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Economic Assessment of Crop Yield Losses from Ozone Exposure

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THE UNECE INTERNATIONAL COOPERATIVE PROGRAMME ON VEGETATION

CONTRACT EPG 1/3/170

ECONOMIC ASSESSMENT OF CROP YIELD LOSSES FROM OZONE EXPOSURE

EXECUTIVE SUMMARY

An economic assessment of the impacts of ozone on crop yield in Europe has been carried out as part of Contract EPG 1/3/170 (The UNECE International Cooperative Programme on Vegetation). This assessment is more detailed and substantially refines previous work performed in this field for UNECE. Crop response functions were derived from a comprehensive literature review conducted by Alan Buse (CEH Bangor). Maps of crop distribution were developed at SEI-Y by Howard Cambridge and Steve Cinderby. Data on crop distribution, concentration-response, and value, were then translated into an economic assessment of the impacts of ozone on agriculture by Mike Holland, netcen, AEAT. This study will in future allow more confidence to be placed in estimates of the benefits to agriculture of European abatement strategies for air pollution.

Refinements to the analysis, in comparison with earlier pan-European estimates, included:

- Updating of exposure-response functions used in the analysis;
- The use of detailed databases to assess crop distribution , with resolution of the mapping being improved by a factor of 9, from 150 x 150 km to 50x50 km;
- Differences in the growing season in different parts of Europe being taken into account;
- Updating of crop valuations.

Through these improvements the assessment moves closer to a Level II analysis. Further information could in future be integrated with the modelling framework developed in this study to move closer to a Level II analysis.

Impacts and costs were quantified for ozone exposures under four of the NOx/VOC emission scenarios considered in the development of the Gothenburg Protocol:

- 1990 Baseline scenario;
- 2010 Reference scenario - essentially business as usual, with legislation that is already in place or in the pipeline taking full effect;
- Gothenburg Protocol - with each country precisely meeting its Gothenburg targets in 2010;
- J1 scenario – the main scenario for 2010 considered in negotiations on the Protocol, that would have required a greater level of abatement than was finally agreed.

Ozone data for this study, taken from the EMEP model, were available only on the 150 x 150 km EMEP grid, though the modelling framework is able to integrate the finer resolution 50 x 50 km data when it becomes available.

Results are listed in detail at the end of the report by country, crop and scenario. Results for the 1990 scenario found damages of £4.3 billion, declining to £2.8 billion in scenario J1 (the scenario with the highest level of abatement). Of these damages, 32% was attributed to wheat, 21% to potato and 9% to sugar beet. Inclusion of reductions in meat and milk production, through effects on grass production could raise these damages by up to 68%, though further discussion on methods is needed in this area.

Future research should concentrate on the following:

- Enhancement of the Level II approach;
- Development of methods for assessment of damages to meat and milk production.

1 INTRODUCTION

1.1 Past economic analyses of crop losses from exposure to ozone

Economic assessments of the effects of ozone on crop yields have been undertaken in the USA since the mid-1980s (as reviewed by Heck, 1989). The first such analysis in Europe was performed by van der Eerden *et al* in 1988 for the Netherlands, considering the effects not just of ozone, but also of SO_2 and HF. This was followed by:

- Work in the Andalusian Region of Spain (AED, 1991)
- The ExternE Project (European Commission, 1995, 1998)
- The Green Accounting Research Project (GARP, Markandya and Pavan, eds., 1999)
- Numerous analyses during discussions of the EU's Directives on air quality limits for ozone and national emission ceilings (AEA Technology, 1998; 1999a)
- Assessment of the UNECE's Gothenburg Protocol (AEA Technology, 1999b)
- Assessment of the UK's National Air Quality Strategy (IGCB, 1999, 2001)
- An updated analysis of pollution impacts on yield in the Netherlands.

Van der Eerden (1988) valued the effects of air pollution - ozone, SO_2, and HF - upon the yield of 14 crop species. All three pollutants were considered to occur in sufficiently high concentrations to cause adverse effects. To establish monetary values, an inventory was made of the cropped area per species for each province and the yield at ambient concentration levels. New prices were calculated for any changes in supply taking into account the price elasticity per species. Estimated yields were not simply valued using current market prices, but a model of supply and demand was used to obtain estimates in the changes in producers' and consumers' surpluses. The study found that pollution affected total production value only marginally because price changes offset production changes. If air pollution were reduced to baseline levels, producer surplus would only decrease by DFL 73 million (about Euro 30 million). Consumers, however, could receive a net loss of as much as DFL 701 million (Euro 300 million) nationally, due to a 5% drop in yield of sensitive crops. Of this 5%, ozone accounted for 3.4% of the loss, SO_2 for 1.2% and HF for 0.4% of the loss. (All figures are in 1990 prices). Although some adjustments were made to allow for price effects, some other effects were ignored. The supply functions were not derived from an overall profit maximisation model of farmer response, so cropping patterns were not fully adjusted to allow for the differential environmental impacts of changes in pollutants on yields. Non-linearity in dose-response relationships will affect the grossing-up of national estimates. Finally the extrapolation of available concentration-response data would have introduced additional error. Another issue is that the type of modelling undertaken in the study required simulation of behaviour in the agricultural sector. Suitable models for this are not available at the European level.

AED (1991) found that the crop loss in the Andalusian region of Spain was in the order of 930 million Pesetas (Euro 8.7 million, 1987). This result was obtained using market prices only. Using market prices in conjunction with a demand and supply model, another estimate of 1.7 billion Pesetas (Euro 15.8 million, 1987) was found (including wheat and corn, all figures in 1987 prices). This indicates that, as in the van Eerden study, the consumer losses from price rises are a significant part of the costs of the air pollution.

A similar pattern has been observed in the USA (Adams *et al*, 1982, 1986; Adams and McCarl, 1985; Shortle *et al*, 1986). In short, a simple model that does not include changes in price, etc., with variation in yield, will in theory provide a less accurate estimate than a more comprehensive economic model, provided of course that the economic model is adequately parameterised.

The analyses using the ExternE and GARP methodologies, including those for the European Commission and UNECE, have been unable to apply a general equilibrium model for assessment of air pollution impacts on agriculture. Instead they have simply applied world market prices (i.e. prices that are little affected by subsidy, see Squire and van der Tak, 1975) to estimates of yield change. This approach was accepted by the UNECE Task Force on Economic Aspects of Abatement Strategies in the discussions that fed into the development of the Gothenburg Protocol as the only practicable approach at the pan-European scale. Given that this is the approach that will be followed here, it is necessary to ask at this early stage what effect there might be on the reliability of the results. There are several reasons for this analysis to be less concerned about the problem. Most importantly, Protocols and Directives bring about incremental changes in production resulting from relatively small changes in air quality, not to the total damage attributable to all air pollution. On this basis, the damage avoided by legislation tends to be much less significant than might be suggested by the work of van der Eerden and others. Another factor is that the European agricultural system may well undergo fundamental change over the next 10 or so years, as a result of reform (of whatever nature) to the Common Agricultural Policy. Models developed now may therefore not be relevant by 2010, or whatever year future analysis is required for. Overall, the simple application of world market prices may not be perfect, but it is transparent, and at the very minimum a useful starting point for analysis.

Some work on refinement of the methods, particularly with respect to the modelling of agricultural economics, is currently being performed by Mr Harris Neeliah at the University of Reading.

The studies for the Commission and UNECE were criticised by some experts in the field as going further than was reasonable given limitations on the state of science. However, the problem faced at the time was that decisions on legislation were to be taken, whether or not the science was able to provide an answer to the magnitude of the benefits of abatement. Against this background it is justifiable to apply the data that are available to at least gauge the order of magnitude of impacts, to see whether they are likely to account for a significant portion of the costs of abatement.

1.2 Scoping the Analysis

The ExternE Project developed the ‘Impact Pathway Approach’ for assessment of the effects of energy systems on health, amenity and the environment. The pathway for agricultural crops is shown in Figure 1.1. It includes effects not just of ozone, but of SO_2 and acidification also (a simplified version specifically for ozone has not been produced for this study because of the potential for interaction between the different pollutants). All known effects, including feed-backs, have been included, whether or not these are thought to be quantifiable at the current time. On the basis of a multiple-stress hypothesis it should be assumed that each effect on an organism may interact with any other impact on that organism, whether they are joined by an arrow or not (depiction of all potential interactions would be confusing). The comprehensive nature of these pathways is intended to allow the effects that have been quantified to be put into perspective with those that have not. Consideration of all potential impacts will also assist in the identification of priorities for future research.

Figure 1.1 shows various mechanisms for air pollutants to affect the value of agricultural produce. It also demonstrates that there are potentially several components of economic impact.

There are three major problems relating to the quantification of effects of air pollution on crops:

1. Lack of suitable concentration-response data available for many of the crops listed in Table 1.1.
2. Variability of the response of crops in the field compared to experimental material
3. Accounting for these problems within a comprehensive, yet comprehensible, assessment of uncertainties.

Table 1.1 Proportion of value of agricultural production across the EU attributable to individual agricultural products (source: Eurostat).

Rank	Product	% share	Rank	Product	% share
1	Milk	17.3	15	Potatoes	2.2
2	Cattle	12.7	16	Maize	1.9
3	Pigs	10.8	17	Olive oil	1.5
4	Fresh vegetables	8.7	18	Citrus fruit	1.2
5	Wheat and spelt	6.3	19	Pulses	0.7
6	Other crops[1]	6.1	20	Tobacco	0.6
7	Grape must and wine	5.8	21	Other industrial crops[1]	0.6
8	Fresh fruit	4.6	22	Other animal products[1]	0.5
9	Poultry	4.3	23	Grape	0.5
10	Other animals[1]	3.2	24	Other cereals[1]	0.4
11	Eggs	2.6	25	Rice	0.4
12	Barley	2.3	26	Table olives	0.2
13	Sugar beet	2.3	27	Hops	0.1
14	Oil seeds and fruit[2]	2.3			

Notes: 1) Includes crops not accounted for specifically elsewhere in the table. 2) Excluding olives which are accounted for separately.

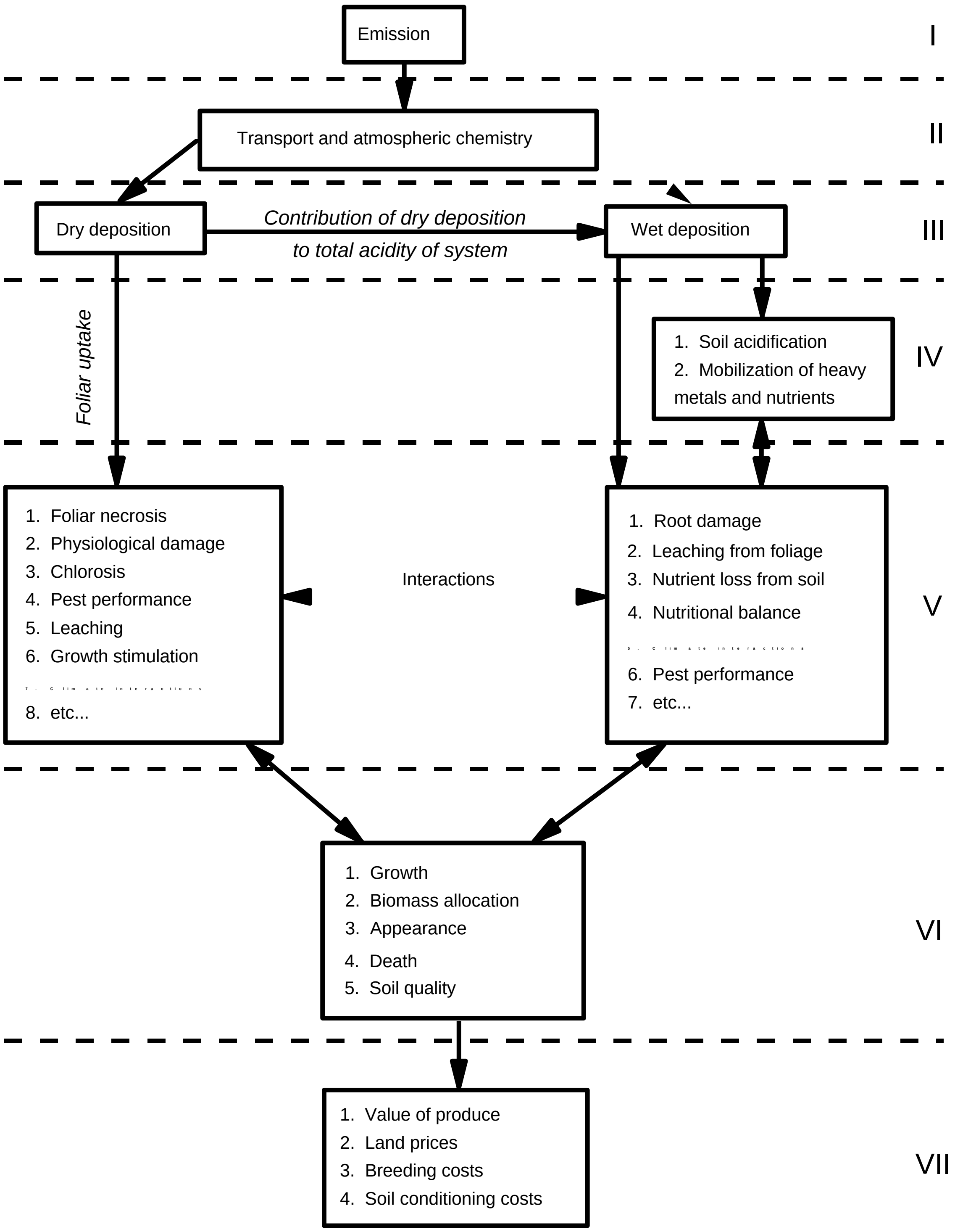


Figure 1.1 Impact pathway illustrating the effects of air pollution on agricultural crops.

Most research in this area has investigated the direct effects of pollutants on crops under conditions that are to a greater or lesser extent artificial. Less effort has been applied to investigation of interactions between pollutants and other stresses, or to experiments under near natural conditions. A given dose of a pollutant will produce a variable response depending on a wide range of factors, including:

1. Age of organism/tissue at time of exposure (Shaw *et al*, 1993; Pääkkonen *et al*, 1995; Kelly *et al*, 1995; Kelting *et al*, 1995; Vandermeiren and De Temmerman, 1996);
2. Other pollutants (Mansfield and McCune, 1988; Jäger and Schulze, 1988; Adaros *et al*, 1991a; b; Ashenden *et al*, 1996);
3. Temporal issues, such as time of day or season, duration of exposure, frequency of episodes (Baker and Fullwood, 1986; Baker *et al*, 1986);
4. Differences in temperature and light levels (Mansfield *et al*, 1986), which is particularly relevant when extrapolating from material exposed in greenhouses or open top chambers;
5. Water status and relative humidity (Mansfield *et al*, 1986; Keller and Hasler, 1988; Somerville *et al*, 1989; Heck, 1989; Freer-Smith and Dobson, 1989; Wieser and Havranek, 1993; Fuhrer, 1995);
6. Soil and plant nutrient status (Schulze *et al*, 1989);
7. Species/cultivar (Taylor *et al*, 1986);
8. Interactions with pests and pathogens (Bolsinger and Flukiger, 1989; Riemer and Whittaker, 1989; Warrington, 1989; Houlden *et al*, 1990);
9. Possible acclimation of plants to higher ambient concentrations (Davison and Reiling, 1995).

