THE ENVIRONMENTAL IMPACT OF OLIVE OIL PRODUCTION IN THE EUROPEAN UNION:

PRACTICAL OPTIONS FOR IMPROVING THE ENVIRONMENTAL IMPACT

This report was produced by the European Forum on Nature Conservation and Pastoralism and the Asociación para el Análisis y Reforma de la Política Agro-rural. The views set out in the report are those of the authors and do not represent the views of the Commission or the Environment Directorate General.

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INDEX

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0 SUMMARY AND CONCLUSIONS

0.1 Background

Olive production is a significant land use in the southern Member States of the EU with important environmental, social and economic considerations. The main areas of olive oil production are in Spain (2.4 million ha), followed by Italy (1.4 million ha), Greece (1 million ha) and Portugal (0.5 million ha). France is a very much smaller producer, with 40,000 ha.

The requirement to integrate environmental concerns into Community policies, including agriculture policy, is enshrined in the European Union (EU) Treaties. However, until now there have been considerable obstacles to achieving this integration, including a lack of clear and comprehensive information concerning the environmental affects of particular agricultural sectors and systems, and an absence of research into practical policy options.

These absences are particularly apparent in the case of certain farming systems characteristic of the Mediterranean region, such as olive production, whose environmental effects have been studied less than farming systems more characteristic of central and northern Europe.

The olive regime of the Common Agricultural Policy (CAP) supports production by means of an annual budget of currently around Euro 2,250 million and has a strong influence on the sector. In 1997, the European Commission (EC) released an “options paper” highlighting the need to reform the olive support regime. This lead to a simplified “interim” regime for the period 1998-2001 which retained production support as the principal measure.

The European Commission (EC) is due to present a proposal during 2000 for a new regime to be implemented from November 2001.

0.2 Study brief

With a view to integrating environmental concerns into agricultural policies affecting olive production, the EC commissioned the present study with the aim of providing a detailed description of the environmental impact (problems and benefits) of olive production in the EU and producing practical suggestions of how to reduce or eliminate any identified negative environmental effects.

The contractor was requested to consider the definition of codes of “good agricultural practice” in relation to olive farming, incorporating basic environmental protection, as well as identifying environmental services which could be considered to go beyond good agricultural practice.

0.3 Olive farming types and environmental effects

This study revealed considerable differences between olive farming areas and, in some cases, between different farms within a given area. These differences are strongly apparent in the physical characteristics of the plantations, management practices, socio-economic situation and environmental effects. Olive farms in the EU range from the very small (<0.5ha) to the very large (>500ha) and from the traditional, low-intensity grove to the intensive, highly mechanised plantation.

Overall, three broad types of plantation were identified:

- Low-input traditional plantations and scattered trees, often with ancient trees and typically planted on terraces, which are managed with few or no chemical inputs, but with a high labour input.

- Intensified traditional plantations which to some extent follow traditional patterns but are under more intensive management making systematic use of artificial fertilisers and pesticides and with more intensive weed control and soil management. There is a tendency to intensify further by means of irrigation, increased tree density and mechanical harvesting.

- Intensive modern plantations of smaller tree varieties, planted at high densities and managed under an intensive and highly mechanised system, usually with irrigation.

As a result of their particular plantation characteristics and farming practices, the low-input traditional plantations have potentially the highest natural value (biodiversity and landscape value) and most positive effects (such as water management in upland areas) as well as the least negative effects on the environment. These plantations are also the least viable in economic terms and hence most vulnerable to abandonment.

The intensified traditional and modern intensive systems are inherently of least natural value and have potentially, and in practice, the greatest negative environmental impacts, particularly in the form of soil erosion, run-off to water bodies, degradation of habitats and landscapes and exploitation of scarce water resources.

Soil erosion is probably the most serious environmental problem associated with olive farming (as distinct from olive processing, which is not covered by this study). Inappropriate weed-control and soil-management practices, combined with the inherently high risk of erosion in many olive farming areas, is leading to desertification on a wide scale in some of the main producing regions, as well as considerable run-off of soils and agro-chemicals into water bodies.

The broad picture for the olive sector is of intensified production leading to certain negative effects on the environment, reflecting similar conclusions for European agriculture in general over recent decades in numerous studies, including the recent EC report on sustainable agriculture (EC, 1999).

However, the present study concludes that, at least in the olive sector, the negative environmental effects of intensification could be reduced considerably by means of appropriate farming practices; and that, with appropriate support, traditional low-input plantations could continue to maintain important natural and social values in marginal areas.

0.4 Objectives for environmental improvements

The study concludes that the following aims need to be addressed in order to improve the environmental effects of olive farming:

Reducing negative effects in traditional-intensified and modern-intensive systems:

- To reduce currently high levels of soil erosion and run-off to water courses, mainly in intensified-traditional and modern-intensive systems, by promoting changes in management practices or, in extreme cases, a change in land use (maintaining olive trees and introducing grazing and/or afforestation).

- To promote a more rational use of agro-chemicals in order to reduce impacts on flora and fauna (biodiversity) and reduce the risks of pollution, especially of soil and water.

- To promote a more sustainable exploitation of water resources for irrigation and control the spread of irrigation in areas with sensitive water resources.

- To prevent the further expansion of olive plantations onto valuable habitats (natural and semi-natural) and soils that are vulnerable to erosion.

Maintaining and improving positive effects:

- To prevent the abandonment of olive plantations where these make a positive contribution to natural and landscape values, mainly low-input traditional systems.

- To further develop and promote sustainable and environmentally-favourable olive farming systems, such as organic and integrated production systems.

- To promote the maintenance and improvement of natural values in olive plantations (maintenance and restoration of habitats and landscape features).

Action is required in four key areas in order to promote the above aims, namely:

- Improving farming practices.
- Monitoring and steering changes in land use (abandonment, expansion and set-aside).
- Information, advice and training for farmers.
- Research, monitoring and the development of data-bases which integrate agronomic, environmental and land-use criteria.

0.5 Policy review

Until now, EU policies have not promoted, at a general level, either sustainable olive farming or the effective integration of environmental concerns into the sector.

This study concludes that the existing system of production support produces negative environmental effects by rewarding intensification and expansion. Whilst most notable in the more productive areas, in the form of developments such as new plantations, irrigation and intensive use of inputs, intensification is also apparent in many marginal areas.

By operating in direct proportion to production, the olive regime offers relatively little support for low-input olive plantations in marginal areas which generally are those of most environmental value. At the same time, the support regime currently includes no specific mechanism for improving the environmental effects of olive production.

Apart from the CAP olive regime, other EU policies of relevance to the study include FEOGA structural measures (e.g. for grubbing-out old groves, for investments in replanting and irrigation and for setting up young farmers), aid for farmers in Less Favoured Areas and, since the mid-1990s, agri-environment programmes established under Regulation 2078/92.

In the framework of these policies, measures to reduce environmental impacts or maintain environmental values have been on an extremely small scale, compared with the resources devoted to production support and production-orientated structural objectives. In particular, agri-environmental schemes under Regulation 2078/92 have had very little impact on olive farming to date (with the exception of Portugal) and have failed to address the scale and range of environmental issues identified in the present study.

Nevertheless, the study revealed examples of positive initiatives in several of the olive producing regions, developed in different cases by agricultural authorities, farmer associations and NGOs, and supported in some instances by EU policies such as Objective 1 rural development programmes and agri-environment schemes. These examples illustrate the great opportunities which exist to promote environmental improvements in olive farming and which could produce benefits on a considerable scale if greater resources were made available for targeted measures with clear environmental objectives.

Significant lessons could also be learned from policy experience in the USA, where soil erosion in arable farming has been tackled successfully over extensive areas by means of "cross-compliance" measures (attaching environmental conditions to support payments).

0.6 Practical suggestions

Important opportunities exist within the current policy framework for promoting environmental improvements in olive farming, notably:

- The CAP olive support regime, due to be reformed during 2000 for the implementation of a new regime from November 2001.

- New environmental measures provided for under Article 3 of the "common rules" Regulation 1259/1999, including the possibility for attaching environmental conditions to CAP support payments.

- Agri-environment measures, previously Regulation 2078/92 and now under Chapter VI of the "rural development" Regulation 1257/1999; and measures for less-favoured areas and areas with environmental restrictions, under Chapter V of Regulation 1257/1999.

- The rural development measures established under Regulation 1257/1999, particularly in Chapter IX (adaptation and development of rural areas) and in Chapter I (investment in agricultural holdings.

Based on the information provided by all of the national and case studies, this report makes the following practical suggestions for integrating environmental protection into the main policies affecting olive farming and in order to promote sustainable practices in the sector:

- The change from production support to a flat-rate area payment unrelated to production or yields. A minimum number of trees per hectare should be established, low enough to allow very extensive, traditional plantations to benefit (e.g. 40-50 trees per hectare). Scattered trees not in plantations and with an overall density below this limit could be paid the same level of aid, but converted to a tree-basis.

- All olive producers receiving CAP support should be required to comply with locally-established codes of Good Agricultural Practice (GAP) incorporating basic environmental protection, within an EU framework.

- A higher level of area payment could be introduced (for example under the Less Favoured Areas scheme or within the proposed area-payment support scheme) for plantations in environmentally very sensitive areas and for which GAP is more demanding and implies a higher cost than in other areas.

- The application of agri-environment programmes to olive farming should be greatly expanded in order to offer payments to all olive farmers in return for additional environmental services which go beyond GAP, under schemes designed to address specific environmental priorities in the region or area.

The authors believe that the policy recommendations made in this study could, if implemented effectively, result in a considerable reduction in the environmental impacts of olive farming, as well as providing significant benefits in terms of the conservation of soil and water resources and of biodiversity and landscape values. Potentially, the proposed measures could also lead to improved viability and employment on olive farms in marginal rural areas.

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1 INTRODUCTION

The requirement to integrate environmental concerns into Community policies, including agriculture policy, is enshrined in the European Union (EU) Treaties. However, until now there have been considerable obstacles to achieving this integration, including a lack of clear and comprehensive information concerning the environmental affects of particular agricultural sectors and systems, and an absence of research into practical policy options.

These absences are particularly apparent in the case of certain farming systems characteristic of the Mediterranean region, such as olive production, whose environmental effects have been studied less than farming systems more characteristic of central and northern Europe.

Olive production is a significant land use in the southern Member States of the EU with important environmental, social and economic considerations. This study covers the four main producing countries: Spain, Italy, Greece and Portugal.

The olive regime of the Common Agricultural Policy (CAP) was introduced in 1966 (Regulation 136/66), when Italy was the only significant producing Member State. It supports production by means of an annual budget of currently around Euro 2,250 million and has a strong influence on the sector.

In 1997, the European Commission (EC) released an "options paper" (COM(97)57) highlighting the need to reform the olive support regime and considering different options for this reform. This subsequently lead to a simplified "interim" regime for the period 1998-2001 under which several elements of the original regime were abolished leaving the production subsidy as the principal measure.

A lack of reliable data, particularly concerning olive-tree numbers, area and yields, was cited as the main reason for not being able to undertake an appropriate long-term reform in 1998. Also apparent in many of the public and political debates which took place before and after the release of the EC's options paper was a lack of information and understanding concerning the environmental effects of olive farming.

The Regulation introducing the interim olive regime (Regulation 1638/98) committed the EC to presenting a proposal during 2000 for a new regime to be implemented from November 2001, replacing the one introduced in 1966. Basic olive data has been improved during the past two years by means of aerial and satellite imagery in order to facilitate the design of an appropriate regime.

With a view to integrating environmental concerns into agricultural policies affecting olive production, the EC commissioned the present study with the following specific objectives:

- First, to provide a comprehensive and detailed description of the environmental impact (problems and benefits) of olive production in the EU, including an examination of several different production and management systems of varying intensity in a wide range of locations.

- Second, to produce a detailed series of practical suggestions of how to reduce or eliminate any identified negative environmental effects of olive production.

The contractor was requested to consider the definition of codes of “good agricultural practice” in relation to olive farming, incorporating basic environmental protection, as well as identifying environmental services which could be considered to go beyond good agricultural practice.

The study was carried out in three phases, as follows:

- A national report was produced for each of the four main producing countries by a national consultant.

- Six case studies were produced by national and local consultants. The case-study areas were selected in order to represent a selection of different olive-producing situations across the EU Mediterranean countries (see Index for areas).

- The main report (this Volume) and summaries of the national and case-study reports (Volume II) were produced by the study co-ordinator and distributed to the national and local consultants for comments.

The study was carried out on the basis of a review of existing literature and research, interviews with key actors and experts and visits to approximately 30 olive farms in the six case-study areas. Where possible, highly technical language has been avoided in order to make the report accessible to a wider group of readers.

The study is concerned specifically with the environmental effects of olive cultivation; the considerable environmental problems associated with the disposal of wastes from olive processing plants were excluded from the terms of reference for the study.

Socio-economic considerations also were not part of the terms of reference for the study. However, the consultants involved in the study and many of the persons interviewed stressed the importance of interactions between environmental and socio-economic considerations and the desirability of developing an integrated policy approach to the olive farming sector. Consequently, certain socio-economic considerations are referred to in this report where these are of particular relevance to the analysis of environmental effects.

2 CURRENT SITUATION OF OLIVE PRODUCTION IN THE EU

2.1 Production and land-use patterns

Olive farming is a significant land use in Mediterranean regions, covering over five million ha in the EU Member States. The main areas of olive oil production are in Spain (2.4 million ha), followed by Italy (1.4 million ha), Greece (1 million ha) and Portugal (0.5 million ha). France is a very much smaller producer, with 40,000 ha.

The percentage of national UAA occupied by olives is 7% and 9% in Spain and Italy respectively, but around 20% in Greece. Whereas 6.5% of all farms in Spain have olives as part of their production, this rises to 15% in Greece and 37% in Italy.

Table 1: General data on olive area and production in EU

	Olive area (ha) (1)	Oil production (tonnes) (2)	Producers (1)	Approx. % world olive oil output (2)
Spain	2,423,841	535,000	396,899	28%
Italy	1,430,589	467,000	998,219	24%
Greece	1,025,748	307,000	780,609	16%
Portugal	529,436	35,000	117,000	2%
France	39,421	2,000	19,271	<0.1%
EU	5,449,035	1,346,000	2,311,998	70%

Sources:
(1) EC figures from "Oliarea" survey, quoted in *Agricultura,* 2000.
(2) Polidori *et al*, 1997. Production figures are annual average 1990/91 to 1995/96, IOOC estimates.

Olive statistics vary considerably, depending on the source and the criteria used. Data from the main producer countries are often inconsistent. The figures in Table 1 relating to olive area and number of producers are from a new survey undertaken by the EC following the interim reform of the CAP olive regime in 1998. This survey suggests a considerably greater olive area and number of producers in the four main producing Member States than was reflected in previous statistics. The production figures are from the International Olive Oil Council (IOOC) for the years 1990/91 to 1995/96. Average production in recent years has been considerably higher, especially in Spain.

Whilst olive plantations are found over most of the Mediterranean region, the greatest concentration of oil production is found in two Spanish provinces, Jaén and Córdoba in Andalucía, which between them account for over a third of EU output.

Plantations which produce table olives cover a far smaller area than those producing olive oil. In Spain, less than 6% of the total area is devoted to table-olive production whereas the figure in Italy is less than 3%.

The EU currently dominates the global market, producing over 70 per cent of the world's olive oil. Tunisia, Turkey and Syria are the only other producers of significance, accounting for over 20 per cent of world production.

2.2 Structural characteristics of olive farms

The average size of olive holding in the EU countries is extremely small. In Italy, the average olive holding has less than 1ha. In Portugal, the average size is 1.8ha, but with notable differences between regions. In Spain the average size of holding with olives as the main product is 7.7ha and over 90 % of olive holdings have an average UAA of less than 15 ha and an average olive area of less than six ha. In addition, olive holdings tend to be highly fragmented, especially in upland areas.

However, large olive holdings are also an important part of the sector even though there are few of them. In Spain, large holdings account for a considerable proportion of the land under olives. In fact 3% of olive holdings have an average UAA of over 40ha and account for 33% of the total area of holdings with olives as the main product (UPA, 1998).

The structural characteristics of olive holdings are relevant to the evaluation of environmental effects as they may have an important influence on the viability of production and thus on the risk of abandonment, which can have significant environmental consequences. It may also be more difficult in practical terms to influence farming practices in areas with a large number of very small, fragmented holdings.

2.3 Socio-economic considerations

Although not the main focus of this study, it is useful to provide a brief review of socio-economic considerations which interact with the environmental issues identified in the study.

Olive farming provides an important source of employment in many rural areas of the Mediterranean, including many marginal areas where it is either a principal employer or an important part-time employer which can be combined with other activities, such as tourism. Olive farming is also an important part of local rural culture and heritage in many areas, and is being maintained and “valorised” through labelling schemes in some cases.

However, this employment is far from secure. In more productive regions, continued mechanisation (especially of harvesting and pruning) in more modern systems is leading to a considerable reduction in labour requirements which is likely to be accentuated in the near future. In marginal areas, employment in olive farming is seasonal and low-paid, and ageing populations and emigration are leading to reduced availability of labour. For similar reasons, the cultural and heritage values are also being lost in many areas.

Olive production is an important economic sector in many rural areas of the Mediterranean. In some areas, it is the principal economic activity and the basis for other sectors, up and down-stream (inputs, processing). The Jaén case study provides an example. The olive sector has developed rapidly in recent years in the main producing regions of Andalucía, with notable increases in both productivity and quality of production. In certain areas of the EU, such as Toscana, a different model has developed, in the form of an artisan olive sector which is closely integrated with rural and cultural tourism.

However, this economic development associated with the sector has been concentrated in certain more progressive regions. Meanwhile, there are other areas where the olive sector has stagnated, kept alive by production subsidies but failing to develop either as a modern industrialised sector (cf. Jaén) or as a cultural-quality sector (cf. Toscana). The Puglia and Cáceres (especially La Vera) cases provide two very different examples of this less optimistic situation. The extremely small size of olive farms (typically around 1 hectare in most regions) and the advanced age of many farmers are fundamental obstacles to development.

3 FACTORS WHICH DETERMINE ENVIRONMENTAL EFFECTS

There are wide variations in olive farming within the EU. These differences are apparent across three broad categories:

- Plantation characteristics and farming practices.
- The physical and biological conditions in which farming takes place.
- The socio-economic situation of the holding.

Given these wide variations in olive farming, it is important to identify the main characteristics which determine the effects on the environment. The main emphasis of the study was on plantation characteristics and farming practices, but it is useful to review other factors briefly before discussing environmental effects in more detail.

3.1 Plantation characteristics and farming practices

It is important to stress the great variation in plantation characteristics and, especially, in olive-farming practices, not only across the EU, but even within particular regions. It is extremely difficult to describe “standard” farming practices in the olive sector. The case studies, interviews and published literature all confirm that the practices recommended for olive cultivation in agronomic text books are applied in only a very small proportion of olive plantations.

In the great majority of plantations, practices depend on a mix of local conditions (physical, biological, socio-economic), tradition, hearsay and the farmer’s own intuition, observation and opinion. Farm advisory services tend to be limited in olive-producing areas, especially in more marginal areas, and the only external advice available for many producers is from agro-chemical salesmen and farmer associations.

