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NEW TOOLS FOR AGRICULTURE AND FORESTRY STATISTICS

Proceedings of the Oporto Workshop, 19 to 20 October 1995

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STATISTISCHES AMT DER EUROPÄISCHEN GEMEINSCHAFTEN
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Y. Franchet
Generaldirektor

It is Eurostat's responsibility to use the European statistical system to meet the requirements of the Commission and all parties involved in the development of the single market.

To ensure that the vast quantity of accessible data is made widely available, and to help each user make proper use of this information, Eurostat has set up two main categories of document: statistical documents and publications.

The statistical document is aimed at specialists and provides the most complete sets of data: reference data where the methodology is well-established, standardized, uniform and scientific. These data are presented in great detail. The statistical document is intended for experts who are capable of using their own means to seek out what they require. The information is provided on paper and/or on diskette, magnetic tape, CD-ROM. The white cover sheet bears a stylized motif which distinguishes the statistical document from other publications.

The publications proper tend to be compiled for a well-defined and targeted public, such as educational circles or political and administrative decision-makers. The information in these documents is selected, sorted and annotated to suit the target public. In this instance, therefore, Eurostat works in an advisory capacity.

Where the readership is wider and less well-defined, Eurostat provides the information required for an initial analysis, such as yearbooks and periodicals which contain data permitting more in-depth studies. These publications are available on paper or in videotext databases.

To help the user focus his research, Eurostat has created 'themes', i.e. subject classifications. The statistical documents and publications are listed by series: e.g. yearbooks, short-term trends or methodology in order to facilitate access to the statistical data.

Y. Franchet
Director-General

Pour établir, évaluer ou apprécier les différentes politiques communautaires, la Commission européenne a besoin d'informations.

Eurostat a pour mission, à travers le système statistique européen, de répondre aux besoins de la Commission et de l'ensemble des personnes impliquées dans le développement du marché unique.

Pour mettre à la disposition de tous l'importante quantité de données accessibles et faire en sorte que chacun puisse s'orienter correctement dans cet ensemble, deux grandes catégories de documents ont été créées: les documents statistiques et les publications.

Le document statistique s'adresse aux spécialistes. Il fournit les données les plus complètes: données de référence où la méthodologie est bien connue, standardisée, normalisée et scientifique. Ces données sont présentées à un niveau très détaillé. Le document statistique est destiné aux experts capables de rechercher, par leurs propres moyens, les données requises. Les informations sont alors disponibles sur papier et/ou sur disquette, bande magnétique, CD-ROM. La couverture blanche ornée d'un graphisme stylisé démarque le document statistique des autres publications.

Les publications proprement dites peuvent, elles, être réalisées pour un public bien déterminé, ciblé, par exemple l'enseignement ou les décideurs politiques ou administratifs. Des informations sélectionnées, triées et commentées en fonction de ce public lui sont apportées. Eurostat joue, dès lors, le rôle de conseiller.

Dans le cas d'un public plus large, moins défini, Eurostat procure des éléments nécessaires à une première analyse, les annuaires et les périodiques, dans lesquels figurent les renseignements adéquats pour approfondir l'étude. Ces publications sont présentées sur papier ou dans des banques de données de type vidéotex.

Pour aider l'utilisateur à s'orienter dans ses recherches, Eurostat a créé les thèmes, c'est-à-dire une classification par sujet. Les documents statistiques et les publications sont répertoriés par série — par exemple, annuaire, conjoncture, méthodologie — afin de faciliter l'accès aux informations statistiques.

Y. Franchet
Directeur général

NEW TOOLS FOR AGRICULTURE AND FORESTRY STATISTICS

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SESSION 1

SPECIFIC CHARACTERISTICS OF SOUTHERN EUROPEAN AGRICULTURE

SPECIFIC ASPECTS OF THE INFORMATION SYSTEMS OF AGRICULTURAL STATISTICS OF THE COUNTRIES OF SOUTHERN EUROPE

Giuseppe Calo´
Eurostat - Luxembourg

Introduction

Responsibility for organising the information systems of agricultural statistics in the countries of southern Europe is generally vested in their National Statistical Institutes (NSIs) and Ministries of Agriculture. The present-day differences in the distribution of responsibility between these two bodies in the different countries reflect the balance in the distribution of administrative functions which has developed historically in each country.

Hence, for example, the striking contrast between the situation in France where the system is strongly concentrated in the Ministry of Agriculture and more particularly in the Central Surveys and Statistical Studies Unit of that Ministry, and the situation in Italy where it is largely the responsibility of the Agricultural Statistics Directorate of the National Statistical Institute (ISTAT). The situation in Greece, Spain and Portugal can be described as half-way between these two extremes.

I have not delved more deeply into the historical reasons for the different patterns of development in the individual countries, but it should be noted that these two bodies have had to cooperate, especially since the establishment of the European Community and the Common Agriculture Policy.

It is also patently obvious to me that the development of the system has been quicker and more effective in the countries in which this cooperation has been based on a distribution of tasks which is geared to the resources that are available. On the other hand, in the countries suffering from a structural imbalance between the distribution of resources and the tasks to be carried out, the system has suffered from functional shortcomings which have necessitated restructuring operations.

The technical and administrative structure of the information systems

The organization of data collection systems for agricultural statistics must be based on an optimally decentralized technical and administrative infrastructure ensuring an accelerated reaction, at no additional cost, to the verification of the data at local level before their transmission to Eurostat.

Ideally, at this stage of the collection process, we should have the computing resources to carry out probability tests when inputting the data supplied in the questionnaire. The quality of the results also depends on the level of training of the enumerators and their familiarity with the subject of the survey.

The Commission's contribution to the establishment of this regional infrastructure throughout the EU has involved the organization of specific projects in certain countries of southern Europe, in particular in connection with the restructuring plans financed by the EU first in Italy, then in Greece and most recently in Portugal.

The inescapable need to regionalize the organization of statistical surveys is imposed by the fact that agriculture in the countries of southern Europe is characterized by a very large number of holdings of very modest size in relation to the EU average. These relatively small holdings still account for a considerable proportion of total agricultural production, and they furthermore need to be treated with particular attention in the context of the rural development of certain regions.

The existing system is based on the EU legislation obliging the Member States to carry out regular surveys of agricultural holdings: these surveys focus on the structural aspects, viticulture, fruit trees, livestock and milk production. There is also an obligation to provide information on the production of cereals, other oleaginous products and protein crops.

All these data collected in accordance with the EU legislation must be broken down on a geographical basis in order to meet the need for information not only at EU level but also at national, regional and even infra-regional level. Hence the EU's strategy of involvement of the local authorities in the phases of collection and use of the data which concern them. The system must implicate local authorities in these two phases in order to ensure their contribution to the collection, processing and dissemination of the data in question.

Introduction of new collection tools into the system

The action taken by Eurostat in the countries of southern Europe (Italy, Greece and Portugal) has consisted in the provision of support for projects like the restructuring plans which are co-financed by the EU Budget.

These projects had two objectives in each Member States:

- the establishment of a permanent technical and administrative infrastructure at the central and local levels with the capacity to carry out the collection, processing and verification stages of surveys of agricultural holdings;
- the establishment of a sample survey system to be implemented by permanent and properly qualified staff.

The present situation is one in which the execution of a large number of annual surveys involving the collection of data from individual holders is a particularly burdensome operation for the following two reasons in particular:

- the high cost of employing qualified personnel to collect the data;
- the annual response workload which the holders have to bear.

Hence the idea of using sampling techniques to reduce both the cost of surveys and the burden on the respondents. It must also be pointed out that a different approach has been adopted in the countries of northern Europe which endeavour to attain the same objectives by exploiting the available administrative data for statistical purposes.

The countries of southern Europe are making more and more use of the sampling techniques which are more readily applicable to their agricultural structures and which include in particular:

a) multi-purpose sampling;

b) area-frame sampling;

c) multi-frame sampling.

Surveys based on a) can minimize the employment of enumerators and enable the collection, in the course of a single visit, of the data required for the purpose of meeting several EU requirements.

Surveys based on b), on the other hand, can mainly be used for integrating the data collected under a) with the data on holdings below a certain threshold, for which the traditional type of survey would be too expensive.

Finally, surveys based on c) are a judicious combination of types a) and type b).

THREE IMPORTANT CHARACTERISTICS: MIXED LAND USE, FALLOW LAND AND SET-ASIDE

Michel Poiret
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Summary

The TERUTI survey is carried out every year as a means of studying land use. It takes the form of direct observation at more than 500 000 locations throughout France. The survey, which is not based on agricultural or forestry activity, provides information on rural land, irrespective of whether it is used, i.e. it covers areas under crops, fallow and waste land, as well as woodland. The observation points are permanent. This makes it possible to study the transition from one type of land use to another, and provides a sampling base which is updated every year. Land use in France's Mediterranean rim and Corsica is very different from that in northern France. What we refer to as the southern zone of France is mainly covered by forests (35% of the total area), moorlands and agricultural land which is fairly unproductive (grazing land, including alpine meadow). A large area is used for purposes other than agriculture. Farms in the region tend to have fewer field crops and perennial crops are more common. Mixed crops (e.g. cereals and fruit trees grown together on one plot) are fairly widespread. It is traditional for part of the UAA to be fallow, depending on the crop rotation system, sowing possibilities and the grubbing of vines and orchards. Because of the small size of holdings in the region, set-aside has led to only a small increase in the amount of fallow land, unlike in northern France. The use to which land is put fluctuates: some parcels are taken out of the UAA and subsequently reincorporated in it. A feature of land use in the southern zone is that the utilization of large areas (e.g. for crops, meadow, moorland or forest) changes considerably over time. Within the UAA, there are vast fluctuations in area devoted to annual crops, fallow land, perennials (vines and fruit trees) and grassland.

Introduction

Some definitions of the terms which will be used in this paper :

- **Fallow land**: land which is included in a crop rotation system and which was cultivated the previous year but is not being used for agricultural purposes in the current year.
- **Set-aside**: land which is not under crops or which is under a crop which will not be harvested or a non-food crop within the meaning of the Common Agricultural Policy and the system of compensatory payments for land set-aside.
- **Waste land**: land which is not included in a crop rotation system and which was formerly cultivated but has not been used for agricultural purposes for several years.
- **Moorland**: a large area of land covered mainly by grass but where ligneous plants occupy more than 25% of the surface and woodland less than 10%.

The southern zone is defined as the area where olive trees have traditionally been grown. It includes three administrative regions which border the Mediterranean. There are two main features of agriculture in this region:

- complex structures which mix perennials (vines and fruit trees) with annual crops, meadow and fallow land;
- fluctuations between types of land use, both agricultural and unused land (e.g. grazing land not under crops and not used every year).

France has developed a tool which provides information on land use, including land not used for agricultural purposes (e.g. pasture and moorland). This tool is the TERUTI (territory utilisation) survey, a land-use survey carried out by means of area sampling.

1. The TERUTI survey

The TERUTI survey is done using area sampling. The sample comprises about 550 000 observation points throughout France, chosen at random and systematically. They are not stratified. Two classifications are used to describe the observation points, which are visited every year. The first, concerned with the physical use of the land observed, records 82 items of information. The second, concerned with the functional use of the land, records 24 items. By way of example: Maize - agricultural production; forest - timber production; moorland - no use. Cross-referencing the two classifications provides information relating to land use.

The sample is permanent. This maximizes the accuracy of the fieldwork and makes it possible to follow trends in land use over time. Extrapolation is simple and robust. The total surface area is 55 million ha. An observed area of 9 m2 is extrapolated to 100 ha. The survey provides information which is representative at département level. At national level, and given a binomial distribution which overestimates relative error, an area of 1 million hectares can be surveyed to within 2% accuracy.

2. Land use in France's southern zone

The southern zone accounts for 12% of French territory, but 42% of its land under perennial crops, 41% of its moorland, grazing land and alpine meadow, 34% of its outcrop, glaciers and inland waters, and 17% of its forest.

Table 1 - Importance of southern zone compared with the total France

VINES AND FRUIT TREES	42 %
MOORLAND,GRAZING LAND,ALPINE MEADOWS	41 %
OUTCROP - GLACIERS - INLAND WATERS	34 %
FOREST	17 %
SOUTHERN ZONE	***12 %***
ANNUAL CROPS	3 %
MEADOWS	3 %

19% of the region is utilized agricultural area, compared with 56% in the rest of the country. Perennials predominate, covering 8% of the region. Vines are usually cultivated as a sole crop (98%). Fruit trees are generally mixed with other crops (28% of the UAA). Plots in the southern zone are usually small and their crops are sometimes mixed with trees. 35% of the region is covered by forest and 27% by moorland, pasture and alpine meadow. Although not formally part of the UAA, some of this land is in fact used for agricultural purposes. 7% of the area under deciduous forest is so used, either regularly or occasionally, while 11% of moorland is occasionally used by farmers. The southern zone is therefore characterized by mixed land use.

Table 2 - Structure of southern zone territory compared with the rest of France

	S. ZONE	REST
FOREST	35	25
MOORLAND, GRAZING LAND, ALPINE MEADOWS	27	5
OUTCROP - GLACIERS - INLAND WATERS	9	3
VINES AND FRUIT TREES	8	2
ANNUAL CROPS	6	31
MEADOWS	5	23
OTHERS	9	11

Most grassland in northern France comprises cultivated meadow which produces more than 1 500 feed units per year. In the southern zone, this type of land accounts for just 18% of total grassland, 42% of which is moorland, 25% grazing land and 11% alpine meadow. Some of this land is shared by several stockowners. There is

25% grazing land and 11% alpine meadow. Some of this land is shared by several stockowners. There is estimated to be 1.4 million hectares of grassland not used for agricultural purposes. The southern zone is therefore characterized by large, fairly unproductive areas under grass (moorland, grazing land and alpine meadow), some of which is not used for agricultural purposes.