Discussion of approaches for describing uncertainties is provided in Section 6.

The scope for the work would ideally cover all agricultural production and account for all of the interactions identified in this section. This will not be possible, but advances in this direction are achievable, most notably with respect to phenology and soil moisture deficit. Whilst previous work has sought to move towards a more comprehensive assessment covering all agricultural production, it is anticipated that this study provides a better forum for discussion of the way that this can best be achieved than earlier work. With respect to valuation there will remain significant gaps. Here, the study is more likely to provide a basis for defining the state of knowledge, and suggesting ways forward and priorities for future research.

2 EXPOSURE-RESPONSE FUNCTIONS FOR YIELD LOSS

Data on the responses of as many crops as possible to ozone were collated at CEHB from the published literature. Data were included only where ozone conditions were recorded as 7h, 8h or 24h means or AOT40[1]. Any other reported ozone parameters (e.g. weighted accumulated dose) were considered unusable due to the errors introduced on conversion to 7h means. For ease, 8h means were considered to equal the 7h mean as small differences in value were unlikely to out-weigh the variation associated with this type of data. Where the ozone conditions were recorded as 24h mean or 7h mean, they were converted to AOT40 using the functions shown in Figures 2 and 3. These were produced from the ICP Vegetation[2] pollution database which comprises quality assured ozone data from 20 sites in 10 countries over 4 summer seasons.

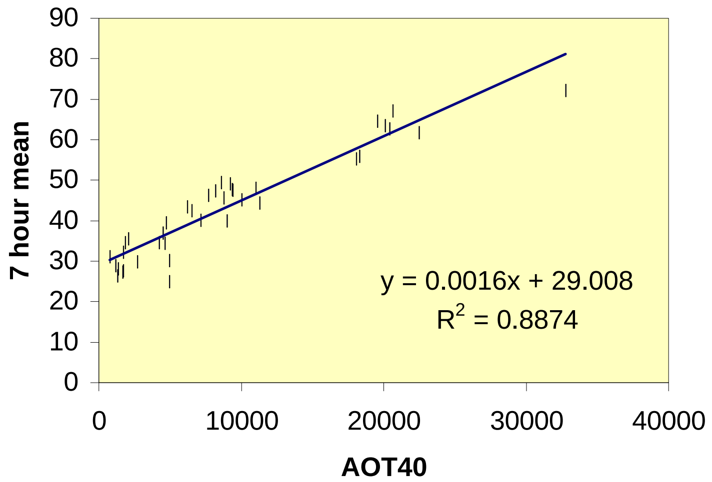


Figure 2.1 The relationship between three-month AOT40 (ppb.h) and three-month 7h mean ozone concentration derived from the ICP Vegetation database (1996 - 1999).

The yield data presented in the papers ranged from "% of control treatment" to "t ha^{-1}" and were all converted to the yield relative to that in the charcoal-filtered air treatment. If no charcoal filtered air treatment was used, the treatment with ambient air was taken as the "control" treatment. Thus, a value of 1 was applied to the yield in filtered (or occasionally non-filtered) air, and a value below 1 indicated a negative effect of ozone on the yield. In the following analysis, each data point represented the mean for one treatment/cultivar combination per year; where more than one cultivar was tested, the data for each of the cultivars were represented by separate data points. Only the data for well-watered plants were included in the analysis. A previous study (Buse *at al*, 2000) showed that there were no statistically significant differences between the data from the USA and EU for each of the crops studied allowing the data to be combined for further analysis. Thus, in this study, the relationship between 7h mean ozone and relative yield was determined for the combined EU and USA data.

[1] The sum of the differences between the hourly mean O_3 concentration (in ppb) and 40 ppb for each hour when the concentration exceeds 40 ppb, accumulated during daylight hours.
[2] The International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

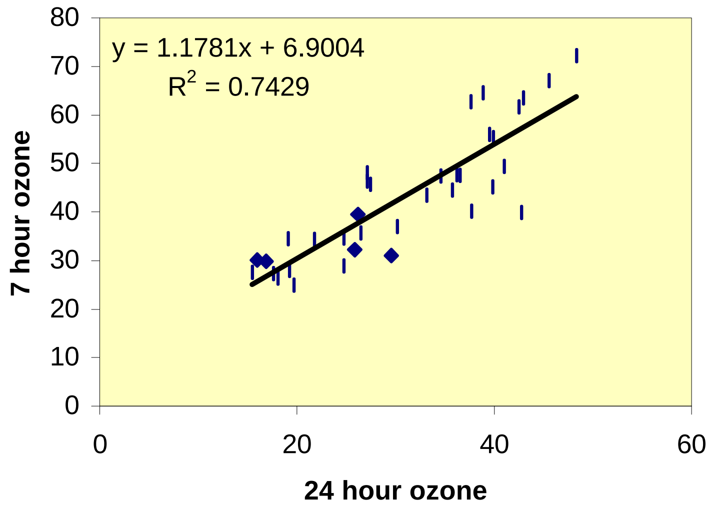


Figure 2.2 The relationship between 24h mean and 7h mean ozone concentration derived from the ICP Vegetation database (1996 - 1999).

Data were excluded from the analysis where the seasonal 7h mean < 29 ppb (the y-intercept on Figure 2) and > 100 ppb (outside the normal ambient concentration range for Europe). Linear regression was used to derive a function for each crop (Figures 4 to 6) and a unit change in yield per ppm.h for use in the economic analysis (Table 2). Further statistical analysis revealed that crops could be divided into the following four distinct groups of decreasing sensitivity to ozone: wheat, soybean, bean, cotton > potato, tobacco, sugar beet, oilseed rape and lucerne > rice, maize, grape > oat and barley, with the latter two crops being considered insensitive at ambient European concentrations. However, the gradient of the linear plot through the grouped data sets was lower than that for the individual crop (data not presented), and it was agreed that all subsequent analysis would be based on the response functions for individual crop species to ensure there was no loss in accuracy.

Our literature surveys have revealed a shortage of information on the effects of level II factors on yield responses to ozone. So far, no useful new information has been found on the influence of growth stage (phenology) on responses to ozone, in addition to that reviewed by Soja *et al*, 2000. Data on the modifying influence of soil moisture content on yield responses is available for a few crops (e.g. wheat and soybean) and is currently being compiled. For other crops, agronomic sources provide information on the effect of timing of irrigation on crop yield *per se*, but there is rarely sufficient information to allow the soil moisture deficit to be calculated. In the next two months, the available data on responses to level II factors will be reconsidered with a view to preparing "generalisations" for consideration at the Gothenburg Workshop, November 2002.

Valuation data, on a simple £/tonne of crop basis, were supplied by Mr. Harris Neeliah of the University of Reading, reflecting world market prices in 1999.

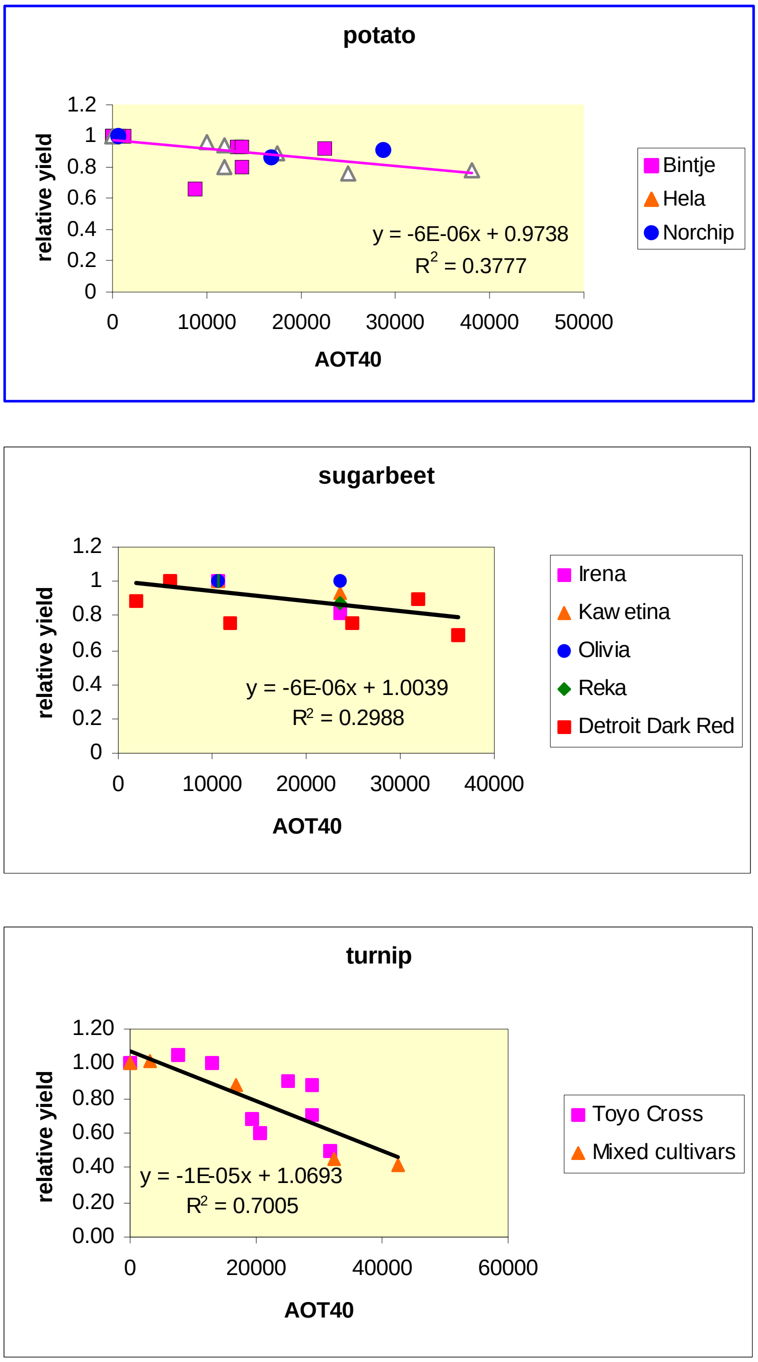


Figure 2.3 The yield response functions of root crops to ozone.

Note. The references used were as follows: potato - de Temmerman *et al*. 2000, Donnelly *et al*. 2001, Kollner *et al*. 2000, Lawson *et al*. 2001, Pell *et al*. 1988, Skarby 1988; sugar beet - Bender *et al*. 1999, McCool *et al*. 1987; turnip – Heagle *et al*. 1985, McCool *et al*. 1987.

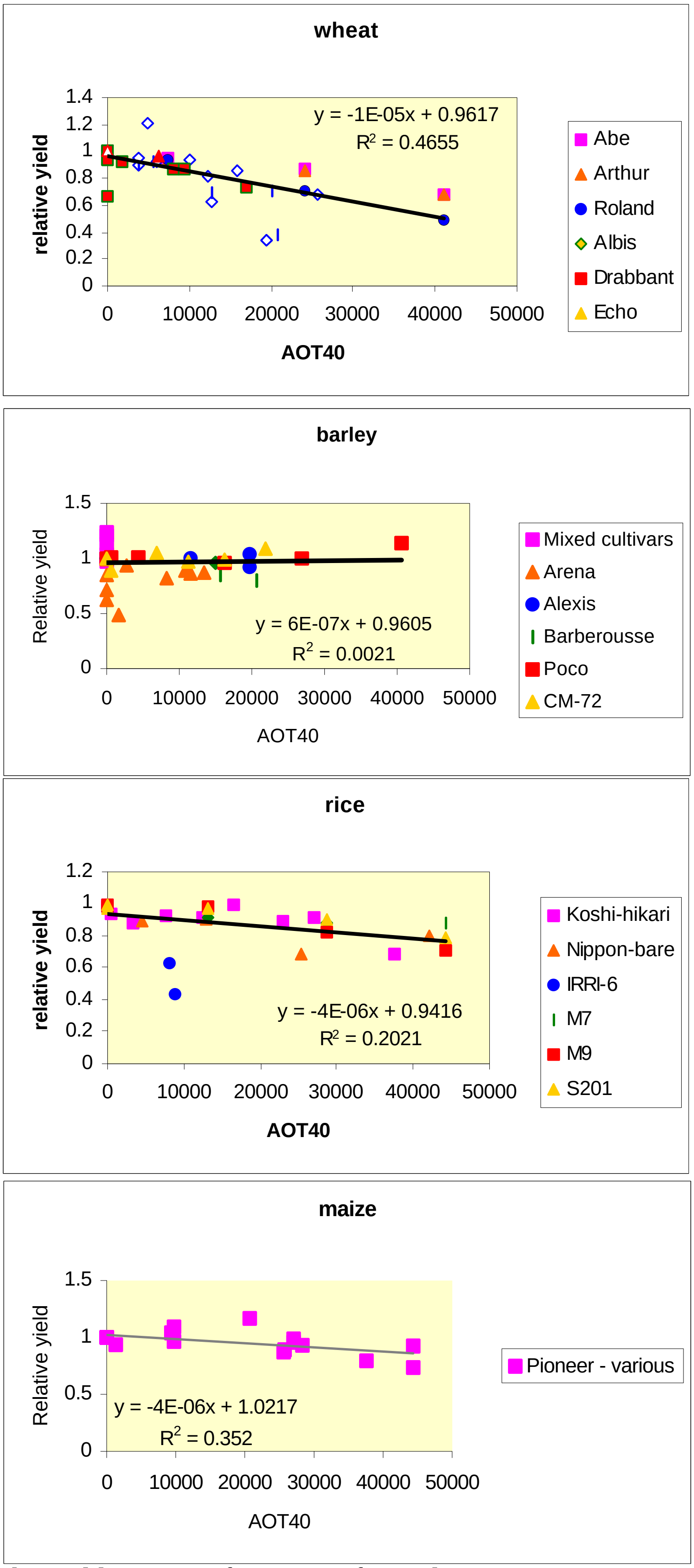
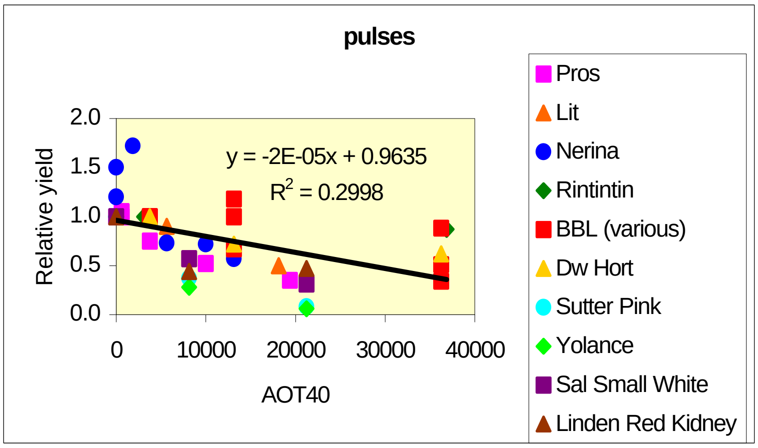
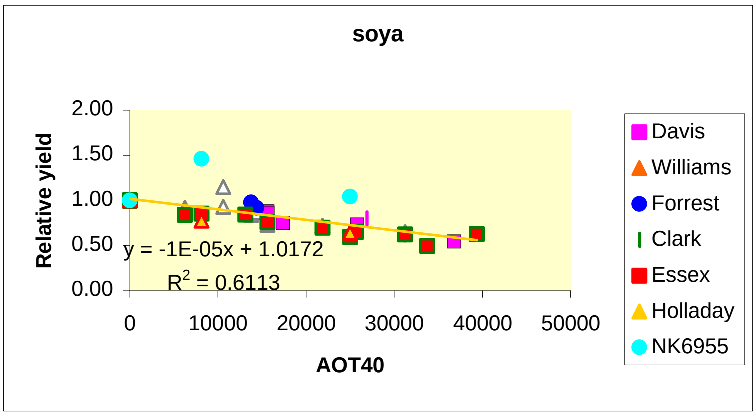


Figure 2.4 The yield response functions of cereals to ozone.