The following review therefore aims to provide an overview of the situation, based on information from the national and case studies, literature and interviews. A more exhaustive analysis was not possible given the resources of the study. More detail on specific practices is provided in the case studies (Volume II).

This review applies to olive farming both for oil and table-olive production. In fact, it is not always possible to make a clear distinction between plantations producing oil or table-olives: many of the varieties used for table-olives are also suitable for oil production and the output of a particular plantation in a given year may go partially for oil and partially for table-olives, depending on various factors including market prices, size and quality of the olives, etc. The differences in production practices are relatively minor, for example, table-olive production usually involves more frequent and labour-intensive pruning and earlier harvesting. Control of olive fly is also especially important, as fruits attacked by this pest have virtually no market value as table olives.

3.1.1 Tree characteristics and management

Olive trees range from ancient, large-canopied trees, which may have been cultivated by grafting onto wild olives and maintained by pruning for over 500 years, to modern dwarf varieties planted in dense lines, which may be grubbed-out and replanted every 25 years.

Tree densities vary from as few as 40-50 stems per hectare noted in some older plantations to 300-400 stems or more per hectare in the most intensive new plantations.

Modern, high-density olive plantations are comparable to intensive plantations of other fruit trees: in fact, they are as different from the traditional concept of an olive grove as an intensive apple plantation is from a traditional apple orchard.

Tree density and planting patterns depend partly on local tradition but water availability is also a determining factor: under rain-fed cultivation, the lower the rainfall, the lower the tree density, by necessity.

For example, in Jaén, an average rainfall of less than 400mm per year allows for densities of less than 80 trees per hectare; with 500mm per year, 100 trees per hectare are possible (Aguilar Ruiz et al, 1995). Irrigation permits much higher densities, typically between 200 and 400 trees per hectare.

Trees may be pruned every year (for table-olive production) or every two or more years, depending on local tradition, the individual farmer, etc. In some marginal situations, trees have not been pruned for many years and have developed a high, dense canopy which could only be recovered for efficient production at considerable cost (see Crete case study).

Pruning usually is carried out manually (with chainsaws for bigger branches) and requires a large labour input (for example, 1/5 to 1/3 of the total labour input on traditional farms in the Cáceres case study). However, the most modern type of plantation (using “dwarf” or “bush” varieties in dense rows) is designed for totally mechanised pruning, which greatly reduces the labour input (this system is not suitable for production of table olives).

There are many different olive-tree varieties, each with particular characteristics. For example, some are more suitable for mechanical harvesting than others: in Portugal the very widespread Galego variety is less suitable as the olives are difficult to shake off the tree. Some varieties, such as Gordal in Sevilla, are only suitable for table-olive production.

3.1.2 Weed control and soil management

Traditionally in many regions, the understorey of olive plantations was used for growing other crops (cereals, vines, etc.) and/or for grazing. This partly explains why tree densities often were very low. Cultivation was with animal traction and a shallow plough which followed the contours of slopes. Weed control was by means of cultivation and grazing or by hand.

From the 1970s, these traditional systems were replaced in the more productive areas and in many marginal areas. Crop cultivation and grazing were abandoned and mechanised tillage was introduced to control weeds. Weed control is considered necessary to prevent them from competing with the olive crop, particularly for moisture during the late spring and summer. Tillage is also thought to improve water penetration and reduce transpiration, although recent research has cast doubt on the usefulness of tillage for this purpose (for example, Guerrero, 1997).

Tillage may be with a cultivator, tine-harrow, disk-harrow or rotovator, or in some cases a plough. The number of passes per year varies considerably, depending on local practice, conditions (e.g. more tillage is needed in the event of high rainfall as this produces more weeds) and the individual farmer. More extensive cultivation systems use one or two passes at the most. Intensive systems use repeated tillage (four or more passes per year).

Herbicides were introduced as a complement or alternative to tillage from the 1970s, but have not been adopted on a large scale until recently. The most widespread types of herbicide are pre-emergence, such as Simazine, which are residual and require only one or two applications per year, and are used to keep the soil free of weeds throughout the year. A typical dosage is 3.5 kg (active ingredients) Simazine per hectare per year (Guerrero, 1997).

Post-emergence contact herbicides such as Glyphosate are also used increasingly, but require more applications, and may be used in combination with pre-emergence types. A typical dosage is 8 litres of 35% Glyphosate per hectare (Guerrero, 1997).

In order to conserve and improve the soil, various systems have been developed in recent years for maintaining a permanent or semi-permanent vegetation cover, either over the whole plantation or in the lines between the tree.

A permanent grass cover over the whole plantation which is maintained by mechanical mowing is known as "inerbimiento" in Italy. At least in areas with sufficient rainfall (or with irrigation), results suggest that this permanent grass cover does not affect the olive crop while soil conservation is extremely good (see Toscana case study). In certain areas of all four countries, sheep raising is practised in olive groves. With appropriate stocking densities, this integration of crop and livestock production is considered environmentally beneficial for several reasons, including effective weed control with a low risk of erosion, fertilisation without external inputs and the maintenance of important biodiversity and landscape values.

Other systems developed in Andalucía involve vegetation strips (spontaneous or sown) in the lines between the trees which are chemically "mown" with herbicides in spring before they start to compete for moisture, while the area under the canopy is kept free of vegetation with residual herbicides (for example, see Pastor and Castro, 1995).

3.1.3 Fertilisation

Fertilisation systems include: no fertilisation (still common in some marginal areas), organic fertilisation (animal manure, leaves, compost, manufactured organic fertilisers), green manures (leguminous crops such as vetch, beans), chemical fertilisers (NPK applied by hand or machine beneath the tree canopy, usually in the form of combined fertilisers), fertilisation though irrigation water and through the foliage (modern intensive systems).

Traditionally, many plantations received no fertilisation, other than dung from grazing animals. Some organic olive farms follow this practice today. However, olive trees respond well to fertilisation and, since the 1970s, the use of chemical fertilisers has become increasingly widespread in most countries, even in many marginal, traditional types of plantation (for example, Crete and Cáceres case studies). “Fertigation” (fertilisation via irrigation water) and foliar systems (fertilisation via leaf sprays) are extending rapidly in the more intensified plantations.

There is no easily-defined standard practice for fertilisation in olive farming. The case studies and farm interviews revealed a range of different practices, from “a barrow-load of farm-yard manure for each tree every four years” to sophisticated systems of nutrient supply via irrigation and based on annual soil and leaf analysis.

Even within a broadly similar plantation types such as low-input traditional or intensified traditional plantations, the use of fertiliser varies enormously, depending on factors such as tree size (bigger trees need more fertiliser), rainfall and irrigation (fertilisers are less effective in very dry conditions), local tradition and the particular farmer.

For example, reported applications of combined chemical fertiliser range from 1kg per tree (e.g. Cáceres) to 6kg per tree (e.g. for the large *Throubolia* variety in Crete), approximately equivalent to a range of between 80kg and 600kg per hectare. In Portugal, applications of up to 400kg per hectare are reported in intensified traditional plantations and of 400-600kg in modern intensive plantations.

Other factors being equal, fertiliser input per hectare tends to increase in proportion to tree density, as tree density itself increases in proportion to the availability of water (precipitation and/or irrigation). Fertiliser input is considerably higher under irrigated systems than under rain-fed conditions.

Guerrero (1997) cites a standard annual dosage of nitrogen of 1 unit per tree, equivalent to 80 units per hectare in low density plantations and 200 units per hectare in plantations with a density of 200 trees per hectare.

For irrigated intensive plantations in Jaén, recommended annual inputs of nitrogen have been calculated at 0.5kg/tree applied to the soil plus 0.8kg/tree applied through irrigation water (Agricultura, 1998b). This equates to approximately 390kg of nitrogen per hectare for a plantation of 300 trees per hectare. In addition to these inputs, the same authors recommend 25kg of potassium nitrate per 1,000 litres of water added to copper or other pesticide sprays, applied three times per year.

Typical recommended doses quoted by Aguilar Ruiz *et al* (1995) for rain-fed cultivation in Jaén in Spain were 3kg combined fertiliser per tree, as follows:

Nitrogen	1.3kg/tree/year
Phosphorous	0.5kg/tree/year
Potassium	1-2kg/tree/year

However, the same authors reported that the fertilisation of olive plantations in the province rarely follows these recommendations and is generally "anarchic", with very little planning and enormous differences between one area and another. Similar situations were reported in the other case-study areas.

3.1.4 Pest control

There are 2-4 significant pests associated with olive plantations plus a further 10 or so of secondary or localised importance (including fungi and other problems). The main pests cited by Cirio (1997) are: *Bactrocera oleae* (olive fly), *Prays oleae, Saissetia oleae* and *Capnodium elaeophilum*. To these should be added *Cycloconium oleaginum*, which Guerrero (1997) cites as a widespread problem in Spain. The presence and seriousness of these pests, fungi, etc., depends partly on prevailing environmental conditions (temperature, humidity), but also on practices such as cultivation, pruning and irrigation (Cirio, 1997).

At least 40 species of "useful" insects are believed to be parasites of *Prays oleae* and a further 20 of olive fly and *Saissetia oleae* (Cirio, 1997). Practices which adversely affect these beneficial species may increase pest problems.

Olive fly is the most important pest. It is much more problematic in more humid, frost-free areas, where it can decimate the olive crop leading to greatly reduced oil quality. However, in dry, high-altitude areas, the presence of olive fly tends to be much less and control measures may not be necessary on a regular basis.

Olive fly is normally treated with Dimethoate sprays, either by the farmer or through large-scale aerial spraying. Typical quantities applied are 1.5 litres of 40% Dimethoate per hectare for terrestrial application or 0.5 litres per hectare for aerial application according to Guerrero (1997). Alternative control systems are being developed, such as mass-trapping using baits, but these are more expensive and labour-intensive.

In some areas, chemical control measures against olive fly only started to be taken relatively recently while in some areas no measures are taken; as a result, olive oil may be of inferior quality, especially in years when this pest is widespread (see Cáceres case study).

Prays is also treated with Dimethoate and with Malathion, although there are many other suitable agents. Many farmers treat for Prays as a matter of course, even though the impact of this pest on production is often minimal, according to some authors (Pajarón Sotomayor, 1997).

Guerrero (1997) points out that Dimethoate is a very wide-spectrum agent which eliminates numerous different types of insect. It is therefore seen as a useful way of "cleansing" an olive plantation of potentially damaging pests, even though it eliminates various beneficial species (e.g. predators of olive fly) at the same time.

For the treatment of *Saissetia oleae*, Guerrero (1997) cites five different pesticides which can be used (for example, Methidathion at a dosage of 0.1-0.15%).

Many other pesticides are used in olive plantations, including Fenthion, Triclorfon, etc. (see case studies for more details). Traditional pest control products, such as copper, lime, white oils, Bordeaux mixture (copper sulphate and lime), are still used in some areas (see Toscana and Crete case studies).

In more traditional plantations, pesticide use is low or non-existent, or limited to traditional products, as mentioned above. For example, in La Vera in Cáceres (Spain) it is estimated that less than five per cent of olive farmers use pest control methods. In organic systems, very high quality oils can be produced with no pest control other than preventive methods of cultivation, pruning, appropriate fertilisation, etc., and traditional products.

However, chemical treatments are relatively cheap and under intensive systems there is a tendency to make repeated applications with a range of pesticides (as many as ten treatments per year, according to Cirio, 1997) according to a fixed calendar, with the aim of ensuring a trouble-free crop. Under modern intensive systems it is common practice to add various pesticides and fungicides to fertilisation sprays (leaf fertilisation), thus further reducing the costs of pesticide application.

3.1.5 Irrigation

Traditionally, olive plantations epitomised dryland farming and were not irrigated, except in certain situations where water was readily available. However, irrigation with relatively small amounts of water enables plantations to produce much higher and more consistent yields. Water use varies considerably according to the irrigation system used, climatic and soil conditions, tree density, etc. Amounts range from under 1,500m3 to over 5,000m3 per hectare per year (see case studies).

In recent years, drip-irrigation has been introduced on a large scale in some areas (see Puglia, Crete and Jaén case studies). In regions where olive production is expanding (e.g. Andalucía, Castilla-La Mancha and Badajoz in Spain, Crete in Greece, parts of Alentejo in Portugal) installing drip-irrigation has become standard practice in new plantations and in traditional plantations which are being intensified and “densified” (new trees planted in the lines between existing trees).

Even in traditional plantations in hilly areas of Crete, irrigation has become extremely widespread (see case study).

Water for irrigation comes from different sources, including bore-holes, surface water courses and private and public reservoirs.

3.1.6 Harvest

The harvest period ranges from September through to February, depending on climatic conditions, variety of olive tree, whether the olives are for table use or oil, etc. There is a tendency in many areas to harvest earlier now than in the past, in the pursuit of improved oil quality.

In most plantations the olive harvest is manual, either by hand, with combs or by beating the branches with sticks to shake the olives off. Nets are usually extended under the tree to catch the olives. Many olives fall on the ground before the harvest, especially when attacked by olive fly. These olives are collected with rakes or new machines (rollers with spikes, vacuums, etc.). For quality oil, it is important to separate these olives from those taken directly from the tree.

Mechanised harvesting is becoming increasingly widespread, both in modern intensive plantations and in intensified traditional plantations (see typology below). Various models of vibrators (tractor-mounted, self-propelled, hand-held) are used to shake the trunk or individual branches of the tree. New "bush" type plantations are designed for harvesting with a vineyard harvester.

Manual harvesting requires a large labour input which can amount to between 1/3 and 2/3 of a plantation's direct costs during the year. Mechanical harvesting requires much less labour. The latest machines with "umbrellas" (a built-in automated net) can be operated by one person. Labour is thus greatly reduced compared with manual harvesting.

According to Tombesi *et al* (1996), one person using various different mechanical harvesting machines can harvest: 17kg, 40kg, 90kg or as much as 200-400kg in one hour, depending on the type of machine. This compares with a maximum under manual harvesting of 15-20kg per person per hour. In other words, to harvest one "average" hectare of 2,500kg manually requires 167 man hours, compared with 6 man hours using the most efficient mechanised systems.

Mechanised harvesting is difficult to introduce in plantations with old, awkwardly shaped trees or if the ground is water-logged, although some machinery is available which is suitable (e.g. hand-held "vibrating poles").

Indirectly, the harvesting method has important implications for the environment, in particular the question of whether olives are collected from the ground or only from the tree. The collection of olives from the ground requires completely bare and flat soil, which is achieved through intensive use of herbicides and/or mechanical methods. Preparing the ground in this way exposes the soil to erosion in winter rains as well as removing an element (the grass layer) in the biodiversity of the plantation. This is the normal system in the main producing regions of Andalucía, Puglia, etc.

On the other hand, if olives which have fallen on the ground are not collected, then it is beneficial to have a grass layer under the trees, as this facilitates the handling of the nets and avoids excessively muddy conditions in wet years, in addition to the environmental benefits of soil protection and biodiversity. This is the case in Toscana, for example, where production is focused on high quality oils and olives which have fallen on the ground before the harvest (and which produce inferior oil) usually are not collected (see case study). In this situation, practices for the pursuit of a high quality product coincide with those for environmental protection.

3.1.7 Yield

Average yields (taking account of good and bad years) range from as little as 200-500kg/ha/year in traditional plantations in marginal areas to as high as 8,000-10,000kg/ha/year in the most modern, intensive plantations on good soils with irrigation.

Consistency of yield is a very important factor in olive farming. The trees have a natural tendency to produce the main harvest once every two years. Traditional pruning and harvesting practices tend to accentuate this tendency, so that harvests may be reduced to almost zero in the "non-harvest" year.

Modern techniques, such as mechanical harvesting, combined with irrigation can reduce this fluctuating tendency greatly: modern intensive plantations with irrigation produce consistently high yields, even though there may be fluctuations from one year to another.

The percentage of oil obtained from olives varies greatly (between 10% and 25% of the olive's weight), principally according to the variety and the climatic conditions.

3.2 Physical and biological conditions

It is important to take account of the physical and biological conditions within which a particular olive plantation is managed. The environmental impact of particular practices depends in part on these conditions. Key factors can be considered according to the following categories: soil, water, biodiversity and landscape. Many of the criteria referred to below could be included relatively simply in a comprehensive data base (Geographic Information System) for olive producing regions in the EU, in addition to more conventional agronomic data. This would provide a basis for integrating environmental considerations into the support regime.

3.2.1 Soil

The soil characteristics of an olive plantation are important especially in terms of vulnerability to erosion and, to a lesser extent, to leaching of potentially contaminating elements contained in fertilisers and pesticides.

The average slope of a plantation also has a major influence on soil erosion. In general terms, a slope of over 10% is considered especially vulnerable, whereas over 20% is an extreme situation in which soil cultivation is considered inadvisable.

However, various authors and commentators have pointed out that serious soil loss can occur on relatively gentle slopes, for example 3-5%, if other factors are favourable (soil type, rainfall, cultivation practices, etc.) (Agricultura, 1998).

In most Mediterranean countries, cartographic studies are available which indicate areas highly vulnerable to soil erosion, as well as average slope. In Spain, all agricultural land within the mountain Less Favoured Areas has an average slope of over 12%. It would be possible to incorporate such criteria into the design of olive support policies.

Traditionally, terraces with supporting walls were constructed on sloping land to conserve the soil. This is an effective measure, although terraces may not eliminate the slope entirely and erosion may still occur.

The quantity and timing of rainfall are also key factors for soil erosion: torrential rains in autumn (and sometimes summer) are characteristic of many olive-growing regions and these can have a particularly erosive effect on bare, dry soils.

3.2.2 Water

The climatic and topographic conditions in some water catchments lead to a high risk of flooding and landslides. The land-use in such areas is an important factor in controlling this risk: for example, terraced land and/or forest cover can help to reduce the speed of run-off as well as the risk of landslides.

The status of water resources (ground and surface) in the farmed area is an important consideration, both in terms of quantity (extraction and recharge rates) and quality (present contaminated status and vulnerability to contamination, for example from leaching and run-off).

Average rainfall, evapo-transpiration and temperatures, as well as soil types and other factors, all have an influence on the benefits produced by irrigation and on the quantity of water consumed.

3.2.3 Biodiversity and landscape

In addition to the characteristics of the olive plantation and the effects of particular management practices, an analysis of the effects of a farming system on biodiversity should take account of the land-use pattern of the area in question. In particular, it is important to consider the land-uses and habitat types adjacent to the olive plantation and the presence in the area of species of conservation importance (e.g. species classified as rare, endangered or vulnerable). In common with many farming systems, olive plantations have more potential to make a positive contribution to biodiversity when they exist in a mosaic with other land uses, such as arable cropping, other tree crops or forest.

Similarly, olive plantations may add landscape diversity when they are present in areas dominated by other land-uses, such as forest or arable land. On the other hand, where olive monocultures themselves dominate the landscape, the result tends to be a monotonous landscape with very limited visual diversity.

3.3 Socio-economic situation

The socio-economic situation of an olive farm is relevant to an analysis of environmental effects because of its influence on the viability of production, on the potential for intensification and on the risk of abandonment. In particular, where olive production is not viable in socio-economic terms, abandonment is likely to occur. The abandonment of olive plantations can have important environmental effects (positive and negative) as discussed in Section 5.