Table 3 - Structure of southern grassland compared with the rest of France

		1000 ha		%	
		S.ZONE	*REST*	*S.ZONE*	*REST*
MOORLAND	no use	920	967	42	7
GRAZING LAND	agricultural use	528	697	25	
MEADOWS	agricultural use	388	11103	18	81
ALPINE MEADOW	agricultural use	241	425	11	3
FALLOW LAND	no use	97	532	4	4

Part of the UAA is traditionally kept fallow, depending on the crop rotation system, the possibilities for sowing and, most importantly, the grubbing of vines and fruit trees. Between 1982 and 1992, most fallow land in France was concentrated in the southern, southwestern and the central regions. Because of the small size and particular features of holdings in the southern zone, set-aside has led to only a small increase in fallow land there, unlike in northern France. The southern zone is therefore characterized by a tradition of fallow land, especially following the grubbing of vines. Set-aside has had only limited impact there.

3. Changes in types of land use over time

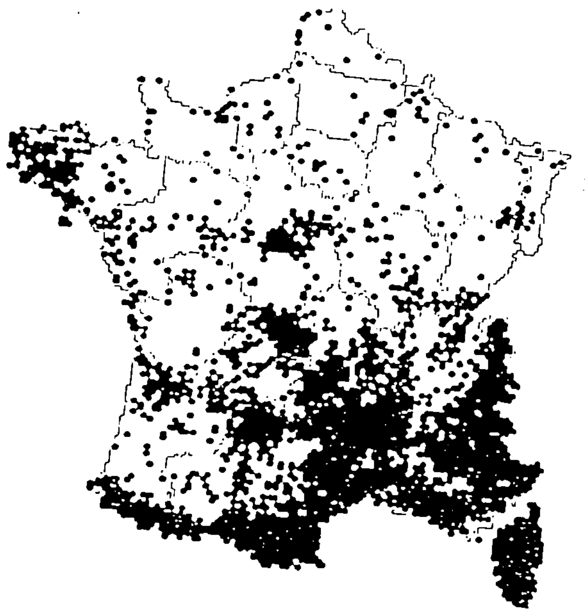
Because of mixed land use and the large area not used for agricultural purposes in the southern zone, changes in the type of land use over time are more frequent there than in the north of the country. Annual crops are rotated with perennials or fairly unproductive grassland (moorland, grazing land and alpine meadow), unlike in northern France, where they are rotated with pasture. In the southern zone, land use exchanges between moorland, grazing land and alpine meadow on the one hand and woodland on the other. The most notable exchanges involve land formerly used for pasture and annual crops being switched to moorland, grazing land and alpine meadow or to forest, an indication of land being set aside.

Conclusion

In northern France, the TERUTI survey provides information on land mainly under field crops (cereals, oilseeds, protein crops and meadows). It also provides an interesting sampling base for plots and the holdings which operate them (for example, the generation of a sample not based on a register plots for studying crop-farming practice and the establishment of a sample of private households cultivating home gardens.

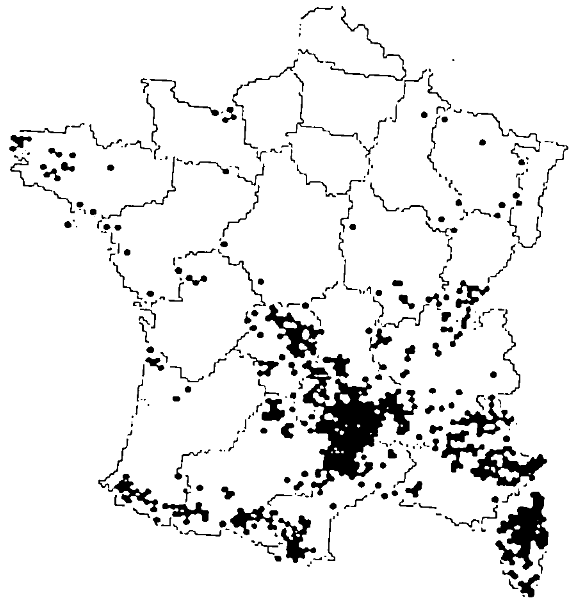
In the southern zone, TERUTI is essential as a means of estimating how much land is used at the limits of agricultural production. By using the same observation points every year, it is possible to study trends in and the numerous exchanges between the different types of land use, for example, set-aside and urban development.

MOORLAND, GRAZING LAND AND ALPINE MEADOW IN 1994



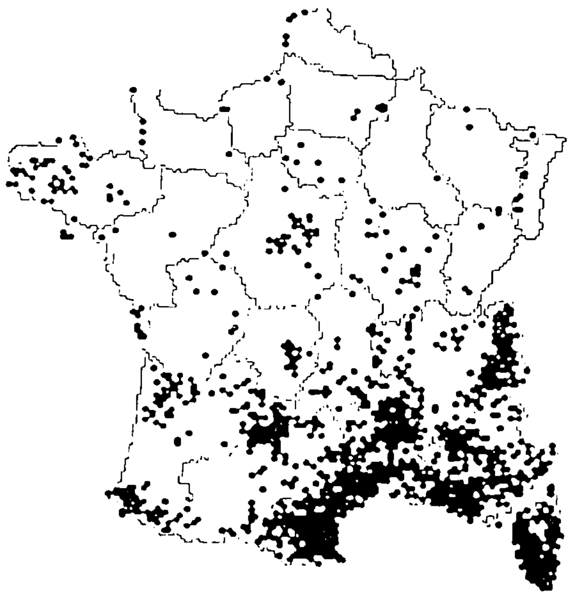
source : SCEES, survey TERUTI

PASTURE LAND IN 1994



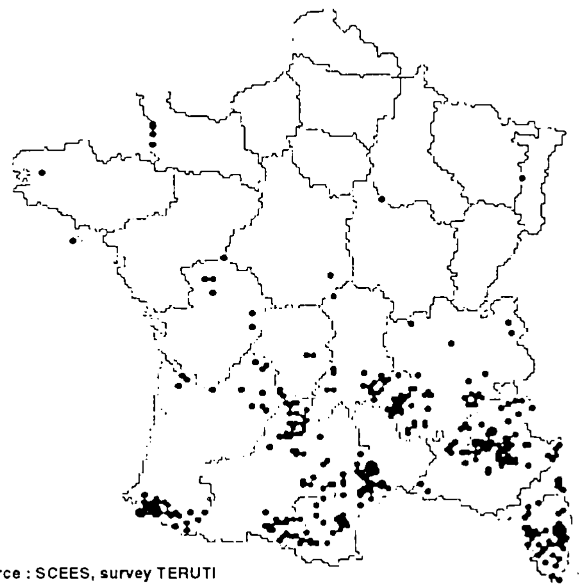
source : SCEES, survey TERUTI

MOORLAND IN 1994



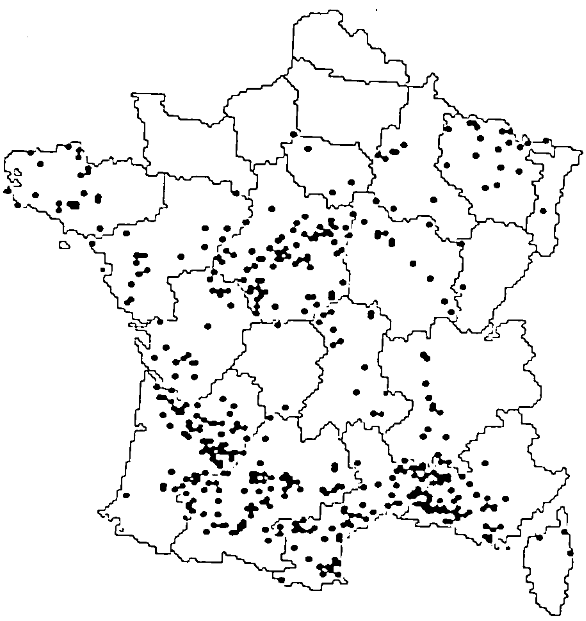
source : SCEES, survey TERUTI

OCCASIONAL AGRICULTURAL USE OR MOORLAND IN 1994



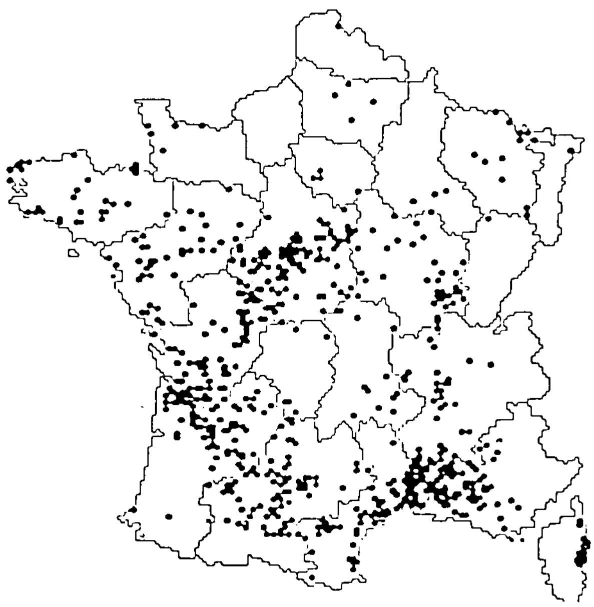
source : SCEES, survey TERUTI

FALLOW LAND IN 1982



source : SCEES, survey TERUTI

FALLOW LAND IN 1988



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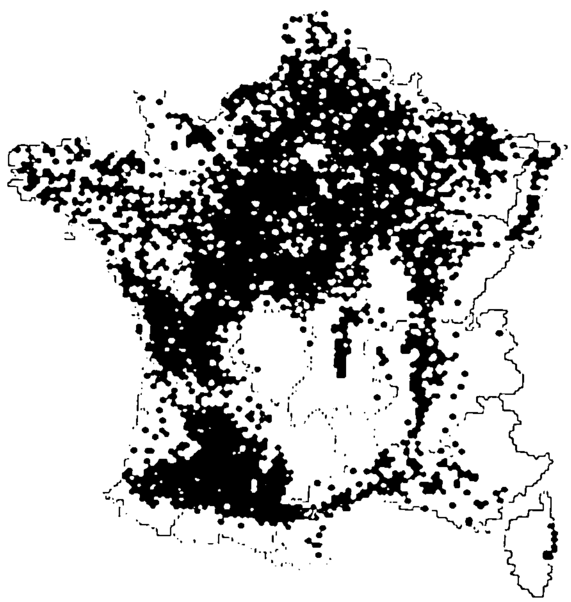
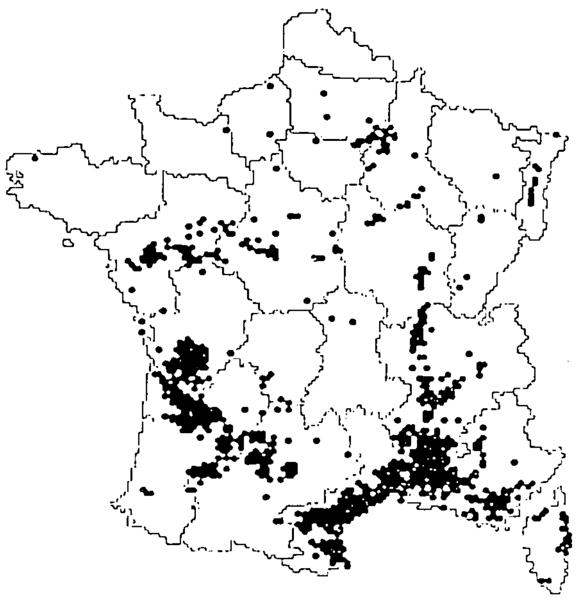
FALLOW LAND IN 1994



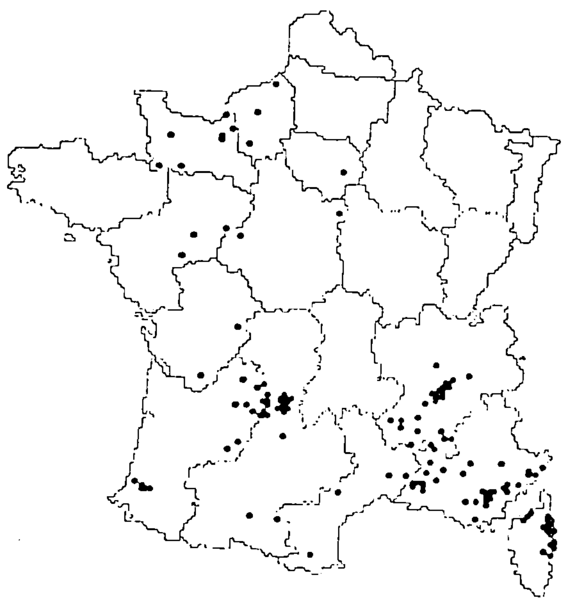
source : SCEES, survey TERUTI

VINES AND FRUIT TREES
IN 1994



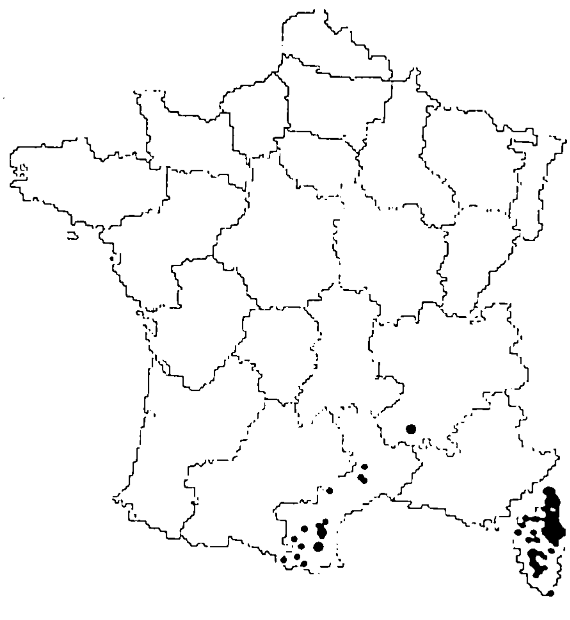
source : SCEES, survey TERUTI

FRUIT TREES GROWN WITH
OTHER CROPS
IN 1994



source : SCEES, survey TERUTI

AGRICULTURAL USE OF
DECIDUOUS FOREST
IN 1994



source : SCEES, survey TERUTI

TABLE OF CHANGES BETWEEN 1993 AND 1994

source : SCEES, TERUTI survey

SOUTHERN ZONE (in hectares)		Moorland-Grazing Land Alpine Meadow in 1994	FOREST in 1994	ANNUAL CROP in 1994	VINES AND FRUIT TREES in 1994	Meadows in 1994	OTHER in 1994	TOTAL in 1994
MOORLAND-GRAZING LAND-ALPINE MEADOW	in 1993	1 681 940	80 406	11 142	5 557	11 645	26 798	1 817 488
FOREST	in 1993	30 864	2 378 439	701	793	699	10 347	2 421 843
ANNUAL CROP	in 1993	21 066	399	351 959	8 383	19 239	3 777	404 823
VINES AND FRUIT TREES	in 1993	8 936	1 377	17 006	525 115	587	2 181	555 202
MEADOWS	in 1993	15 385	1 888	21 150	1 179	274 503	3 081	317 186
OTHER	in 1993	28 530	21 285	2 289	2 972	1 185	1 254 512	1 310 773
TOTAL	in 1993	1 786 721	2 483 794	404 247	543 999	307 858	1 300 696	6 827 315