Note. The references used were as follows: wheat – de Temmerman *et al.* 1992, Fuhrer *et al.* 1989,1992, Kress *et al.* 1985b, Pleijel *et al.* 1991; barley - Adaros *et al.* 1991a,b, Fumagalli *et al.* 1999, Skarby *et al.* 1992, Temple *et al.* 1985; rice - Kats *et al.* 1985, Kobayashi *et al.* 1995, Maggs *et al.* 1998; maize - Kress *et al.* 1985a, Mulchi *et al.* 1995, Rudorff *et al.* 1996.





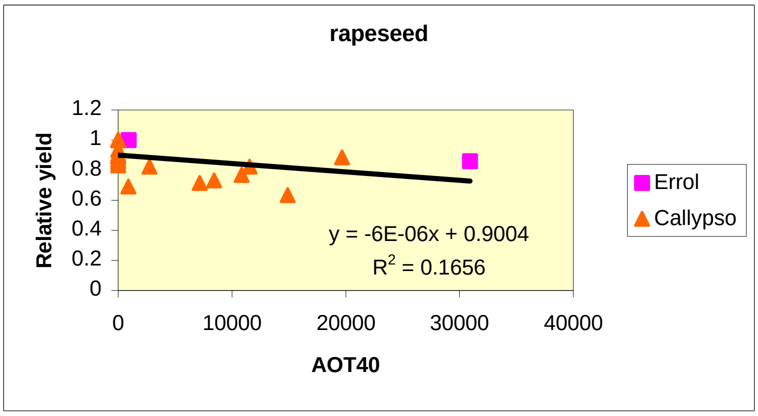


Figure 2.5 The yield response functions of pulses, soya and rapeseed to ozone.

Note. The references used were: pulses - Adaros *et al.* 1990, Heck *et al.* 1988, Sanders *et al.* 1992a,b, Temple 1991; Tonneijck *et al.* 1998; soya – Fiscus *et al.* 1997, Heagle *et al.* 1986b,1987a,1998, Heggestad *et al.* 1985,1988,1990, Mulchi *et al.* 1995; rapeseed - Adaros *et al.* 1991a,c, Ollerenshaw *et al.* 1999.

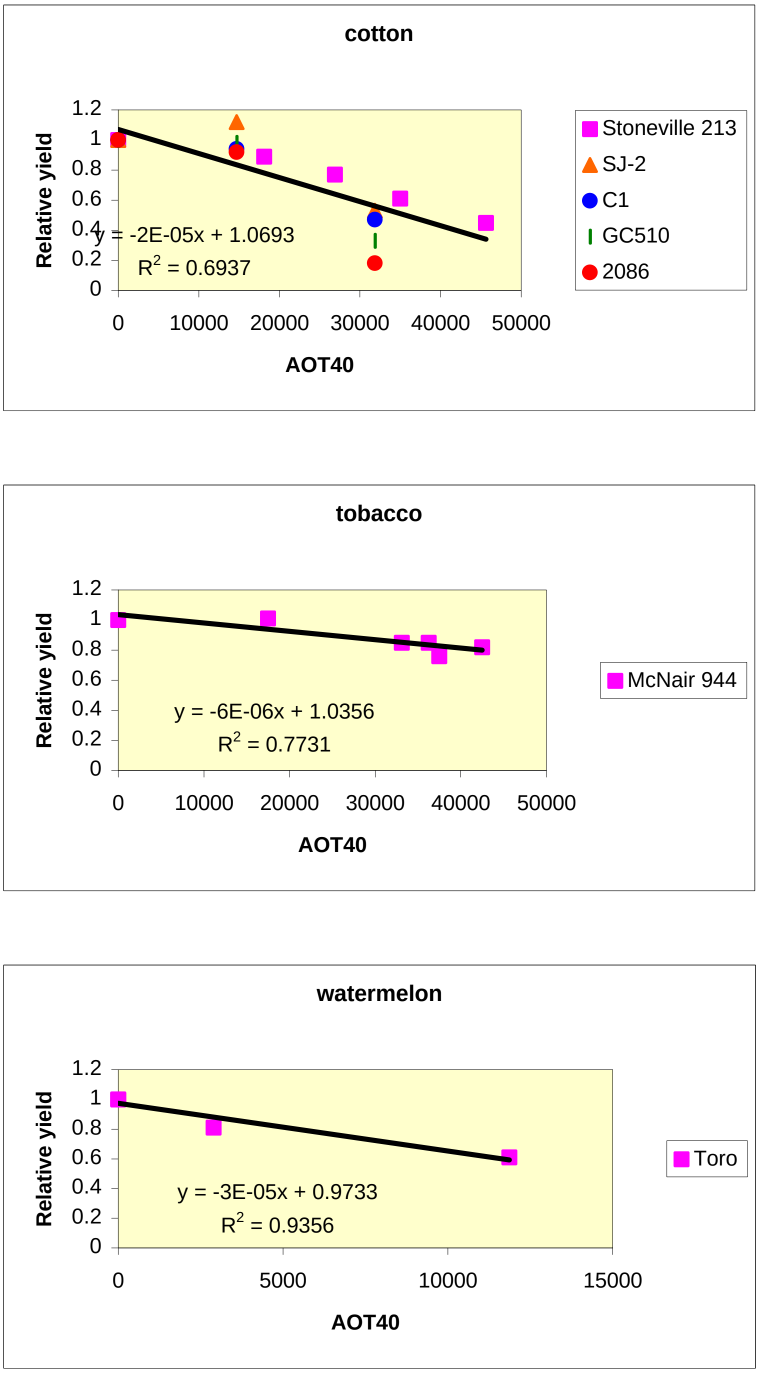
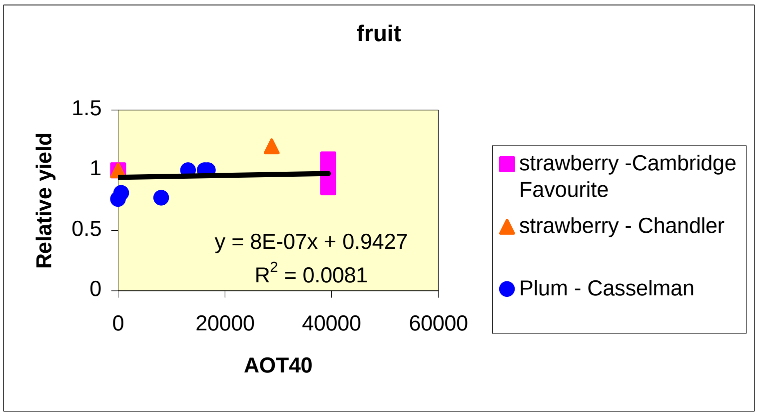
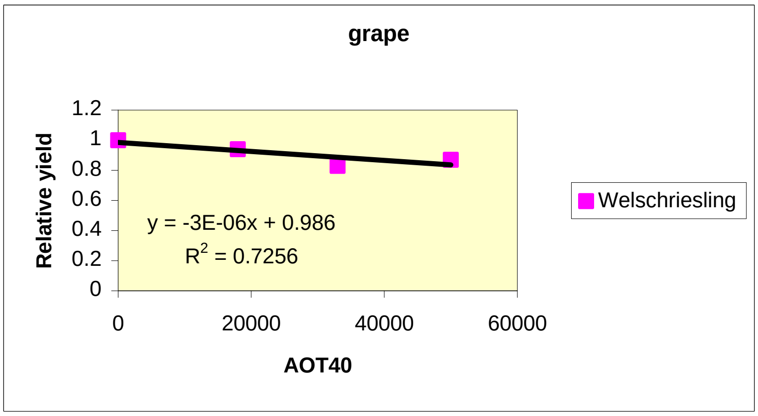


Figure 2.6 The yield response functions of cotton, tobacco and watermelon to ozone.

Note: The references used were: cotton – Heagle *et al.*1986a, Temple 1990; tobacco – Heagle *et al.* 1987b; watermelon - Gimeno *et al.* 1999.





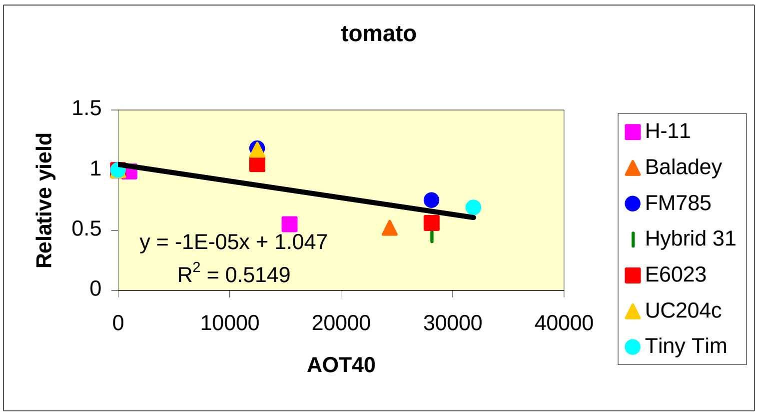
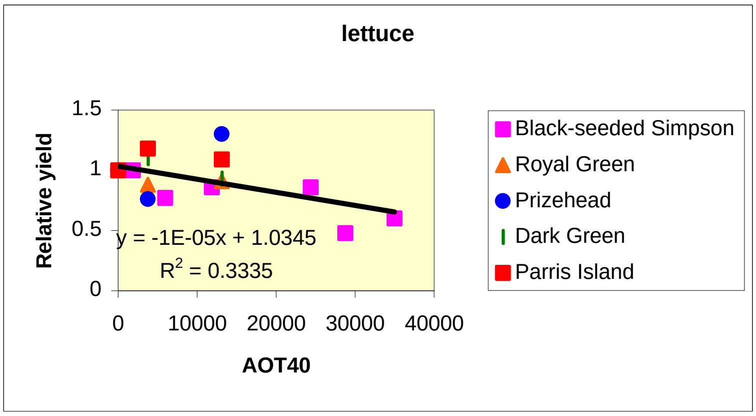
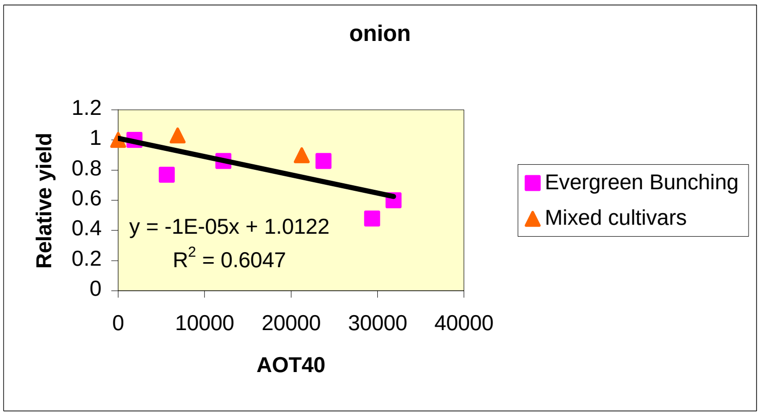


Figure 2.7 The yield response functions of fruit to ozone.

Note. The references used were: strawberry - Drogoudi *et al*. 2000, Takemoto *et al*. 1988; plum – Retzlaff *et al*. 1997; grape – Soja *et al*. 1997; tomato - Hassan *et al*. 1999, Oshima *et al*. 1975, Reinert *et al*.1997, Temple 1990.





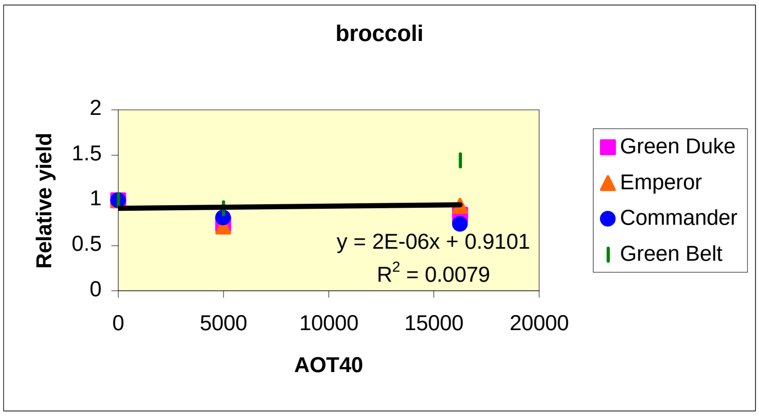


Figure 2.8 The yield response functions of fresh vegetables to ozone.

Note. The references used were: lettuce - McCool *et al*. 1987, Temple *et al*. 1990; onion - McCool *et al*. 1987, Temple *et al*. 1990 ; broccoli – Temple *et al*. 1990.