It is clear from the national and case studies that there is a very wide range of socio-economic situations in olive farming in the EU. Many small holdings in marginal areas appear to operate below the conventional limits of economic viability in the sense that the economic returns from the farming activity do not cover the labour costs involved. Olive production continues on these holdings because the labour input of the farmer and other family members is provided at no cost or below the prevailing rate for farm labour in the area. On the other hand, some of the larger and more productive olive holdings produce strong net margins under current market and support conditions.

Although the analysis of socio-economic factors was not included in the terms of reference for the present study it is clear that the risk of abandonment is far greater in certain situations (usually marginal areas with highly fragmented holdings) than in others. The indications from the present study are that the risk of abandonment is currently minimal in the main producing areas (see Section 4).

A socio-economic analysis into which types of olive holding and in which areas are most at risk of abandonment would provide an essential complement to the analysis of the potential environmental effects of abandonment. In turn, this would enable support measures to be targeted in order to prevent abandonment where this would be expected to have negative environmental effects.

3.4 Unified typology of production systems for the four countries

There seems to be no widely used and accepted typology of olive production systems in the EU. This report uses a simple typology which is adapted from that used by Petretti in Italy (Petretti, 1995) and which is similar to those used by other authors.

The typology covers general plantation characteristics and farming practices: due to the limited resources of the present study it does not incorporate wider physical and socio-economic criteria, although this would be desirable as a basis for more effective policy making.

Three broad types of plantation are identified (see Table 2 for more detail):

- Low-input traditional plantations and scattered trees, often with ancient trees and typically planted on terraces, which are managed with few or no chemical inputs, but with a high labour input.

- Intensified traditional plantations which to some extent follow traditional patterns but are under more intensive management making systematic use of artificial fertilisers and pesticides and with more intensive weed control and soil management. There is a tendency to intensify further by means of irrigation, increased tree density and mechanical harvesting.

- Intensive modern plantations of smaller tree varieties, planted at high densities and managed under an intensive and highly mechanised system, usually with irrigation. A second type of modern plantation uses “bushes” in dense rows, resembling vineyards, which are almost totally mechanised.

It must be emphasised that this typology represents a considerable simplification of real conditions. Especially in the first two categories, the reality on the ground is more complex and it is not always easy to determine which category is appropriate for a particular plantation.

Nevertheless, the broad categories presented here reflect the different environmental considerations associated with olive production and provide a basis for their examination (see Section 5).

As a result of their particular plantation characteristics and farming practices, the low-input traditional plantations have potentially the highest natural value (biodiversity and landscape value) and most positive effects (such as water management in upland areas) as well as the least negative effects on the environment. These plantations are also the least viable in economic terms and hence most vulnerable to abandonment.

The intensified traditional and modern intensive systems are inherently of least natural value and have potentially, and in practice, the greatest negative environmental impacts, particularly in the form of soil erosion, run-off to water bodies, degradation of habitats and landscapes and exploitation of scarce water resources.

The broad picture for the olive sector is of intensified production leading to certain negative effects on the environment, reflecting similar conclusions for European agriculture in general over recent decades in numerous studies, including the recent EC report on sustainable agriculture (EC, 1999).

However, the present study concludes that, at least in the olive sector, the negative environmental effects of intensification could be reduced considerably by means of appropriate farming practices; and that, with appropriate support, traditional low-input plantations could continue to maintain important natural and social values in marginal areas.

Table 3 illustrates the approximate distribution of these typologies in the four Member States covered by this study. No data are available to indicate the area covered by each plantation type in each Member State. The study consultants in Spain and Greece estimated that approximately 55-65% of the national olive areas corresponds to the "intensified traditional" type, with only 5-10% in the "low-input traditional" category and the remainder being "modern intensive" plantations. In Portugal, a far larger proportion of plantations was estimated to be of the low-input traditional type (70-80%). However, all of these figures are purely illustrative and based on estimates rather than concrete data.

Table 4 provides an illustration of the economic characteristics of the different plantation types in Spain, comparing approximate costs and incomes per hectare under the current CAP olive regime. The figures illustrate the very large differences in economic returns per hectare from the different plantation types and may provide some indication of the relative risk of abandonment, although a far more exhaustive analysis is required of this issue.

Table 2: General characteristics of the three main types of olive plantation – see main text and case studies for more details

	Low-input traditional plantations, scattered trees.	**Intensified traditional plantations.**	**Intensive modern plantations.**
Typical location	Hill and mountain areas. Also in marginal lowland areas and around villages.	Hills and rolling plains.	Rolling and flat plains.
Range of tree density	40-250 per ha and scattered trees.	80-250 per ha	200-400 per ha
Tree characteristics and management	Old or ancient. Usually pruned, although may be infrequent. In some cases, pruning is very limited or non-existent and trees are allowed to develop a very large canopy. Olives may be in mixed orchards with other fruit trees.	Trees may be younger (due to replanting) and have a regularly pruned canopy. There is a tendency to increase the tree density in traditional plantations by planting between existing rows.	Short-stem varieties. “Dwarf” or “bush” varieties may be replanted at 25-30 years and mechanically pruned.
Terraces with supporting walls	Common.	Common in some hill areas.	Very rare.
Management of understorey	Grazing and/or mowing and/or tillage, which may be frequent or occasional. Animal traction or rotovators and hand mowers on narrow terraces.	Repeated cultivation and/or herbicides (e.g. Simazine, Glyphosate).	Repeated use of herbicides (e.g. Simazine, Glyphosate).
Fertilisation	None or manure and/or chemical fertilisers (e.g. 1-2kg combined fertiliser per tree).	Chemical fertilisers (e.g. 2-6kg combined fertiliser per tree depending on plantation, rainfall, irrigation, etc.).	Chemical fertilisers usually applied through irrigation and/or leaf sprays. Nitrogen input 150-350kg/ha.
Pesticide use	None or occasional. Sometimes use traditional products, such as Bordeaux mixture, copper, lime.	2-10 treatments per year depending on the area, pests, year, etc. See main text.	2-10 treatments per year depending on the area, pests, year, etc. See main text.
Irrigation	Not usual, although becoming common in certain specific areas, such as Crete.	Increasingly common (mostly drip although some sprinkler systems).	Usual (drip system).
Harvest method	By hand, or may be left in years of little harvest.	By hand or mechanical.	Mechanical.
Typical yield	200-1,500 kg/ha	1,500-4,000 kg/ha	4,000-10,000 kg/ha
Consistency of annual yield	Very low	Low	High
Labour requirement	Very high: harvest, pruning, maintenance of terraces and walls, scrub control, etc.	High: harvest (when manual), pruning.	Low.

Table 3: Distribution of different types of olive grove

	Low-input traditional plantations and scattered trees	**Intensified traditional plantations**	**Intensive modern plantations (1)**
Spain	All olive regions in marginal hill, mountain and some lowland areas and around villages.	Large areas of Andalucía, Castilla-La Mancha and parts of Extremadura.	Andalucía, southern half of Castilla-La Mancha, Badajoz.
Italy	Liguria, Toscana, Marche, Umbria, Lazio, Abruzzo, Molise, Campania, Basilicata, Calabria, Sardegna	Toscana, Umbria, Lazio, Campania, Calabria, Puglia, Sicilia, Sardegna	Campania, Puglia, Calabria, Sicilia
Greece	In marginal mountainous areas and in some small islands.	Aegean islands, Ionian islands, Sterea Ellada, areas of Crete, Peloponese, Evia and coastal areas of Ionian sea.	Crete, Peloponese, Makedonia, Evia, coastal areas of Ionian sea
Portugal	All olive regions in marginal hill, mountain and some lowland areas and around villages.	Alentejo, Tras-os-montes, Ribatejo-Oeste, Beira Interior.	Mainly Alentejo and Tras-os-montes. Some in Ribatejo-Oeste and Beira Interior.

Notes:
(1) Many of these plantations are not yet in full production.

Table 4: Approximate economic characteristics of the main types of olive plantation in Spain under the current support regime - figures show estimated annual average *per hectare* for a representative plantation of each type. Monetary unit = Euro.

	Low-input traditional plantation	**Intensified traditional plantation**	**Intensive modern plantation with irrigation**
Average annual yield of olives/oil (1)	500 / 75	2,500 / 375	6,500 / 975
Sales income (Euro 0.30 per kg olives)	150	750	1,950
Direct costs	650 (2)	900 (3)	1,547 (4)
Production support (Euro 1.30 per kg oil)	97.50	487.5	975
Gross income with production support	247.50	1,237.50	2,925
Net income with production support (4)	-402.50	+337.50	+1,378

<u>Notes</u>:

(1) Oil production based on an average oil yield of 15kg per 100kg of olives. In practice, the percentage of oil extracted from olives varies considerably (ranges from 10% to 25%), depending on climate, olive variety, etc.

(2) From Cáceres case study, 1999. These costs include all labour input (including maintenance of terraces and walls) at local rates for farm labour. In practice, a large part of the labour in traditional plantations is provided by the farmer and his family so is not paid for directly. The negative net income shown in the table therefore does not reflect a real monetary deficit. Nevertheless, this is a real labour input which should be costed, as it gives an indication of the very low level of remuneration of this farm type and consequent risk of abandonment.

(3) From ETSIA/UPA, 1998

(4) Adapted (5% inflation added) from Guerrero, 1997.

(5) Gross income minus direct costs.

4 MAJOR TRENDS IN OLIVE FARMING SYSTEMS

The area of land under olives in the EU countries has fluctuated considerably over recent decades, following different national and regional patterns. In general, a decline in the area of old olive plantations during the 1970s and 1980s due to a combination of abandonment and restructuring programmes (grants for grubbing-out old trees) seems to be common to all Mediterranean countries.

In the 1980s and 1990s, there was a strong expansion of new plantations especially in regions with a comparative advantage, in Spain and Greece and to a lesser extent in Italy and Portugal. Currently there is a tendency for planting up the lines between trees in existing plantations in order to increase the density, especially when irrigation is added.

In addition to these land-use changes there have been significant changes in production practices since the 1970s. Notable changes have been the abandonment of mixed cropping and livestock grazing in olive plantations, the mechanisation of tillage and the introduction of chemical fertilisers, crop-protection products, herbicides and modern irrigation systems.

These changes have occurred in most of the main producing regions, but in some more marginal areas, largely traditional practices survive, including minimal use of agrochemicals, sheep grazing and, in some cases, animal traction on land with difficult access for machinery. Data are not available to quantify this process of intensification in olive farming (data on input use usually relate to agriculture in general).

The abandonment and grubbing-out of traditional plantations, expansion of new plantations and intensification of production systems all have important environmental consequences which are discussed in Section 5.

4.1 Spain

In Spain, olive plantations reached their greatest extent in the mid-1960s, when they covered nearly 2.4 million hectares, which was about three times the area covered only a hundred years previously. This expansion took place largely at the expense of Mediterranean woodlands, as a result of land privatisation (Parra, 1990). This was followed by the abandonment and subsidised grubbing-out of many older plantations in the 1970s and early 1980s. Some 300,000ha were cleared in Andalucía under a government restructuring scheme started in 1972, to be replaced mostly by arable crops (MAPA, 1988).

However, from the mid-1980s, this situation began to be reversed. Spain joined the European Community in 1986 and as CAP support for olive production in Spain and Portugal came up to the same level as for other Member States (accession period), the CAP regime appears to have provided an incentive to increase production, and new plantations have increased steadily while grubbing-out schemes ceased in the 1980s.

New plantations have been created over large areas of land previously under arable crops, grassland, scrub and forest, particularly in provinces with a high concentration of commercially orientated producers, such as Jaén, Córdoba, Sevilla, Ciudad Real, Toledo and Badajoz. In some cases, natural vegetation is cleared illegally to make way for new plantations (see Jaén case study).

In 1995 alone, 67,000 ha of olives were reportedly planted in Spain (López Sánchez-Cantalejo, 1996). From the mid-1990s to 1998, it is estimated that around 150,000 ha of new plantations were created (ETSIA/UPA, 1998). The latest data produced by the EC as a result of research carried out following the 1998 interim reform of the CAP olive regime indicates a total olive area in Spain of just over 2.4 million ha, representing an increase of around 400,000 ha compared with the Spanish Ministry of Agriculture statistics for 1991 (*Agricultura*, 2000 and MAPA, 1992).

Overall, these figures indicate an average planting rate during the 1990s of about 50,000 ha per year. New plantations are still being established even though under the 1998 interim reform of the support regime subsequent plantations cannot receive CAP aid. New plantations, with trees clearly planted in the 1998-99 planting season and in some cases covering hundreds of hectares, were observed by the author in late 1999 and 2000 in parts of Córdoba, Badajoz and Toledo.

As several interviewees commented, if the current production aid continues, it will be very difficult (probably impossible in practical terms) for the authorities to prevent these plantations from receiving production support, as there is no system for knowing which trees a particular delivery of olives has come from.

The Spanish case studies confirm the above picture. In Cáceres (an essentially marginal region), some localised abandonment and grubbing-out in the late 1970s and early 1980s was more or less halted by accession to the EC in 1986. Over the past ten years, the situation has remained largely stable, with minimal abandonment and new planting in areas with a concentration of olive production.

In Jaén (by and large a productive region, although with some more marginal areas), there has been no significant abandonment (only some grubbing-out in the 1970s) and, in recent years, a steady increase in planting at the expense of scrub/forest and arable crops.

Intensification has been widespread in Spain since the 1980s. With the exception of organic producers, chemical pest control is practised in all but a few marginal areas. The use of chemical fertilisers is increasingly universal. Irrigation is becoming increasingly widespread in lowland areas and is standard in new plantations. Mechanical harvesting is also standard in new plantations and increasingly adopted in intensified traditional plantations, although the great majority of olive plantations continue to be harvested manually.

In more marginal upland areas, low-input systems are still present, at least among a significant proportion of producers. This is the case, for example, in much of Cáceres and to a lesser extent in certain upland districts of Jaén (see case studies).

Organic production is increasing rapidly, although still only a very small proportion of the total area and output. The largest number of organic producers is in Extremadura, where low-input traditional farmers have signed up for the agri-environment scheme.

Integrated pest control and integrated production systems have also developed, especially in Andalucía, although also on a small scale.

4.2 Italy

Different authors report slightly different situations in Italy. INEA (1998) reports that over the past 15 year period Italian oil production and surface area under olives have not substantially changed: there has been a very slight increase in the total surface area of olives but total production has remained stable, apart from the usual annual fluctuation. This suggests that, during the same period, significant technical innovations that would have increased output and consistency of yield from one year to the next did not take place on a large scale in Italy (e.g. introduction of new varieties, irrigation systems, fertilisation, pruning and harvesting techniques). The same conclusions are drawn from the recorded olive yields per hectare (INEA, 1998).

Petretti (1995) paints a rather different picture, reporting that in the period 1985-1989 53,645 ha of olive grove were lost in Italy (to replanting with citrus and vines in more productive areas and to abandonment in marginal areas) and a further 200,000 ha during 1990-95. Overall, a decrease in olive area of -7.2% 1974-90 apparently was compensated by an increase in productivity per hectare of +9.2%.

However, the latest data produced by the EC´s “Oliarea” survey indicates a total olive area in Italy of 1.4 million ha, which represents a 400,000 ha increase compared with the area thought to exist at the start of the 1990s.

It is clear that there are significant differences in trends between regions. For example, there seems to have been a considerable decline in olive area in Liguria and significant increases in area in Sardegna and Puglia (ISTAT, 1991). In Liguria the decline has been due mainly to abandonment.

In some regions, intensification has occurred, through the use of specialised cultivars (in some plain areas, old olive trees have been grubbed out, especially at the end of the 1980s, and new, easier and more productive cultivars were planted), specific farming techniques, irrigation, and a heavy mechanisation (for example, see Puglia case study). However, the scale of these developments in recent years seems not to be comparable with the situation in Spain.

The partial conversion of the olive-growing sector from traditional productive systems to modern systems was foreseen by a specific National Action Plan (*Piano Olivicolo Nazionale*) approved in 1990. The intention was to convert 25% of the total Italian olive area. In practice, the Plan has remained mostly non-operative, due to the lack of financial resources.

Organic olive-oil production is increasing in Italy: at the end of the 1980s, only 200ha of olive-groves were organic, but in 1996 the organic surface was approaching 6,200ha, plus 15,200ha in conversion (Santucci, 1997). This is still a very small proportion of the total olive area (just over 1%) but the tendency is increasing, partly thanks to the EC Regulation 2078/92.

4.3 Greece

The area of olive groves in Greece has increased constantly during the last 25 years as a result of the plantation of new groves with high-density plantings. In the same period the production of olive oil has increased considerably while there has been a small increase in the production of table olives.

Olive groves for olive oil have expanded in many semi-mountainous and coastal areas (mainly in Crete and Peloponese) and low stem varieties like the Koroneiki are predominant. Besides, levelling of the land, mechanisation, increased external inputs and irrigation in these groves has expanded.

This is due to a) the intensification and mechanisation as well as the use of external inputs and irrigation, b) improvements in olive cultivation, c) the sufficient net income comparing to other crops due to the high level of CAP support and high olive-oil prices and d) the lack of opportunities for other crops because the agro-climatic and socio-economic conditions.

On the other hand, for similar reasons (cultivation in more fertile soils, where other more profitable crops bear, as well as for socio-economic reasons) the production and the area of table olives has remained constant for the last 25 years, reflecting the fact that this sector did not receive CAP support until 1998/99.

The tendency in olive production is to intensify production through mechanisation and increased used of external inputs. The mixed cultivation of olive trees with other tree or arable crops is disappearing. Olive trees are almost exclusively cultivated in single-species plantations. Old groves with large ancient trees are being grubbed-out for the establishment of new intensive plantations (see Crete case study).

These tendencies differ from region to region and are more apparent in the major producing departments and in the plain and semi-mountainous areas. This is because of the favourable agro-climatic conditions for olive production as well as the specialisation in olive production. This tendency is also more apparent in areas were irrigation water is available. Drip irrigation is expanding wherever irrigation water is available.

In the smaller islands and in higher mountainous areas olive production has not been intensified so much, due to the ageing population, urbanisation, farming is not attractive for the younger generations, competition from the tourist industry for labour and investments, harsh agro-climatic conditions (lack of irrigation water, rocky fields, small size of fields, difficulties of mechanisation, etc.).

In these areas olive production can be characterised as low-input and the groves are increasingly neglected often leading to the creation of a semi-natural agroecosystem. For example, this is the case in Corfu, Lesbos and the Aegean islands where farms are very small and tourism is well-developed. Organic farming is also a tendency and organic farming projects have been started in these areas.

4.4 Portugal

Low-input traditional olive plantations still predominate in Portugal. Overall, average yields in Portugal are notably lower than in Spain, Italy and Greece.

However, new intensive plantations with densities of 200-300 trees per ha have been established in recent years: some 15,000ha were planted in the period 1987-96 (Castro *et al*, 1997).

In contrast to the other Member States, the olive area and total production in Portugal declined steadily from the 1950s. This process has been accelerated by structural programmes. By 1996, some 30,000ha of old plantations had been removed under the PEDAP programme since 1986, which was funded by FEOGA with the aim of aiding the adaptation of Portuguese agriculture to EC market conditions.

Intensification has been less apparent in Portugal than in Spain and Greece, although there is a tendency to develop more intensive irrigated production systems in some areas.