SOUTHERN ZONE (in %)		Moorland-Grazing Land Alpine Meadow in 1994	FOREST in 1994	ANNUAL CROP in 1994	VINES AND FRUIT TREES in 1994	Meadows in 1994	OTHER in 1994	TOTAL in 1994
MOORLAND-GRAZING LAND-ALPINE MEADOW	in 1993	94	3	3	1	4	2	27
FOREST	in 1993	2	96	0	0	0	1	35
ANNUAL CROP	in 1993	1	0	87	2	6	0	6
VINES AND FRUIT TREES	in 1993	1	0	4	97	0	0	8
MEADOWS	in 1993	1	0	5	0	89	0	5
OTHER	in 1993	2	1	1	1	0	96	19
TOTAL	in 1993	100	100	100	100	100	100	100

SOUTHERN ZONE (en %)		Moorland-Grazing Land Alpine Meadow in 1994	FOREST in 1994	ANNUAL CROP in 1994	VINES AND FRUIT TREES in 1994	Meadows in 1994	OTHER in 1994	TOTAL in 1994
MOORLAND-GRAZING LAND-ALPINE MEADOW	in 1993	93	4	1	0	1	1	100
FOREST	in 1993	1	98	0	0	0	0	100
ANNUAL CROP	in 1993	5	0	87	2	5	1	100
VINES AND FRUIT TREES	in 1993	2	0	3	95	0	0	100
MEADOWS	in 1993	5	1	7	0	87	1	100
OTHER	in 1993	2	2	0	0	0	96	100
TOTAL	in 1993	26	36	6	8	5	19	100

TABLE OF CHANGES BETWEEN 1993 AND 1994

source : SCEES, TERUTI survey

REST OF FRANCE (in hectares)		Moorland-Grazing Land Alpine Meadow in 1994	FOREST in 1994	ANNUAL CROP in 1994	VINES AND FRUIT TREES in 1994	Meadows in 1994	OTHER in 1994	TOTAL in 1994
MOORLAND-GRAZING LAND-ALPINE MEADOW	in 1993	2 392 441	73 907	39 893	1 856	69 899	51 439	2 629 435
FOREST	in 1993	14 989	12 110 793	5 415	496	5 858	32 668	12 170 219
ANNUAL CROP	in 1993	66 020	8 199	13 838 199	18 888	815 329	46 312	14 792 947
VINES AND FRUIT TREES	in 1993	4 213	1 516	16 608	735 561	3 111	2 397	763 406
MEADOWS	in 1993	117 767	9 521	831 671	4 201	########	44 212	11 191 881
OTHER	in 1993	24 489	33 255	25 140	2 807	24 024	6 432 471	6 542 186
TOTAL	in 1993	2 619 919	12 237 191	14 756 926	763 809	########	6 609 499	48 090 074

REST OF FRANCE (in %)		Moorland-Grazing Land Alpine Meadow in 1994	FOREST in 1994	ANNUAL CROP in 1994	VINES AND FRUIT TREES in 1994	Meadows in 1994	OTHER in 1994	TOTAL in 1994
MOORLAND-GRAZING LAND-ALPINE MEADOW	in 1993	91	1	0	0	1	1	5
FOREST	in 1993	1	99	0	0	0	0	25
ANNUAL CROP	in 1993	3	0	94	2	7	1	31
VINES AND FRUIT TREES	in 1993	0	0	0	96	0	0	2
MEADOWS	in 1993	4	0	6	1	92	1	23
OTHER	in 1993	1	0	0	0	0	97	14
TOTAL	in 1993	100	100	100	100	100	100	100

REST OF FRANCE (in %)		Moorland-Grazing Land Alpine Meadow in 1994	FOREST in 1994	ANNUAL CROP in 1994	VINES AND FRUIT TREES in 1994	Meadows in 1994	OTHER in 1994	TOTAL in 1994
MOORLAND-GRAZING LAND-ALPINE MEADOW	in 1993	91	3	2	0	3	2	100
FOREST	in 1993	0	100	0	0	0	0	100
ANNUAL CROP	in 1993	0	0	94	0	6	0	100
VINES AND FRUIT TREES	in 1993	1	0	2	96	0	0	100
MEADOWS	in 1993	1	0	7	0	91	0	100
OTHER	in 1993	0	1	0	0	0	98	100
TOTAL	in 1993	5	25	31	2	23	14	100

FRUIT CROPS AND VINEYARDS IN SPAIN : SPECIFIC STATISTICS

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1. General concepts

Fruit and vine are basic crops in Spanish agricultural production. Fresh fruit, citrus and tropical fruits account for 22% of total agricultural production and wine grape, must and table grape for 5.4%; figures which show the great importance of these crops in the Spanish agricultural economy. In comparison with corresponding production in the European Union, and referring specifically to the seven main types of fruit crops (apple, pear, peach, apricot, orange, mandarin and lemon), Spanish plantations account for 35% of the land used in the European Union for the growing of these crops and wine growing in Spain accounts for 32% of the total European growing area. This underlines the importance of having reliable statistics on these productions available and justifies the effort made by the Spanish government to adapt its statistical system to Community regulations, even, in some cases, to the point of developing methodology specific to Spanish needs

2. Surveys carried out on fruit crops

Basic information on fruit crops is obtained by means of the Survey on Fruit Crop Plantations, set out in the Council Directive 76/625/EEC. This operation comes within the scope of the Framework System of Areas - Surveys of Territorial Segments, prepared by the Ministry of Agriculture for Surveys on Areas and Crop Yields. In the case of the Survey on Fruit Crops, the land is stratified taking into account the density of the plantations and sampling is considerably increased in the strata with the largest concentration of fruit crops.

The use of censuses or territorial surveys in Spain to define fruit-growing areas goes back to 1971 when the first Citrus Fruit Census was conducted. In 1979, an Inventory of Citrus and Fruit Crops was carried out using the same procedure and after Spain's entry into the EEC, the Surveys on Fruit Crop Plantations began to be conducted on a sample taken from the aforementioned inventory. The procedure adopted for the inventory consists of investigating the plantations in the field, after having divided the land into sections depending on the degree of the density of fruit crops and with the help of aerial photography. For the Surveys on Fruit Crop Plantations, a sample of the sections taken from the inventory was initially used. The progressive ageing of the inventory has been the main reason why the last Survey on Fruit Crops, carried out in 1994, was based on the framework of areas used for the Surveys on Areas and Crop Yields, consisting of dividing the land into squares of 1 km x 1 km, in accordance with the UTM projection of the National Topographic Map on the scale of 1:50,000.

2.1 Stratification of the land

Using the information available from the agricultural zones, territorial strata have been established formed by groups of zones with significant similarities in the growing of fruit:

- Level A - Zones which together make up less than 5% of the national fruit-growing area
- Level B - Zones which make up between 5% and 20%, without exceeding 30% of each type of fruit nor 30% of the total of fruit grown in each Autonomous Community
- Level C - Those zones excluded in Level B
- Level D - Zones which make up between 20% and 100% of the national fruit-growing area

The large concentration of fruit plantations in a reduced number of zones gives rise to the phenomenon that level C + D zones, covering only 13.2% of the geographic area, account for 82.5% of the total national fruit-growing area.

2.2 Procedure for the gathering of information

The procedure for obtaining basic information depends on the stratum into which each zone has been classified. In the zones with lesser fruit-growing area (Levels A and B), information available from the Ministry or from the Autonomous Communities has been used while statistical methods, in the strictest sense of the term, have been kept for the zones with significant fruit-growing area (levels C and D). In level C and D zones, a sample of 9 squares from each block of 100 squares (10 km x 10 Km) has been used. Three of these squares are common to those making up the sample from the Survey on Areas and Crop Yields, and the remaining six have been chosen so that there is no more than one in each row or in each column. In each square of the sample, only a territorial segment of 700 m x 700 m, lying on its angle S0, is taken in the field.

2.3 Documentation and material

The carrying out of work in the field requires extensive cartographic and photographic documentation consisting of:

- Provincial maps on the scale of 1:200,000, with the areas well-defined, the sheets of the National Topographic Map on a scale of 1:50,000, the blocks of 10 km x 10 km and the location of the segments
- Sheets of the National Topographic Map, with the location of the segments
- Aerial contact shots on a scale of 1:20,000 or similar, with each segment approximately defined
- Aerial shots blown up to a scale of 1:5,000, with each segment exactly defined.

Likewise, it is also necessary to have different materials such as sheets of polyester paper, marking pens, tape measure, etc. Lastly, it is necessary to draw up a "Manual for Field Work" for use by those carrying out the survey.

2.4 Field Personnel

Due to the specific nature of field work, the survey team must be carefully selected and made up of technical agricultural staff specialized in fruit crops. In the Spanish survey carried out in 1994, a total of 28 survey staff and two coordinators took part. In order to prepare the survey staff thoroughly, both as regards the methods of the survey and the material to be used, 5 one-day training courses were held in the regions with citrus fruit crops and 4 in the regions with non-citrus fruit crops.

2.5 Field work

The gathering of information in the field entails examining each of the existing fruit plots in the segments of the sample. The following operations can be schematically defined:

- Location of the segment on the land
- Definition of fruit plots on a sheet of transparent paper superimposed on the blown-up aerial shot of the segment
- Correlative numbering of the fruit plots of the segment on the transparent paper
- Definition of the technical characteristics of each fruit plot which has been defined and numbered: variety, age, density, etc.
- Counting of points for a quick calculation of the areas, by superimposing a template of 196 points on the transparent map
- Filling in of a field questionnaire.

2.6 Drawing up of results

The drawing up of the results is organized in two converging processes, from the recording of the field questionnaires and from the digitilization of the transparent maps, so enabling errors to be doubly checked. The different stages of this work are as follows:

- Recording of the information contained in the field questionnaires
- Validation of the information, at the time of recording and afterwards
- Digitilization of the maps of the plots of the segments
- Cross-checking of the alphanumeric information (from the questionnaires) and the graphic information (from the maps of the plots). Detection of inconsistencies. Inclusion of the areas to be digitilized.
- Drawing up of files on the segments
- Calculation of errors in sampling
- Inclusion of information from Level A + B zones
- Final results.

2.7 Statistical estimators

As the segments of the sample are uniformly distributed throughout the territory of the stratum to be sampled (zones C + D), the percentage which a certain fruit crop occupies in the area is estimated by the average percentage that said fruit crop occupies in the segments of the sample.

The total area A occupied by the fruit crop in the stratum is estimated by simply applying said percentage P to the total surface area S_0 of the stratum:

$$\hat{A} = \frac{\hat{P}}{100} S_G$$

An estimation of the variance of Â is calculated, taking into consideration that the sample of segments comes from a sampling of conglomerates, in which each conglomerate is made up of the segments which occupy the same relative position in each one of the 10 km x 10 km blocks.

The formula used is the following:

$$v(\hat{A}) = \frac{S_G^2}{100^2} \frac{1-f}{\overline{M}^2 n(n-1)} \left(\sum_{i=1}^{h} A_i^2 - n\overline{A}^2\right)$$

where:

1-f = 0.91 is the correction coefficient for finite population

n = 9 is the number of conglomerates in the sample

$\overline{M}$ = is the average number of segments per conglomerate

$A_i = \sum_{i=1}^{M_i} P_{ij}$ is the accumulate of the of the percentages occupied by the fruit crop in the M_i segments of the conglomerate i

$\overline{A}$ is the mean of A_i

2.8 Annual variations

The Directive 76/625/EEC states that the Survey on Fruit Crop Plantations should be carried out every 5 years. However, it also requests the Member States to provide annual estimations on the uprooting and planting of the different types of fruit crops. This information is obtained in Spain from the Survey in Areas and Crop Yields conducted by the Ministry of Agriculture each year and which is taken over a wide range of crops grown and areas used.

2.9 Improvements in methodology under way

The Ministry is at present working on the preparation of the next basic survey for 1997 which it hopes to test on a Spanish region. With the experience acquired from the previous basic survey, effort is now concentrated on the following points:

- Adoption of stratification of the territory depending on the degree of density of the fruit crops, based on the information available on the 10 km x 10 km blocks of land. This stratification should be more efficient than that based on the zone system, since the latter is very heterogeneous.
- Revision, renovation and organization of the photographic files of segments of the Fruit Crop Survey, in coordination with the photographic files of the Areas and Crop Yield Survey.
- Coordination of tasks, especially as regards the registering of information, between the Fruit Crop Survey and the Areas and Crop Yield Survey, with the aim of reducing costs.

3. Survey on vineyards

The EEC Council Ruling 357/79 referring to the Statistical Surveys on Wine Growing Areas, provides for the Member States to carry out a basic survey every 10 years and annual intermediate surveys. The information to be gathered in the basic survey is, in essence, the following:

- Agricultural area used
- Vine growing area: table grape, wine grape, v.q.p.r.d. and other vines, etc.
- Varieties
- Age of the plantations
- Types of yield.