Table 2.1 Exposure-response and valuation data. All valuations taken from the FAO website.

	Unit change in yield/ppm.hour	Source	£/tonne
Wheat	0.011	CEHB	83
Barley	0.000001	See note 1	86
Rye	0.000001	See note 1	59
Oats	0.000001	See note 1	79
Millet	0.0039	Set equal to rice	62
Maize	0.0036	CEHB	74
Rice	0.0039	CEHB	198
Soya	0.012	CEHB	166
Pulses	0.017	CEHB	228
Rape	0.0056	CEHB	169
Sugar beet	0.0058	CEHB	41
Potatoes	0.0056	CEHB	178
Tobacco	0.0055	CEHB	2883
Sunflower	0.012	Average of wheat, pulses, tomato, potato (see note 2)	172
Cotton	0.016	CEHB	965
Olives	0.000001	See note 1	379
Hops	0.0092	Average of all sensitive crops	2945
Grape	0.0030	CEHB	255
Fruit	0.000001	See note 3	483
Carrots	0.0092	Average of all sensitive crops	246
Tomato	0.014	CEHB	574
Water melon	0.031	CEHB	103
Fresh vegetables	0.0095	CEHB	241

Note 1: Available data suggest that these crops (barley, rye, oats and olives) are not sensitive. A function of 1/1,000,000 has been set for them to facilitate sensitivity analysis if necessary.

Note 2: Average for sunflower based on crops given a similar sensitivity rating by Jones and Hornung (in European Commission, 1998).

Note 3: Function for strawberry and plum, averaged across available data, suggests no sensitivity. However, this is heavily skewed by the data for strawberry. In applying the function shown a similar logic has been adopted to that given in note 1.

3 SCENARIOS AND OZONE DATA

Crop yield changes have been assessed against four of the scenarios used in the negotiations on the Gothenburg Protocol:

- 1990 baseline – ozone levels in Europe with emissions of NOx and VOCs at 1990 levels.
- 2010 Reference - ozone levels in Europe with emissions of NOx and VOCs at levels forecast for 2010 if all legislation current and in the pipeline prior to Gothenburg is implemented according to IIASA's estimates.
- GP (Gothenburg Protocol) – ozone levels in 2010 with exact compliance against Gothenburg limits.
- J1 – ozone levels in 2010 under the original proposal for Gothenburg.

Ozone data were taken from results supplied to IIASA by David Simpson, using the EMEP model. They were transformed by Chris Heyes at IIASA, providing AOT40 data for four periods of the year, reflecting the growing seasons in different parts of Europe (Scandinavia, Mediterranean, Central and Eastern Europe and North and North-western Europe). Allocation of countries to these regions is shown in Table 3. For the most part this allocation was straightforward. However, for some countries, notably France and the Russian Federation, further discussion may be needed. The importance of taking account of the growing period is demonstrated by the results shown in Figure 7 and Figure 8.

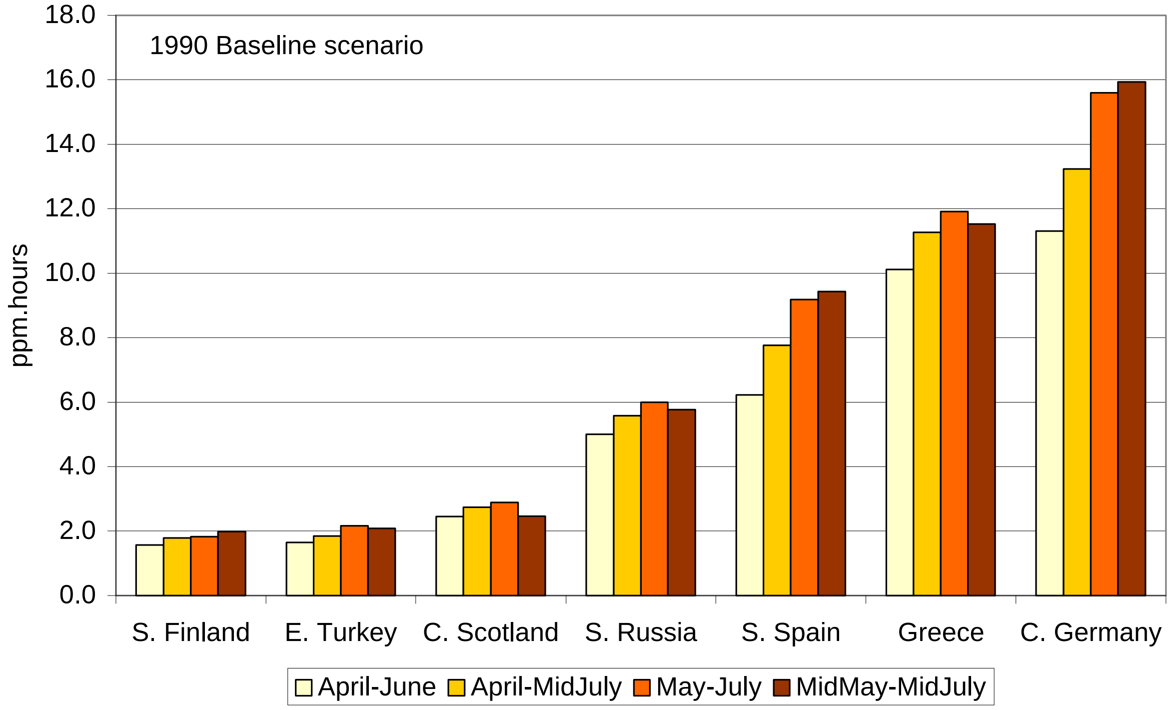
The ozone data are on the 150x150 km EMEP grid. The modelling system developed in this study can easily be adapted to deal with the higher resolution 50x 50 km grid once ozone data are available at that resolution.

Table 3.1 Allocation of countries to climatic zones for identification of the appropriate ozone exposure period for application of functions in each country.

Code	Area	Period
1	Mediterranean	April to June
2	Central and Eastern Europe	April to mid-July
3	West and North-western Europe	May to July
4	Scandinavia	Mid-May to mid-July

Code	Country	Area
1	Albania	Mediterranean
2	Armenia	Central and Eastern Europe
2	Austria	Central and Eastern Europe
2	Azerbaijan	Central and Eastern Europe
2	Belarus	Central and Eastern Europe
3	Belgium	West and North-western Europe
1	Bosnia	Mediterranean
1	Bulgaria	Mediterranean
1	Croatia	Mediterranean
1	Cyprus	Mediterranean
2	Czech Republic	Central and Eastern Europe
4	Denmark	Scandinavia
4	Estonia	Scandinavia

Code	Country	Area
4	Faero Islands	Scandinavia
4	Finland	Scandinavia
2	France	C/E Europe (as an average between Mediterranean and W/NW Europe)
2	Georgia	Central and Eastern Europe
3	Germany	West and North-western Europe
1	Greece	Mediterranean
3	Guernsey	West and North-western Europe
2	Hungary	Central and Eastern Europe
4	Iceland	Scandinavia
3	Ireland	West and North-western Europe
3	Isle of Man	West and North-western Europe
1	Italy	Mediterranean
3	Jersey	West and North-western Europe
2	Kazakhstan	Central and Eastern Europe
2	Krygyzstan	Central and Eastern Europe
4	Latvia	Scandinavia
2	Liechtenstein	Central and Eastern Europe
4	Lithuania	Scandinavia
3	Luxembourg	West and North-western Europe
1	FYR Macedonia	Mediterranean
1	Malta	Mediterranean
2	Moldova	Central and Eastern Europe
3	Netherlands	West and North-western Europe
4	Norway	Scandinavia
2	Poland	Central and Eastern Europe
1	Portugal	Mediterranean
2	Romania	Central and Eastern Europe
2	Russian Federation	Central and Eastern Europe
2	Slovakia	Central and Eastern Europe
1	Slovenia	Mediterranean
1	Spain	Mediterranean
4	Sweden	Scandinavia
2	Switzerland	Central and Eastern Europe
1	Turkey	Mediterranean
3	United Kingdom	West and North-western Europe
2	Ukraine	Central and Eastern Europe
1	Yugoslavia	Mediterranean



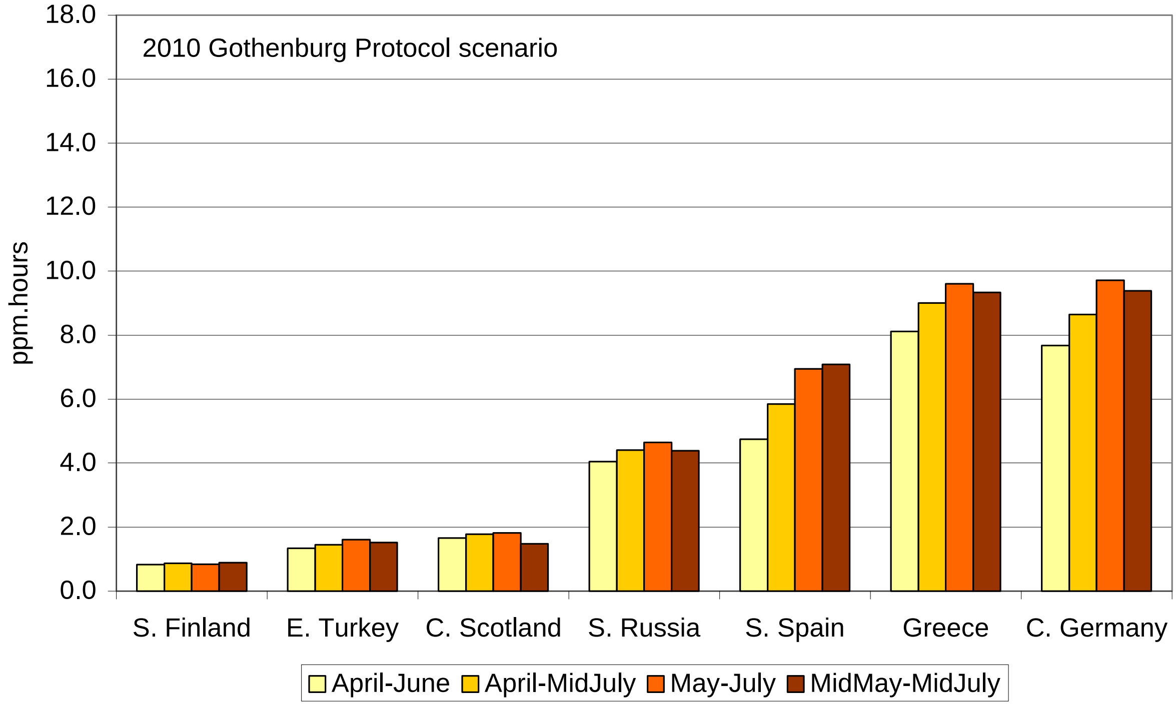
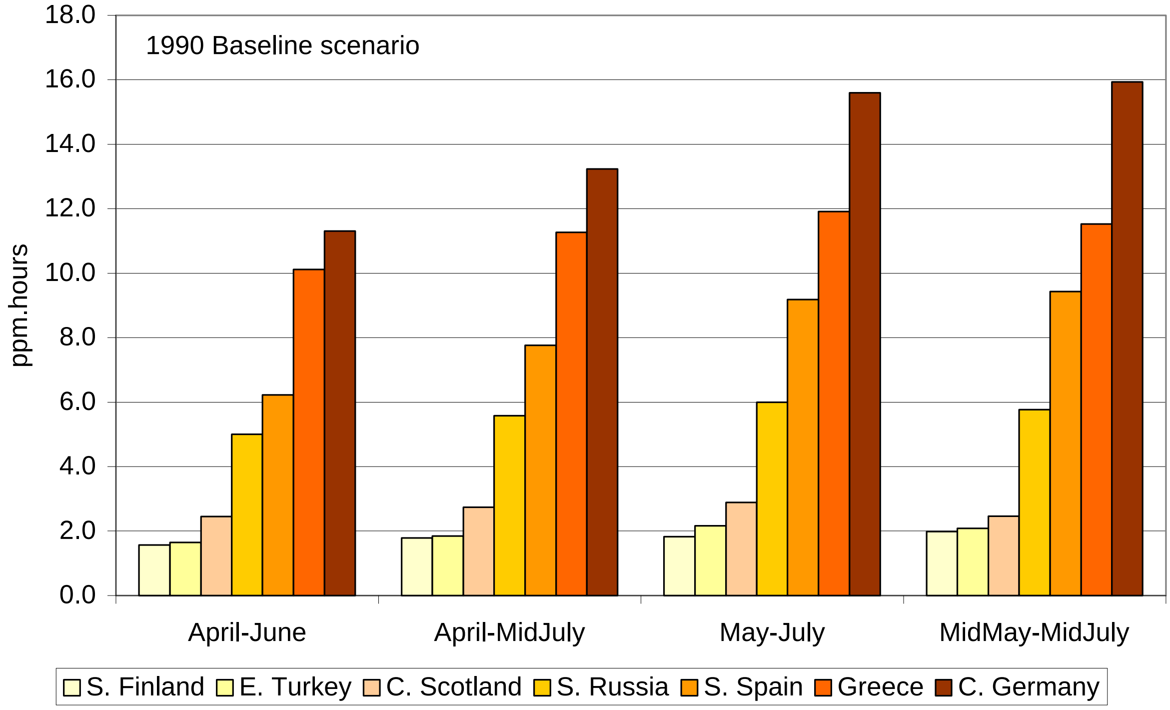


Figure 3.1 AOT40 data in different parts of Europe for different periods.