5 ENVIRONMENTAL EFFECTS OF OLIVE PRODUCTION IN THE EU

Generally speaking, there is an absence of concrete data concerning the environmental effects of olive farming in EU Member States, especially quantitative data on specific impacts such as soil erosion, water exploitation, chemical pollution and clearance of valued habitats. Concerning the biodiversity and habitat value of olive plantations, there is very little data on the effects of different production practices and systems.

However, an increasing number of reports and published articles make references to environmental issues associated with olive farming, suggesting an increasing awareness (for example, see Montiel Bueno, 1998 and Guzmán Álvarez, 1999). Furthermore, there seems to be general agreement in the scientific literature and among interviewed experts concerning environmental effects and their causes.

A clear overall conclusion is that olive farming has both positive and negative environmental effects. These effects depend on several factors, including prevailing environmental conditions in and around the plantation (soil type, slope, rainfall, adjacent land-uses, presence of water bodies, etc.) and farm management practices. Especially influential practices are weed control and soil management, pest control, irrigation and the type of land (and previous land cover) on which new plantations are established.

On the basis of the reviews and interviews undertaken in the course of this study in the four Member States, the following are considered the main categories of actual and potential environmental effects associated with the management of olive plantations:

- Soil
- Water
- Air
- Biodiversity (flora and fauna)
- Landscape
- Other effects

In relation to some of these categories, the information reported in this study refers predominantly to Spain and particularly to Andalucía. This reflects several factors: that a quarter of the EU olive area and nearly a half of EU olive production is concentrated in this region; that land use in certain provinces of the region is increasingly dominated by olive cultivation, often under intensive systems; and that more information is available generally on environmental impacts of olive farming in this region, compared with other parts of the EU, probably because the impacts are more widespread.

The question of water pollution resulting from the olive-oil production process off the farm, which is a serious environmental problem in many olive producing regions, is not covered in this study.

5.1 Soil

Soil erosion is cited in numerous publications as one of the principal environmental problems associated with olive farming in Mediterranean regions (Tombesi, Michelakis and Pastor, 1996). Soil erosion has various environmental impacts, notably the loss of productive capacity, leading to the need for increased external inputs and ultimately to desertification; and the down-stream effects of run-off, as topsoil, fertiliser and herbicides are washed into water courses and water bodies (García Torres, 1999).

Soil erosion also results in significant economic losses, although no data were encountered on this for the EU Member States. Studies in the US in the 1980s estimated the economic losses due to soil erosion caused by agriculture at $US 44,000 million per year, of which $US 27,000 million were due to the loss of soil fertility (García Torres, 1999). This calculation was based on an average rate of erosion of 17 tons/ha/year, which is very much lower than the 80 tonnes/ha/year estimated average rate of erosion in olive plantations in Andalucía, for example (see below).

Soil erosion results from a combination of soil type, slope, rainfall patterns and inappropriate farming practices. Intensive tillage not only exposes the soil to the erosive effects of rainfall, it also increases the soil's vulnerability by reducing its organic content, especially when combined with the use of non-organic fertilisers and residual herbicides. The decline in the organic matter content of many soils in southern Europe, as a result of intensive cultivation practices, has become a major process of land degradation (European Soil Bureau, 1999).

The most detailed and extensive information on the soil-erosion effects of olive farming concerns Spain, probably reflecting that the problem of soil erosion generally is more widespread and more extreme in this country. However, all of the national and case studies refer to soil erosion as a serious problem where inappropriate cultivation practices coincide with vulnerable soils.

In **Spain**, soil erosion is widely cited as the principal environmental problem associated with olive plantations. Dryland tree crops on slopes, principally olive plantations, have been identified as the land use with the highest rates of soil erosion (Díaz Alvarez and Almorox Alonso, 1994).

According to the draft National Action Plan Against Desertication (MMA, 1999), "very severe soil erosion" affects some 9 million ha or 18% of the national territory. Very severe erosion is defined as an average rate of 50 t/ha/year or more. The natural process of soil formation is approximately 2-12 t/ha/year, depending on physical and biological conditions.

Aggregate losses of topsoil from olive plantations in Andalucía have been estimated at 80 t/ha per annum (Pastor and Castro, 1995; MAPA, 1999), with even higher rates in certain situations. These estimates, which concur with others for the region (see references in Pastor and Castro, 1995), indicate a totally unsustainable farming system which is resulting in widespread desertification[1], as defined by the draft National Action Plan Against Desertication (MMA, 1999). On the basis of these estimates, the approximately one million hectares of olive plantations in Andalucía are loosing as much as 80 million tonnes of soil per year.

Around 40% of olive plantations in Andalucía are reported to suffer serious erosion problems while some 20 per cent of all olive plantations in Spain are reported to have lost the upper soil horizon due to erosion (López Cuervo 1990, cited in Martín Bellido (ed.), 1999).

Soil erosion is especially severe on steep slopes (e.g. over 10%) but, with inappropriate management, considerable losses of topsoil can occur on slopes of only 3-5%, especially in the longer term (Agricultura, 1998). For example, Aguilar and Cuenca (1997) recorded soil losses of 40t/ha/year in olive plantations on flat land under conventional (repeated) tillage systems.

The problem of erosion has been greatly exacerbated since the 1970s by changes in practices associated with mechanisation of tillage (Díaz Alvarez and Almorox Alonso, 1994). It is now widespread practice, especially in intensified traditional plantations, for farmers to keep the soil of olive plantations bare of vegetation all the year round, by regular cultivation. Often, this tillage is carried out up and down the slope, rather than following the contours. The most severe erosion takes place with the arrival of the autumn rains on bare soils which have been cultivated to a fine tilth by summer harrowing.

In their book on olive production in Jaén, the soil-agronomists Aguilar Ruiz et al (1995) state that: “we should not forget that the Mediterranean region has witnessed in recent years the highest rate of soil loss in all Spain, and that this fact is due, at least in part, to the bad management of olive plantations”.

Various factors are cited in Spain which account for the fact that very few olive producers have adopted soil conservation techniques (such as minimum or non-tillage cultivation systems):

- An ingrained mentality that land must be kept entirely free of weeds. Most farmers have a tractor and harrow and take pride in having a "clean" olive plantation completely free of weeds.
- Changing to a non-tillage system would require the purchase of new machinery in many cases, for applying herbicides or for mowing spontaneous vegetation.

[1] Desertification is defined as “serious degradation of the soil, for example through erosion, salinisation, etc”.

- Grazing generally is not a practical option as sheep often are no longer present in olive producing areas.
- Lack of awareness and information. Farm extension services in most regions do not have inadequate resources for promoting alternative management systems among farmers.

Abandonment of olive plantations can also lead to erosion in certain very dry areas, especially when terraces collapse. This is a relatively localised problem, for example, in parts of south-east Spain. Erosion may also be a problem when plantations are grubbed-out prior to land abandonment, as occurred in some instances under national grant schemes in the 1970s and 80s, due to the removal of tree cover. However, such schemes have not existed for several years in Spain.

Except in very adverse conditions, abandonment without tree removal tends to result in scrub invasion and the gradual development of natural woodland, which provides a high level of soil protection, so long as the vegetation is not destroyed by repeated fires. A low level of continuous management (e.g. through light grazing and browsing) is advisable to reduce the fire risk of abandoned farmland.

Overall, soil erosion and desertification in Spain are problems associated with intensive and inappropriate cultivation of olive plantations, rather than with their abandonment.

In **Greece**, extensive hilly areas are cultivated with olives on shallow soils, which are very sensitive to erosion. These areas become especially vulnerable to erosion for two main reasons. First, because of the inadequate protection with vegetation due to intensive cultivation. Second, due to the reduction of infiltration rates which follows the compaction from farm machinery and the formation of soil surface crust (CEC, 1992; Yassoglou, 1971).

Widespread olive production in semi-mountainous and mountainous areas of Greece, in combination with the natural lack of water and with excessive grazing pressure, has resulted in desertification problems in semi arid areas, for example in South coastal areas of Peloponese, Central and East Crete, Central and East Aegean islands.

Also in Greece, large areas of land have been cleared in recent years for new olive plantations and are subsequently eroded by gullies. Soil erosion is also caused in some areas when intensive goat and sheep grazing follows the abandonment of olive cultivation.

In **Italy** intensive exploitation of the land through the continuous tillage or spraying of residual herbicides to control weeds is reported to cause an impoverishment of the soil and the loss of its structure leading to erosion, although more concrete data were not found in the course of the national study. In the Toscana case study it is reported that the predominant soil type is highly vulnerable to erosion. In those cases where the soil is often tilled, erosion is particularly serious and the loss of the fertile layer of the soil can easily be observed. Until recently, much of the land under olives was tilled repeatedly to control spontaneous grass and other weeds, although this practice is becoming less common in the study area.

The abandonment of olive plantations in marginal northern regions, such as Liguria, is a particular environmental problem in Italy. This has lead to an increased incidence of wild fires and subsequent risk of soil erosion. Soil erosion is also caused in some areas when intensive grazing follows the abandonment of olive cultivation.

5.2 Water

5.2.1 Controlling run-off in upland areas

Olive plantations on terraces (and their associated channels and ditches) in upland areas can help to slow run-off and improve water penetration, thus reducing the risk of floods in lowland areas following heavy periods of rainfall. This positive role is reported in all four countries, although without specific data to quantify the effect or identify the specific areas concerned.

5.2.2 Run-off to surface waters of soil, fertilisers and pesticides

In Andalucía, the pollution of surface waters by fertilisers and pesticides is an important consequence of soil erosion caused by olive cultivation, as confirmed by official government publications. Soil run-off into reservoirs also leads to important economic costs, for example Guadalén reservoir in Jaén (Pastor, Castro, Humanes and Saavedra, 1997). High levels of nitrates (>50mg/litre) have been reported in drinking water supplies in the lower Guadalquivir river basin and the run-off of nitrogen fertilisers into surface waters is thought to be one of the causes (García Rey, pers. com.).

Simazine (a residual herbicide very widely used in intensified traditional and modern intensive plantations) remains highly concentrated in the top 5-15cm of soil, even after several months, and spreads into untreated areas owing to soil erosion (Cirio, 1997). Where residual herbicides are used widely and intensively, large quantities are washed into streams, rivers and reservoirs with the soil that is eroded in heavy rains (e.g. see Jaén case study). In some EU countries, such as Sweden, the use of Simazine has been restricted due to its potentially negative impact on the environment.

5.2.3 Pollution of ground water

Excessive applications of nitrogen fertilisers in continuous cultivation without cover cropping can lead to nitrogen leaching. Nitrogen leaching may pollute surface and groundwater with hazardous compounds. Excess of potassium and phosphorus fertilisers contaminates also the soil with these macro-nutrients. This contamination may create nutrient deficiencies in olive trees and even leaching of these nutrients to surface and groundwater (Androulakis & Loupasaki, 1990; Gavalas, 1978; Kedros *et al*, 1988). Soil and water can be contaminated by the random uses and the overdoses of synthetic fertilisers and other agrochemicals (GEO.C.G, 1990; Vassiliou, 1989).

Kabourakis reports that concrete data on the extent of this problem are not yet available in Greece. The Ministry of Agriculture has only recently started a monitoring programme of ground water throughout the country, including olive producing areas. See Greece national overview.

In Spain, it is reported that monitoring of groundwater quality has only taken place in a few specific areas of the country which do not coincide with the main olive-producing areas (González Yélamos, 1997).

In general, no concrete data was encountered on the contamination of ground water due to olive cultivation in the EU, but it should be noted that nitrogen inputs in the most intensive, irrigated olive farming can reach relatively high levels (e.g. up to 350kg per hectare – see Section 3.1.3 above).

5.2.4 Exploitation of ground and surface waters for irrigation

Although drip irrigation is the most widespread system of irrigation in olive plantations and the quantities used per hectare are relatively low compared with arable cropping, irrigated olive plantations cover an increasingly large area in some regions are their total impact on water resources is considerable. The regions concerned often have serious water deficit problems (e.g. Puglia, Jaén and Crete case studies).

In the three areas studied, irrigated olive plantations have continued to expand even though ground waters are severely depleted (and suffering from salinisation, in the case of Puglia). There appear to be insufficient mechanisms to ensure that irrigation does not exceed the sustainable capacity of water resources.

Kabourakis reports that in Greece the ground water level is an important index for assessing both anthropogenic and climatic causes of desertification in many semi-arid olive production areas. Deep wells and irrigation has been installed in many areas especially in plains and their surrounding hills, which has converted what used to be dry cultivation of olive trees to drip-irrigated cultivation. The rise in productivity in olive groves has been achieved at the cost of a dramatic reduction in the groundwater level in many cases, as there is no effective control on the amount of water which is extracted.

Angelakis, et al. (1998) report that in parts of Messara plain there has been a 20 metre dramatic drop in the groundwater level since 1985 (see Crete case study), although it is not known to what extent olive irrigation has contributed to this over-exploitation. The question of which crops are the principal cause of over-exploitation needs to be clarified if the problem is to be addressed effectively.

In the case of Jaén, according to data from the regional environmental authorities, groundwater resources in the province were very near to over-exploitation in 1996, with extractions reaching over 95% of the recharge rate (Consejería de Medio Ambiente, 1996). These extraction figures do not take account of extractions from illegal bore-holes, which are thought to be numerous.

Overall, the regional government's data for 1997 indicates a deficit of 480 hm3 for the Guadalquivir river basin (Consejería de Medio Ambiente, 1997), a problem which has been aggravated in recent years by the expansion in irrigated olive plantations, especially in Jaén (Pastor, Castro and Vega, 1998).

During the 1990s, irrigated olive plantations expanded greatly as farmers have exploited all available surface waters (including seasonal streams) and have taken advantage of modern techniques for drilling deep bore-holes. In some areas bore-holes of 200-300 metres depth are widespread (Aguilar Ruiz *et al*, 1995). The only cost of water to the farmer is the energy used to extract the water. Irrigated olives continue to expand in the province although it is reported that these often are not registered as such, due to the illegality of many bore-holes.

Agriculture accounted for 2,874 hm3 of the total 3,578 hm3 of water extracted from the Guadalquivir river basin in 1997. Although data are not available on the total quantity of water consumed by olive plantations, based on a theoretical average consumption of 2,000m3/ha/year and an estimated irrigated olive area of 150,000 ha, a very approximate estimate would be 300 hm3 per year for Jaén province. This theoretical figure represents 10% of total water consumption by agriculture in the Guadalquivir basin and is equivalent to some 60% of the deficit in this river basin in 1997.

The increasing demand for irrigation water leads to an indirect impact on the environment through the construction of reservoirs to supply irrigation water (see sections on biodiversity and landscapes, below). For example, in southern Spain and Portugal, several major dam-building projects have been identified as amongst the principal threats to the survival of the Iberian lynx (*Lynx pardinus* – an endemic Iberian species on the verge of extinction, strictly protected under the EC Habitats Directive) (WWF, 1999). The projects in question have a combination of objectives, including improved domestic supplies and providing water for the needs of irrigated crops, including olives.

On the other hand, the creation of small reservoirs and ponds for the irrigation of individual plantations can make a positive contribution to biodiversity, if these are constructed in harmony with existing landscape and habitat values (see Portugal and Moura studies).

5.3 Air

No concrete data were encountered concerning effects on air. Factors to consider could include:

- Air pollution from burning pruning residues and the leaves and twigs washed from the olives before processing. The total volume of material burned is considerable but apparently no analysis has been made of the resulting air pollution.

- Air pollution resulting from chemical treatments, especially aerial spraying against olive fly (see Greece national overview for an estimate of air-exposure to biocides).

- Carbon dioxide emissions resulting from tractors, especially in the case of repeated tillage (Fernández Quintanilla, 1999).

- Carbon dioxide emissions resulting from the break-down of organic matter in the soil, which is accelerated by excessive tillage (Fernández Quintanilla, 1999).

- The natural function of olive trees in absorbing carbon dioxide and producing oxygen. No estimation of the scale of this function was encountered during the study. In making such an estimation it would be necessary to take into account the loss of natural vegetation cleared for olive plantations.

5.4 Biodiversity

The biodiversity value of olive plantations varies according to a range of interconnected factors. Key factors to consider on the holding include:

- The type, quantity and timing of pesticides used.
- The method, frequency and timing of weed-control and whether a seasonal understorey is allowed to become established beneath the trees.
- The presence of natural and semi-natural features, such as scrub, woodland, dry-stone walls, ponds, etc.
- The age of the trees.

Potentially, olive plantations may harbour a notable diversity of species. For example, Saavedra Saavedra (1998) reports as many as 100 species of plant per hectare in the ground flora and over 500 species in the olive area of Córdoba province. The spontaneous vegetation which develops between tillage can be of a high floral diversity, if sufficient time is allowed for it to develop. In a selection of plantations in western Andalucía, 75 plant species were recorded prior to the spring cultivation (Rodenas *et al*, 1977). Montiel Bueno (1998) refers to 120 plant species, 70 vertebrates and 160 invertebrates associated with olive plantations.

However, it is also apparent from the national and case studies that the intensive application of techniques intended to increase production (especially frequent tillage and heavy herbicide and insecticide use) has a strongly detrimental effect on ground flora and insect populations and generally results in a very considerable reduction in the diversity and total numbers of flora and fauna.

Flora and invertebrate fauna are the foundations of biodiversity on which many of the typical communities of fauna in traditional olive plantations depend (mammals, birds, reptiles). Consequently, given the same soil, climate and variety of tree, low-yielding plantations tend to be of higher natural value than those from which high-yields are achieved through intensive management practices.

Little research is available concerning the effects on biodiversity of different olive management systems. However, there are specific data on the effects of certain products and practices. For example, Cirio found that treating plantations with Dimethoate (used very widely to treat olive fly) caused a heavy reduction in the number of individuals belonging to the 12 taxa of anthropods studied. The negative effect persisted over a month after treatment (Cirio, 1997).

Similarly, Ruiz Torres (1998) found that anthropod communities were dramatically affected by Dimethoate treatments, with a decrease in numbers by up to 44% and with no significant recovery one month after application. However, aerial treatments with the same insecticide were found to have a very much reduced impact on the same communities.

The use of growth regulators such as Fenoxycarb to control scale and olive-kernel borer has serious collateral effects on fauna, especially on useful insects such as *Neuroptera coccinellidae* (Cirio, 1997).

Biodiversity tends to be high in traditionally managed olive plantations as their structural diversity (trees and understorey) provides a variety of habitats. The older trees support a high diversity and density of insects which, together with the tree's fruit, provide an abundant supply of food (Parra, 1990). The low level of pesticide use allows a rich flora and insect fauna to flourish, which in turn provides a valuable food source for a variety of avifauna.

Consequently, traditional olive plantations generally support a high diversity of wildlife, including reptiles, butterflies and other invertebrates, birds and small mammals. As well as many passerine species, typical nesting birds in Spain include hoopoe (*Upupa epops*), roller (*Coracias garrulus*) and scops owl (*Otus scops*). The little owl (*Athene noctua*) traditionally is associated with old olive plantations where it nests in the hollows of older trees and hunts insects, lizards and small mammals. The trunks of older trees are also used by mammals, such as the genet (*Genetta genetta*), and by reptiles.

Concerning bird species, intensification of management is expected to be to the detriment of species that breed in the knarled trunks of old trees (e.g. little owls) or breed or feed in the vegetation around the bases of trees (quail and partridge) or between the trees on semi-open ground (woodlark and stone curlew) as many of these features are lost or modified through intensification (Pain, 1994).

