool (Tellería, 1992).

Another type of environmental benefit is water and soil conservation. The existence of arboreal and shrub cover has positive effects on soil and water conservation for the following reasons:

- Protects the upper layer against erosion caused by abiotic agents
- Forest cover is positively related with water quality;
- The soil infiltration rates increase
- The roots constitute a structural support that strengthens the soil resistance to abiotic and biotic agents.
- The riparian vegetation represents the habitat of a wide number of species, while playing an essential role in maintaining water quality and the stability of the margins of watercourses.

Guidelines:

Once the decision to plant an area has been taken, it is then essential to achieve the best design for wildlife and landscape (Petty & Avery, 1990). Pragmatism and-cost-effectiveness are as important in wildlife management as in landscape design. There are many potential different ways of benefiting wildlife through practical management, and their costs vary greatly. It is important to develop a permanent zone of widely spaced trees (conifers and broad-leaves) at the forest edge for species such as red-legged partridge and some raptors.

We suggest the following general recommendations for biodiversity conservation in woodlands (adapted from Smart & Andrews 1985):

i) The use of indigenous broadleaved trees should be promoted on commercial forest stands; ii) Site surveys should be undertaken in order to identify potentially important conservation areas; iii) Non-productive areas (such as rides) and unproductive ground (such as streams) should be identified and managed with conservation objectives; iv) Large woods are better than small ones; v) forest stands should be managed for both common and uncommon species.

Thinning and maintenance recommendations:
i) Crown thinnings are preferable, especially if they confer diversity to the existing structure; ii) Thinnings should be performed as early as possible in the thicket stage; iii) Suppressed trees which have no economic value and whose removal will therefore represent a cost, should be left on the ground; iv) Cultural operations should not be performed during the breeding season (March-mid June).

Harvesting recommendations:
i) In general, it is preferable to intervene in small areas than in large ones. ii) Felling operations should not be considered separately from other sylvicultural practices. Harvesting should be planned in order to promote structural diversity of the forest; iii) Sylvicultural operations should not be performed during the breeding season; iv) It is recommend to leave some standing trees or groups of trees instead of undertaking a clear cut; v) extraction routes should be planned in advance to avoid unnecessary damage to the trees and the understorey vegetation.

Cost:

Considering the intervention in 0.5 million ha of *Pinus* and *Eucalyptus* stands the cost will be about M€25.

Agricultural implications:

The minimisation of some afforestation negative impacts on biological diversity implies the use of some alternative management practices, some of them may imply some reduction on timber volume production.

Suggested payment:

€50\ha\year

1

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