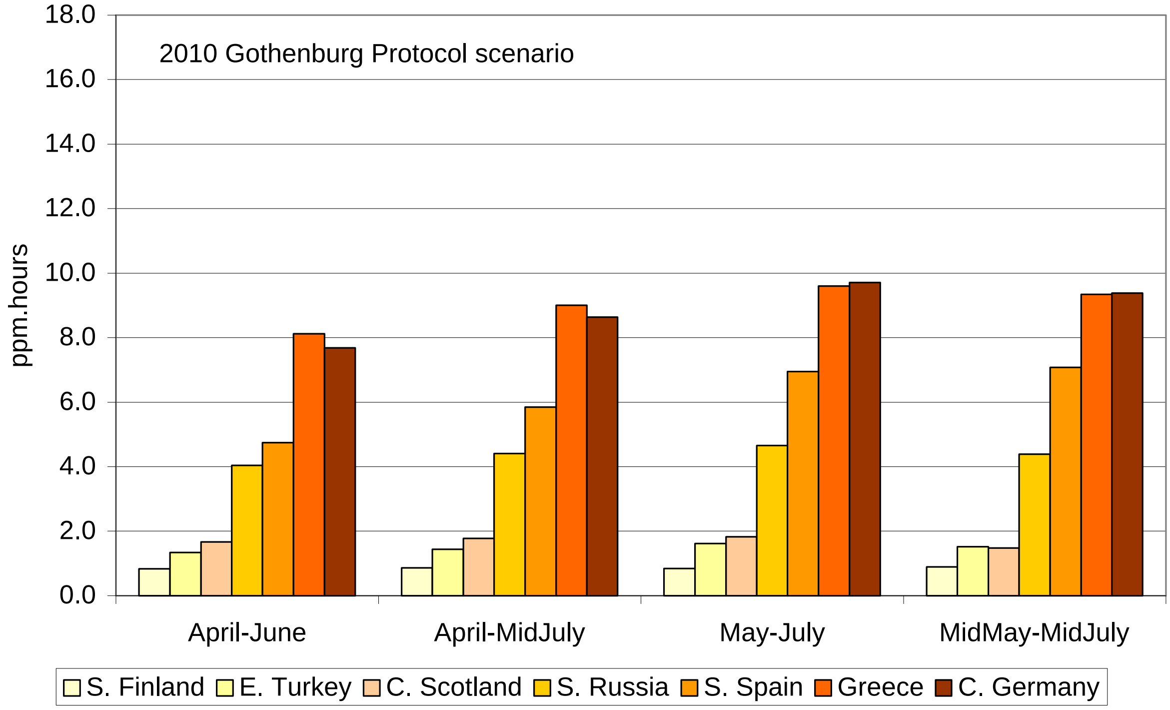


Figure 3.2 AOT40 data in different parts of Europe for different periods.

4 MAPPING OF AGRICULTURAL AREAS AND CROP YIELD DATA

4.1 Agricultural areas

The spatial delimitation of agricultural areas has formed one component of the updated land cover mapping performed at SEIY by Howard Cambridge and Steve Cinderby. The updated land cover mapping has been completed in discrete data layers (forests, semi-natural vegetation, urban, water bodies etc.). Each data layer has been created by combining various existing land cover data sets using the most appropriate method of combination. For the delimitation of agricultural areas and their linkage to the crop production statistics three data layers were combined:

Data Layers	IGBP Global Land Cover (GLC) agricultural information
	SEI Land Cover agricultural information
	Bartholomew Country and NUTS region boundaries

Areas of potential agriculture across Europe were identified by excluding polygons classified on the updated SEI land cover map as forest, semi-natural vegetation, urban and water. The extent of agriculture in the remaining areas was then determined by combining the GLC agricultural data with the existing SEI agricultural map.

The GLC classification of agricultural classes has been the dominant data source used to spatially delimit the distribution and type of crop lands across Europe. The existing SEI land cover map originally only contained information on the dominant crop by country generated from FAO and EU statistics. This classification has now been superseded.

The GLC map was converted into three data layers. Firstly the areas which were purely agricultural were identified, for example, "Cropland (Winter Wheat, Small Grains)". Secondly the areas that were of mixed classes combined with forestry were delimited, for example, "Cropland (Rice, Wheat) with Woodland". For these polygons the areas that overlapped with forestry (as previously identified on an updated land cover layer) were excluded with the remaining areas classified as agriculture (with the classification obtained from the GLC land cover class). Thirdly, areas that were mixed classes of agriculture, forestry and grassland were identified, for example, "Cropland and Pasture (Wheat, Orchards, Vineyards) with Woodland". In these polygons the area that overlapped with the existing forestry layer were excluded. The existing SEI agriculture map was then used to differentiate the extent of cropland from pasture.

The existing SEI land cover map was used to identify the extent of agriculture across Europe but with no classification of the type of cropland. The distribution and classification of horticulture was derived from the existing SEI land cover data base.

The five maps were combined in the geographic information system (GIS) using unique conditions modelling and the resulting table exported in a spreadsheet to determine the classification and distribution of agriculture and horticulture. The classes obtained from the GLC map took precedence in the revised data set except for the areas horticulture which were identified from the SEI data layer. The reclassified data contained approximately 250 discrete classes. This spatial database was then combined with the agricultural statistics to obtain an assessment of the location, type and yield of crop in countries and regions across Europe.

4.2 Linking the revised agricultural map to agricultural production statistics

In order to combine the spatial database with the statistical crop information the agricultural map was overlaid with data sets showing the distribution of country boundaries, distribution of European NUTS level II areas and the EMEP 50km grid using unique condition modelling. This produced a database onto which country and NUTS specific information on yield and crop coverage could be appended and the results analysed by EMEP grid square. This data was then combined with statistical information from the EUROSTAT Agricultural Statistics for EU NUTS Level II and the FAO AGROSTAT Agricultural Statistics for the remaining European Countries.

For each country a specific database of the percentage coverage of crops and yields linked to the agricultural map was produced using the FAO agrostat data. The breakdown of crop classes included in the databases can be seen in Table 4.1.

Table 4.1 Sources of data on the distribution of crop production

Crop Type	Included in FAO Agrostat	Included in Eurostat
Barley	Yes	Yes
Carrots	Yes	
Cotton	Yes	Yes
Flax		Yes
Fresh Vegetables	Yes	
Fruit	Yes	
Grapes	Yes	
Hops	Yes	
Maize	Yes	Yes
Millet	Yes	
Oats	Yes	
Olives	Yes	Yes
Orchards		Yes
Potatoes	Yes	Yes
Pulses	Yes	Yes
Rape	Yes	Yes
Rice	Yes	Yes
Rye	Yes	Yes
Soya	Yes	Yes
Sugar Beet	Yes	Yes
Sun Flowers	Yes	Yes
Tobacco	Yes	Yes
Tomato	Yes	
Vineyards		Yes
Water Melon	Yes	
Wheat	Yes	

For the general agricultural class, "Cropland", the statistics were used to determine the actual percentage of different crop types grown (excluding horticulture)in that country. The cereals class on the map was defined as wheat, barley, rye, oats, millet, maize and rice. The grain class from the map was defined as wheat, barley, rye, oats and millet with small grains being the subset of wheat, barley, rye and oats. From this classification the actual percentage of each crop grown in that country was determined. The example of the small grains class in Austria is illustrated in Table 4.2.

Table 4.2 Breakdown of cereal production in Austria

Crop Type	% of Total Agricultural Area	% of Small Grains
Wheat	22.3	22.3/53.3 = 43.7
Barley	21.8	21.8/53.3 = 40.9
Rye	5.0	5.0/53.3 = 9.0
Oats	3.2	3.2/53.3 = 6.0
Total	**53.3**	**100.0**

The breakdown of the actual split of crop types by country in each polygon of the agricultural map was then used to calculate the actual area and yield of crops in each EMEP 50km grid square.

A similar activity was performed for NUTS Level II regions for those countries who had reported yields and crop areas for 1999. The countries included in this more detailed disaggregation were the UK, Italy, France, Germany, Finland, Belgium and Luxembourg.

The final stage of the mapping exercise required normalisation of estimated yields against total annual yields in each country.

5 RESULTS OF ECONOMIC ASSESSMENT

5.1 Results by crop, scenario and country

The results by scenario and country are summarised in Table 6 for 1990 and the three 2010 emission scenarios. Losses for agricultural and horticultural crops are included, but any effects of reductions in pasture quality/quantity on animal and milk production are not (however, see section 6.2).

Losses for 1990 are estimated at £4.3 billion across Europe, falling to £3.1 billion assuming implementation of the Gothenburg protocol across Europe in 2010. The highest losses in crop production for 1990, the reference year, are predicted for France (£1.1 billion) and Germany (£0.6 billion), with losses of over £136 million predicted for the UK. The differences between individual countries reflect the crops grown, level of agricultural production, timing of crop growth in relation to the months with the highest ozone concentration, climate and location in Europe in relation to emission sources, with those countries closest to central Europe experiencing the greatest losses in production. The benefits of moving to the different 2010 scenarios are shown in Table 7. Benefits are greatest in France, followed by Germany, Poland, Italy and Ukraine, reflecting the reasons just given.

Table 8 shows total damages for each crop, by scenario. Table 9 then clearly shows that more than half of the damages are attributed to wheat (32%) and potato (21%). The other crops for which damages account for more than 5% of the total are sugar beet, pulses and grape. Whilst wheat has been studied extensively, potatoes and sugar beet have attracted little attention in the past. Further work on them is clearly warranted.

Appendix 1 provides a more detailed breakdown of the results, by country, emission scenario and crop type.

5.2 Impacts on production of meat and milk

Production of meat and milk accounts for more than half of European agricultural production, so their exclusion from the analysis may lead to a significant underestimation of impacts. This section seeks to underline the need to include meat and milk and to raise discussion of the methods of their analysis.

In assessment of impacts to animal production (in its widest sense), it seems appropriate to exclude production of eggs, chicken, pigs and some other groups, where production is not linked to open grazing. The impact on animals given processed feed should be minimal, to the extent that the price of the feed is not affected by wider impacts of ozone on agricultural production. These groups account for 18% of production, leaving 33% in the categories meat and milk, compared to 49% from crop production.

If it is assumed that pasture has average sensitivity compared to the other crops assessed, and that changes in meat and milk production are linearly related with changes in pasture production, total damages would rise by 68% (33/49, the share of meat and milk production divided by crop production). This would lead to total damages (i.e. crops + meat + milk) of £7.2 billion in 1990 and £5.2 billion in 2010 under the Gothenburg Protocol, compared to £4.3 and 3.1 billion respectively (increases of £2.9 and 2.1 billion). This underlines the need to account fully for agricultural production in such assessment.

Further refinements of these methods is clearly needed, drawing on the experience of experts in animal production. Whilst the figures given here provide a ball park guide to the possible magnitude of impacts it must be said that it is quite possible that impacts of ozone on pasture do not lead to any change in meat and milk production. With this in mind, it is probably appropriate to quote changes to meat and milk production in response to the effects of exposure to ozone as a range from £0 to 2.9 billion in 1990, and £0 to 2.1 billion in 2010 under Gothenburg.

Table 5.1 Estimated changes in crop production (£000) by scenario and country.

	1990	Ref2010	Protocol	J1	Rank1990
Albania	5,588	4,530	4,330	4,033	29
Armenia(no ozone data)					37
Austria	45,160	32,762	30,845	27,863	17
Azerbaijan(no ozone data)					37
Belgium and Luxembourg	74,692	64,754	58,130	54,223	14
Bosnia	8,121	6,409	6,083	5,538	26
Bulgaria	38,912	33,947	32,353	30,108	18
Croatia	31,342	24,883	23,639	21,684	21
Czech Republic	89,504	67,853	61,710	55,333	13
Denmark	47,424	32,666	29,944	27,562	16
Estonia	1,301	803	706	668	34
Faeroe Islands (no ozone data)					37
Finland	2,220	1,120	990	897	33
France	1,059,864	729,134	688,399	624,245	1
FYR Macedonia	8,190	6,950	6,692	6,288	25
Georgia	4,299	2,216	1,923	1,763	31
Germany	647,520	457,577	417,143	385,934	2
Greece	149,350	124,516	119,425	113,570	9
Hungary	112,723	89,119	84,259	73,953	12
Ireland	3,844	2,885	2,607	2,403	32
Italy	310,357	236,804	224,782	206,717	4
Kazakhstan (no ozone data)					37
Kyrgysztan (no ozone data)					37
Latvia	4,585	3,151	2,746	2,696	30
Liechtenstein	-	-	-	-	37
Lithuania	15,149	10,512	9,273	8,858	24
Luxembourg (see Belgium)	-	-	-	-	37
Malta(no ozone data)	-	-	-	-	37
Moldova	32,093	25,968	25,192	22,314	20
Netherlands	119,630	102,419	92,691	86,466	11
Norway	1,011	623	544	501	35
Poland	305,693	232,255	214,044	188,463	5
Portugal	22,965	18,776	19,769	16,824	22
Romania	177,474	146,530	140,270	124,232	8
Russian Federation	221,372	177,009	170,499	167,767	6
Slovakia	33,982	27,306	25,641	22,635	19
Slovenia	6,977	5,509	5,252	4,831	28
Spain	185,716	141,374	142,177	125,576	7
Sweden	7,317	4,325	3,774	3,463	27
Switzerland	15,383	10,413	9,907	9,217	23
Turkey (very limited data)	2	2	2	2	36
Ukraine	344,223	279,500	263,931	247,840	3
United Kingdom	136,995	130,519	113,618	103,912	10
Yugoslavia	50,907	41,771	39,868	36,244	15
Total	**4,321,886**	**3,276,890**	**3,073,159**	**2,814,623**	

Where: 1990 = Baseline scenario; 2010 Ref = Reference Scenario, essentially business as usual, with legislation that is already in place or in the pipeline taking full effect; GP = Gothenburg Protocol - with each country precisely meeting its Gothenburg targets in 2010;
J1 scenario = the main scenario for 2010 considered in negotiations on the Protocol, that would have required a greater level of abatement than was finally agreed.

Table 5.2 Estimated benefits of each scenario compared to 1990 (£000) by country. See notes to Table 5.1 for details of the scenarios.

	Ref2010	**Protocol**	**J1**
Albania	1,059	1,258	1,556
Armenia (no ozone data)	-	-	-
Austria	12,398	14,315	17,297
Azerbaijan (no ozone data)	-	-	-
Belgium and Luxembourg	9,938	16,562	20,469
Bosnia	1,712	2,039	2,583
Bulgaria	4,965	6,559	8,805
Croatia	6,458	7,702	9,658
Czech Republic	21,651	27,793	34,170
Denmark	14,759	17,480	19,862
Estonia	498	595	633
Faeroe Islands (no ozone data)	-	-	-
Finland	1,100	1,230	1,323
France	330,730	371,465	435,619
FYR Macedonia	1,240	1,498	1,902
Georgia	2,083	2,376	2,536
Germany	189,943	230,377	261,586
Greece	24,834	29,924	35,779
Hungary	23,605	28,464	38,770
Ireland	959	1,237	1,441
Italy	73,552	85,575	103,640
Kazakhstan (no ozone data)	-	-	-
Kyrgysztan (no ozone data)	-	-	-
Latvia	1,434	1,839	1,889
Liechtenstein	-	-	-
Lithuania	4,637	5,876	6,291
Luxembourg (see Belgium)	-	-	-
Malta (no ozone data)	-	-	-
Moldova	6,126	6,901	9,779
Netherlands	17,211	26,939	33,164
Norway	389	467	510
Poland	73,438	91,649	117,230
Portugal	4,189	3,196	6,141
Romania	30,944	37,204	53,241
Russian Federation	44,363	50,873	53,605
Slovakia	6,676	8,341	11,347
Slovenia	1,468	1,725	2,145
Spain	44,342	43,539	60,140
Sweden	2,993	3,543	3,855
Switzerland	4,969	5,476	6,166
Turkey (very limited data)	0	0	0
Ukraine	64,724	80,292	96,384
United Kingdom	6,476	23,376	33,083
Yugoslavia	9,135	11,039	14,662
Total	**1,044,995**	**1,248,726**	**1,507,262**

Table 5.3 Estimated changes in crop production (£000) by scenario and crop. See notes to Table 5.1 for details of the scenarios.