The use of Mediterranean olive plantations as a food source by very large numbers of migrant passerine birds, both from northern and central Europe and from Africa, is well documented. Where pesticides are used intensively to control specific parasites, the overall insect population inevitably suffers and the trees' overall value as a food source for birds is reduced, although the olive fruit is still available to them.

Research seems to show that birds feeding on olives do not have a significant impact on production. The fruits taken are generally over-ripe, fallen to the ground and/or have been attacked by olive fly, and are therefore of little value. Birds may even help to control pests by eating infected fruits. This was confirmed by commentators, including some farmers.

The intermittent harvesting of olives which often occurs in marginal plantations is not detrimental to their natural value; on the contrary, research has shown that in drought years when many plantations are not harvested, birds take particular advantage of the availability of olives, given the scarcity of wild fruits. One option for the management of non-viable plantations may be to introduce livestock to graze the spontaneous vegetation. This is reported to have happened in some less-productive plantations west of Sevilla in Spain (Rodenas *et al*, 1977). The result is a more natural, *dehesa* type of landscape. The Cáceres case study suggests that sheep raising in olive groves is an interesting economic alternative to cultivation only for olive production.

On the other hand, the total abandonment of olive plantations leads to scrub invasion through natural succession, and consequently to a more fundamental ecological change. Forest fires permitting, some form of woodland or Mediterranean *maquis* will result. Research undertaken in Grosseto province in Italy has shown that abandoned olive plantations in this area develop into dense woodland within a period of 9-15 years. As a result, many species associated with the extensively managed olive plantations of the area decline or disappear, particularly reptiles, butterflies and birds. On the other hand, woodland species tend to benefit (Petretti, 1995).

The natural woodland which results from abandonment may develop into a habitat of high natural value. However, it is important to consider the wider context of the landscape within which abandonment takes place. In upland regions which have suffered agricultural abandonment in recent decades, and in which landscapes are in danger of becoming dominated by forest and scrub, remaining olive plantations provide an important element of more open habitat which should benefit overall biodiversity (Petretti, 1995). They also provide effective firebreaks, a very important consideration in Mediterranean areas suffering from widespread abandonment and forest fires.

The converse of the abandonment phenomenon can be seen in certain other regions. In the 1980s and 1990s, there has been an expansion in olive plantations in the main producing areas of Spain and Greece. In some cases, this expansion has taken place at the expense of natural woodland and other vegetation which is of high conservation value, because it contributes an element of diversity in landscapes already dominated by intensively managed olive plantations.

Although there has been little monitoring of such changes in land-use, a local project in Córdoba province revealed over 50 cases of clearance of Mediterranean forest habitats to make way for new olive plantations during the 1990s, including cases within protected areas such as the Parque Natural de las Sierras Subbéticas (see Jaén case study).

In Greece, Kabourakis reports that many olive producing areas were densely forested in the past and diverse in agricultural crops till the post war period. The forests were degraded during the centuries and this is completed today though the mismanagement and overgrazing, while crop diversity has been reduced drastically due to intensification and olive monocultures (see Greece national report).

There is also concern amongst conservationists in Spain and Portugal about intensive olive plantations encroaching on arable land in areas of importance for steppeland bird communities. This has happened to some extent in Córdoba and Málaga in Andalucía (F. Cabello de Alba Jurado, personal communication) and in Alentejo (see Portugal national overview).

5.5 Landscape

Where olives form a part of a diverse land use system, for example in combination with pastures, arable cultivation and vineyards or where vines are grown between rows of olive trees, they are an important landscape feature (as well as adding considerably to habitat diversity, particularly in countryside with few other trees). Traditional olive terraces are a characteristic of upland landscapes in many Mediterranean regions.

However, in certain oil-producing regions such as Andalucía, olive plantations dominate the landscape in some areas, forming vast monocultures in which the trees themselves are the only form of vegetation for the greater part of the year. In this situation, landscape and habitat diversity are very limited.

5.6 Other effects

In certain areas with a high proportion of scrub and forest vegetation and a high risk of wild fires, olive plantations can act as useful firebreaks. Conversely, farmers may use fire to clear invasive scrub on their land, which adds to the fire risk in the event of fires getting out if control (for example, Toscana and Cáceres cases studies).

Indiscriminate use of wide spectrum products has led in some cases to explosions in coccid populations and other pests due to the removal of their natural enemies. Excessive herbicide treatment has caused die-back in the olive trees of some plantations. The creation of high levels of background pollution is a concern in regions where olive plantations cover extensive areas of land (Civantos, 1995).

Energy consumption in agriculture is an environmental concern which often receives less attention than other, more obvious, impacts. In general, fertilisers and diesel fuel are reported to represent the most significant consumption of non-renewable energy sources in agriculture (around 50% and 35% respectively according to Fernández Quintanilla, 1999). Energy consumption therefore may be a significant criteria for evaluating the environmental effects of intensive olive production, due to its relatively high use of manufactured fertilisers and repeated soil tillage.

Table 5: Summary of the environmental effects of different types of olive farming

	Low-input traditional plantations and scattered trees	Intensified traditional plantations	Intensive modern plantations
Soil	Low rates of erosion except in case of excessive tillage on slopes and vulnerable soils. Where manure and grass cover are used, organic content is maintained, reducing erosion risk.	Repeated tillage or herbicide use and chemical fertilisers reduce organic content and make soil more vulnerable to erosion. Some farmers now chip pruning residues which adds organic matter. Erosion also depends on slope, presence of terraces, rainfall patterns and practices. Repeated tillage not along contours can lead to very severe erosion even on moderate slopes, especially if soil is bare in autumn-winter rains.	Repeated tillage or herbicide use and chemical fertilisers reduce organic content and make soil more vulnerable to erosion. Some farmers now chip pruning residues which adds organic matter. Erosion is not normally severe as plantations are not on steep slopes and no-tillage systems are common.
Water	Terracing controls run-off and increases infiltration on hillsides.	Run-off of soil (often laden with herbicides) into water courses and reservoirs. Potential over-exploitation of surface and groundwater in some areas.	Possibly some run-off of soil (often laden with herbicides) into water courses and reservoirs and leaching to groundwater. Potential over-exploitation of surface and groundwater in some areas.
Air	Some air pollution from burning of pruning residues and invasive scrub.	Some air pollution from burning of pruning residues.	Some air pollution from burning of pruning residues.
Biodiversity	High due to habitat diversity (old trees, grass layer, adjacent land-use diversity) and minimum or no use of biocides.	Low due to reduced habitat diversity (especially understorey) and intensive use of biocides.	Very low due to reduced habitat diversity (especially understorey) and intensive use of biocides.
Landscape	High due to features such as terraces, old trees, stone walls, floral diversity.	Ranges from low to high, depending on overall landscape diversity.	Low to moderate, depending on age and overall landscape diversity.
Other environment effects	Important role as fire break in areas with high proportion of scrub/forest. But fires can be caused by farmers burning invasive scrub.	Local impact on habitats and landscapes of reservoir construction for irrigation.	Local impact on habitats and landscapes of reservoir construction for irrigation.

6 KEY ISSUES FOR IMPROVING THE ENVIRONMENTAL EFFECTS OF OLIVE FARMING

On the basis of the present study, we can identify four key areas which need to be addressed in order to improve the environmental effects of olive farming:

- Improvement of farming practices.
- Monitoring and steering changes in land use.
- Providing effective information, advice and training for farmers.
- Researching and monitoring environmental effects and building integrated databases.

6.1 Improvement of farming practices

In each of the countries and areas studied, there is ample scope for improving the environmental effects of olive production through changes in farming practice, particularly in the intensified-traditional systems and modern-intensive systems. The studies suggest that significant benefits could be achieved in terms of biodiversity, soil and water conservation.

In some cases, changes are required urgently in order to reduce severe and large-scale environmental impacts (for example, soil erosion in Jaén case study) or to prevent impacts in the near future (for example, increasing over-exploitation of water sources in Crete, Puglia and Jaén, soil salinisation in Crete and Puglia).

In certain areas, current practices are largely positive for the environment, with the exception of some farms where improvements could be achieved (for example, see Toscana case study).

As an overall recommendation, it is desirable for each olive farmer to prepare a management plan, with expert advice, to address the specific environmental issues on the plantation (or for the whole farm).

Possible improvements to current practices are discussed below according to the categories discussed in section 3.1 above. The following is a brief review of the scope for improvement. More detail is provided in the case studies.

6.1.1 Tree management

The biodiversity and landscape value of old olive trees has been stressed in Section 5. When replanting old plantations, a proportion of old trees should be maintained.

Some of the case studies highlight the importance of regular pruning following established codes of practice in order to maintain trees in a healthy condition and as a preventive measure against certain pests and fungi (see Crete case study). Good tree management therefore can contribute to a more rational use of pesticides.

Pruning residues should be incorporated in the soil, rather than burnt, to increase the organic content. This practice is becoming more common in some regions.

6.1.2 Weed control and soil management

As discussed in Section 5, inappropriate soil management is a major cause of soil erosion in olive farming. Changes in practice are required, even on land which is relatively flat (e.g. 3-5% slope).

There are various systems for reducing erosion, including contour tillage, minimum tillage (shallower and less frequent) and no-tillage. According to experts, the frequent tillage which is widely practised is of doubtful agronomic value. Shallower and less frequent cultivation would be equally effective as a means of controlling ground vegetation and would reduce the soil's vulnerability to erosion. However, several authors stress that it is difficult, if not impossible, to eliminate soil erosion entirely, especially on sloping land (Guzmán Álvarez, 1999).

Measures to increase the organic content are a very important part of good soil management in Mediterranean regions, especially to reduce vulnerability to erosion (European Soil Bureau, 1999). Practical measures are based on the incorporation of organic matter such as farm-yard manure, cover crops, pruning and processing residues, and on reduced tillage of the soil.

New minimum tillage and non-tillage systems have been developed which produce higher yields than conventional systems. These systems include techniques which greatly reduce erosion, particularly the maintenance of plant cover (crops such as barley or vetch, or spontaneous vegetation) on the strips of land between the lines of olive trees.

In Andalucía, no-tillage and reduced tillage systems have been shown to be effective in greatly reducing soil erosion in olive plantations, compared with conventional tillage systems. In the great majority of trials, yields have been found to increase under such systems, while costs tend to be reduced. In Spain there are now numerous publications on the trials and results of these systems. See for example Pastor, Castro and Humanes, 1997.

However, it is important to distinguish between the different systems. For example, the maintenance of a grass or crop cover on 30-50% of the soil area (between tree rows) has proved to be more effective in controlling erosion than "bare soil" systems based on intensive use of herbicides. In fact, no-tillage systems which involve an excessively intensive use of herbicides can expose the soil to severe erosion.

Under the systems developed in Andalucía, the plant cover is normally eliminated with herbicides, rather than by mechanical cultivation. The herbicides which are used are mostly residual products of relatively high toxicity (for example, Simazine and Diuron) (Guerrero, 1994). More environmentally friendly options are available, such as Glyphosate, but require more frequent application as they are not residual. Herbicides also may be combined with reduced-tillage systems (e.g. one shallow pass every 1-4 years).

Mechanical mowing or grazing by livestock to control vegetation involve more complex management and costs and may result in lower yields in some circumstances, but are preferable from an environmental point of view, especially the use of livestock grazing. In the case-study area of Toscana, permanent grass-cover systems which are managed through mowing and/or grazing have become widespread. Several of the case-study farms in the Cáceres study area use a permanent grass cover which is grazed by sheep. This system tends to be associated particularly with organic olive production.

With appropriate stocking densities and management, sheep grazing probably can be considered the most environmentally beneficial system of understorey management, both in terms of biodiversity and landscape and in wider terms of sustainability. For example, sheep dung provides an adequate level and balance of fertilisation, so that external inputs of fertiliser are not required and the organic matter content of the soil is increased.

However, this system problematic for many farmers for practical reasons, such as the disappearance of sheep from many intensive olive-farming areas in recent years, the very small size of many olive holdings, a lack of shepherds and a lack of knowledge and expertise about livestock among olive farmers. Incentives and other measures would be needed to promote the integration of sheep and olive production on a significant scale.

Especially in upland areas where olives are planted on terraces, the maintenance of these features is of great importance, both as a soil-conservation measure, and as a landscape feature. In many areas, the stone walls supporting terraces are neglected, leading to gradual degradation and, ultimately, their collapse. Maintaining stone walls is a labour-intensive and expensive activity.

6.1.3 Fertilisation

In many cases farmers apply much more fertiliser than the crop really needs (Tombesi, Michelakis and Pastor, 1996). Most integrated production systems propose fertilisation on basis of soil and leaf analysis of tree requirements.

The regulation for integrated olive production in Andalucía (Regional Government Order of 12.08.97) sets maximum inputs of nitrogen at N75kg/year/ha (dryland traditional), N100kg (dryland intensive), N120kg (irrigated traditional) and N150kg (irrigated intensive). See Toscana case study for other proposed fertilisation guidelines.

The use of organic fertilisers and green manures can make a considerable contribution to improving the organic content of the soil and thus reducing vulnerability to erosion (see Crete case study).

6.1.4 Pest control

Measures have been taken in some intensive-producing areas to promote a more rational use of chemicals, according to principles of tolerance thresholds and pest monitoring (see Jaén case study). In practice, it seems to be possible to control pests in olive plantations with a much lower and more rational chemical input than has become the norm on many intensive farms.

Sánchez Parra (1998) found that new systems of “rational control” with insecticides rather than according to a fixed calendar produced a notable reduction in the level of residues in the plantation of organo-phosphate pesticides.

Biological and other control methods with a reduced environmental impact (mass-trapping of olive fly and biological control of *Prays* with *Bacillus thurigiensis*) have been developed and could become much more widespread, especially if economic incentives were provided to help cover the increased cost compared with conventional chemical treatments.

6.1.5 Irrigation

As with fertilisation and pest control, there is great scope for improvement in this area. Currently, the irrigation of olive plantations often has little agronomic foundation, in terms of the quantities and timing of water applications and many farmers apply more water than is necessary or desirable for the health of the plantation and state of the soil (see Crete and Jaén case studies). In Andalucía, there have been some positive initiatives from the authorities, farm associations and researchers to promote a more rational use of irrigation in olive farming (Hidalgo et al, 1998).

There is an urgent need to establish guidelines and targets for the sustainable management of ground and surface water resources. The expansion of irrigation should be controlled by legal measures in areas with resources that are experiencing, or threatened with, over-exploitation.

6.1.6 Biodiversity and landscape conservation

Several of the national and case studies emphasise the importance for biodiversity of maintaining the "ecological infrastructure" of the olive plantation. This infrastructure is made up of elements such as patches of natural and semi-natural vegetation, hedges, dry-stone walls, wet areas and old trees. The elimination of such features has become common practice in many areas, as part of a general process of rationalisation and intensification of farm management (for example, see Crete and Jaén case studies). In some cases, the prevailing pattern is one of neglect rather than elimination.

The maintenance or restoration of these ecological features could be promoted in order to increase the natural value of olive plantations. At the same time, these features often contribute to landscape value and, in the case of terraces, stone walls and patches of vegetation, play an important role in reducing soil erosion.

6.2 Monitoring and steering changes in land use

A "change in land use" in this context refers to a change to or from use as an olive plantation, in other words, the establishment of a new plantation on land previously under another use (including natural vegetation) or the abandonment, grubbing-up or withdrawal from production (set-aside) of an existing plantation.

Both the expansion of new olive plantations and the abandonment of old plantations are occurring currently in the EU and both phenomena can have important environmental effects, as discussed above in Sections 5.4 and 5.5.

6.2.1 New planting

Controls are needed on new planting, which is still occurring on a considerable scale and, in some cases, causing the destruction of valuable semi-natural and natural habitats (see Greece and Spain overviews and case studies).

6.2.2 Abandonment and grubbing-up

Both the abandonment and grubbing-up of olive plantations should be avoided where this will lead to significant loss of natural and landscape values or where it might result in the increase of environmental problems, such as wild fires and land-slips.

6.2.3 Set-aside of olive plantations

Where olive cultivation is causing extreme soil erosion on steep slopes (e.g. over 20%), changes to farming practices may not be sufficient to address the problem. In this situation, a change of land use is recommended, for example, to grazing and/or natural forest. The olive trees should not be grubbed-out, but rather should provide the basis for a dehesa-type of pasture or for sensitive afforestation projects. This could be a useful example of long-term set-aside with specific environmental objectives.

6.3 Information, advice and training

The case studies stress the need to providing effective information, advice and training to olive farmers on environmentally beneficial practices. Currently this only occurs on an extremely limited scale. An interesting model is the establishment of farmer associations who employ their own technical adviser (usually with financial aid from the government) as occurs under the Integrated Production Associations (API) scheme in Andalucía. By creating a much more direct link between the farmer and a specialist adviser, this system may be more effective than conventional farm advisory services or occasional training course and information campaigns.

6.4 Research, monitoring and data-bases

The present study provides an overview of the environmental effects of olive farming in the EU and highlights certain practices which are beneficial and others which are environmentally damaging. However, it also reveals that in most of the olive-producing regions of the EU there is a startling absence of data on these issues.

It is essential to undertake more comprehensive studies in each region in order to identify and quantify key environmental effects and thus provide the basis for effective policy measures with which to address them. Once problems have been identified and quantified, effective instruments can be designed to tackle them. It is important to set targets and to establish effective systems of monitoring.

Research and pilot projects are also required to develop and test alternative management systems for olive production, including organic systems for weed and pest control. Currently these exist only on a very limited scale.

To facilitate the quantification and monitoring of environmental effects, environmental criteria should be incorporated into the olive databases which currently are being developed, following the 1998 interim reform of the regime. With currently available technology (Geographic Information Systems, satellite imagery, etc.) and existing data and maps, it would be relatively simple to develop a cartographic data-base for all olive growing areas, including information such as:

- Soil type and vulnerability to erosion
- Average slope
- Satellite imagery of vegetation cover and the presence of terraces and other features (e.g. surface water bodies)
- Climate (rainfall etc.)
- Altitude
- Average olive yields according to homogeneous production areas
- Number of trees per hectare

Additional data could be provided for each holding by adding environmental criteria to the existing olive register. For example, producers could be required to include data on their normal farming practices (especially soil management, use of pesticides, irrigation, grazing) with the information they already provide on surface area and tree numbers.

7 OPTIONS FOR IMPROVING THE ENVIRONMENTAL EFFECTS OF OLIVE FARMING IN THE CONTEXT OF EXISTING POLICIES

From the data and analysis presented in Section 5, we can conclude that the following aims need to be addressed in order to improve the environmental effects of olive farming:

Reducing negative effects:

- To reduce currently high levels of soil erosion and run-off to water courses, mainly in intensified-traditional and modern-intensive systems, by promoting changes in management practices or, in extreme cases, a change in land use (maintaining olive trees and introducing grazing and/or afforestation).
- To promote a more rational use of agro-chemicals in order to reduce impacts on flora and fauna (biodiversity) and reduce the risks of pollution, especially of soil and water.
- To promote a more sustainable exploitation of water resources for irrigation and control the spread of irrigation in areas with sensitive water resources.
- To prevent the further expansion of olive plantations onto valuable habitats (natural and semi-natural) and soils that are vulnerable to erosion.