The annual intermediate surveys are aimed to gather information on the following points with respect to vineyards for wine grape, always separating v.q.p.r.d and other vines:

- Area of new plantations and replantations
- Area of vineyards whose crop has been uprooted or abandoned
- Yield per hectare according to types of yield.

3.1 Basic Survey

In Europe, the basic surveys on vineyards are generally carried out to coincide with the Survey on the Structure of Land for Agricultural Use, which is also on a ten-year basis. In keeping with this, the first basic survey to be carried out in Spain would have been in 1989, but due to the great importance of Spanish vineyards, it was agreed in the Membership Treaty that Spain should carry out its first basic survey in the year following its entrance to the EEC, that is to say, in 1987. Spain later also carried out the other basic survey in 1989. The Ruling 357/79 provides for surveys on vineyards to be carried out by means of an exhaustive census or by a survey by sampling. Nevertheless, it also specifically requires that the information on used agricultural area and vineyard area in the basic survey be gathered taking the vineyard as a unit of investigation. This has been the reason why the basic surveys on vineyards in Spain have not been incorporated into the Framework System of Areas - Surveys of Territorial Segments, used by the Surveys on Areas and Crop Yield, as have the Surveys on Fruit Crops.

In 1987 a survey by sampling was conducted on all the farms which, in the Agricultural Census of 1992, had some area of vineyard and in 1989, the basic survey was incorporated into the Agricultural Census programme, with research into vineyards being carried out at the same time and in coordination with that of the Census.

The methodology and problems encountered in the Agricultural Censuses, that is to say, the Survey on Structures in Community terminology, is not considered to be the aim of this paper and it would be enough to say that in

Spain, the Agricultural Censuses are investigations which cover all farms exhaustively and that the gathering of information on vineyards has been achieved by means of an additional questionnaire, which has been filled in in the case of a farmer having a vineyard.

3.2 Intermediate surveys

If we analyse the information requirements set in the Ruling 357/79 for intermediate surveys on vineyards, we come to the conclusion that these surveys can be considered equivalent to a detailed balance sheet (in accounting terms) of the variation of the area used for vineyards: new plantations, replantations, uprooting and abandonment, and all of this taking into account young plantations, those already producing, those of v.q.p.r.d and others. In our opinion, the gathering of this information would require massive surveys which would be extremely expensive. Fortunately, the Ruling allows for the use, in this case, of information of the type held by public administration and this is the procedure which, in general, the Statistic Services of the Ministry have been using. The main problem arises from the fact that the information held by different official and professional organizations does not always coincide and it is necessary to carefully filter the information to be able to conduct the survey. Nevertheless, research into the yield or production of vineyards is being included within the Framework System of Areas - Surveys of Territorial Segments by means of a new operation called the Territorial Panel for the Seasonal Monitoring of Crops, which will be dealt with in a special paper.

4. Conclusion

The great importance of fruit crops and vineyards in Spain justifies the need for specific statistics which would comply with the requirements of reliability and objectivity set out in the Community regulations. The Ministry of Agriculture, Fisheries and Food has developed a methodology of statistical research of the areas and production of agricultural crops by means of a Framework System of Areas - Surveys of Territorial Segments, which has given satisfactory results for the surveys on cereals and other agricultural products (Survey on Areas and Crop Yields). Information on fruit crops is mainly obtained from the Survey on Fruit Crop Plantations, which has been integrated within the aforementioned Framework System, thus making the cost of the system more profitable and, at the same time, results coherent with the rest of the statistical information are obtained. On the other hand, it has not been possible to integrate the information on vineyards into the Framework System of Areas because of the requirements of the corresponding Ruling. This information is at present being obtained parallel to the ten-year Agricultural Censuses.

USE OF ADMINISTRATIVE SOURCES FOR STATISTICAL PURPOSES

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Introduction

The growing use being made of administrative data in official statistics is one of the main current axes of development of the agricultural statistics system in the European Union. Whilst it is true that the statistical programme for agriculture remains very extensive — so extensive that it is sometimes questioned by statisticians working in other areas of the economy — it is also true that the sheer numbers of users of agricultural statistics, and the level of their demands on the system, have grown significantly over recent decades.

The present system has not only to ensure the production of data on traditional areas, but to extend cover to areas of statistics which did not previously have their modern-day importance. But in parallel, the resources available for the fulfilment of these responsibilities are becoming constantly scarcer, obliging the system to re-engineer the conventional solutions hitherto adopted in producing data.

Against this background of increasing demands being faced by the agricultural statistics system, there have been changes in the Common Agricultural Policy to meet new internal and external circumstances. Those changes have resulted in a plethora of administrative procedures, themselves producing substantial flows of data within administrative departments which are, as a rule, very close to the statistical system. This points to a theoretical answer to the earlier problem. The statistical system might be able to use those data flows, with obvious benefits in its own financial situation. But the successful implementation of this solution raises many problems, both institutional and methodological. Current statistical literature has a wealth of references to the use of administrative sources in agricultural statistics, either by producing data directly, or by improving the efficiency of the system in the accomplishment of specific tasks.

This paper is intended to contribute to the discussion, form the point of view of a generic agricultural statistical system. It presents some results of work in 1994 by a team from the Portuguese Ministry of Agriculture set up with the task of describing the situation of the country's agricultural information system. This team's work permitted the identification, description and detailed analysis of around 260 administrative processes of various types. This was a decisive step in clarifying a number of aspects of the general problem. From the work it was possible to draw a number of conclusions useful in the debate on the use of administrative sources by the statistical system. Before studying those conclusions, however, it is necessary to outline the conceptual framework used.

Conceptual framework

The following concepts were defined and applied:

Agricultural statistical information system – all the operations performed by all the structures involved in the collection, processing and dissemination of data. The data may originate in processes designed for statistics, or be extracted from administrative acts which may but need not have been performed in direct contact with economic agents generating data on the activities of the agricultural sector (in its broad sense), on the conditions in which those activities are exercised, on the economic activities upstream and downstream of production, and on the various markets.

Statistical data – all the significant elements obtained from registers created with a view to their aggregation without the possibility of identifying their source, i.e. data whose existence was never connected with a decision-making process affecting an individual. "Individual" means a statistical unit whether a natural person, a company, a household or geographical site, used as a source of data. The statistical data are, however, used in decision-making involving the suppliers of the data, or at least in decisions by which "individuals" might be affected. This is the case, for example, with agricultural policy measures and the contribution normally made by statistical data in the conception, monitoring and review of such policy.

Administrative data – all the significant elements obtained from registers created within the context of an administrative process or a process created for administrative purposes. Those purposes may be the result of one or more legislative acts at national or community level, an aid to decision-making directly affecting the entity to which the data relate.

Administrative process – all the procedures based on legal instruments established with a view to the implementation by economic agents of a given right or obligation. This may involve public departments or private agencies to which specific competence has been delegated, or both.

Information flow – the process by which data are transferred from a specific administrative (or statistical) process generating the data from which information is obtainable. Such an administrative process may contain one or more information flows, depending on it internal organisation and the number of information-holding organisations involved.

Administrative source – henceforth referred to as "information pool" – may be defined as the store of data whose origin lies in a specific information flow, used in an administrative process.

Table 1: Information flows, by type of potential data

Type of information	Number	%
Agricultural firm	121	45
Processing and marketing	34	14
Producers' organisation	11	4
Administrative inspection	54	20
Statistics	24	9
Other	22	8
Total	**266**	**100**

In practice none of the organisations concerned had either an inventory of its administrative sources or sufficient coherent information to establish one rapidly. In the event, 266 information flows of various types were processed. Observed information flows are distributed over several fields: 45% of them concern farms and 20% are obtained by means of administrative control procedures. Barely 9% of flows deal directly with the production of statistical data (see Table 1). In this respect, for reasons connected with the procedure itself and with the conceptual framework used, two bodies involved in the same procedure are deemed to represent two distinct sources of information. This is justified when the two bodies in question take part in the same procedure in different phases, each one acting within the framework of its competences, and store information in accordance with its official duties corresponding, in the field of information production, to two distinct realities.

Main factors determining the potential for use of administrative sources for statistical purposes

Agricultural statistical information systems generally raise four fundamental questions:

- the need to reduce appreciably the cost of satisfying huge demand arising from legal or other obligations;
- the need to guarantee the coherence of information available on the sector's structure and activity, which is of great importance because of its own limitations and of the proliferation of partial sources of information which appear independently and in isolation, and are sometimes subject to specific distribution processes;

- in addition to these two aspects, it is important to mention the problems involved in the matching of statistical data to reality in a period of rapid and major change;
- finally, the need to intervene in the distribution of information is clear from the fact that annual investment in the system can show a profit only by the use of the data produced, this itself being largely dependent on the effectiveness of the information diffusion channels.

Table 2 - Complexity, diversity of information and degree of computerization of information flows by area of normative incidence

	Average number of bodies concerned	Number of data fields recorded	% of flows processed by computer
Income support	8,0	2,1	100
Investment support	9,2	3,5	72
Processing and marketing	6,8	2,3	93
Producers' federations	8,9	3,0	95
Taxation	6,6	1,6	42
Administrative inspection	6,6	2,4	61
Measures with several aims	6,2	2,6	81
Statistics	4,0	3,2	100
Others	6,8	1,8	71
Average (weighted)	**7,1**	**2,7**	**79**

One fundamental element becomes apparent from all these problems, namely the compatibility of the data resulting from the many administrative procedures launched within the framework of agricultural policy with those provided by the "traditional" statistical system. Agricultural activity is subject to a legislative arsenal both within the framework of the sectoral development policy and in its current activity sphere. These two types of information are based on farmers' statements - compulsory or optional according to the nature of the political measure in which they arise - on the strength of which the departments concerned take Decisions in their field of competence.

The administrative procedures can be of varying complexity since they often concern several bodies, whether those are branches of the same body in the territory (dispersal as a response by the administrative system to the users' growth in numbers and geographical dispersal) or independent bodies cooperating among themselves in certain phases of the procedures according to the competences allotted to them by law. The result is the creation of pools of incomplete information on a given administrative procedure. For all the flows identified in the study referred to above, for example, the average number of bodies taking part in a given procedure is 7.1, and this figure can be as high as 10. It is curious to note that it is the statistical procedures which involve the smallest number of bodies (only 4, see table 2). This type of procedure contains various types of data. Table 2 shows that it is possible to obtain data on an average three fields of information. The level of computerization is also highly significant when evaluating the potential usefulness of data. In this respect, some heterogeneity is noted, depending on the area of normative incidence of which these flows form part.

Information pools are often sources of direct or indirect statistical interest. In the majority of cases, the use of these pools for statistical purposes, or even in the management of the administrative system as a whole, poses problems on several levels:

- incompatibility between them due to partial or even total lack of common planning;
- lack of coherence between them both in data storage and in data content.

With regard to the first, resulting from the limited overall planning of projects, it is frequent that data processing problems are analysed or solved only after the legislation for a given procedure has been enacted. Thus generally the solutions adopted address the major problems encountered by the body concerned, or a particular phase of the procedure, and often take no account of the broader administrative context. Consequently, the greater the number of bodies or structures taking part in a procedure, the greater the risk of inconsistencies. In these cases it is the culture of each structure, its traditions and potential, which mould the (partial) solutions adopted. In addition, the system includes numerous duplications; furthermore not all the bodies generally have access to all the data from the processes in which they play a part.

Given, however, that in these cases communication between pools is non-existent or difficult to establish, that sometimes not even the minimum requirements of compatibility are met, and that each body in fact develops data according to its technical and administrative function, the production of overall information on procedures structured in these terms becomes a complex operation in some cases and quite impossible in others, since many data structures must be consulted to be able to obtain an overall statistical view of the procedure concerned. Another aspect must be stressed in connection with the coherence of information in such systems. Because these are not integrated information systems, at worst no updating of procedures takes place at all, and at best it is not uniform in all the constituent data pools. Thus, not all bodies are in a position to provide exhaustive information on each procedure: each ensures only the validity of the data for the phase of the procedure with which it is concerned. In addition, the timetable of an administrative procedure does not always match that of the statistical system, and in practice this can vitiate the potential usefulness of this type of source (see Table 3 on the availability of data). Statistical data can be compiled or updated by conventional methods, i.e. by surveys of a fraction (samples or panels) of the population (universe) questioned on given characteristics (variables) or by operations of the census type which address the entire target population. These surveys are based on direct interviews or on postal questionnaires. Similarly, statistical data may be compiled or updated from administrative data and are generally submitted to further essential adjustments owing to the conceptual differences between the administrative and statistical procedures. Since agriculture is liable to a significant number of administrative procedures which use criteria or data also pertaining to the field of statistics, cooperation between the two types of action would appear to be valuable.

Table 3: Percentage of flows according to degree of availability of information, type of measurement and are of normative incidence

	Information available		
	provisional/final	**permanent**	**not available**
Income support	23%	25%	52%
Investment support	7%	47%	46%
Processing and marketing	13%	10%	77%
Producers' organisation	-	52%	48%
Taxation	7%	33%	60%
Administrative inspection	17%	36%	47%
Measures with several aims	13%	61%	26%
Statistics	51%	49%	-
Others	1%	57%	42%
Average (weighted)	**16%**	**35%**	**49%**

From the statistician's point of view, administrative sources are often regarded as support for statistical work and, in certain cases, as a direct source of data. As data structures supporting statistical activities, they have a great importance in the ongoing updating of the variables which make up the register of statistical units compiled from the censuses effected periodically (every ten years) by the statistical system. This ongoing updating process is a prerequisite to quality statistics, since the register constitutes the sampling base which underlies each project undertaken.

With regard to the direct use of administrative data for statistical needs, a given administrative procedure is a source of information which, when it relates to units of statistical interest, can theoretically replace, in whole or in part, one or more survey operations.This possibility must always be borne in mind, which implies that organizations with statistical responsibilities must have access to administrative information. From the financial point of view this type of procedure has an obvious advantage for the administration since it makes it possible to reduce the costs.