Scenario	1990	2010Ref	Protocol	J1
Barley	-	-	-	-
Carrots	13,529	10,893	10,494	10,011
Cotton	154,885	125,816	122,309	113,907
Fresh vegetables	26,976	21,748	21,062	20,005
Fruit	-	-	-	-
Grape	254,493	188,150	180,780	163,821
Hops	20,367	14,759	13,695	12,564
Maize	198,075	149,788	142,407	128,738
Millet	104	82	77	68
Oats	-	-	-	-
Olives	-	-	-	-
Potatoes	926,256	714,228	662,980	607,787
Pulses	275,526	200,046	187,164	170,762
Rape	154,648	111,409	102,976	93,918
Rice	19,035	14,571	14,144	12,858
Rye	-	-	-	-
Soya	40,044	30,346	28,794	26,290
Sugar beet	408,968	307,382	285,707	261,579
Sunflower seed	190,354	146,468	139,182	127,259
Tobacco	74,947	58,279	55,509	50,801
Tomato	144,154	117,007	112,465	103,773
Water melon	8,724	7,045	6,755	6,364
Wheat	1,410,352	1,058,535	986,338	903,827
Total, £000	**4,321,886**	**3,276,890**	**3,073,159**	**2,814,623**

Table 5.4 % damage for each scenario by crop.
See notes to Table 5.1 for details of the scenarios.

Scenario	**1990**	**2010 Ref**	**Protocol**	**J1**
Wheat	32.6%	32.3%	32.1%	32.1%
Potatoes	21.4%	21.8%	21.6%	21.6%
Sugar beet	9.5%	9.4%	9.3%	9.3%
Pulses	6.4%	6.1%	6.1%	6.1%
Grape	5.9%	5.7%	5.9%	5.8%
Maize	4.6%	4.6%	4.6%	4.6%
Sunflower	4.4%	4.5%	4.5%	4.5%
Cotton	3.6%	3.8%	4.0%	4.0%
Rape	3.6%	3.4%	3.4%	3.3%
Tomato	3.3%	3.6%	3.7%	3.7%
Tobacco	1.7%	1.8%	1.8%	1.8%
Soya	0.9%	0.9%	0.9%	0.9%
Fresh vegetables	0.6%	0.7%	0.7%	0.7%
Hops	0.5%	0.5%	0.4%	0.4%
Rice	0.4%	0.4%	0.5%	0.5%
Carrots	0.3%	0.3%	0.3%	0.4%
Water melon	0.2%	0.2%	0.2%	0.2%
Millet	0.0%	0.0%	0.0%	0.0%
Barley	0.0%	0.0%	0.0%	0.0%
Fruit	0.0%	0.0%	0.0%	0.0%
Oats	0.0%	0.0%	0.0%	0.0%
Olives	0.0%	0.0%	0.0%	0.0%
Rye	0.0%	0.0%	0.0%	0.0%
Total, £000	**100.0%**	**100.0%**	**100.0%**	**100.0%**

6 DEALING WITH UNCERTAINTIES

There are several areas where uncertainty will arise in the assessment, summarised in Table 6.1. These are:

1. Quantification of pollutant dispersion and ozone formation.
2. Characterisation of the distribution of agricultural productivity.
3. Combination of exposure data with information on soil moisture deficit and phenology.
4. Experimental quantification of concentration-response functions.
5. Extrapolation of these functions to other locations.
6. Extrapolation of these functions to other crops.
7. Application of international prices for valuation.
8. Omission of factors from the assessment, such as interactions of crops with pests and pathogens, effects of yield changes on price, etc.

At the same time, there are several tools available for dealing with these uncertainties:

1. Statistical assessment, based on observed variation in experimental data.
2. Macro-analysis, investigating the factors and similarities in results from different experiments or situations.
3. Sensitivity analysis.
4. Ranking of quantified impacts according to the confidence in which individual results are held.

Table 6.1 Summary of the assessment of uncertainties for variables in the quantification of the effects of ozone on crops, and identification of second stage methods for dealing with those uncertainties.

Stage of assessment	**Level of uncertainty?**	**Methods**
Quantification of pollutant dispersion and ozone formation.	Medium	Comparison of modelled and monitored data.
Characterisation of the distribution of agricultural productivity.	To be assessed	Sensitivity analysis could be used for countries where the potential level of geographical disaggregation of crop production is poor.
Combination of exposure data with information on soil moisture deficit and phenology.	Low	For discussion with the project team.
Experimental quantification of concentration-response functions.	Low	Standard statistical analysis of experimental data.
Extrapolation of these functions to other locations.	Medium	Sensitivity analysis based on variance across the results of different experiments.
Extrapolation of these functions to other crops.	High	Sensitivity analysis, drawing on potential ranges.
Application of international prices for valuation.	Insignificant	-
Omission of factors from the assessment, such as interactions of crops with pests and pathogens, effects of yield changes on price, etc.	High	Transparent reporting of areas where omissions are likely, and qualitative discussion of perceived significance compared to effects that have been quantified.

The ideal treatment of each of the areas listed above where uncertainty will appear varies from case to case. For example, consideration of the error in exposure-response functions from experimental observation should be carried out using standard statistical techniques. Extrapolation of the results cannot be done this way because it involves application of data to situations where (presumably) there is no specific data available. Under this circumstance it would be more appropriate to use the results of a macro-analysis (if possible) or sensitivity analysis. A quantified treatment of uncertainty is not presented here as the importance of the various elements of uncertainty needs to be debated by a wider audience, and because the relative importance of the uncertainties in the assessment of ozone damage to crops needs to be put in the context of pollution abatement costs and the benefits of reducing other impacts, for example on health. However, the study has succeeded in elaborating a framework for describing uncertainty when it is needed.

7 FUTURE WORK

The study has focussed on developing the computational framework for the analysis. The framework developed can easily be adapted to accept new data as needed, including extension of the crops and other agricultural products covered.

Future work will need to address the following issues in particular:
1. Irrigation of crops;
2. Higher resolution ozone data;
3. The consequences of visible injury on price;
4. Interactions between ozone and pests and pathogens;
5. Impacts on livestock;
6. Consideration of the wider economic consequences of yield changes. Here, analysis has simply multiplied changes in crop yield by world market price to assess the reduction in damages as emissions fall.

With respect to experimental work it is suggested that the relative importance of the different crops as estimated here be used as input to deciding which should be used in future experimental work. We suggest that potatoes, in particular, need further assessment.

The first three of these improvements can easily be factored in once data are available. With respect to issue 4, available data suggest that ozone signifiantly worsens the effects of pests. Further work on issue 6 (broader economic changes) is currently being undertaken by Harris Neeliah at the University of Reading.

8 CONCLUSIONS

This substantial undertaking has involved the joining of three areas of work:

- Derivation of crop response functions from information published in over 800 journal papers and reports (by Alan Buse, CEHB);
- Mapping of agricultural areas by crops and compilation of production data (by Howard Cambridge and Steve Cinderby, SEI-Y); and
- Use of EMEP 2010 emission scenarios to calculate ozone-induced losses for each crop in each LRTAP country in Europe for 2010Ref (business as usual with current legislation), implementation of the Gothenburg Protocol, and J1 (a scenario considered in the Protocol negotiations that required greater commitment) against 1990 as a baseline.

Results show that ozone impacts on crops are estimated to reduce production by several billion £ per year across Europe. Significant reductions in damage will result from existing legislation through to 2010, though there is scope for further benefit from reducing crop exposure to ozone beyond then.

A number of areas have been identified for further work. Development of the Level II approach and inclusion of changes to livestock production are probably the most important of these. Actions are already underway elsewhere (e.g. as part of this overall project, at EMEP and at the University of Reading) that will further advance this work, when they are complete.

The framework that has been developed will allow predictions of ozone effects on crop production to be made with both more accuracy and confidence than has been possible in the past. Although the computational demands of the system are high, the flexibility of the framework will permit future improvements in data and methods to be factored in very easily.

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APPENDIX 1: DETAILED RESULTS

Detailed results by country and crop, all expressed in units of £ thousands, are shown in three blocks, comprised of the following crops:
Block 1: Wheat, Barley, Rye, Oats, Millet, Maize, Rice, Soya, Pulses, Oilseed rape
Block 2:, Sugar beet, Potatoes, Tobacco, Sunflower seed and Cotton Olives, Hops, Grape, Fruit, Carrots
Block 3: Tomato, Water melons and Fresh Vegetables

Block 1, results for wheat, barley, rye, oats, millet, maize, rice, soya, pulses and rape, all results in £000

Albania	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	5,588	1,830	-	0	0	-	386	-	16	765	-
Ref2010	4,530	1,485	-	0	0	-	313	-	13	620	-
GP	4,330	1,420	-	0	0	-	299	-	12	592	-
J1	4,033	1,323	-	0	0	-	279	-	11	552	-
Austria	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	45,160	14,524	1	0	0	-	4,778	-	992	2,677	1,900
Ref2010	32,762	10,516	1	0	0	-	3,464	-	717	1,937	1,375
GP	30,845	9,867	1	0	0	-	3,270	-	677	1,829	1,299
J1	27,863	8,873	1	0	0	-	2,968	-	616	1,661	1,179
Belgium and Luxembourg	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	74,692	17,046	0	0	0	-	1,280	-	-	691	319
Ref2010	64,754	14,778	0	0	0	-	1,110	-	-	599	277
GP	58,130	13,267	0	0	0	-	996	-	-	538	248
J1	54,223	12,375	0	0	0	-	929	-	-	502	232
Bosnia	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	8,121	2,013	0	0	0	-	2,035	-	143	531	10
Ref2010	6,409	1,588	0	0	0	-	1,603	-	113	419	8
GP	6,083	1,507	0	0	0	-	1,522	-	107	398	8
J1	5,538	1,371	0	0	0	-	1,386	-	98	362	7
Bulgaria	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	38,912	16,610	0	0	0	-	3,118	37	62	995	-
Ref2010	33,947	14,482	0	0	0	-	2,719	32	54	868	-
GP	32,353	13,806	0	0	0	-	2,593	30	51	827	-
J1	30,108	12,834	0	0	0	-	2,410	28	48	770	-
Croatia	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	31,342	5,200	0	0	0	0	5,937	-	2,316	1,024	322
Ref2010	24,883	4,130	0	0	0	0	4,715	-	1,839	813	255
GP	23,639	3,920	0	0	0	0	4,478	-	1,746	772	242
J1	21,684	3,582	0	0	0	0	4,103	-	1,603	709	223

Block 1 continued, all results in £000

Czech Republic	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	89,504	44,322	2	0	0	11	835	-	5	5,178	10,450
Ref2010	67,853	33,673	2	0	0	9	636	-	4	3,921	7,913
GP	61,710	30,707	1	0	0	8	577	-	3	3,551	7,167
J1	55,333	27,425	1	0	0	7	518	-	3	3,201	6,460
Denmark	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	47,424	27,988	2	0	0	-	-	-	-	3,883	2,060
Ref2010	32,666	19,237	1	0	0	-	-	-	-	2,685	1,425
GP	29,944	17,646	1	0	0	-	-	-	-	2,458	1,304
J1	27,562	16,240	1	0	0	-	-	-	-	2,262	1,201
Estonia	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	1,301	203	0	0	0	-	-	-	-	29	70
Ref2010	803	125	0	0	0	-	-	-	-	18	43
GP	706	110	0	0	0	-	-	-	-	16	38
J1	668	104	0	0	0	-	-	-	-	15	36
Finland	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	2,220	413	0	0	0	-	-	-	-	42	128
Ref2010	1,120	211	0	0	0	-	-	-	-	21	64
GP	990	186	0	0	0	-	-	-	-	18	57
J1	897	170	0	0	0	-	-	-	-	17	51
France	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	1,059,864	463,033	11	0	1	-	54,861	1,033	7,032	137,594	56,760
Ref2010	729,134	321,554	8	0	0	-	36,891	692	4,796	93,841	38,711
GP	688,399	303,098	7	0	0	-	35,016	660	4,532	88,635	36,563
J1	-	-	-	-	-	-	-	-	-	-	-
J1	624,245	275,051	7	0	0	-	31,630	596	4,110	80,374	33,156
FYR Macedonia	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	8,190	2,036	0	0	0	0	315	91	-	596	3
Ref2010	6,950	1,728	0	0	0	0	267	78	-	506	3
GP	6,692	1,663	0	0	0	0	257	75	-	487	3
J1	6,288	1,562	0	0	0	0	241	70	-	458	3

Block 1 continued, all results in £000

Georgia	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	4,299	1,226	0	0	0	-	-	-	-	71	217
Ref2010	2,216	632	0	0	0	-	-	-	-	36	112
GP	1,923	548	0	0	0	-	-	-	-	32	97
J1	1,763	503	0	0	0	-	-	-	-	29	89
Germany	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	647,520	250,242	16	3	1	-	11,910	-	27	40,723	54,563
Ref2010	457,577	176,066	11	2	1	-	8,427	-	19	28,884	38,701
GP	417,143	159,696	10	2	1	-	7,679	-	17	26,387	35,356
J1	385,934	147,197	9	2	1	-	7,104	-	16	24,472	32,790
Greece	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	149,350	10,590	0	0	0	-	3,048	724	44	939	-
Ref2010	124,516	8,890	0	0	0	-	2,538	604	37	779	-
GP	119,425	8,524	0	0	0	-	2,433	579	35	747	-
J1	113,570	8,104	0	0	0	-	2,312	551	33	710	-
Guernsey	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Hungary	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	112,723	28,318	1	0	0	84	22,882	68	1,786	5,408	3,760
Ref2010	89,119	22,425	1	0	0	66	18,090	54	1,409	4,268	2,967
GP	84,259	21,195	1	0	0	63	17,102	51	1,333	4,036	2,806
J1	73,953	18,553	1	0	0	55	14,983	45	1,171	3,555	2,471
Ireland	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	3,844	662	0	0	0	-	-	-	-	73	225
Ref2010	2,885	488	0	0	0	-	-	-	-	55	170
GP	2,607	441	0	0	0	-	-	-	-	50	153
J1	2,403	406	0	0	0	-	-	-	-	46	141