Maintaining and improving positive effects:

- To prevent the abandonment of olive plantations where these make a positive contribution to natural and landscape values, mainly low-input traditional systems.
- To further develop and promote sustainable and environmentally-favourable olive farming systems, such as organic and integrated production systems.
- To promote the maintenance and improvement of natural values in olive plantations (maintenance and restoration of habitats and landscape features).

Furthermore, in Section 6 we conclude that action is required in four key areas in order to promote the above aims, namely:

- Improving farming practices.
- Monitoring and steering changes in land use.
- Information, advice and training.

- Research, monitoring and data-bases.

In this Section, we review the present policy framework affecting olive-farming and identify opportunities for implementing practical measures in these four areas, with a view to promoting the environmental aims set out above.

7.1 Review of the existing policy framework affecting olive farming

Community policies are the most significant policies affecting olive farming in the EU Member States. There are very few national and regional measures of significance outside the EU policy framework: some of these are relevant to the present study (for example, farm advisory services) while others are less relevant (for example, crop insurance schemes).

In particular, the CAP support regime for olive production, with an annual budget of 2,250 million Euros, has played a powerful role in the way in which the olive sector has developed since the 1980s (in Greece, Spain and Portugal) and earlier in Italy. The support regime continues to be an important driving force which strongly influences the scale and nature of olive farming in the EU.

Apart from the CAP olive regime, other EU policies of relevance include FEOGA structural measures (e.g. for grubbing-up old groves, for investments in replanting and irrigation and for setting up young farmers), aid for farmers in Less Favoured Areas and, since the mid-1990s, agri-environment programmes established under Regulation 2078/92.

Obviously these policies are not the only factor influencing olive farming in the EU Member States. Socio-economic and technological changes also play a fundamental role and it is not easy to distinguish these influences from those of policy.

The main policy measures of relevance to the present study and with opportunities for the establishment of practical measures for promoting environmental improvements are as follows:

- The CAP olive support regime, due to be reformed during 2000 for the implementation of a new regime from November 2001.

- New environmental measures provided for under Article 3 of the “common rules” Regulation 1259/1999, including the possibility for attaching environmental conditions to CAP support payments.

- Agri-environment measures, previously Regulation 2078/92 and now under Chapter VI of the “rural development” Regulation 1257/1999; and measures for less-favoured areas and areas with environmental restrictions, under Chapter V of Regulation 1257/1999.

- The rural development measures established under Regulation 1257/1999, particularly in Chapter IX (adaptation and development of rural areas) and in Chapter I (investment in agricultural holdings.

The following discussion considers the environmental consequences of existing policies, as far as these can be evaluated, and reviews the practical options for improving the environmental effects of olive farming in the context of the above opportunities.

7.2 The CAP olive support regime and options for reform

7.2.1 Environmental consequences of the existing olive support regime

Since the 1998 “interim reform” of the CAP olive regime, the basic support provided for olive farming has been in the form of a subsidy paid in direct proportion to the production of olive oil or table olives. Previously, small producers (those producing less than 500kg of oil per year), received a support payment based on tree numbers and historic yields in the district.

While it is not possible, without more comprehensive research, to ascertain the exact role of the CAP olive regime in defining production patterns and tendencies, certain influences may be identified from the present study.

In Greece and Spain, the introduction of this policy during the 1980s and 1990s has coincided with intensification and increased planting and output in the main producing regions, with generally negative consequences for the environment. Furthermore, prior to Spain’s accession to the EC in 1986, olive farming was in decline in this country. Intensification and expansion processes have been less pronounced in Portugal, where olive farming had been in strong decline for many years at the time of EC accession, but are discernible nevertheless. Factors not directly linked to the CAP, such as technological developments, no doubt have also contributed to the intensification of production systems.

In Italy, different circumstances seem to apply. The CAP regime has applied since the 1960s, but a large proportion of producers received aid on the basis of tree numbers, rather than real production. Holdings are smaller on average than the other countries and a significant proportion of production is for home consumption. Rural areas generally are not so dependent on olive production as equivalent areas in Spain and Greece; the agricultural economy tends to be more diversified.

For these and other reasons, it seems that the CAP olive regime has not promoted olive expansion and intensification in many parts of Italy on the same scale as in Spain and Greece. Even so, modern intensive systems have been developed in specific areas with favourable conditions (e.g. availability of irrigation water), such as in Puglia.

Some economists have concluded that the subsidisation of olive production provides a powerful incentive to maximise returns by for intensifying production systems (see for example Fotopoulos, Liodakis and Tzouvelekas, 1997). Whilst most notable in the more productive areas, in the form of developments such as new plantations, irrigation and intensive use of inputs, intensification is also apparent in many marginal areas (see Crete and Cáceres case studies).

The case studies and Section 5 of the present volume illustrate how the intensification process has lead to a reduction in environmental values (particularly biodiversity) and an increase in negative impacts (notably soil erosion and over-exploitation of scarce water resources) in many olive-farming areas of the EU. However, they also highlight the clear potential for reducing negative environmental effects by modifying farming practices.

The Spanish national overview illustrates the incentive to intensify provided by the production support in the case of irrigated and non-irrigated intensive plantations: according to the calculations made, conversion to irrigation results in a gain in net returns of Euro 530/ha with the production support, compared with a gain of only Euro 90/ha without the production support.

The current production support clearly provides a very strong incentive for converting to irrigated production (almost a 600% increase in net return compared with a non-subsidised situation), with the potential environmental impacts that this involves (see Section 5.2 above). The role of CAP support in promoting a rapid expansion in olive irrigation in Andalucía has been recognised by some authors (for example, Hidalgo et al, 1998). At a more general level, in the proceedings of a recent seminar on the implementation of the EC Water Framework Directive, the role of CAP production support regimes in favouring irrigated cropping in various sectors, including olives, is highlighted as a key issue to be addressed in order to establish sustainable river-basin management (WWF, 2000).

In interviews carried out in the course of the present study, some farmers commented that they probably exceed a rational level of pest control because of the large difference in income between a good and a poor harvest. In other words, excessive chemical treatments are considered a sort of "insurance policy" to ensure that income is not affected by pests. Irrigation serves a similar purpose: it provides a guarantee of income in dry years, when the crop might otherwise be poor. Clearly a production subsidy, as opposed to some other form of support "decoupled" from production, accentuates this attitude, as the farmer's income from both the market and the CAP regime depends entirely on output.

A more environmentally-positive influence of the CAP olive regime is that it probably has helped to reduce the abandonment of small, traditional plantations in many marginal regions, thus preventing the loss of certain environmental and social values. However, these values have also been eroded through intensification in some of the areas studied (see Cáceres and Crete case studies).

Furthermore, the support provided for the traditional low-input type of plantation is relatively low. Intensive systems produce very much higher yields and consequently benefit from a far higher level of production support per hectare than the former type. The production support for an intensive irrigated plantation is approximately ten times greater per hectare per year than the support for a traditional, non-intensive plantation. Furthermore, an intensive irrigated plantation achieves a relatively consistent harvest each year, which is reflected in the production support received; a traditional low-input plantation produces a harvest every two years, and consequently only receives support every two years.

The economic viability of farming, and the role of the CAP support regime in maintaining the viability of different types of olive farm, is an important environmental consideration, as it has a direct influence on the risk of abandonment and on the probability of expansion of new plantations. The current production-related support system accentuates the inherent economic advantages of intensively managed plantations compared with traditional, low-input olive farming, whilst providing a lower level of support to the types of plantation most at risk from abandonment.

Indeed, traditional low-input plantations are barely viable under the present support system and many do not produce a positive net income (see Table 4 above and the Toscana and Cáceres case studies). Their relatively high costs per hectare reflect the high labour requirements of these systems (maintenance of terraces, difficulties of mechanisation, etc.), whilst their output is extremely low. The features which lead to high labour costs (terraces, old trees, etc.) also form an integral part of their environmental value.

In addition, the olive-oil regime has promoted a considerable increase in productivity and production, leading to a situation in which structural surpluses threaten to push down both prices and the level of support (through the penalisation mechanism) and thus further reduce the viability of marginal olive farms. This process continues today as new plantations continue to be established in the main producing regions.

Plantation prices in Spain provide an illustration of the expansionist influence of the CAP regime in this country. Average prices have increased by 300% since 1983, with striking increases registered since 1992, as the full rate of production support came into force in Spain, combined with strong market prices. In the most intensive producing areas, such as Córdoba and Jaén, average plantation prices were over Euro 12,000 per hectare by 1999, reaching Euro 24,000 per hectare in some cases (Europa Agraria, May 1997). These are exceptional price levels for farmland.

Not surprisingly under these circumstances, there has been a very strong expansion of new planting on marginal cereal and grazing or scrub land (Europa Agraria, May 1997). It was observed during the present study that this process continued during 1999-2000. See Section 4.

This study concludes that the existing production-support system produces negative environmental effects by rewarding intensification and expansion. Based on observations and interviews during 1999-2000, maintaining this system unchanged could push this process further for some more years, even with the national maximum guaranteed quantities and penalisation mechanism (see Spain national overview).

In addition to the negative effects of intensification and expansion, these processes would lead to increasing production and thus lower prices and subsidies for all producers, with potentially negative effects on low-input traditional farms which are of most environmental value but which are also at or below the limits of economic viability at present.

7.2.2 Options for improving the environmental consequences of the olive support regime

All of the national and case studies concluded that converting all or a part of the current production support into a direct payment decoupled from production would reduce the incentive for intensification (and promote some reduction in intensity) and thus could be considered broadly positive in environmental terms.

Direct payments also would provide an important continuity of income for more traditional producers and thus may help to prevent abandonment of low-input, marginal plantations. All producers would benefit from the regularity of an area payment paid each year, as compared with a production subsidy which depends on the vagaries of rainfall, availability of irrigation water, pests and the alternate-year yield of olive trees. There would be less incentive for practices such as “total” pest and weed control, and irrigation.

An area-payment system would put the olive support regime on the same basis as other major CAP support regimes (e.g. cereals) and avoid the severe distortions inherent in a tree payment system. It would also achieve more clearly the objective of decoupling support from production. There would be no incentive for clearing older trees to create new intensive, higher-density plantations. To avoid claims from the owners of fields with only one or two trees, a minimum number per hectare would be required; this should be low enough to allow very extensive, traditional plantations to benefit (e.g. 40-50 trees per hectare). Scattered trees not in plantations and with an overall density below this limit could be paid the same level of aid, but converted to a tree-basis.

Some concerns have been raised about the economic viability of the olive harvest in the absence of production support. This report suggests that the concerns are genuine in some marginal areas but are probably exaggerated in general and especially in the main producing areas. No research was encountered in the course of this study to evaluate the possible effects on harvesting of removing production support.

In some marginal areas, olives currently are harvested by informal tenants purely for the market return on the oil, as the owner keeps the production subsidy (see Cáceres case study). This suggests that, at least in some areas, production support is not necessary to ensure that olives are harvested at present and should not be in the future, assuming that prices are not driven down by over-production.

To help address this concern, a continuation of management and harvesting could be pursued through the attachment of conditions to support payments. One option would be to require all producers to demonstrate that their olives have been processed. However, this would be difficult to verify as it is usually very easy to acquire enough olives to deliver to an oil-mill (this was the basis for the fraud problems attached to the old small-producer aid).

Another possibility would be to require the recipients of the aid to maintain their plantations in production by undertaken particular management tasks. This would be a form of environmental and social “cross-compliance” (see Section 7.3, below): the direct payment would be for recognisable and regularly pruned olive plantations, not those invaded by scrub or woodland. The requirement could be to maintain the basic structure of an olive plantation with its key components (pruned trees and cultivated, grazed or mown understorey).

If required to maintain their plantation in this way, most owners probably would continue to harvest, with prices at current levels. It would be relatively simple to verify whether an olive plantation was being maintained to this basic standard, on the basis of spot-inspections and/or aerial and satellite observation.

From an environmental point of view, a reduced level of harvesting (for example, not harvesting in very low-yielding years or leaving the more inaccessible olives on the tree) can provide benefits for fauna. Research has shown that in drought years when many marginal plantations are not harvested at present, birds take particular advantage of the availability of olives, given the scarcity of wild fruits.

The removal of production support may result in some reduction in output throughout the EU, or at least a reduction in the current rate of growth, which should help to maintain stronger prices. Concerted programmes to improve quality and marketing, especially in marginal regions, should also strengthen demand in these areas. Several of the commentators interviewed during this study suggested that the economic viability of production should be pursued through strong demand and high prices for a quality product.

As with the direct payments in the arable and livestock sectors, a system of "base areas" would need to be established in order to prevent fraud or an unlimited expansion of area payments. However, it would be wrong to fossilise existing land use patterns and prevent all further expansion. From an environmental point of view, the main concern is to steer any future expansion of olive plantations onto the most appropriate land. This means principally avoiding steep slopes and land with particular conservation values, such as woodland, steppelands and wetlands.

Following such an approach there would still be areas of land currently under low-yielding arable cultivation, and with edapho-climatic conditions highly suitable for olive production, which could be planted with olives without environmental damage, and with potential environmental benefits, depending on the types of plantation and the management practices.

There is also a need to take some plantations out of production, where extreme soil erosion cannot otherwise be avoided. A base-area system therefore should be flexible enough to allow some redistribution.

An important question is whether a system of area payments should be weighted or “modulated” in order to provide more support to certain types of plantation, for example, reducing the amount of aid going to the most productive plantations and in order to direct more support towards plantations of environmental value and which are in danger of abandonment under current levels of support.

Ideally, environmental modulation should relate to particular management practices, or to the production of specific environmental benefits. For example, a higher level of support payment could be the maintenance of a permanent or semi-permanent grass understorey, cultivated no more than twice per year and managed without the use of residual herbicides.

Another criteria could be to allocate a higher payment for olives on terraces with retaining walls. This would help to correct the current situation under which a producer who is causing serious soil erosion by repeated tillage on steep slopes receives the same support as a producer who is conserving the soil and landscape through the maintenance of traditional terraces.

However, trying to adjust the level of support on the basis of such criteria would be complex and expensive to administer. A simpler solution may be to introduce a flat-rate payment of basic support (i.e. the same level of payment per hectare for all olive plantations) supplemented by additional targeted payments under agri-environment programmes. The change from production support to this flat-rate payment could be introduced over time while additional targeted payments are introduced in response to regional assessments of the main issues to be addressed.

7.3 Article 3 of Regulation 1259/1999 and proposals for good agricultural and environmental practice in olive farming

The possibility of attaching environmental conditions to CAP support (sometimes know as “cross-compliance”) was introduced in 1999 as part of the Agenda 2000 reform process.

Article 3 of Regulation 1259/1999 provides for Member States to take various environmental measures in relation to agriculture, when they consider these to be appropriate. These measures may include “specific environmental requirements constituting a condition for direct payments”. Member States shall decide on the appropriate penalties for not observing environmental requirements, including the possibility of withholding payments. These provisions apply to the current production support for olive oil.

It is important to establish which type of environmental conditions would appropriate to attach to the receipt of support payments and, in particular, to differentiate these from environmental commitments which warrant the payment of an additional level of support, as occurs under the agri-environment programmes.

Regulation 1257/1999, which establishes the current Community framework for agri-environment programmes, states in Article 23 that “agri-environment commitments shall involve more than the application of usual good farming practice” and that “they shall provide for services which are not provided by other support measures”.

The logical conclusion from this is that there should be two levels of environmental commitment:

- Basic environmental responsibility, included within the concept of good agricultural practice, which constitutes a condition for the receipt of CAP support.

- Additional environmental services which go beyond currently accepted good agricultural practice and which a farmer provides in return for agri-environment payments.

7.3.1 Definition of good agricultural practice in olive farming

The concept of Good Agricultural Practice (GAP) is not clearly defined at present. GAP means different things to different people, depending on their point of view. Within the farming sector, it is a concept associated more with promoting efficient agricultural production than with achieving environmental protection.

However, many Codes of Practice in agriculture and in other sectors do address environmental issues. As the requirement to promote sustainable development and to integrate environmental protection into all policy areas is now enshrined in the EU Treaties, it is clearly necessary to incorporate environmental criteria into the concept of GAP.

GAP therefore should include a basic level of environmental responsibility or protection in the light of current environmental knowledge, concerns and legislation. All farmers should be required to comply with locally, regionally or nationally developed codes of GAP in order to promote this basic level of protection.

Beyond this level of basic environmental responsibility and protection there are additional levels of environmental action which involve the maintenance or creation of special environmental values, coinciding with the concept of special “stewardship” or “praesidium”.

During the course of the study, only one example of a code of practice designed specifically for olive farming and incorporating concepts of sustainability was encountered (UPA-C-LM, 1999). The national and case-study consultants were therefore asked to develop proposals based on available material and interviews with farmers and other experts.

In making these proposals, it is important to distinguish *Good* Agricultural Practice from *common*, *widespread* or *standard* agricultural practice. Standard practice may not be good practice. This is why Codes of Practice are developed: in order to improve standards. From the reviews and interviews undertaken in the course of this study, it is clear that many olive producers currently do not comply with conventional, “agronomic” GAP: for example, many practise tillage up and down slopes instead of following contours; pest control is practised mostly according to fixed calendars and dosages, rather than monitoring pest thresholds; fertilisation is based often on “hearsay” rather than on technical recommendations.

Table 6 provides an overview of proposals for GAP for olive farming in the EU, incorporating basic environmental protection, as well as proposals for additional “environmental services” beyond GAP. The proposals in Table 6 cover aspects of agricultural practice which have significant environmental effects; full GAP should of course include other agronomic aspects, for example, to ensure a high quality of production, but these have not been included here.

It must be stressed that the best practice for environmental protection cannot be standardised across countries, regions or even at the local level. To tackle soil erosion, for example, each plantation requires an approach tailored to its circumstances (Tombesi, Michelakis and Pastor, 1996). Ideally, each farmer should prepare a management plan, with expert advice, to address the specific environmental issues on the plantation (or better still, for the whole farm).

It is important for the of GAP to be developed at a local level, as conditions vary widely throughout the EU producer countries, even in a clearly Mediterranean sector such as olives. Comparisons between different areas and conditions should be very informative and help to develop a system which is fair and widely accepted.

More detailed GAP proposals for specific areas are provided in the case studies (see Annexes).

Table 6: Summary of proposals for Good Agricultural Practice and additional Environmental Services in olive farming

	Proposed Good Agricultural Practice incorporating basic environmental protection (1)	**Costs to farmers**	**Environmental services in return for agri-environment payments (in addition to GAP) (2)**	**Costs to farmers**
Weed control / understorey management	Till slopes following contours. Till no more than twice per year (shallow tillage with harrow). Allow vegetation to develop during Autumn-Spring period to reduce erosion and run-off. On slopes >5%, maintain permanent cover between tree rows (superficial tillage at most once per year).	No significant costs if permanent vegetation is managed with herbicides – possibly reduced costs and improved yields. Mechanical mowing requires purchase or rental of mower.	Maintain a permanent cover with mechanical mowing and/or livestock. Occasional tillage (every 1-4 years) if necessary, following GAP. Plough and disk harrow not permitted. Residual herbicides not permitted.	Costs of machinery (mower) and/or bringing in livestock.
Measures to conserve soil and reduce run-off (in addition to above)	-	-	Reduce vulnerability of soil by adding organic matter. Create small earth works to reduce run-off on steep slopes. Maintain all existing terraces and their supporting walls.	Transport and spreading costs of organic matter. Cost of earthworks. Cost of maintaining terraces.
Fertiliser use	Follow regional guidelines for quantity and timing of fertiliser application in order to minimise risk of run-off, leaching and soil acidification.	No cost to the farmer. Possible savings from reducing excessive fertiliser application. Possible increase in yields due to improved fertilisation.	Fertilise on basis of soil and leaf analysis of crop requirements. Follow principles of integrated or organic production (minimise or eliminate use of chemical fertilisers).	Soil and leaf analysis is expensive (e.g. 50 Euro/ha/year). Overall organic production costs are estimated 20% higher than conventional.
Pest control	Only treat pests when above thresholds on advice of local advisor. Follow regional guidelines. No aerial spraying. Minimise pollution (air and water) pollution and impacts on fauna.	No costs to farmer if monitoring and advice is provided by authorities or other bodies. Possible savings from reducing excessive insecticide application. Possible improved production due to improved control.	Minimise use of chemical (and biological) insecticides following principles of integrated or organic production.	Integrated production involves minimal extra costs for farmer if pest monitoring and advice is provided by authorities or other bodies (co-ops., etc). Organic production costs are 20% higher than conventional.