Another argument for this type of structure is the organizational and institutional aspect. 365 senior Ministry of Agriculture officials surveyed on their willingness to integrate their departmental activity into the production of statistics were almost unanimously in favour of standardizing this type of procedure (Table 4). The reasons advanced are centred primarily on the organizational aspects of the activity of all structures, on questions of a methodological nature and, finally, on the aspects which would contribute to an appreciable increase in the quality of the data produced. The main arguments justifying the alignment of systems relate to organization (46 % of replies) and statistical methodology.

Table 4: Main arguments for and against the statistical use of administrative sources

Arguments	for	against
institutional organization	127 (46%)	8
statistical methodology	82 (30%)	20
data quality	53 (20%)	-
others	2 (1%)	-
with restrictions	8 (3%)	-
Total	**272 (100%)**	**28**

With regard to the use of administrative sources for statistical purposes, the following aspects should be taken into consideration:

- frequent incompatibility between statistical definitions and those used by the administrations:
- the degree of coverage of the administrative procedure's target population for statistical needs;
- the length or period of validity of administrative procedures: when they are not permanent, their statistical use is always limited in the time:
- administrative procedures are generally less stable than statistical procedures in terms of both of the data handled and the basic definitions;
- administrative and statistical traditions must also be taken into account to establish possible gateways between the two types of flows, arising in particular from the participation of departments whose responsibilities are very different in nature.

Lastly, when an administrative procedure is simultaneously designed to respond to statistical needs, the quantity of data required of producers usually increases significantly. This entails factors which can harm, sometimes irremediably, the quality of the statistical data.

Conclusions

The use of administrative sources in statistics is a highly complex question involving legal issues, problems of institutional relations between the various bodies and the need to ensure the effective and smooth operation of the statistical system as a whole. Conversely, statistical data are vital to the political and administrative authorities to analyse the effectiveness and scope of agricultural policy measures; this is why the statistical system has to meet the administration's needs for information. Alignment between the statistical and administrative systems, the potential value of which is unanimously recognized, will have to be accomplished gradually, and every occasion grasped to encourage its achievement. In certain cases, the organizational development of certain structures is required before the necessary conditions can be met for the promotion of development and the conversion of the statistical system in the desired direction.

ORGANIZATION OF THE GREEK STATISTICAL INFORMATION SYSTEM IN AGRICULTURE

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I. Introduction

In modern societies statistical information is an essential requirement because of technological development and its positive and negative impact on social, political and economic structures. Agriculture is a dynamic sector which has been undergoing radical changes in recent years. Against the background of the GATT decisions and the enlargement of the Community, the common agricultural policy has had to develop new strategies to tackle the disparities within the Community, the change in the economic climate and the needs of the environment and consumers. Implementing the common agricultural policy in the various sectors calls for a study of the parameters on which it is based, and this in turn requires reliable and up-to-date statistical information. This is the basis on which the Greek agricultural statistical system was established. To make it easier to understand the structure of the system of agricultural statistical information in Greece, it is worth starting with a description of the geographical and administrative division of the country, as well as a description of the type of agriculture in Greece and its special features and problems which influence the collection and flow of statistical information.

II. Administrative and geographical division of the country

There is a close link between the agricultural statistics and the administrative and geographical division of the country. The entire country (level I) is subdivided administratively into 13 development regions (IPA) corresponding to level II of the EC nomenclature of territorial units (NUTS), 51 *nomi* (level III) and 5.922 municipalities and communes (level IV).

III. Agriculture in Greece - special features and problems

Agriculture in the broad sense of the term (farming, livestock rearing, forestry and fisheries) in Greece is an important factor in the economy, accounting for the 15% of GNP. Total employment in Agriculture accounts for 21% of total employment in all categories of economic activity. According to the data from the last census of agriculture and livestock rearing in 1991, the structure of Greek agriculture is as follows : the total area of the country is 132.000 km², of which 30% is cultivated land, 22% is forest and 40% is permanent meadows and pastures ;the total number of agricultural and livestock holdings in Greece are 860.000.

Greek agriculture is marked by the diversity of the holdings in terms of area of production (mixed holdings) and their dispersal throughout the country, the small (technical and economic) size of a large number of holdings, the fragmentation of their total area - which in most cases accompanied by the marked dispersal of the fields. In quite a number of cases the parcels of the same holding are normally located far from the farmhouse and very distant from each other. Most agricultural and livestock holdings are family undertakings where the owner is also the manager of the holding. The several farm works are mainly carried out by the owner and the members of his family as a principal or secondary occupation. During some periods, particularly harvest time, seasonal workers are employed or assistance is given by other relatives. Only a very few holdings keep proper accounts.

Another major dimension to the problems facing agriculture in Greece is the morphology of the ground. Greece has extensive mountainous areas and includes a large number of islands, and this hampers communications and prevents adequate access to these regions. Besides due to the relief of the country a great variety of environments (soil-climate conditions) is observed. As a result there is also a great variety of goods produced, especially of vegetal production.

This important agricultural sector presents features which reflect the domestic structural weaknesses of Greek farming and pose problems which raise (economic and technical) hindrances in all areas. All these difficulties facing Greek agriculture - and which are not easy to overcome- obviously have negative impact on the system of agricultural statistical information. These special features have to be borne in mind when designing a survey or selecting a suitable sampling method as well as the sample size. Data collection is also hampered by these features, and the difficulties encountered when trying to collect the required information are obvious.

IV. Greek system of agricultural information

The organisation of the current system of agricultural statistical information is aimed at meeting national needs for such information for the purposes of planning and implementing agricultural policy, and at providing effective support for the Community's common agricultural policy. The statistical information system in agriculture is mainly based on the N.S.S.G. and secondary on the Ministry of Agriculture. In accordance with Greek legislation, the National Statistical Service of Greece is responsible for collecting, processing and analysing national statistical data. The various bodies, government services, companies and every citizen are obliged to provide the NSSG with the requisite data, and the confidentiality of the data is enshrined in law. By definition, therefore, the NSSG is the body responsible for producing official statistics on the primary sector (agriculture, livestock rearing, forestry and fisheries) and is essentially responsible for developing the system of agricultural statistics. The Ministry of Agriculture, which is the principal user of the NSSG's various agricultural statistical data, is obliged, as the body responsible for agricultural policy, to carry out regular forecasts and estimates of national interest, as well as certain surveys which require short-term data collection.

Organisational structure of the NSSG

The NSSG is an independent public body under the supervision of the Ministry of Economic Affairs. The organisational structure and the responsibilities of the services of the NSSG are as follows :

The central service is responsible for the collection and statistical analysis of the basic and general-interest data, as well as for the coordination of the activities of the statistical directorates,the services in the ministries and the regional services of the *Nomi*. The units involved in agricultural statistics are :

1. Division for the Primary Sector
   - Section for the survey of the structure of agricultural and livestock holdings
   - Section for Livestock and Crops
   - Section for the annual agricultural survey and fisheries
2. Division for Censuses
   - Section for the census of agriculture and livestock rearing
   - Section for employment and unemployment
3. Division for Economic Indicators
   - Section for wholesale prices and special indices (establishment of indicators for the prices received by farmers)
4. Division for the Distributive Trades and Services
   - Section for statistics on housing, the environment and public works (environmental statistics)
5. Division for Computer Applications
6. Division for Methodology and Planning

The statistical services of the ministries and other bodies, which are responsible for drawing up detailed programmes pertaining to the needs of both these ministries and bodies and the NSSG.

The regional statistical services of the *nomi*, which collect and process the data for the *nomi* for which they are responsible in accordance with the instructions of the central service of the NSSG. With particular reference to agricultural statistics the regional services are also entrusted with data processing for the surveys.

Organisational structure of the ministry of agriculture

At central level, the organisational structure of those services of the Ministry of Agriculture involved in agricultural statistics is as follows :

1. Division for Agricultural Policy and Documentation
   - Agricultural policy section
   - Documentation section
2. Division for Agricultural Applications
   - FADN section
3. Computer Applications Division

At regional level, responsibility lies with the Agriculture Divisions in the *nomi*, which are made up of two offices involved in statistical information - the statistical office and the FADN office.

Problems and special features of the statistical system - Agricultural statistical applications

The rapid developments in agriculture in the 1980s brought about by the Government's objectives of developing this sector, increasing productivity and improving structures and Greek farmers' incomes, created a need for the collection of more representative, reliable and up-to-date data. At the same time, needs in terms of statistical data rocketed after Greece's accession to the EU. The Greek information system was not in a position to respond effectively and promptly to these needs. The system was found to operate inflexibly and sluggishly. There were substantial delays in collecting and processing the data for the surveys. In general, the flow of data between the bodies involved - the NSSG and the Ministry of Agriculture - and national and international bodies was neither rapid nor flexible, while production and analysis were limited and the data were usually presented late, so that the statistical data were already out-of-date. Moreover, the data did not have an acceptable level of reliability, and the methodology used was not in line with the corresponding Community frameworks.

The weaknesses of the system were basically due to the centralised system of carrying out and processing the surveys, the lack of staff and the low level of specialisation of the staff involved in agricultural statistics at central and regional level, as well as the lack of suitable equipment for processing, transmitting and presenting the statistical information. The domestic structural problems of Greek agriculture only added to these weaknesses of the system. These problems led to the implementation, in 1985, of an -initially- five-year Community programme (Council Decision 85/360) for the restructuring of the system of agricultural statistics in Greece. Because of the restricted policy of the different Greek Governments the implementation of the programme faced many problems, so that the programme was extended to 1996. The aims of the programme are as follows :

a) reinforcement of the central technical and administrative infrastructure to ensure the organisation and programming of the collection and processing of agricultural statistical information.

b) reinforcement of the regional technical and administrative infrastructure to ensure the implementation of the required surveys, the collection of the data, the checking and computer processing of the data, where methodologically permissible and, finally, the transmission of the data to the NSSG and the Ministry of Agriculture.

c) improvement of the sampling bases for carrying out surveys on the holdings, using the register of agricultural holdings.

d) the gradual implementation of a coherent programme of statistical surveys which will be carried out on the basis of sampling at the level of the agricultural holdings, with the aim of providing the Community with the statistical information needed for implementation of the agricultural programme of the European Union.

Against this background, a modern and specialised system of statistical information was designed and set up in Greece and is currently being finalised. This system provides new facilities to help in the decision-making process in both Greece and the EU. At the same time, it is capable of ongoing development and adaptation to take account of new needs in the future. The existing system is based on a coherent programme of surveys. The main part of the programme is made up of statistical surveys (sample and exhaustive) carried out by the NSSG using the agricultural or livestock holding as the reference unit. The programme is supported by parallel surveys (annual agricultural survey, area frame sampling, remote sensing e.t.c.) which exploit data and information mainly from administrative sources as well as estimates drawn up by experts and which supplement the official agricultural statistical information. The new system was founded on the following :

Creation of a suitable infrastructure (technical and administrative).

The introduction of modern technology ensures that the agricultural applications are designed along modern lines, so as to provide more rapid, more complete and more reliable information.The two bodies (NSSG- MINAG) installed two indepented information systems. The structure of these systems is based on an inter country network operating throught telephone networks. At the central level the network is directly connected to central service units, while in the region have been installed work stations. At both central and regional levels an efficient number of equipment has been forwarded as well as the corresponding number of s/w editions and the pacages used to support the agricultural applications. At the same time the extend, upgrading and renewal of equipment to meet future needs has been secured. Besides all necessary statistical tools (SPSS, SAS e.t.c.) allowing the wider statistical analysis of the results obtained from agricultural surveys are already available. A system for the management of data bases has been developed and there is a posibility for the central bases to communicate directly with the regional work stations. The databases which have been developed by the NSSG concern all data from the 1991 agricultural census as well as those of the structure surveys and annual agricultural statistical surveys while the creation of additional databases for all other agricultural applications is under preparation. In the Ministry of Agriculture on the other hand, databases containing the estimates of various applications regarding vegetable product have been developed. The on-line network of transferring data from/to the regions is improving. It is expected that, after the full staffing of all NSSG regional offices, the communication with all regional development services and *Nomi*, will become possible. The Ministry of Agriculture's network is fully operational. During the last few years, all the statistical applications have been updated and adapted to the new computer systems, which has led, not only to an important reduction in the time processing for the surveys, but also to an improvement of the quality of the data produced. In 1994, NSSG started the procedure of redesigning all the agricultural applications by using new tools and methods. This concerned, particularly the client server methodology for both, the automatic updating of the register and the transmission of the whole administration of the data to the service involved. Staffing needs have been met through recruitment and the establishment of temporary staff. Special programmes were drawn up to train newly-recruited staff and for the further training of all staff involved in agricultural statistics in the use of the new tools and techniques. Courses were also given in the techniques used for the collection and processing of data.

Decentralisation of the work involved in carrying out and processing the surveys.

The regional units were staffed and equipped to allow the complete decentralisation of the work involved in collecting and processing the data in the surveys. The measures to publicise the surveys, the possibility of selecting the enumerators and the training provided for them by the heads of the regional units have resulted in a high response rate (about 95%) and the collection of more objective information. Processing close to source resulted in much improved quality of data and speeded up to work involved.

Establishment of new methods and procedures for producing statistical information.

All the surveys are harmonised with the corresponding surveys in the other Member States in terms of methods, characteristics and definitions. The agricultural or livestock holding was selected as the survey unit, and the data are obtained through a direct interview with the owner of the holding. The register of agricultural and livestock holdings established from the data of 1991 agricultural and livestock census and is the basis for designing all the surveys. The basic guiding principles on which the design of the Register was based are as follows :

- clear and individualized recognition of agricultural holdings;
- indication of the geographical location of the holdings in question (headquarters of the holding or address of its head);
- information on the presence and relative importance of certain holding characteristics;

- possibility of an individualized description and classification of agricultural holdings based on these characteristics;
- availability of an updated base that could be used both for updating the list of holdings in preparation for the agricultural census, and for conducting sample surveys for agricultural holdings.