Block 1 continued, all results in £000

Isle of Man	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Italy	**Total, £000**	**Wheat**	**Barley**	**Rye**	**Oats**	**Millet**	**Maize**	**Rice**	**Soya**	**Pulses**	**Rape**
1990	310,357	78,369	1	0	0	-	29,398	10,887	18,448	5,612	546
Ref2010	236,804	60,202	1	0	0	-	22,519	8,329	13,880	4,192	408
GP	224,782	57,291	1	0	0	-	21,417	7,926	13,136	3,960	385
J1	206,717	52,755	1	0	0	-	19,728	7,303	12,050	3,627	353
Jersey	**Total, £000**	**Wheat**	**Barley**	**Rye**	**Oats**	**Millet**	**Maize**	**Rice**	**Soya**	**Pulses**	**Rape**
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Latvia	**Total, £000**	**Wheat**	**Barley**	**Rye**	**Oats**	**Millet**	**Maize**	**Rice**	**Soya**	**Pulses**	**Rape**
1990	4,585	1,212	0	0	0	-	-	-	-	74	40
Ref2010	3,151	824	0	0	0	-	-	-	-	51	28
GP	2,746	719	0	0	0	-	-	-	-	44	24
J1	2,696	702	0	0	0	-	-	-	-	43	24
Liechtenstein	**Total, £000**	**Wheat**	**Barley**	**Rye**	**Oats**	**Millet**	**Maize**	**Rice**	**Soya**	**Pulses**	**Rape**
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Lithuania	**Total, £000**	**Wheat**	**Barley**	**Rye**	**Oats**	**Millet**	**Maize**	**Rice**	**Soya**	**Pulses**	**Rape**
1990	15,149	3,695	0	0	0	-	-	-	-	2,341	490
Ref2010	10,512	2,585	0	0	0	-	-	-	-	1,620	339
GP	9,273	2,280	0	0	0	-	-	-	-	1,429	299
J1	8,858	2,171	0	0	0	-	-	-	-	1,367	286

Block 1 continued, all results in £000

Luxembourg (see Belgium)	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Malta	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Moldova	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	32,093	4,984	0	0	0	-	2,158	-	185	1,522	-
Ref2010	25,968	3,971	0	0	0	-	1,753	-	149	1,230	-
GP	25,192	3,844	0	0	0	-	1,704	-	144	1,197	-
J1	22,314	3,421	0	0	0	-	1,512	-	128	1,060	-
Netherlands	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	119,630	8,830	0	0	0	-	342	-	-	804	55
Ref2010	102,419	7,708	0	0	0	-	295	-	-	687	47
GP	92,691	6,968	0	0	0	-	267	-	-	622	42
J1	86,466	6,492	0	0	0	-	249	-	-	581	39
Norway	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	1,011	370	0	0	0	-	-	-	-	-	15
Ref2010	623	228	0	0	0	-	-	-	-	-	9
GP	544	199	0	0	0	-	-	-	-	-	8
J1	501	184	0	0	0	-	-	-	-	-	7
Poland	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	305,693	76,005	3	3	1	-	1,499	-	-	10,492	9,409
Ref2010	232,255	58,088	2	2	1	-	1,149	-	-	7,955	7,133
GP	214,044	53,515	2	2	1	-	1,059	-	-	7,332	6,575
J1	188,463	46,937	2	2	1	-	931	-	-	6,465	5,797

Block 1 continued, all results in £000

		Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
Portugal		Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
	1990	22,965	2,420	0	0	0	-	1,825	821	-	775	-
	Ref2010	18,776	1,979	0	0	0	-	1,492	670	-	634	-
	GP	19,769	2,083	0	0	0	-	1,571	706	-	667	-
	J1	16,824	1,773	0	0	0	-	1,337	599	-	568	-
Romania		Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
	1990	177,474	36,159	1	0	0	1	23,262	26	2,786	2,277	829
	Ref2010	146,530	29,972	1	0	0	1	19,387	22	2,294	1,876	683
	GP	140,270	28,561	1	0	0	1	18,557	21	2,186	1,786	650
	J1	124,232	25,287	1	0	0	1	16,515	19	1,932	1,579	575
Russian Federation		Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
	1990	221,372	82,175	3	1	1	-	910	234	1,282	5,390	230
	Ref2010	177,009	65,707	2	1	1	-	727	187	1,025	4,310	184
	GP	170,499	62,772	2	1	1	-	715	186	998	4,150	177
	J1	167,767	61,803	2	1	1	-	704	183	984	4,090	174
Slovakia		Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
	1990	33,982	13,008	1	0	0	3	2,444	-	134	3,833	2,554
	Ref2010	27,306	10,420	1	0	0	2	1,962	-	108	3,090	2,059
	GP	25,641	9,783	1	0	0	2	1,842	-	101	2,902	1,934
	J1	22,635	8,639	0	0	0	2	1,626	-	90	2,561	1,707
Slovenia		Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
	1990	6,977	1,124	0	0	0	1	865	-	-	208	-
	Ref2010	5,509	887	0	0	0	1	683	-	-	164	-
	GP	5,252	846	0	0	0	1	652	-	-	157	-
	J1	4,831	779	0	0	0	1	600	-	-	145	-
Spain		Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
	1990	185,716	35,027	5	0	0	1	7,616	4,733	130	7,024	445
	Ref2010	141,374	26,658	4	0	0	1	5,796	3,590	99	5,355	339
	GP	142,177	26,699	4	0	0	1	5,799	3,614	100	5,374	340
	J1	125,576	23,709	3	0	0	0	5,157	3,183	88	4,761	301

Block 1 continued, all results in £000

Sweden	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	7,317	3,581	0	0	0	-	-	-	-	843	246
Ref2010	4,325	2,151	0	0	0	-	-	-	-	490	143
GP	3,774	1,893	0	0	0	-	-	-	-	424	124
J1	3,463	1,740	0	0	0	-	-	-	-	389	113
Switzerland	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	15,383	4,649	0	0	0	-	532	-	144	415	363
Ref2010	10,413	3,142	0	0	0	-	359	-	97	281	246
GP	9,907	2,989	0	0	0	-	342	-	93	267	234
J1	9,217	2,782	0	0	0	-	318	-	86	249	218
Turkey	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	2	-	-	0	-	2	-	-	-	-	-
Ref2010	2	-	-	0	-	2	-	-	-	-	-
GP	2	-	-	0	-	2	-	-	-	-	-
J1	2	-	-	0	-	2	-	-	-	-	-
Ukraine	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	344,223	88,952	4	0	0	-	3,318	380	544	16,393	970
Ref2010	279,500	72,491	3	0	0	-	2,680	312	445	13,292	786
GP	263,931	68,264	3	0	0	-	2,528	296	420	12,530	741
J1	247,840	65,127	3	0	0	-	2,382	281	399	11,721	693
United Kingdom	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	136,995	68,955	3	0	0	-	-	-	-	12,850	7,656
Ref2010	130,519	67,553	3	0	0	-	-	-	-	11,698	6,969
GP	113,618	58,631	2	0	0	-	-	-	-	10,221	6,090
J1	103,912	53,534	2	0	0	-	-	-	-	9,368	5,581
Yugoslavia	Total, £000	Wheat	Barley	Rye	Oats	Millet	Maize	Rice	Soya	Pulses	Rape
1990	50,907	14,582	0	0	0	-	12,523	-	3,969	3,455	13
Ref2010	41,771	11,960	0	0	0	-	10,212	-	3,249	2,850	11
GP	39,868	11,398	0	0	0	-	9,731	-	3,102	2,727	11
J1	36,244	10,320	0	0	0	-	8,814	-	2,824	2,495	10

Block 2, results for sugar beet, potatoes, tobacco, sunflower, cotton, olives, hops, grape, fruit and carrot, all results in £000

Albania	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	5,588	69	1,162	842	40	83	0	-	395	0	-
Ref2010	4,530	56	942	682	32	68	0	-	318	0	-
GP	4,330	54	900	652	31	65	0	-	304	0	-
J1	4,033	50	838	607	29	61	0	-	283	0	-
Austria	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	45,160	7,984	7,355	37	1,350	-	-	115	3,442	6	-
Ref2010	32,762	5,781	5,323	26	977	-	-	85	2,554	4	-
GP	30,845	5,459	5,027	25	922	-	-	79	2,384	4	-
J1	27,863	4,956	4,565	23	838	-	-	70	2,110	4	-
Belgium and Luxembourg	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	74,692	19,795	34,922	245	-	-	-	165	223	5	-
Ref2010	64,754	17,161	30,275	212	-	-	-	143	193	4	-
GP	58,130	15,406	27,178	191	-	-	-	129	173	4	-
J1	54,223	14,370	25,352	178	-	-	-	120	162	3	-
Bosnia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	8,121	-	2,941	370	1	-	-	-	78	1	-
Ref2010	6,409	-	2,323	292	1	-	-	-	61	0	-
GP	6,083	-	2,205	277	1	-	-	-	58	0	-
J1	5,538	-	2,009	252	1	-	-	-	52	0	-
Bulgaria	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	38,912	86	3,619	3,445	7,959	952	-	80	1,948	2	-
Ref2010	33,947	76	3,158	3,006	6,946	832	-	70	1,703	2	-
GP	32,353	72	3,010	2,865	6,619	791	-	66	1,621	2	-
J1	30,108	67	2,803	2,668	6,164	740	-	62	1,510	2	-
Croatia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	31,342	2,765	7,586	1,680	1,538	-	-	-	2,971	3	-
Ref2010	24,883	2,195	6,021	1,334	1,221	-	-	-	2,360	2	-
GP	23,639	2,085	5,720	1,267	1,160	-	-	-	2,247	2	-
J1	21,684	1,914	5,255	1,164	1,065	-	-	-	2,063	2	-

Block 2 continued, all results in £000

Czech Republic	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	89,504	7,636	16,657	-	1,528	-	-	2,257	620	3	-
Ref2010	67,853	5,781	12,613	-	1,157	-	-	1,681	462	2	-
GP	61,710	5,237	11,425	-	1,048	-	-	1,556	427	2	-
J1	55,333	4,719	10,297	-	944	-	-	1,376	378	2	-
Denmark	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	47,424	5,547	7,943	-	-	-	-	-	-	0	-
Ref2010	32,666	3,823	5,493	-	-	-	-	-	-	0	-
GP	29,944	3,506	5,028	-	-	-	-	-	-	0	-
J1	27,562	3,230	4,628	-	-	-	-	-	-	0	-
Estonia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	1,301	-	999	-	-	-	-	-	-	-	-
Ref2010	803	-	617	-	-	-	-	-	-	-	-
GP	706	-	542	-	-	-	-	-	-	-	-
J1	668	-	513	-	-	-	-	-	-	-	-
Finland	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	2,220	429	1,209	-	-	-	-	-	-	-	-
Ref2010	1,120	216	608	-	-	-	-	-	-	-	-
GP	990	191	537	-	-	-	-	-	-	-	-
J1	897	173	486	-	-	-	-	-	-	-	-
France	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	1,059,864	109,622	89,022	5,628	51,076	-	0	518	83,598	77	-
Ref2010	729,134	76,559	60,714	3,839	34,834	-	0	349	56,293	53	-
GP	688,399	71,979	57,346	3,626	32,902	-	0	332	53,653	50	-
J1	-	-	-	-	-	-	-	-	-	-	-
J1	624,245	65,384	52,001	3,288	29,835	-	0	300	48,469	45	-
FYR Macedonia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	8,190	91	934	2,909	162	-	-	-	1,050	1	-
Ref2010	6,950	77	793	2,469	137	-	-	-	891	1	-
GP	6,692	74	763	2,377	132	-	-	-	858	1	-
J1	6,288	70	717	2,234	124	-	-	-	807	1	-

Block 2 continued, all results in £000

Georgia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	4,299	730	2,055	-	-	-	-	-	-	-	-
Ref2010	2,216	376	1,059	-	-	-	-	-	-	-	-
GP	1,923	326	919	-	-	-	-	-	-	-	-
J1	1,763	299	843	-	-	-	-	-	-	-	-
Germany	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	647,520	87,679	161,635	1,834	2,230	-	-	14,274	22,347	37	-
Ref2010	457,577	62,400	114,645	1,301	1,581	-	-	9,945	15,569	26	-
GP	417,143	56,951	104,735	1,188	1,445	-	-	9,219	14,433	23	-
J1	385,934	52,794	97,135	1,102	1,340	-	-	8,556	13,395	22	-
Greece	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	149,350	3,275	4,962	12,850	421	107,352	6	-	5,128	11	-
Ref2010	124,516	2,730	4,116	10,658	349	89,546	4	-	4,257	9	-
GP	119,425	2,616	3,945	10,217	334	85,892	4	-	4,088	9	-
J1	113,570	2,486	3,749	9,709	318	81,683	4	-	3,904	9	-
Guernsey	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Hungary	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	112,723	8,081	14,497	3,047	19,571	-	-	-	5,213	8	-
Ref2010	89,119	6,411	11,441	2,404	15,445	-	-	-	4,130	6	-
GP	84,259	6,063	10,819	2,274	14,605	-	-	-	3,905	6	-
J1	73,953	5,297	9,530	2,003	12,865	-	-	-	3,418	5	-
Ireland	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	3,844	756	2,127	-	-	-	-	-	-	0	-
Ref2010	2,885	569	1,602	-	-	-	-	-	-	0	-
GP	2,607	515	1,448	-	-	-	-	-	-	0	-
J1	2,403	474	1,336	-	-	-	-	-	-	0	-

Block 2 continued, all results in £000

Isle of Man	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Italy	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	310,357	35,532	22,929	23,305	9,811	-	12	-	75,408	96	-
Ref2010	236,804	26,646	17,128	17,409	7,329	-	9	-	58,679	73	-
GP	224,782	25,190	16,178	16,443	6,922	-	8	-	55,856	69	-
J1	206,717	23,083	14,817	15,060	6,340	-	7	-	51,529	63	-
Jersey	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Latvia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	4,585	390	2,869	-	-	-	-	-	-	-	-
Ref2010	3,151	269	1,980	-	-	-	-	-	-	-	-
GP	2,746	235	1,724	-	-	-	-	-	-	-	-
J1	2,696	231	1,696	-	-	-	-	-	-	-	-
Liechtenstein	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Lithuania	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	15,149	938	7,685	-	-	-	-	-	-	-	-
Ref2010	10,512	649	5,318	-	-	-	-	-	-	-	-
GP	9,273	573	4,692	-	-	-	-	-	-	-	-
J1	8,858	548	4,486	-	-	-	-	-	-	-	-