Table 6: Summary of proposals for Good Agricultural Practice and additional Environmental Services in olive farming (continued)

Irrigation	Respect all laws on water extraction and sinking of bore holes. Respect established limits (laws and codes) on water use according to crop needs and sustainable water management. Reduce water losses to minimum.	Reducing water use and losses may require investment in repair and/or replacement of equipment.	Irrigate only in exceptional circumstances (drought years, newly planted trees) and not in areas with water scarcity or where irrigation infrastructure is a significant threat to environmental or landscape quality.	Under the current support regime and very low water costs, ceasing irrigation implies a considerable loss of income. This loss would be smaller if subsidies were de-coupled from production and/or if environmental and public costs were internalised in water charges.
Tree management	Avoid excessive pruning. Do not burn prunings – these should be chipped and incorporated in the soil. Maintain a proportion of old trees when replanting or increasing tree density.	Chipping pruning residues has significant costs in machinery and labour.	Maintain all old trees.	This service implies not being allowed to rationalise production by replanting old groves, hence there is a restriction on increasing productivity. However, removing and replanting old trees is expensive and normally only undertaken with grant-aid. Grubbing-out probably would not occur if subsidies were de-coupled.
New plantations	Comply with existing laws on land-use planning, EIA, etc. Avoid planting in sensitive habitat and/or landscape areas (e.g. steppes, forest). No planting on slopes over 20% except with existing terracing or permanent grass cover.	No costs.	Maintain or create natural and semi-natural elements, such as field boundaries, dry-stone walls, patches of scrub, other tree species, etc.	Costs depend on the situation of each farm and the type and extent of features created and maintained.
Care of biodiversity	Comply with existing laws on species and habitat protection.	No costs.	Maintain and improve habitats and biodiversity. Following guidelines of official biodiversity strategies.	Costs depend on the situation of each farm and the type and extent of features created and maintained.
Care of landscape	Comply with existing laws on landscape protection.	No costs.	Maintain all landscape features and improve, following guidelines of official landscape strategies.	Costs depend on the situation of each farm and the type and extent of features created and maintained.

7.3.2 Practical application of environmental conditions to olive support payments

The present study concludes that in order to promote improved farming practices and environmental effects, as well as to ensure that plantations receiving aid are kept in good management, all CAP payments to olive farms should require compliance with GAP incorporating basic environmental protection and responsibility. All of the consultants involved and the majority of interviewees considered this an essential step for integrating environmental protection into the olive regime, whether or not there is a change from production to area payments.

In general, people consulted in the course of this study (including extension advisors currently involved in making farm inspections for compliance with the CAP arable regime and agri-environment schemes) felt that cross-compliance could be applied effectively to olive farming, if appropriate conditions and criteria are established.

The findings of this study indicate that the definition in Article 28 of Regulation 1257/1999 for "usual good farming practice" as "the standard of farming which a reasonable farmer would follow in the region concerned", should be applied with care, as the predominant olive farming practices in some regions appear to be unsustainable and cause significant environmental degradation.

New codes of good practice should aim to address this situation by improving existing practices. Such codes should be drawn up at the level of areas which are homogeneous in agricultural and environmental terms, with the full participation of agricultural and environmental authorities and non-government experts and bodies. At the same time, an EU framework is needed in order to ensure that standards are set at comparable levels between one region and another.

An interesting precedent is provided by the cross-compliance measures applied in the USA from the 1980s, especially since one of the principal environmental problems addressed by these measures was soil erosion. Farmers with highly erodible crop land were required to draw up and implement a soil-conservation plan in order to be eligible for crop support payments. These plans include options such as conservation tillage, contouring and the construction of terraces (Baldock and Mitchell, 1995).

Positive results seem to have been achieved in this case by requiring a change in "standard" farming practices in areas sensitive to erosion. Of the 59 million hectares identified as highly erodible at the start of the programme in the mid-1980s, conservation plans had been approved on 57 million hectares and fully applied on 34 million hectares by the early 1990s (USDA, 1993 quoted in Baldock and Mitchell, 1995).

In drawing up codes of GAP, certain common principles should be followed. For example, a report produced by the Institute for European Environmental Policy in 1995 suggested some basic criteria for defining minimum environmental conditions: relatively low cost of compliance for farmers; clear environmental benefits; administrative workability; monitorability; enforceability and familiarity to farmers (Baldock and Mitchell, 1995).

In some particularly sensitive situations, it may be necessary to incorporate stricter environmental requirements into GAP in order to achieve a basic level of protection. Examples of such situations might include:

- Severely depleted aquifers or surface waters, where exceptional restrictions beyond existing limits are needed in order to restore the resource to a sustainable level.

- Land highly vulnerable to erosion (for example, vulnerable soil types on exceptional slopes in areas with torrential autumn rains).

- Areas with exceptionally high fire risks (restrictions would include no use of fire as a management tool, e.g. for scrub control).

- Presence of protected species and/or habitats requiring especially sensitive or specific management practices.

The payment of additional aid for compliance with stricter conditions could be implemented by means of the scheme for "less-favoured areas and areas with environmental restrictions" under Article 13(b) of Regulation 1257/1999 (this can be applied only to compensate for economic losses resulting from the implementation of Community environmental legislation). However, currently the Less Favoured Areas scheme operates on a very crude level of geographic zones and a large proportion of olive farmers are excluded due to the criteria applied (for example, minimum farm size, only full-time farmers are eligible, etc.).

Another possibility in this situation is to pay financial assistance under agri-environment schemes (as happens now under many 2078/92 programmes). This would be permitted under the new EU Rural Development Regulation only if the undertakings paid for are considered as environmental services which go beyond GAP. See 7.4.1 below. Also, the budget currently available for this programme is not sufficient to allow its application on a very wide scale in the main olive-producing regions.

Alternatively, if production subsidies are converted into a new olive area payment, this payment could be weighted or "modulated" in order to provide more support for olive groves in areas with particular environmental values and/or handicaps.

Finally, an attempt was made in the present study to address the question of costs to farmers of complying with GAP. In many cases, it was found that compliance would involve no costs, or that the farmer would have potential economic benefits through reduced costs and/or improved production (quantity and/or quality). However, with certain specific exceptions, it is very difficult to quantify these costs and benefits at present. In many cases, the outcome will depend on the circumstances of each particular holding. Such calculations should be undertaken at the local level through consultation with a wider group of farmers and other experts.

7.4 Rural Development Regulation 1257/1999

7.4.1 Agri-environment programmes

During the eight years since they became obligatory for Member States under Regulation 2078/92 (and 15 years during which they have existed at least as an option) agri-environment programmes have been established slowly and often ineffectively in the case of olive farming.

Data are not available from the EC on the uptake of agri-environment measures by farming sector, but from the national and case studies it is apparent that, with the exception of Portugal, only an extremely small fraction of the current olive area is under agri-environment contracts. Most of these are for organic production, with rules which do not address directly two of the principal environmental concerns: soil and water conservation. Overall, agri-environment programmes have failed to address the scale and range of environmental issues identified in the present study.

Measures for promoting "integrated production", of particular environmental interest in more intensively farmed areas, have been developed extremely slowly, with limited results to date due to delayed or ineffective implementation (see Puglia and Moura case studies). Also, these programmes have different criteria depending on the region and/or country. It is important that the conditions for integrated production should include criteria relating to soil and water conservation and fertilisation, and not merely to pest control.

Agri-environment measures specifically designed for traditional olive groves, with features such as terraces and dry-stone walls, have been implemented on a significant scale only in Portugal. This is a striking absence in the case of the other three Member States covered by the study, given that traditional olive farming is a particular and valuable feature of the Mediterranean landscapes in these countries, a fact that is reflected extensively in existing literature.

There is an urgent need for all of the Member States concerned to develop comprehensive and effective agri-environment programmes for olive farming. These should not be limited to particular cultivation systems, such as organic and integrated production, as such systems generally do not address the full range of environmental issues concerning olive farming. Programmes should aim to integrate a set of measures with a view to addressing the range of environmental issues. Examples are shown in Table 7.

Table 6 (last column) summarises the type of conditions that should be required in agri-environment programmes as distinct from conditions for Good Agricultural Practice. They should have clear aims and quantifiable objectives, with monitoring programmes to ensure that results are achieved or, if not, that the programmes are revised.

To promote benefits more effectively, it would be desirable if all farms receiving agri-environment aids were required to produce and maintain an integrated farm management plan, specifying environmental objectives and practices to be followed. The costs of these plans could be covered by a specific payment under the agri-environment schemes.

Comprehensive programmes of this sort potentially could result in significant new employment in marginal rural areas in activities such as:

- The maintenance and restoration of landscape and habitat features which are currently abandoned, including terraces.

- More labour-intensive farming systems, such as organic systems and systems involving livestock raising in association with olive plantations.

- Development and monitoring of integrated farm management plans.

Such programmes should also increase the tourist value of marginal areas through improved landscape value.

Table 7: Environmental aims to be pursued through agri-environment measures

Environmental aim	**Actions to be promoted**
Soil conservation	Maintenance of terraces and walls. Establishment of permanent grass-cover systems (*inerbimento*) maintained without residual herbicides with additional incentives for control by sheep grazing. Adoption of organic systems involving specific commitments to improve soil fertility and resistance to erosion through increased organic matter. Creation of small earth works to reduce run-off on steep slopes. Sensitive afforestation of plantations on extreme slopes.
Sustainable water use	Conversion of irrigation to "deficit systems" for use only in critical circumstances, such as drought. This would reduce extraction in areas with over-exploited resources.
Landscape conservation and improvement	Maintenance of all existing landscape features (walls, buildings, hedges, trees), removal of constructions which degrade landscape, establishment of new features in harmony with landscape.
Biodiversity conservation and improvement	Maintenance of all existing habitats and creation of new habitats (natural vegetation, small ponds, etc. Measures to favour species conservation.

7.4.2 Rural development measures

Structural policies (FEOGA-Guidance horizontal measures and Objective 1 regional programmes) have added to the impetus for intensification, promoting actions such as grubbing out of old olive groves and the establishment of new plantations with irrigation (see Portugal and Italy national overviews).

They have also funded some important initiatives for improving environmental integration, such as funding for ATRIAs (*Agrupaciones para Tratamientos Integrados en Agricultura*) in Spain. These are associations of farmers which employ a technical adviser to promote a more rational use of pesticides by means of integrated pest control – see Spain national overview. To date, the scope of these initiatives has been somewhat restricted due to the limited availability of funding, but they provide a model which should be developed further and on a larger scale.

Measures providing farm investment aid and aid for setting-up young farmers exclude a very large number of small olive farms which do not meet the eligibility requirements concerning economic viability. Apart from being "condemned" in this way to perpetual non-viability (by definition, they are also excluded from diversification aid), such farms also have not been able to receive aid for environmental improvements, such as restoring stone walls, old buildings or other features (see Toscana and Cáceres case studies).

To be sustainable in socio-economic terms and reduce the threat of abandonment, olive farming in many marginal areas requires a concerted programme of awareness-raising, training, incentives and investment aids. Until now, horizontal and regional programmes funded by FEOGA have tended to focus on increasing productivity and quality in areas that are not marginal, in the context of the region in question. Initiatives such as LEADER offer interesting opportunities, but only on a limited scale until now.

Specific programmes aimed at addressing the needs of the olive sector in the most marginal areas are needed, with a view to:

- Improving farming practices through advisory, training and information programmes. These should apply to environmental aspects and also factors such as and cultivation and harvesting techniques to improve quality.

- Improving farm structures and co-operation between farmers.

- Improving the "valorisation" of natural and cultural values through labelling and marketing schemes.

- Promoting agro-tourism and other forms of diversification on olive farms.

These points were made strongly by many of the people interviewed during the study in all countries.

8 PRACTICAL SUGGESTIONS FOR INTEGRATING ENVIRONMENTAL PROTECTION INTO EXISTING POLICIES

Based on the information provided by all of the national and case studies and the discussion presented above, this report proposes the following policy framework for integrating environmental concerns into the CAP olive regime:

- The change from production support to a flat-rate area payment unrelated to production or yields. With the current olive regime budget and total EU olive area, a flat-rate payment would equate to approximately Euro 450 per hectare. A minimum number of trees per hectare should be established, low enough to allow very extensive, traditional plantations to benefit (e.g. 40-50 trees per hectare). Scattered trees not in plantations and with an overall density below this limit could be paid the same level of aid, but converted to a tree-basis.

- All olive producers receiving CAP support would be required to comply with locally-established codes of Good Agricultural Practice (GAP) incorporating basic environmental protection, within an EU framework.

- A higher level of area payment could be introduced (for example under the Less Favoured Areas scheme or within the proposed area-payment support scheme) for plantations in environmentally very sensitive areas and for which GAP is more demanding and implies a higher cost than in other areas.

- Agri-environment programmes would offer payments to all olive farmers in return for additional environmental services beyond GAP under schemes designed to address specific environmental priorities in the region or area.

Under a flat-rate area payment of Euro 450 per hectare, the level of support per hectare for the average, semi-intensive plantation producing around 2,500 kg of olives per hectare would be similar to at present. The support for marginal plantations would be considerably higher than at present whereas there would be a reduction from the current level of support for the most intensive plantations.

For the many marginal plantations which are not economically viable under the current regime, this higher and more consistent payment could greatly reduce the threat of abandonment and associated environmental problems.

The authors believe that the policy recommendations made in this study could, if implemented effectively, result in:

- Reduced environmental impacts of intensified olive farming, with effective maintenance and improvement of existing environmental values.

- Reduced economic losses resulting from the over-exploitation and degradation of natural resources, especially soil and water.

- Improved incomes, viability and employment on olive farms in marginal rural areas.

- Reduced production incentive leading to less risk of structural surpluses and thus more stable prices and improved viability for marginal farms.

- Practical control of payments, so that plantations established since 1998 would not receive production support, as intended by Regulation 1638/1998.

9 REFERENCES

Accademia Nazionale di Agricoltura, 1992. *Agricoltura e Ambiente.* Edagricole.

Agricultura, 1998a. *El problema eterno de la erosión.* Editorial in Agricultura No. 794, September 1998. Editorial Agrícola Española, S.A. Madrid.

Agricultura, 1998b. *Programación de riegos en olivar en la provincia de Jaén: recomendaciones de riego para el olivar en el año 1998.* Agricultura No. 795, October 1998, p 810. Editorial Agrícola Española, S.A. Madrid.

Agricultura, 2000. *Bruselas "contó" olivares y olivos.* Agricultura No. 812, February 2000, pp 95-96. Editorial Agrícola Española, S.A. Madrid.

Aguilar J.C. and Cuenca A. D., 1997. *Técnicas isotópicas para la cuantificación de la erosión.* Agricultura No. 776, March 1997, pp. 230-234. Editorial Agrícola Española, S.A. Madrid.

Aguilar Ruiz *et al*, 1995, *El olivar jiennense*. Universidad de Jaén.

Alexandrakis V., 1990. *Effect of Dacus control sprays, by air or ground, on the ecology of* Aspidiotus nerii *Bouche (Hom. Diaspididae)*. Acta Horticulturae, 286: 339-342.

Alexiou S., Platon N. and Guanella H., 1968. *Ancient Crete*. London, UK.

Allaya M. (ed.), 1988. *The olive economy*. Proc. EC-ICAMAS Ceminar, Tunisia, 20-22 January 1987. Options Mediterrannées, OQEH. Tunis, Tunisia.

AMAB, 1999. *Disciplinare di produzione.* Conditions for obtaining the brand «Garanzia Biologico AMAB». Associazione Mediterranea Agricoltura Biologica.

Anagnostopoulos P. T., 1951. *The origins of the olive tree*. Athens, Greece. (In Greek).

Androulakis I. and Loupasaki M., 1990. Effects of synthetic fertilisers on soil fertility. In: GEO. C. G. *Agrochemicals and Environment*. Proc. GEO.C.G Workshop, Chania, Crete. 7-8 Dec. 1989. Chania, Greece. (In Greek.)

Angelakis A. N., 1993. Integrated water resources management in the region of Crete. In: *Water resource management in Crete*. Greek Geotechnical Chamber, Dpt. Of Crete. May 27-28, Chania, Crete.

Angelakis A., Kosmas C. and Monopolis D., 1998. Land and water resources and their degradation in the island of Crete, Greece. *Desertification Control Bulletin, 32: 40-50*

ARSIA, 1996. *Disciplinare di produzione integrata olivo.*

ARSIA, undated. *Regione Toscana "Dieci anni di sperimentazione olivicola in Toscana".*

Associazione Culturale Buggiano Castello, undated. *Atti dei convegni "Premio Le colline dell'ulivo" 1992-95*. Provincia di Pistoia.

Associazione di produttori olivicoli, 1997. *Esperienze di assistenza tecnica in olivicolture nella provincia di Bari,* a cura di ASSO. Pr.Oli.

Balatsouras G., 1994. *The olive tree.* Pelekanos, Athens (In Greek).

Baldari M. and Di Gregorio D., 1997. *Produzioni biologiche e biodiversità: effetti del Reg. 2078 sull'olivicoltura calabrese.* Seminar report.

Baldock D. and Mitchell K., 1995. *Cross-compliance within the Common Agricultural Policy: a review of options for landscape and nature conservation.* Institute for European Environmental Policy. London.

Beaufoy G., Baldock D. and Clark J., 1994. *The Nature of Farming: low-intensity farming systems in nine European countries*. Institute for European Environmental Policy, London.

Benvenuti V., 1995. *Agricoltura Ecocompatibile - per ridurre il rischio chimico.* Provincia di Roma.

Briccoli Bati C., undated. *Metodi e sistemi dell'impianto degli oliveti*. Convegno AIAB, Cosenza.

Buckwell A., Campli M., Davidora S., Hervieu B., Rabinowicz E., Sotte F., Sumpsi Viñas J.S. and Von Meyer H., 1997. *Coltivare l'Europa*. Liocorno.

Castro C., Guerreiro M., Caldeira F. and Pinto P., 1997. *The Olive Oil Sector in Portugal: General Aspects*. Olivae 66, April 1997. International Olive Oil Council, Madrid.

CEC, 1992. *CORINE - Soil erosion risks and important land resources in the southern regions of the European Community*. EUR 13233. Office for the Official Publications of the European Community. Luxembourg.