Precise determination of the system of updating the register of agricultural holdings from administrative sources, combined with the updating provided by the individual sample surveys, and the planned for 1996 intermediate census -which will supply essential information on basic characteristics- will ensure the necessary methodological framework for precise sampling and reliable results. The use of the new register has led to the redesign of all surveys. At the same time, the questionnaires have been modified in order to be adapted to the decentralised processing needs and the automatic updating of the register. The new structure of the questionnaires facilitates the collection of unbiased and correct information.

Area frame sampling

Since 1991 has been started the implementation of the area frame sampling, for the estimation of cultivated areas in the framework of Action I of the MARS programme in cooperation with the Institute for Remote Sensing Applications of the Joint Research Centre in Ispra. The transfer of the necessary know-how from the Centre has now been completed as has the equipment required for implementation of the application. Evaluation of the method has given acceptable results only for land uses with a relatively high distribution over the whole of the area under study (such as cereals, cotton, tobacco, total area of olive plantations and total area of vineyards). In addition to the method of registering fields, which has been used up till now, the points method for the extraction of comparative data has also been tried out. On the other hand yield survey from the area frame sampling is carried out with direct interviews with the producers, using the existing method of carrying out surveys with experienced and trained enumerators.

Future development of the intergrated statistical geographical system of the Ministry of Agriculture

Within the framework of the functioning programme of the Agricultural Sector 1994-1999, the Ministry of Agriculture has included the development of the programme "Geographic system of combined exploitation of the existing information systems". The whole work is targeting to provide both the Services of the Ministry of Agriculture and other users with the necessary information on the evolution of all important magnitudes in Agriculture, Forestry, Livestock rearing and Fishery at place, time and field level. Indicatively, the programme will include :

- Statistical and other primary information of the Primary Sector, in general.
- System for the management of crucial Statistical documents and studies of the Ministry of Agriculture.
- System for the updating of basic financial data of the programmes of the same Ministry.
- System for the electronic access to the E.C'S legislation, to other Eurobases and to Internet network .
- System for the access and further analysis of the Eurostat import- export archives (in CD).
- System for demographic and economic analysis with emphasis to agricultural employment, from Community to Country 's total level, with estimations and projections for the future.
- Analysis system by 4- digit code of the establishments surveys of the NSSG with emphasis on the analysis of the local advandages and specialization indices of the branches related to agriculture.
- System for the total time- series analysis of the basic agro-economic indices.
- System for the analysis of the trends and specialization of the supplementary branches of agriculture.
- System for the macro- economic analysis of the demand and supply of basic agricultural products (supply correlations e.t.c.).

Cooperation between the two bodies

The close and ongoing cooperation at all levels between the two bodies - the NSSG and the Ministry of Agriculture- is a good basis for restructuring the entire system of information in the field of agriculture and ensures the continuous flow and dissemination of the information.

Agricultural statistical applications

The surveys carried out by the two bodies are as follows :

NSSG

- Census of agriculture and livestock rearing
- Survey of the structure of agricultural and livestock holdings
- Surveys of livestock (cattle, pigs, sheep, goats)
- Surveys of fruit trees (oranges, lemons, small citrus fruit, apples, pears, apricots, peaches, cherries)
- Survey of vineyards
- Survey of cereals
- Survey of slaughterings
- Annual agricultural survey
- Survey of sea fisheries and aquaculture
- Survey on the labour force agriculture
- Agricultural price indices

Ministry of Agriculture

- Area frame sampling
- Statistics on milk and milk products
- Statistics on plant production (forecasts, ongoing estimates and special surveys using experts)
- FADN statistical application
- Statistics on production and trade in eggs for incubation
- Balance sheets for supplies of agricultural products and animal feeds
- Forestry statistics

V. The future of the greek system of agricultural information

At the threshold of a new century, we have to think about the future of agricultural statistics. Of the last ten years we can say that the foundations have been laid for a dynamic system of agricultural statistical information system in Greece. The main point was that the two bodies involved in Greece embarked upon a consideration of the form of the system and the opportunities for its ongoing development and rapid adaptation to meet any new challenges which may arise. The future form of the Greek system of agricultural statistics will be based on the new orientation of the common agricultural policy and the new decisions and objectives of national policy. More specifically, the programme of statistical applications must be revised and adapted to the new needs after an evaluation of current applications and the establishment of new objectives against the background of the strengthening of policies for protecting the environment against the effects of agricultural activities, the enlargement of the Community, etc. At the same time, evaluation of the use of new methods, such as area frame sampling, will be useful in drawing conclusions as to their role within the system as a whole. The use of new tools such as Optical Cracter Recognition, Geographic Information System, rapid printers, optical disks, will give a new dimension not only to the production but also to the analysis and dissemination of statistical information. The creation of a sub-system comprising all agricultural and livestock surveys, will permit the immediate delivery of data, assuring their confidentiality. Decentralisation opens up new horizons for the Greek system of agricultural statistical information. In future, the role played by the regional units in producing and disseminating statistical information on their respective regions will be strengthened by the completion of the databases operation and the full activation of the data transmission network to the NUTS levels II and III, as well as the extension of the end-user-tools to support client server methodology, in the regions. The central service will have more of a staff and research function. Our target will always be to find new methods of applying traditional surveys and to exploit the new technology with a view to being in a position to respond immediately to any new needs.

THE AGRICULTURAL STATISTICS SYSTEM IN ITALY

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1 - Introduction

The main characteristic of primary-sector production activity is that it supplies the population with a wide variety and very extensive range of products which ensure subsistence and provide the main nutrients essential to life when consumed fresh or after various stages of processing. The objective need to be aware of the availability of the various agricultural crops, types of meat and other animal products has given rise both nationally and internationally to the compilation of statistics on cultivated land area, number of head of livestock and quantities produced.

Similar reasons are at the root of the evolution of both agricultural and official statistics in Italy. The need for increasingly detailed information on the situation of agriculture has meant an expansion in agricultural statistics over the years to keep pace with requirements for the information which is essential for all decision-making and for implementing both centralised and local programmes. With the birth of the European Economic Community and the increasing demands arising from the need for an effective Community policy which would create a more balanced market situation, surveys on the agricultural sector proliferated. The complex picture presented by the organisational structure and form of the surveys carried out in Italy today is very largely a result of the demands made by the Community policy (CAP) in force since 1961.

2 - Organisation of surveys for the purposes of agricultural statistics

To meet the many and varied information requirements and supply the appropriate statistical data with adequate geographical coverage, an infrastructure is needed which is adaptable to both centralised and regional operations.

Within the National Statistical System (SISTAN) established in Italy by Law 322-1989, there are many public bodies carrying out statistical surveys on the primary sector on a subannual, annual or multiannual basis. There are 75 such surveys, which form an integral part of the National Statistical Programme. As well as the National Statistical Institute (ISTAT), which, with around 60 surveys, provides 80% of the information on this sector, a considerable contribution is made by the Ministry of Agriculture, Food and Forestry (MIRAAF), the National Institute for Agricultural Economics (INEA) and the Agricultural Intervention Body (EIMA).

The organisational structure employed by ISTAT for the agricultural sector provides comprehensive coverage at both central and regional level. At central level, ISTAT is responsible for coordinating the various operational phases of each survey, via specific internal structures and in collaboration with the MIRAAF. Some of its main tasks are to draw up the survey forms, methodology, technical standards and organisational procedures and sometimes to provide support for the bodies actually conducting the surveys. It is also responsible for analysing the data collected and collating and disseminating the results via specific publications or computer transmission. At local level, the Institute uses specific bodies (regional, provincial, district) depending on the survey.

Generally speaking, under the above-mentioned law establishing the National Statistical System, implementation of surveys is the responsibility of the regional statistical offices, or, where such offices do not yet exist, the Assessorati Regionali all'Agricoltura, which use existing provincial bodies for survey operations and are normally composed of the provincial Agricultural Inspectorates. In order to safeguard the quality of the information collected and ensure that timescales are properly respected, interviews with farm managers are carried out by experienced researchers, who are generally responsible to the above-mentioned provincial offices. Surveys conducted on a provincial basis are subsequently coordinated by an appointed regional representative chosen from among the relevant authority's staff.

For the censuses covering all existing agricultural holdings in the country (over three million at the last census in 1990), there is still room for improvement in the structure at local level, which should include, along with the regional and provincial bodies, the local district offices, for which it is easy to find the extra resources during the census period to cope with all the checking and monitoring procedures.

3 - Agricultural surveys in Italy

3.1 - General information

As stated above, statistics on the agricultural sector are provided by various surveys run by ISTAT or other bodies, using different methods and criteria. The surveys can be subdivided into:

a) Surveys of production units, essentially covering holdings producing crops and livestock and, to a lesser extent, holdings whose products are intended for use in agriculture (fertiliser, pesticides, animal feed, etc.) or establishments processing products from the sector: cooperatives, abattoirs, dairies, etc.

b) Short-term surveys on land area used for various crops and other types of production, involving provisional estimates and forecasting at various levels (district, agricultural region, province, region).

c) Remote sensing by satellite, which, while not part of the official system, produces information on land use and production of the main cereal and herbaceous crops.

d) Surveys by other bodies and administrative statistics from public bodies or sectoral associations.

3.2 - Surveys of production units

Surveys based on production units can be subdivided into exhaustive and sample types.

Of the exhaustive type, by far the most important, supplying comprehensive information on rural activities, is the agricultural census which is carried out approximately every ten years. In Italy, the results of the fourth agricultural census, which took place in October 1990, were widely disseminated and have been in use for some considerable time. The three previous censuses were in 1961, 1970 and 1982. The very comprehensive information gathered through the census provides the basis for a thorough and exhaustive examination of socio-economic and structural developments in the Italian agricultural sector. While complex and costly in terms of resources, exhaustive surveys are essential because they provide a sufficiently precise and detailed gauge of the many phenomena which define agricultural activity: number and organisation of farms at local level, legal status and demographic characteristics of the farm manager and his family, analysis of production factors (land use for the various crops, livestock resources by species, labour, fixed assets and mechanical equipment), type of farm organisation and management (irrigation, means of production, system of animal rearing, etc.). The exhaustive survey of the universe of production units in agriculture, differentiated according to their characteristics within each census ward, apart from generally satisfying the need for highly diverse information, even at local level, also supplies the essential elements for the ten-yearly update of the registers on agricultural holdings. Samples of agricultural holdings can then be extracted, which, if properly stratified according to specified characteristics, can be used as the basic survey units for partial and representative surveys carried out between the main censuses.

Apart from the main census, there are two other exhaustive surveys in Italy of considerable importance from the point of view of information, concerning the livestock sector. The first of these is a monthly survey on milk and dairy products and covers establishments collecting and processing milk. The main purpose of the survey, which is based on a specific Community Directive, is to establish the quantities of different types of milk (cow and cow buffalo, sheep and goat) produced on farms and determine their various uses. They also record the dairy products obtained from processing of the basic products. The second, also on a monthly basis, is on livestock slaughtered, recording the quantities of meat from cattle and buffalo, pigs, sheep, goats and horses. The survey covers public, private, industrial and small-scale abattoirs and home slaughtering. For the various categories of livestock slaughtered, the three basic elements recorded are number of head, live weight and dead weight.

Finally, there are specific surveys covering processing establishments, such as the quantity of beet processed in sugar refineries and sunflower and soya seeds processed in oil plants.

Of the sample surveys, the most important, because it is part of a Community programme in existence since 1967, is the two-yearly survey on the structure of agricultural holdings. The survey frequency and methodology, and the variables under observation, are standard for all the Member States to ensure that the data are internationally comparable. The survey form used is generally the same as that for the census but with fewer questions. The information gathered includes the legal status of the holding, type of tenure, land use, number of head of livestock and labour force. It is this survey which, from 1993, in order to meet future Community requirements for rationalisation of the survey system in the agricultural sector, for the first time included production figures for individual crops at the level of the individual farm. So far, ISTAT has carried out at least eight surveys on the structure of agricultural holdings, in 1967, 1975, 1977, 1985, 1986, 1987, 1988 and 1993.

The ninth survey is scheduled for the end of this year and will cover, in addition to cereal and ligneous crop production as in 1993, information on cattle, buffalo, pigs, sheep and goats. The structural survey will thus replace the end-of-year sample surveys on livestock, at the same time meeting at least seven of the Community's stipulations. The number of farms forming the sample for the survey rose to around 80 000 for the first time in 1993 and will stay at that level for the December 1995 survey. In previous surveys, the sample comprised around 40 to 50 000 units. The importance of the livestock surveys should, of course, not be forgotten. Although this year this information is included in the survey on the structure of agricultural holdings, there is still the June survey on bovine animals and buffalo and the April and August surveys on pigs. The purpose of these surveys, which are all regulated by Community legislation, is to monitor, more frequently than once a year, the production resources and utilisation of milk from cows, buffalo cows, sheep and goats. The above-mentioned surveys include agricultural and livestock holdings with no agricultural land which are rearing the livestock in question on the reference date. The samples, which are representative at regional level, comprise around 10 500 farms for the survey on bovine animals and buffalo, 8 000 for pigs and 10 000 for sheep and goats. They are stratified for the former two surveys, the latter being organised more simply.

There is also a five-yearly sample survey on certain species of fruit trees, including citrus. The purpose of the survey, run as the result of a specific Community Directive, is to gather information on ligneous crops, which are particularly important from the point of view of commercial production: apple, pear, peach, apricot, orange, lemon, clementine, mandarin and hybrid trees. There have been five surveys to date (1974, 1977, 1982, 1987 and 1992), each covering around 40 000 representative agricultural holdings at regional level. The field of observation comprises agricultural holdings with land given over to one or more fruit and/or citrus crops

3.3 - Ongoing and short-term surveys on land area and production

Surveys of this type are based on estimates and supply data on land use and the production of the various crops. The information, which is obtained quickly and provides descriptive analysis at local level, is used for short-term analysis of the sector and provides a basis for anticipating provisional data on land use and production before the results are obtained from the surveys of agricultural holdings.

The definitive annual data, on the other hand, as mentioned above, are extrapolated from the sample surveys of agricultural holdings. The way in which the estimated surveys are structured regionally also enables variables to be established at provincial level, which is not possible with the sample survey of agricultural holdings, the representativeness of which is only regional.