Block 2 continued, all results in £000

Luxembourg (see Belgium)	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Malta	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	-	-	-	-	-	-	-	-	-	-	-
Ref2010	-	-	-	-	-	-	-	-	-	-	-
GP	-	-	-	-	-	-	-	-	-	-	-
J1	-	-	-	-	-	-	-	-	-	-	-
Moldova	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	32,093	1,700	2,305	2,517	4,077	-	-	-	2,466	2	333
Ref2010	25,968	1,373	1,863	2,035	3,295	-	-	-	2,009	2	271
GP	25,192	1,337	1,813	1,980	3,207	-	-	-	1,943	2	263
J1	22,314	1,184	1,606	1,753	2,840	-	-	-	1,718	1	232
Netherlands	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	119,630	15,163	94,430	-	-	-	-	-	2	4	-
Ref2010	102,419	12,962	80,713	-	-	-	-	-	2	4	-
GP	92,691	11,731	73,055	-	-	-	-	-	1	3	-
J1	86,466	10,944	68,157	-	-	-	-	-	1	3	-
Norway	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	1,011	-	626	-	-	-	-	-	-	-	-
Ref2010	623	-	386	-	-	-	-	-	-	-	-
GP	544	-	337	-	-	-	-	-	-	-	-
J1	501	-	310	-	-	-	-	-	-	-	-
Poland	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	305,693	26,649	174,752	6,151	-	-	-	719	-	11	-
Ref2010	232,255	20,217	132,484	4,664	-	-	-	552	-	8	-
GP	214,044	18,629	122,112	4,298	-	-	-	512	-	8	-
J1	188,463	16,423	107,669	3,790	-	-	-	441	-	7	-

Block 2 continued, all results in £000

Portugal	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	22,965	845	9,513	646	442	-	1	10	5,661	6	-
Ref2010	18,776	691	7,781	528	362	-	1	8	4,626	5	-
GP	19,769	727	8,192	556	381	-	1	9	4,871	5	-
J1	16,824	619	6,974	473	324	-	1	8	4,144	4	-
Romania	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	177,474	2,714	31,075	1,866	20,848	2	-	84	7,017	8	-
Ref2010	146,530	2,237	25,596	1,537	17,172	2	-	70	5,874	7	-
GP	140,270	2,130	24,376	1,464	16,353	2	-	67	5,620	7	-
J1	124,232	1,883	21,549	1,294	14,457	2	-	60	4,994	6	-
Russian Federation	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	221,372	6,657	56,249	44	15,197	-	-	58	397	2	6,806
Ref2010	177,009	5,323	44,977	35	12,151	-	-	47	318	2	5,442
GP	170,499	5,125	43,303	34	11,699	-	-	46	310	2	5,309
J1	167,767	5,051	42,679	33	11,530	-	-	45	304	2	5,205
Slovakia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	33,982	3,827	4,369	235	2,900	-	-	85	587	1	-
Ref2010	27,306	3,085	3,522	190	2,338	-	-	67	462	1	-
GP	25,641	2,897	3,307	178	2,196	-	-	63	433	1	-
J1	22,635	2,557	2,919	157	1,938	-	-	56	383	1	-
Slovenia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	6,977	1,156	2,006	-	3	-	-	822	791	1	-
Ref2010	5,509	913	1,583	-	2	-	-	649	625	1	-
GP	5,252	871	1,511	-	2	-	-	617	594	1	-
J1	4,831	802	1,392	-	2	-	-	566	545	1	-
Spain	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	185,716	14,325	24,558	5,270	8,621	46,496	11	262	31,139	53	-
Ref2010	141,374	10,917	18,725	4,018	6,574	35,369	8	199	23,683	40	-
GP	142,177	10,950	18,790	4,032	6,597	35,559	8	202	24,067	41	-
J1	125,576	9,707	16,648	3,572	5,845	31,422	7	176	20,959	35	-

Block 2 continued, all results in £000

Sweden	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	7,317	1,062	1,585	-	-	-	-	-	-	0	-
Ref2010	4,325	618	922	-	-	-	-	-	-	0	-
GP	3,774	535	798	-	-	-	-	-	-	0	-
J1	3,463	490	730	-	-	-	-	-	-	0	-
Switzerland	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	15,383	2,822	4,833	177	101	-	-	13	1,331	3	-
Ref2010	10,413	1,913	3,276	120	69	-	-	9	900	2	-
GP	9,907	1,821	3,115	114	65	-	-	9	857	2	-
J1	9,217	1,693	2,899	106	61	-	-	8	794	2	-
Turkey	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	2	-	-	-	-	-	-	-	-	-	-
Ref2010	2	-	-	-	-	-	-	-	-	-	-
GP	2	-	-	-	-	-	-	-	-	-	-
J1	2	-	-	-	-	-	-	-	-	-	-
Ukraine	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	344,223	22,959	87,994	316	38,812	-	-	76	1,358	3	6,389
Ref2010	279,500	18,656	71,349	257	31,470	-	-	62	1,101	3	5,180
GP	263,931	17,587	67,258	242	29,666	-	-	59	1,046	3	4,923
J1	247,840	16,512	62,914	226	27,750	-	-	55	972	2	4,574
United Kingdom	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	136,995	13,702	33,158	-	-	-	-	661	8	1	-
Ref2010	130,519	13,417	30,183	-	-	-	-	686	8	1	-
GP	113,618	11,692	26,374	-	-	-	-	599	7	1	-
J1	103,912	10,699	24,172	-	-	-	-	548	7	1	-
Yugoslavia	Total, £000	SugarB	Potatoes	Tobac	SunFlow	Cotton	Olives	Hops	Grape	Fruit	Carrots
1990	50,907	3,982	5,695	1,533	3,668	-	-	168	1,314	4	-
Ref2010	41,771	3,287	4,698	1,265	3,026	-	-	137	1,073	3	-
GP	39,868	3,143	4,496	1,210	2,895	-	-	130	1,021	3	-
J1	36,244	2,872	4,113	1,107	2,649	-	-	118	921	3	-

Block 3: Result for tomato, watermelon and fresh vegetables, all results in £000

Albania	Total, £000	Tomato	WaterM	FreshVeg
1990	5,588	-	-	-
Ref2010	4,530	-	-	-
GP	4,330	-	-	-
J1	4,033	-	-	-
Austria	Total, £000	Tomato	WaterM	FreshVeg
1990	45,160	-	-	-
Ref2010	32,762	-	-	-
GP	30,845	-	-	-
J1	27,863	-	-	-
Belgium and Luxembourg	Total, £000	Tomato	WaterM	FreshVeg
1990	74,692	-	-	-
Ref2010	64,754	-	-	-
GP	58,130	-	-	-
J1	54,223	-	-	-
Bosnia	Total, £000	Tomato	WaterM	FreshVeg
1990	8,121	-	-	-
Ref2010	6,409	-	-	-
GP	6,083	-	-	-
J1	5,538	-	-	-
Bulgaria	Total, £000	Tomato	WaterM	FreshVeg
1990	38,912	-	-	-
Ref2010	33,947	-	-	-
GP	32,353	-	-	-
J1	30,108	-	-	-
Croatia	Total, £000	Tomato	WaterM	FreshVeg
1990	31,342	-	-	-
Ref2010	24,883	-	-	-
GP	23,639	-	-	-
J1	21,684	-	-	-

Block 3 continued, all results in £000

Czech Republic		Total, £000	Tomato	WaterM	FreshVeg
	1990	89,504	-	-	-
	Ref2010	67,853	-	-	-
	GP	61,710	-	-	-
	J1	55,333	-	-	-
Denmark		Total, £000	Tomato	WaterM	FreshVeg
	1990	47,424	-	-	-
	Ref2010	32,666	-	-	-
	GP	29,944	-	-	-
	J1	27,562	-	-	-
Estonia		Total, £000	Tomato	WaterM	FreshVeg
	1990	1,301	-	-	-
	Ref2010	803	-	-	-
	GP	706	-	-	-
	J1	668	-	-	-
Finland		Total, £000	Tomato	WaterM	FreshVeg
	1990	2,220	-	-	-
	Ref2010	1,120	-	-	-
	GP	990	-	-	-
	J1	897	-	-	-
France		Total, £000	Tomato	WaterM	FreshVeg
	1990	1,059,864	-	-	-
	Ref2010	729,134	-	-	-
	GP	688,399	-	-	-
	J1	-	-	-	-
	J1	624,245	-	-	-
FYR Macedonia		Total, £000	Tomato	WaterM	FreshVeg
	1990	8,190	-	-	-
	Ref2010	6,950	-	-	-
	GP	6,692	-	-	-
	J1	6,288	-	-	-

Block 3 continued, all results in £000

Georgia	Total, £000	Tomato	WaterM	FreshVeg
1990	4,299	-	-	-
Ref2010	2,216	-	-	-
GP	1,923	-	-	-
J1	1,763	-	-	-
Germany	**Total, £000**	**Tomato**	**WaterM**	**FreshVeg**
1990	647,520	-	-	-
Ref2010	457,577	-	-	-
GP	417,143	-	-	-
J1	385,934	-	-	-
Greece	**Total, £000**	**Tomato**	**WaterM**	**FreshVeg**
1990	149,350	-	-	-
Ref2010	124,516	-	-	-
GP	119,425	-	-	-
J1	113,570	-	-	-
Guernsey	**Total, £000**	**Tomato**	**WaterM**	**FreshVeg**
1990	-	-	-	-
Ref2010	-	-	-	-
GP	-	-	-	-
J1	-	-	-	-
Hungary	**Total, £000**	**Tomato**	**WaterM**	**FreshVeg**
1990	112,723	-	-	-
Ref2010	89,119	-	-	-
GP	84,259	-	-	-
J1	73,953	-	-	-
Ireland	**Total, £000**	**Tomato**	**WaterM**	**FreshVeg**
1990	3,844	-	-	-
Ref2010	2,885	-	-	-
GP	2,607	-	-	-
J1	2,403	-	-	-

Block 3 continued, all results in £000

Isle of Man	Total, £000	Tomato	WaterM	FreshVeg
1990	-	-	-	-
Ref2010	-	-	-	-
GP	-	-	-	-
J1	-	-	-	-
Italy	Total, £000	Tomato	WaterM	FreshVeg
1990	310,357	-	-	-
Ref2010	236,804	-	-	-
GP	224,782	-	-	-
J1	206,717	-	-	-
Jersey	Total, £000	Tomato	WaterM	FreshVeg
1990	-	-	-	-
Ref2010	-	-	-	-
GP	-	-	-	-
J1	-	-	-	-
Latvia	Total, £000	Tomato	WaterM	FreshVeg
1990	4,585	-	-	-
Ref2010	3,151	-	-	-
GP	2,746	-	-	-
J1	2,696	-	-	-
Liechtenstein	Total, £000	Tomato	WaterM	FreshVeg
1990	-	-	-	-
Ref2010	-	-	-	-
GP	-	-	-	-
J1	-	-	-	-
Lithuania	Total, £000	Tomato	WaterM	FreshVeg
1990	15,149	-	-	-
Ref2010	10,512	-	-	-
GP	9,273	-	-	-
J1	8,858	-	-	-

Block 3 continued, all results in £000

Luxembourg (see Belgium)	Total, £000	Tomato	WaterM	FreshVeg
1990	-	-	-	-
Ref2010	-	-	-	-
GP	-	-	-	-
J1	-	-	-	-
Malta	Total, £000	Tomato	WaterM	FreshVeg
1990	-	-	-	-
Ref2010	-	-	-	-
GP	-	-	-	-
J1	-	-	-	-
Moldova	Total, £000	Tomato	WaterM	FreshVeg
1990	32,093	9,146	490	207
Ref2010	25,968	7,449	399	169
GP	25,192	7,207	387	163
J1	22,314	6,371	342	144
Netherlands	Total, £000	Tomato	WaterM	FreshVeg
1990	119,630	-	-	-
Ref2010	102,419	-	-	-
GP	92,691	-	-	-
J1	86,466	-	-	-
Norway	Total, £000	Tomato	WaterM	FreshVeg
1990	1,011	-	-	-
Ref2010	623	-	-	-
GP	544	-	-	-
J1	501	-	-	-
Poland	Total, £000	Tomato	WaterM	FreshVeg
1990	305,693	-	-	-
Ref2010	232,255	-	-	-
GP	214,044	-	-	-
J1	188,463	-	-	-

Block 3 continued, all results in £000

Portugal	Total, £000	Tomato	WaterM	FreshVeg
1990	22,965	-	-	-
Ref2010	18,776	-	-	-
GP	19,769	-	-	-
J1	16,824	-	-	-
Romania	Total, £000	Tomato	WaterM	FreshVeg
1990	177,474	43,057	-	5,461
Ref2010	146,530	35,319	-	4,480
GP	140,270	34,156	-	4,332
J1	124,232	30,243	-	3,836
Russian Federation	Total, £000	Tomato	WaterM	FreshVeg
1990	221,372	27,338	2,628	15,770
Ref2010	177,009	21,860	2,101	12,610
GP	170,499	21,322	2,049	12,299
J1	167,767	20,907	2,009	12,060
Slovakia	Total, £000	Tomato	WaterM	FreshVeg
1990	33,982	-	-	-
Ref2010	27,306	-	-	-
GP	25,641	-	-	-
J1	22,635	-	-	-
Slovenia	Total, £000	Tomato	WaterM	FreshVeg
1990	6,977	-	-	-
Ref2010	5,509	-	-	-
GP	5,252	-	-	-
J1	4,831	-	-	-
Spain	Total, £000	Tomato	WaterM	FreshVeg
1990	185,716	-	-	-
Ref2010	141,374	-	-	-
GP	142,177	-	-	-
J1	125,576	-	-	-

Block 3 continued, all results in £000

Sweden	Total, £000	Tomato	WaterM	FreshVeg
1990	7,317	-	-	-
Ref2010	4,325	-	-	-
GP	3,774	-	-	-
J1	3,463	-	-	-
Switzerland	Total, £000	Tomato	WaterM	FreshVeg
1990	15,383	-	-	-
Ref2010	10,413	-	-	-
GP	9,907	-	-	-
J1	9,217	-	-	-
Turkey	Total, £000	Tomato	WaterM	FreshVeg
1990	2	-	-	-
Ref2010	2	-	-	-
GP	2	-	-	-
J1	2	-	-	-
Ukraine	Total, £000	Tomato	WaterM	FreshVeg
1990	344,223	64,612	5,606	5,538
Ref2010	279,500	52,379	4,544	4,490
GP	263,931	49,781	4,319	4,267
J1	247,840	46,251	4,013	3,964
United Kingdom	Total, £000	Tomato	WaterM	FreshVeg
1990	136,995	-	-	-
Ref2010	130,519	-	-	-
GP	113,618	-	-	-
J1	103,912	-	-	-
Yugoslavia	Total, £000	Tomato	WaterM	FreshVeg
1990	50,907	-	-	-
Ref2010	41,771	-	-	-
GP	39,868	-	-	-
J1	36,244	-	-	-