Cirio U., 1997. *Agrichemicals and Environmental Impact in Olive Farming*. Olivae 65, February 1997. International Olive Oil Council, Madrid.

Civantos M., 1995. *Development of integrated pest control in Spanish olive orchards*. Olivae N°59: 75-81, December 1995. International Olive Oil Council, Madrid.

CNEL – Consiglio Nazionale dell'Economia e del lavoro, 1998. *La strategia della qualità nella filiera agricolo-alimentare*, 3rd Dossier, 1998.

Consejería de Medio Ambiente, 1996. *La información ambiental de Andalucía*. Junta de Andalucía. Sevilla.

Consejería de Medio Ambiente, 1997. *La información ambiental de Andalucía*. Junta de Andalucía. Sevilla.

Consorzio Interprovinciale per il Montalbano, 1993. *Montalbano, geologia, flora, fauna, storia, arte* and *Montalbano, itinerari storico-naturalistici*. Tamari Montagna Edizioni.

Convenzione ARSIA e Associazione Ambiente Lavoro Toscana, 1999. *Progetto contabilita' ambientale in agricoltura.* Final report 1999.

Delrio G., 1992. Integrated control in olive groves. In: J. C. van Lenteren, A. K. Minks and O. M. B. de Ponti (ed.) *Biological control and integrated crop protection: towards environmentally safer agriculture*. Pudoc, Wageningen, The Netherlands.

Díaz Alvarez M. C. and Almorox Alonso J., 1994. La erosión del suelo. In *Agricultura y Medio Ambiente*. El Campo, BBV, Bilbao.

EC, 1997. COM(97)57 final. Commission of the European Communities, Brussels.

EC, 1999. *Directions towards sustainable agriculture.* COM(1999)22 final. Commission of the European Communities, Brussels.

Elaiourgiki, 1996. Information Bulletin, 40 (in Greek).

European Soil Bureau, 1999. *Organic matter in the soils of southern Europe.* European Commission Joint Research Centre. Ispra.

FAO, 1972. *Study of water resources and their exploitation for irrigation in eastern Crete, Greece. Overall study of the Messara plain.* UNDP and FAO, Iraklion, Greece.

Farina A., 1981. *Osservazioni sul comportamento alimentare di alcune specie di uccelli passeriformi svernanti in zone coltivate ad olivo.* Atti Congr. S.I.E., Firenze

Fernández Quintanilla C., 1999. *Impacto ambiental de las prácticas agrícolas.* Agricultura No 810, pp. 1092-1096. Madrid.

Fialho M., 1996. *Olival & azeite: recuperar o atraso*. III Congresso da Agricultura Alentejana, Évora, 1.2.1996.

Fontanazza G., 1993. *Olivicoltura intensiva meccanizzata.* Edagricole, Bologna.

Fotopoulos C., Liodakis G. and Tzouvelekas V., 1997. *The changing policy agenda for European agriculture: its implications for the Greek olive-oil sector*. In Tracy, M., (ed.) CAP reform: the southern products. Agricultural Policy Studies, Belgium.

García Torres L., 1999. *Agricultura de conservación: estado actual y perspectivas*. Universidad Internacional de Andalucía, Baeza, 23-25 February 1999.

Gavalas N. A., 1978. *The mineral nutrition and the fertilisation of the olive tree*. Benaki Phytopathological Institute. Athens, Greece. (In Greek.).

GEO. C. G, 1993. *Management of the water resources of Crete*. Proc. GEO. C. G Workshop, Chania, Crete. 27-28 May. 1993. Chania, Greece. (In Greek.)

GEO. C. G, 1990. *Agrochemicals and Environment*. Proc. GEO.C.G Workshop, Chania, Crete. 7-8 Dec. 1989. Chania, Greece. (In Greek.)

GEO.C.G, 1994. *Management of liquid waste from oil mills*. Proc. GEO. C. G 3rd International Conference on Management of Liquid Waste from Oil Mills, Sitia, Crete. 16-7 June. 1994, Sitia, Greece.

Giuseppe de Meo, 1996. *La filiera olivicola – olearia in Puglia.* Puglia grafica Sud – Bari.

González Yélamos J., 1997. *La contaminación de acuíferos por pesticidas agrícolas.* Vida Rural No.55, 15 November 1997, p.72.

Grazia Valentino, Domenico Ragno, Sebastian De Giuseppe, 1998. *Le politiche agroambientali*, Rapporto annuale-sistema agroambientale e programmazione, INEA.

GRFA, 1987. *Gli antiparassitari nell'agricoltura italiana - Effetti su salute e ambiente.* Atti.

Grove A. T. and Rackham O., 1996. *Physical, biological and human aspects of environmental change*. In: Medalus II Project 3, Managing desertification. EV5V-CT92-0165.

Grove J. M. and O. Rackham, 1993. *Threatened landscapes in the Mediterranean: examples from Crete*. Landscape and Urban Planning, 24:279-292.

Grove J. M., Grove A. T. and Rackham O., 1991. *Crete and the South Aegean Islands: effects of changing climate on the environment*. Unpublished Report. EC Contract EV4C-0073-UK.

Guerrero A., 1994. *Nueva olivicultura*. Third edition. Ediciones Mundi Prensa.

Guerrero A., 1997. *Nueva olivicultura*. Fourth edition. Ediciones Mundi Prensa.

Guzmán Álvarez J. R., 1999. *Olivar y ecología:estado de la cuestión en España.* Olivae No. 78, October 1999, pp. 41-49. International Olive Oil Council, Madrid.

Hartmann H. T., Optiz K. W. and Beutel A. J., 1980. *Olive production in California*. Division of Agricultural Sciences, University of California, Davis, Leaflet 2474:45.

Hidalgo J., Bellver A., Gallego C., Vega V. and Pastor M., 1998. *Olivares de riego en Jaén.* Agricultura No. 795, October 1998, pp 806-809. Editorial Agrícola Española, S.A. Madrid.

Iacoponi L., Miele M. and Rovai M., 1988. *Strutture e tecniche produttive nell'agricoltura intensiva e riflessi ambientali.* In Atti del XXV Convegno studi SIDEA. Ancona.

Iannotta N. and Maiolo B.. *Valore territoriale dell'olivicoltura: sistemi olivicoli e paesaggio*. Convegno AIAB, Cosenza.

Il Divulgatore, 1997. *Agricoltura e dissesto Idrogeologico CDA*. Edagricole.

Il Divulgatore, Monography, 1998. *Olio, Qualità e Tipicità.* Centro Divulgazione Agricola, Provincia di Bologna, Dec. 1998.

INEA, 1997. *L'Agricoltura in Puglia 1997*, Osservatorio sul mondo rurale e sul sistema agroindustriale della Puglia. Istituto Nazionale di Economia Agraria.

INEA, 1998. *Rapporto sull'olio di oliva*. Istituto Nazionale di Economia Agraria. September 1998.

INEA, 1999. *Le misure agroambientali in Italia - Analisi e valutazione del Reg. 2078/92 nel quadriennio 1994-97 - Rapporti regionali ; Rapporto nazionale* (2 volumes). Istituto Nazionale di Economia Agraria.

IOOC, 1996. Information report. 806, Madrid: IOOC.

IRPET (Istituto per la Programmazione economica della Toscana), 1981. *Schema di piano per l'area del Montalbano*. Relazioni ed interventi del convegno di Vinci, July 1981.

ISMEA, 1998. *La filiera dell'olio di oliva*.

ISPOT/IOOC, 1980. *Proceeding of the IIId International Congress on the biological value of the olive oil*. Institute of Subtropical Plants and Olive Tree, Crete. 8-10 Sep. 1980, Chania, Greece.

ISPOT/IOOC, 1991. *Olive oil quality improvement*. Proc. Institute of Subtropical Plants and Olive Tree International Seminar, Chania 26 Nov.-1 Dec. 1990, Crete, Greece.

ISTAT, 1995. Agricultural Statistics. Istituto Italiano di Statistica.

Jardak T. and Ksantini M., 1996. *Key elements of, and economic and environmental need for, a modified approach to olive crop care in Tunisia*. Olivae 61:24-33

Junta de Andalucía, 1997. *Orden de 12 de agosto de 1997, por la que se aprueba el Reglamento Específico de Producción Integrada de Olivar.* Boletín Oficial Junta de Andalucía No 100, pp. 10,543-10,555. Sevilla.

Kabourakis E., 1995. *Designing ecologically advanced olive production*. Proc. 10th IFOAM Scientific Conference, Lincoln University, New Zealand, 11-16 December 1994, Lincoln University, New Zealand.

Kabourakis E., 1995. *Practiche colturali per un'olivicoltura ecologicamente avanzata: l'esperienza di Creta.* Bioagricultura, July 1995 (In Italian).

Kabourakis E., 1996. *Prototyping and dissemination of ecological olive production systems. A methodology for designing and a first step towards validation and dissemination of prototype ecological olive production systems (EOPS) in Crete.* PhD Thesis. Wageningen Agricultural University. The Netherlands.

Kabourakis E., 1996. *Prototyping and dissemination of ecological olive production systems. A methodology for designing and a first step towards validation and dissemination of prototype ecological olive productions systems (EOPS) in Crete.* Published PhD thesis. Wageningen Agricultural University, The Netherlands.

Kabourakis E., 1997. Corrette pratiche di olivicoltura ecologica a creta. In: *Tembi, modi e problematiche della fase di conversione*. Proceedings of an international seminar, 27 September, Umbertide (PG), ARUSIA, Perugia, Italy. (In Italian).

Kabourakis E., 1998. Ogranic olive production. In: *2000 olive production*. Agricultural Technology Publications, Athens Greece (In Greek).

Kabourakis E., 1998. *Traditional mixed farming systems in Crete - paradigms of developing sustainable farming systems*. Proc. Workshop on Mixed Farming Systems in Europe, 25-28 May, Wageningen, The Netherlands.

Kabourakis E., 1999. *Code of practices for ecological olive production systems in Crete.* Olivae 77: 46-55

Kedros, K., Margaris N. S. And Chodzeas S. (eds.), 1988. *The olive groves of the Aegean Sea*. Proceedings of the scientific conference in Mitilini 25-27/2/1988. University of Aegean Sea, Ministry of Agriculture, District of Lesbos, Mitilini, Greece. (In Greek.)

Lenza, X. 1991. *Biocide residues in olive oil. A primary qualitative characteristic.* (In Greek) Elaiourgiki 25: 37-49.

López Sánchez-Cantalejo J., 1996. *1983-1995: trece años de mudanza en la agricultura española*. In El Boletín N°31, Ministerio de Agricultura, Pesca y Alimentación, Madrid.

MAPA, 1988. *El olivar español: planes de reestructuración y reconversión*. Ministerio de Agricultura, Pesca y Alimentación, Madrid.

MAPA, 1994. *Programa de ayudas para fomentar métodos de producción agraria compatibles con las exigencias de la protección y la conservación del espacio natural*. Ministerio de Agricultura, Pesca y Alimentación, Madrid.

MAPA, 1999. *Programa agroambiental de apoyo y mantenimiento del olivar* - draft. Ministerio de Agricultura, Pesca y Alimentación, Madrid.

Martín Bellido M. (ed.), 1999. *Congreso hispano-luso: agricultura de conservación y medio ambiente.* Proceedings p123. Don Benito 21-22 October 1999. Junta de Extremadura. Badajoz.

Ministry of Agriculture, 1993. *Medias Agro-Ambientais: Proposta de Aplicacão a Portugal Para o Período 1994-1998*. Instituto das Estruturas Agrárias e Desenvolvimento Rural. December 1993. Lisbon.

Ministry of Agriculture, 1999. *Medias Agro-ambientais 1998/99.* Lisbon

Ministry of National Economy 1992. Report/discussion paper on the oil sector. Athens.

Mitsotakis A., 1999*. Sectorial study for the production and process of oils with special emphasis in olive oil*. ATE, Athens. In press.

MMA, 1999. *Programa de acción nacional contra la desertificación. Borrador de trabajo.* Ministerio de Medio Ambiente, Secretaría General de Medio Ambiente. Madrid.

MODAA, 1998. *A Agricultura Alentejana e o Futuro.*

Mondo Agricolo: Difesa dell’olio d’oliva, un impegno a 360 gradi (Oct. 1998)

Montiel Bueno A., 1998. *Olivicultura tradicional, olivicultura sostenible.* Agricultura No. 795, October 1998, pp 802-804. Editorial Agrícola Española, S.A. Madrid.

National Statistical Service. *Agricultural statistics*. Several years. Athens, Greece

Naveh Z., 1993. *Red books for threatened Mediterranean landscapes as an innovative tool for holistic landscape conservation. Introduction to the western Crete red book case study.* Landscape and Urban Planning 24*:* 241-247.

Pain D, 1994, Case studies of farming and birds in Europe: olive farming in Portugal. *Studies in European Agriculture and Environment Policy N°9*, RSPB, Birdlife International.

Pajarón Sotomayor M., 1997. *Manual para el cultivo ecológico del olivar.* Paper presented at Ecoliva 1997, Jaén.

Papageorgiou, C. L. 1994. *The role of the olive tree in Greece*. Olivae 19 : 7-11.

Parra, F., 1990, *La dehesa y el olivar*. Enciclopedia de la Naturaleza de España. Editorial Debate/Adena-WWF España, Madrid.

Pastor M. and Castro J., 1995. *Soil management systems and erosion*. Olivae N°59, December 1995. International Olive Oil Council, Madrid.

Pastor M., Castro J. and Humanes M. D., 1997. *La erosión y el olivar*. AELC/SV Ficha técnica no. 2, Córdoba.

Pastor M., Castro J. And Vega V., 1998. *Programación del riego de olivar en Andalucía.* Agricultura No. 788, March 1998, pp 206-207. Editorial Agrícola Española, S.A. Madrid.

Pastor M., Castro J., Humanes M. D. and Saavedra M., 1997. *La erosión y el olivar: cultivo con cubierta vegetal*. Junta de Andalucía, 1997.

Petretti F., 1995. *The cultivation of olive trees in Grosseto.* Unpublished report produced for the Institute for European Environmental Policy, London.

Polidori R., Rocchi B. and Stefani G., 1997. Reform of the CMO for olive oil: current situation and future prospects. In Tracy, M., (ed.) *CAP reform: the southern products*. Agricultural Policy Studies, Belgium.

Porciani G., undated. *Manuale Edagricole*, Edizioni agricole.

Provincia di Pistoia, Servizio Economie aziendali: atti della Conferenza Provinciale Agraria, 8 novembre 1996

Regione Toscana, proposta di Deliberazione n. 2095: *Piano di sviluppo rurale della Toscana periogdo 2000-2006* Reg. (CE) n. 1257 del 17/05/99 *Sostegno dello sviluppo rurale da parte della FEOGA*

Regolamento C.E. 528/99 *Progetto Regionale per il miglioramento qualitativo M,della produzione di olio di oliva*

Renato Ferretti, undated. *Agricoltura collinare, difesa del suolo e ruolo dell'olivicoltura in Valdinievole*. Associazione culturale Buggiano Castello, Provincia di Pistoia.

Rodenas Lario M., Sancho Royo F., Ramirez Díaz L. and Gonzalez Bernaldez F., 1977. Ecosistemas del area de influencia de Sevilla. Monografía 18. Doñana: *Prospección e Inventario de Ecosistemas*. ICONA, Madrid.

Rubiales M. D., 1996. *La pérdida de biodiversidad y la erosión provocan la emigración de tierras agrarias.* Europa Agraria, December 1996, p.46. Sevilla.

Rubio J. L. and Rickson R. J., 1990. *Strategies to combat desertification in Mediterranean Europe*. CEC, EUR 11175, Office for Official Publications of the European Communities, Luxembourg.

Ruiz Torres M. J., 1998. *Efectos secundarios de plaguicidas sobre la entomofauna del olivar.* Paper presented at Ecoliva, II Jornadas mediterráneas de olivar ecológico.

Saavedra Saavedra M. M., 1998. *Flora del olivar y manejo de herbicidas.* Paper presented at Universidad Internacional de Andalucía, Baeza.

Sánchez Parra I., 1998. *Estudio comparativo de residuos de pesticidas producidos por diferentes técnicas de control de plagas del olivo*. Paper presented at Ecoliva, II Jornadas mediterráneas de olivar ecológico.

Scazziota B., Toscano P. and Agostino M., 1999. *Olivicoltura di qualità a basso impatto ambientale.* Bio Agricoltura – AIAB.

Sfakiotakis E., 1993. *Courses on olive growing*. Typo MAN. Thesaloniki, Greece (In Greek).

Sfikas G., 1989. *Animals and mammals of Crete*. Efstathiadis. Athens, Greece.

Sfikas G., 1992. *Wild flowers of Crete*. Efstathiadis. Athens, Greece.

Silvestri E., 1999. *Le catture massali per il controllo della Mosca delle olive*, Olivo & Olio No. 9.

Standish R., 1960. *The first of trees: the story of olive*. London: Phoenix House Ltd.

Stobbelaar D. J., Kuiper J., van Mansvelt J. D. and Kabourakis E., 2000. *The landscape quality on organic farms in the Messara valley, Crete. Organic farms as components in the landscape*. Agriculture, ecosystems and environment 77 (2000) 79-93

Studio preliminare sull'agricoltura biologica in Puglia, Istituto Agronomico di Bari, 1998.

Tombesi A., Michelakis N. and Pastor M., 1996. *Recommendations of the Working Group on Olive Farming Production Techniques and Productivity*. Olivae 63, October 1996.

Tzouvalekas V., 1998. *Efficiency in agricultural production: the case study of olive-growing farms in Greece*. PhD Thesis. Welsh Institute of Rural Studies. University of Wales, Aberystwyth.

UPA, 1998. *Resumen del informe de UPA sobre la reforma del sector olivarero.* La Tierra No. 147, March-April 1998. Unión de Pequeños Agricultores, Madrid.

UPA-C-LM, 1999. *Manual de buenas prácticas agrarias: vid y olivo.* Unión de Pequeños Agricultores Castilla-La Mancha and Instituto de Formación y Estudios Sociales. Toledo.

Vardavas, I. M., Kolovos A. and Papamastorakis A., 1999. *A daily rainfall-runoff water budget model for the desertification threatened Messara valley in Crete.* In press. Water Resources Research.

Vassiliou A., (forthcoming). *Farm structure optimisation of, and the impact of widespread conversion to Ecological Olive Production Systems*. PhD Dissertation. WIRS University of Wales.

Vassiliou A., Anefalos and Ntafis A., 1992. *Performance and economies of scale of the large agricultural cooperatives of Crete*. Mediterranean Agronomic Institute of Chania, Chania.

Vassiliou, G., Fytizas R. and Ioannou A., 1985. *Toxic effects on the mosquito-fish from insecticides air-spays against* Dacus olea. Med. Fac. Landbouww. Rijksuniv. Gent, 50/3a, 1985

WWF, 1999. *A last chance for the Iberian lynx?* World Wide Fund for Nature, UK. Godalming.

WWF, 2000. *Implementing the EU Water Framework Directive: A seminar series on water.* Proceedings of Seminar 1, 10-11 February 2000. WWF European Policy Office. Brussels.

Yassoglou N., 1971. *A study of the soil of Messara valley in Crete, Greece*. Greek Nuclear Research Centre, Athens, Greece.