The surveys cover crops grown on national territory, both herbaceous (cereals, leguminous plants for grain, horticultural cultivation either in the open or under glass, industrial plants, fodder crops, flowers) and ligneous (vines, olive trees, citrus fruits, orchard fruits). Information is also collected on the varieties of certain agricultural products (wheat, potatoes, tobacco, dessert grapes, peaches, pears, apples and citrus fruits). The timescales for collection of exhaustive data are based on the crop cycle and evaluations of "experts", i.e. civil servants specialised in this area belonging to the bodies responsible for agriculture at provincial level.

The surveys based on estimates therefore require the use of structures and highly skilled personnel at local level. This method does, however, have its limitations, since the expert's evaluation can suffer to varying degrees from the use of subjective criteria. Reliability of the data is dependent on scrupulous compliance with strict methodological criteria by the expert concerned. It is particularly important to start from a reliable reference point, which would generally be the relevant data from the census, which can be used as the basis for the estimate for the forthcoming period. This is also true of successive estimates, each of which must be consistent with that for the preceding period. This method is used until there is a sound reference against which the estimates can be checked, taken from a sample survey of agricultural holdings or the results of the most recent census. At the time of the survey and expert's estimate, a comparison must also be made with the corresponding estimates of neighbouring regions or regions with similar morphological characteristics and agricultural land use.

Given the subjective elements which, in some cases, can distort the survey results, this estimation method, which is currently still widely used, must, in the long term, be replaced by alternative methods, corresponding more closely with requirements and producing more reliable data. However, in view of the range of crops grown in Italy and the low cost of this estimation method, it will probably continue to be used, though gradually being displaced by new and more reliable survey methods.

3.4 - Remote sensing

Although not yet officially recognised, the use of satellite data for agricultural statistics has recently become standard practice in Italy, dating back to 1987 and the first national estimate of areas and forecasts of maize production.

The Ministry of Agriculture, Food and Forestry (MIRAAF), which has the distinction of having introduced this type of survey in Italy, produces estimates of land use and production forecasts for the main crops via the AGRIT programme (AGRISTAT project). These estimates, which currently cover 10 crops (durum and common wheat, barley, rape, grain maize, soya, sunflowers, tomatoes, sugar beet and tobacco), are sufficiently representative, at least for the main cereal crops: durum wheat, maize, common wheat, etc.

This method, developed in Italy on behalf of the Ministry of Agriculture, Food and Forestry by a consortium of private agricultural holdings specialising in the use and supply of satellite products (ITA Consortium), is essentially based on field surveys using area sampling. The forecasting aspect of these surveys has been improved by the use of multispectral satellite data processed using a spectro-agro-meteorological statistical model (SAM). Stratification of the geographical area and the number of samples was so proportioned as to ensure that the regional estimates were sufficiently significant. The AGRIT project is currently increasing the number of reference crops and working on producing significant estimates at provincial level. The initial pilot projects at provincial level were carried out in the Marche region, and subsequently extended to Venezia and Campania.

Despite the many positive reactions and the consensus on these technologically highly advanced methods, agricultural statistics based on remote sensing cannot yet be considered official, despite having been in existence for around ten years. Before they can be fully recognised, a detailed cost/benefit analysis and an additional experimentation period are considered necessary. The supplementary period is needed to increase the significance of the land use estimates and production forecasts. The data must also be extended to cover a wider variety of crops and to take in the provincial as well as the regional level.

3.5 - Surveys by other bodies/administrative sources

The Institute of Agrarian Economy (INEA) plays a special part in agricultural statistics in Italy, having since the mid-60s carried out the Farm Accountancy Data Network (FADN) survey set up under EC Regulation 79 of 1965 to provide information on the accounts of agriculture holdings. The FADN is based on a sample of agricultural holdings and measures annual trends in agricultural income from the various accounting items recorded. The data are set out in an EEC "form of farm return", ensuring a certain consistency of methods and information throughout the Community. The sample currently comprises 18 000 agricultural holdings selected on the basis of two criteria:

- category of holding according to type of farming
- definition of the field of observation by setting a minimum threshold for inclusion, which since 1986 has been two European Size Units (ESU).

The choice of holdings is not random because of the problems farmers have in supplying the requisite data. Holdings are selected from those which have made a loan application for account-keeping purposes, as these are the only ones for which the technician has access to the accounting data. The sample obtained in this way cannot really be considered significant from the point of view of probability, but taking its scale into consideration, it can be considered valid for describing certain aspects which are of considerable economic importance for regional and national agriculture. However, the INEA has developed special procedures for a posteriori checking of the representativeness of the survey and for estimating the data for the total universe. The survey covers the accounting year from 1 January to 31 December and collects information on actual agricultural activity, forestry and rural tourism. All the data are taken from accounts including chronological records of income and outgoings throughout the year.

Other information on agriculture-related activities is available in Italy from the administrative archives, essentially based on the declarations made by farmers to the competent authorities in order to obtain Community subsidies. The administrative archives contain data on around 1 900 000 holdings and, along with the usual details on the holder, provide information on certain structural features of the holding, including land area and crop production. Of particular interest are the computerised archives held by the Ministry of Agriculture, Food and Forestry (MIRAAF) via a service company (FINSIEL), which manages the information system, on the wine-growing sector (around 400 000 vineyards), the olive-growing sector (around 1 000 000 holdings), cereals (around 240 000 holdings) and fruit and vegetables (around 130 000 holdings). FINSIEL has also computerised the data on sheep and goat rearing from the census carried out by the Agriculture Ministry in March 1992.

Finally, at provincial level, another service company (CERVED), on behalf of the Chamber of Commerce manages the vineyard registers kept in each province for production of wine with registered designation of origin.

4 - Changes currently under way and future plans

Only the most important surveys in the agricultural sector have been mentioned in this document. It is clear from this, however, that the system is in need of overhaul and rationalisation to eliminate existing redundancies, thereby reducing the nuisance factor as perceived by certain agricultural holdings, which find themselves involved in an endless stream of different surveys.

The inclusion in the next survey on the structure of agricultural holdings of questions on land use and crop and livestock production is a first step in this direction. As stated previously, this will enable at least seven different requirements of Community law to be met, while reducing the workload of local survey structures and of the farms involved in the survey. The main purpose of the change is to establish a single annual general survey of agricultural holdings which will cover most of the information currently obtained from several different surveys. It will also rationalise and simplify the data available to international bodies and national users, providing a much clearer picture of this highly complex sector.

To fill the gaps left by the main survey, specific interim sample surveys could be carried out for certain sectors (vegetables, crops under glass, flowers, nurseries, fodder crops, etc.), restricted in scope and covering only the areas in which the phenomenon under investigation is most highly represented. Planned for future programmes are a new policy on surveys in the agri-foodstuffs sector, together with the information required for industrial statistics, and a new sample survey on the animal feedingstuffs sector to determine the different ingredients of the feedingstuffs concerned.

In the immediate future, improvements are planned for the INEA's survey for the Farm Accountancy Data Network via direct action by ISTAT, to ensure that the sample is random and significant, and include, as from next year, economic questions to be inserted in the register for the survey of farm data. The FADN survey thus improved will expand the range of information on the agricultural sector and enable the methodological criteria set out in the most recent version of the European System of Integrated Economic Accounts (ESA) to be adopted. With the information from the survey, it will be possible to move gradually from the current method of estimating the gross saleable production to the new method based on actual farm accounts. It will also be possible to use the same survey to assess farm expenditure, which is of particular importance for drawing up the input-output tables.

Finally, with regard to the application of remote sensing techniques to agricultural statistics, experimental work is soon to be stepped up by means of increased cooperation between ISTAT and MIRAAF. The main objective of this operation is to enable the forecasts on land use and crop production, currently based on estimates, at least where the agricultural production of relevance to the Common Agricultural Policy (CAP) is concerned, to be replaced progressively by new specific surveys based on area sampling. This latter initiative will enable the sample size to be reduced, thereby also cutting down the workload, and could also be of practical use to the local survey structures.

These new initiatives have been submitted to the ISTAT's Study Group for assessment in the light of the various aspects of agricultural statistics. The Study Group is responsible for improving and rationalising information on the primary sector of national and Community interest and is scheduled to complete its work in two years' time. It is chaired by Professor Guido Fabiani, Chairman of the "Federico Caffe" Economics Faculty at the Third University of Rome, and is composed of ISTAT specialists, representatives of bodies producing statistics on the agricultural sector, university lecturers, and experts on the sector and on statistical applications of satellite remote sensing.

5 - Summary and conclusions

Described above are the most representative bodies producing statistics on agriculture, and those employed by the National Statistical Institute to carry out agricultural surveys. Emphasis has been laid on the geographical structure, which comprises a central service operated by the Agriculture Department in conjunction with ISTAT, 20 regional offices with specific responsibilities, around 100 provincial offices and, for the exhaustive census-type surveys, just over 8 000 local offices.

The analysis of the main sources of agricultural statistics divides the basic surveys into the following groups:

- surveys of production units (exhaustive surveys of agricultural undertakings and holdings, as in the census, or sample surveys such as that on the structure of agricultural holdings);
- short-term surveys on land use and crop production based on estimates;
- information obtained by remote sensing;
- data from other bodies and statistics from administrative sources.

The report concludes with an outline of the changes currently under way and probable future developments in the system of agricultural statistics in Italy. The first point made is the planned expansion of the information covered by the structural survey for the end of 1996, to include questions on land use and crop and livestock production. In future, the Farm Accountancy Data Network survey carried out by INEA will be improved in terms of the information and the representativeness of the sample, and more use will be made of remote sensing. Consideration will also be given to the possibility of providing more information on certain specific crops through one-off targeted sample surveys.

In conclusion, the agricultural statistics system in Italy has a long history to be proud of, and has absorbed many new initiatives and built up considerable experience in the field of research and survey techniques. There are, however, certain changes and improvements to be made to enable developments in the rural sphere to be traced more quickly and with greater accuracy.

SESSION 2

SPECIFIC CHARACTERISTICS OF SOUTHERN EUROPEAN FORESTS

SOUTHERN FORESTRY STATISTICS IN THE CONTEXT OF EUROPEAN FORESTRY STATISTICS

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Introduction

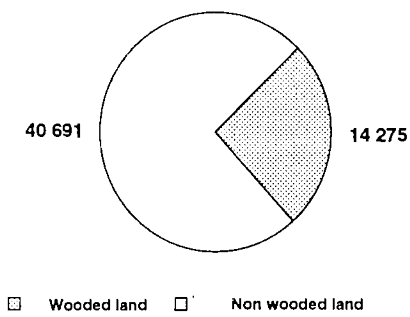
As in all European countries, French legislation limits the rights of forest owners. The "*Jus utendi et abutendi*" of Roman law thus no longer applies. Restrictions basically concern exercising the right to grub up forest land, clear fell and, in the case of some forests, the obligation to manage them in accordance with a development or operational plan approved by an administrative body. Furthermore, the law protects owners by prohibiting potential damage by third parties, and encourages the development of forests by allowing owners to receive public subsidies.

Perhaps the most distinctive feature of French forestry law is the way in which legislation differs according to whether the forest belongs to the State, local authorities or private individuals. State forests are managed according to strict rules by a public-law body, the Office national des forêts [National forestry board]. The State closely supervises local authority forests via this same body, which monitors forests, draws up development plans, marks areas to be felled and arranges for the marketing of forestry products. Forests owned by private individuals are subject to much less stringent control by the government and various other public-law bodies. The obligation to comply with a management plan in particular applies only to forests covering more than 25 ha and owned by a single person.

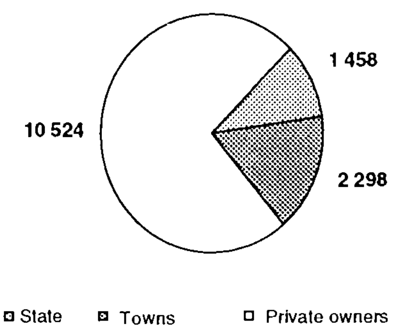
The consequence of this dual approach is that, although the State, thanks to the structure and activity of the National forestry board, has a sound knowledge of forests managed by this body, traditional administrative sources provide it with very little information about forests owned by private individuals, even though these form around three-quarters of the entire area under forest. These sources do not allow it to gauge the impact of its policies - thus, in the fifties, information on basic parameters such as total forested area was poor. The most recent set of statistics dated from before the First World War, and were obtained by means of an administrative survey.

In 1958, the State thus introduced into forestry law a provision for carrying out a permanent survey of forestry resources, irrespective of ownership. This allows authorized personnel to enter land, whoever it is owned by, and carry out the necessary operations. To this end, the State created a special service, the National Forest Survey (NFS).

Breaddown of territory
Surface (1 000 ha)



Breakdown of wooded lands according to ownership
Surface (1 000 ha)



General characteristics of the forest survey

The French forest survey is national, meaning that it is carried out at the initiative of the State for a single purpose, using methods and procedures that are identical nationwide (mainland France and Corsica). Raw data - and some processed data - are stored in several databases depending on their nature, not on their geographical origin. However, as the work unit (other than in the Paris region) is the administrative subdivision known as the département, i.e. around one-hundredth of the territory (500 000 ha), it is possible to take account of local features (cf. below). Each département is surveyed every ten to twelve years. Follow-up work is spread over several years. The "period" is the interval between the end of two consecutive surveys.

The survey uses the following concepts, which apply to all areas (sites) that are deemed to be sufficiently homogeneous in respect of the characteristic in question:

- **land cover,** describing the biophysical elements on the site according to their respective cover ratios, may be:
  - **dense forest**, with over 40% forest-tree cover;
  - **open forest**, with 10-40% forest-tree cover;
  - **heathland**, with non-ligneous vegetation or wild bushes and less than 10% forest-tree cover;
  - **poplar stand**;
  - **agricultural land**;
  - **inland waters**;
  - **other** (less than 10% vegetation or water).

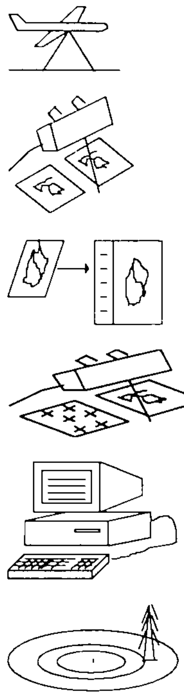
  "Forest" trees are defined in a restrictive list. They must have individual, relatively straight trunks and, in the vast majority of cases, have their first branches some 1.5 m above the ground. For saplings, cover is fixed at a flat-rate of 2 m.2.

- **economic function,** in the case of open forest, dense forest, heathland or poplar stands, may be:
  - **timber production as the main function;**
  - **other main function** (protective, recreational, etc.).
- **type of forest stand,** in the case of dense forest used for timber production, may be:
  - **broadleaf high forest;**
  - **mixed high forest;**
  - **conifer high forest;**
  - **broadleaf high forest with coppice**
  - **conifer high forest with coppice;**
  - **coppice.**

- **type of vegetation,** combining the above characteristics, providing this makes sense (e.g. **dense protective forest, mixed high forest in production).**

Main Phases of a Survey

1. Aerial photographs
2. Land cover typing on aerial photographs
3. Mapping
4. First phase sample interpretation
5. Stratification and field sample preparation
6. Field measurements and observations
7. Computation and storage



The survey is carried out by interpreting aerial photographs and making field measurements and observations. Fieldwork is done on what are known in French survey terminology as "plots", meaning both the geographical reference point, the associated sample plot and the work protocol. The aerial photographs used are taken specially for the survey. The scale is 1:17 000 to 1:25 000, with an emulsion that is sensitive to infra-red. Overlap ensures stereoscopic coverage.

The first stage of work involves tracing the limits of areas with the same type of vegetation onto the aerial photographs. These are then transferred to 1:25 000 topographical maps, so producing digitized vegetation maps.

The second stage of work is done by sampling. A network of points (approximately one point to 40 ha) comprising a first-phase sample is laid onto the photographs, and observations made by photointerpretation on circular plots, 25 m in diameter, centred on these points. **Land cover** and **economic function** (cf. above) are estimated for each of these plots, independently of the mapping work done previously. When land cover is of the forest type, estimates are also made of other features, such as the size of the stand and volume per unit area. Sample plots are temporary and are used for a single survey only.

First-phase sampling points are then stratified according to land cover and economic function. A number of points are then selected at random from each stratum to produce a second-phase sample. Virtually all of this new sample is forested, each point covering some 100 to 150 ha. In open areas, study of this sample involves taking into account only a fraction of the total wooded area, corresponding to the portion of plot samples containing forest trees.

Fieldwork is then carried out, viz.:

- checks are carried out on the type of land cover and economic function to identify any changes that may have occurred since the aerial photographs were taken;
- tree measurements and observations are carried out on circular sample plots;
- ecological measurements and observations are carried out, especially a count of all species of vegetation within a radius of 15 m and determination of soil characteristics.

Work is completed by calculating results and inputting them into databases.

The above operations provide estimates of the extent of the forest, its distribution across various geographical zones according to the types of stand defined, as well as the classic tree characteristics of stands and their accessibility. Previously collected data have been used to devise models for drawing up volume tables and, by making certain assumptions about forest management, simulating the development of stands and calculating resources actually available. NFS mapping data can be incorporated into an existing geographical information system. This is becoming standard practice amongst government bodies for regional planning studies. The combination of mapping and tree data enables a geographical information system to be drawn up for forestry. This is currently being developed, one of the objectives being to produce tree estimates for an area chosen by the user that does not correspond to an area originally mapped by the NFS. Two or three surveys have already been carried out in each dèpartement.

Extent of Mediterranean territory

Thirteen French départements are considered **Mediterranean**, either wholly or in part. These are the nine bordering the Mediterranean sea, including the two that make up Corsica, plus four other départements with a Mediterranean-type climate over most of their territory, characterized by marked summer drought having a major impact on vegetation. The total area of these départements is 69 600 km2, or 13% of the national territory surveyed. The extent of the Mediterranean zone can be defined more accurately on the basis of work done by the NFS itself. When the first survey was carried out, **forest regions** were delimited. A forest region is a territorial division (which may traditionally have been recognized as such) characterized by similar conditions from a forestry point of view, generally with comparable types of forest or countryside. Almost all such regions are so large that the relevant survey results can be considered sufficiently accurate.

Because of the way in which the survey is carried out (by *département*), forest regions were first created in each *département*. However, contiguous regions in neighbouring *départements* were then grouped together to create **national forest regions**, the limits of which have remained unchanged. There are 309 such regions. This has become the standard regional breakdown for French forestry, serving as a basis for drafting the planning and management guidelines imposed on owners by the State.

Forest regions fall into three **geographical vegetation zones**, as follows:

- plains and hills (outside the Mediterranean zone);
- mountains (outside the Mediterranean zone);
- Mediterranean zone (plains, hills or mountains).

Of the 309 forest regions, 39 belong to the Mediterranean vegetation zone, covering a total area of 41 700 km2, or 7.6% of the territory surveyed. In other words, the average area of regions in this zone is less than the average area calculated for France as a whole. The Mediterranean region is relatively heterogeneous.

Application of the general method in south-east France

Organisation

The survey is implemented from five sites in France. All *départements* which are Mediterranean in character are allocated to the Montpellier site, regardless of the administrative breakdown of France. These *départements* are thus treated uniformly.

Forest species

As mentioned above, the wooded nature of a site is determined by land cover, itself defined by the cover ratio of the vegetation present on that site. A forest site is one with at least 10% forest-tree cover. Mediterranean species such as the holm oak (*Quercus ilex*), the cork oak (*Quercus suber*), the South European hackberry (*Celtis australis*), the almond tree (*Pirus amygdalus*), the olive tree (*Olea europæa*), the European hop-hornbeam (*Ostrya carpinifolia*), the stone pine (*Pinus pinea*), the Aleppo pine (*Pinus halepensis*), the Atlantic cedar (*Cedrus atlantica*) and the evergreen cypress (*Cupressus sempervirens*) have been on the list since the survey began. Some years ago, the strawberry tree (*Arbutus unedo*) was added.

Land cover and types of vegetation

In the Mediterranean area, **open forest** (average cover ratio of 10-40%) is called **wooded garrigue** if the subsoil is chalky and **wooded maquis** if it is sandy.

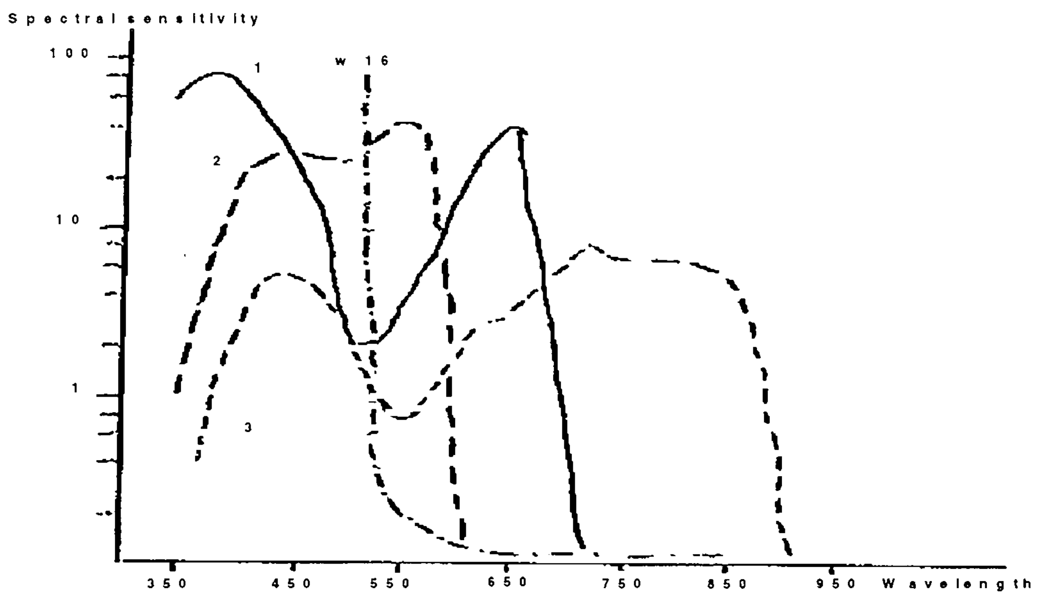
Types of vegetation (cf. above) are subdivided as follows, when the survey of individual *départements* shows land cover to be of the forest type:

- predominant species, or groups of species which are mixed or which it is not worthwhile or possible to distinguish;
- the overall structure, i.e. high forest, coppice or mixed high forest/coppice (dense forest only).

In Mediterranean-type *départements*, open forest is always subdivided according to predominant species. These are generally the holm oak (*Quercus ilex*), the pubescent oak (*Quercus lanuginosa*), the sweet chestnut (*Castanea sativa*), the maritime pine (*Pinus pinaster*) and the Aleppo pine (*Pinus halepensis*).

Aerial photographs

The emulsion used at the start of survey work for the territory as a whole was an infrared-sensitive black-and-white emulsion. This allowed deciduous trees and conifers to be easily distinguished. Since 1974, systematic use has been made in south-east France of an infrared-sensitive reversal colour film. This film is used with a Wratten No 16 filter to eliminate the blue radiation to which the top three layers of the film are sensitive. This radiation provides very little information and is highly sensitive to scattering from airborne particles. Under these conditions, the cyan generating coat is most sensitive at a wavelength of 650 nm, the yellow generating coat at 550 nm and the magenta generating coat at 750 nm. After development, blue corresponds to the 500 to 600 nm wavelengths, green to 600-700 nm and red to 700-900 nm. Numerous species can be distinguished within broadleaf or coniferous groups. Furthermore, use of a film base allows higher-magnification stereoscopes to be used than is possible with paper photographs, thus making optimum use of the visual material. All these advantages are particularly important in a zone where land-use varies over short distances and where vegetation is in various stages of decay and recolonisation.



IRC FILM SPECTRAL SENSITIVITY

1. Cyan generating coat
2. Yellow generating coat
3. Magenta generating coat
Wratten Nr 16 Kodak filter

Cork survey

There are major stands of cork oak (Quercus suber) in some regions bordering the Mediterranean, including Corsica. There was once a major cork industry, and although it is much less important nowadays, and cork stands are not maintained as carefully as they should be, it was thought important in certain départements to carry out special measurements to estimate the volume of cork. Computer programs have been written to supplement existing programs and produce the following estimates in the départements concerned:

- extent of cork oak, by forest region;
- area of stands where cork oak is predominant, with portion in production;
- area of stands where cork oak is secondary, with portion in production;
- number of trees in production;
- volume of cork;
- annual increase in volume of cork;
- average thickness of cork;
- average height stripped of outer cork;
- distribution of volume of reproduction cork by quality (category);
- distribution of area under production by number-class of stripped trees per hectare;
- generating area, volume and growth of reproduction cork;
- number of trees bearing virgin cork, generating area and volume of virgin cork;
- distribution of volume of virgin cork by quality category.

These estimates are for mature trees growing in wooded areas.

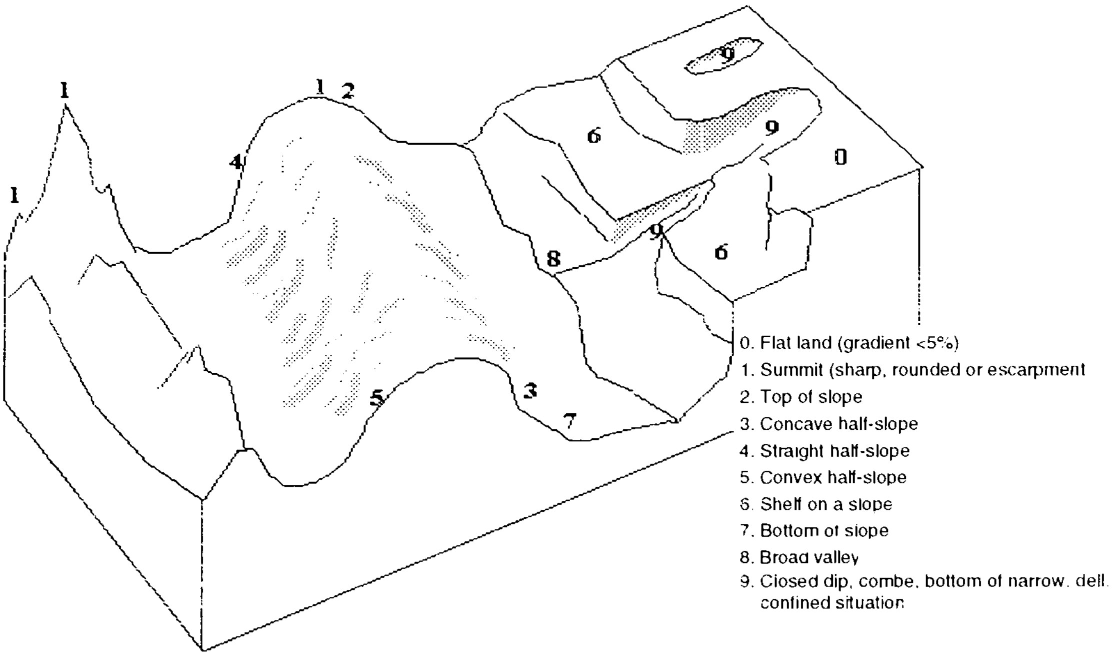
Current trends

Ecological observations

Since the survey began, non-forest features have also been monitored on sample plots - local relief, aspect, gradient, parent rock, soil texture, soil depth, presence of pebbles, soil moisture. Herbaceous vegetation was originally investigated exhaustively within a radius of 6 m. Work was most detailed in the Montpellier area. Ecological measurements have taken on greater importance over the past few years. The description of local relief has become more detailed. Soil is now classified according to the French soil nomenclature. If necessary, classification is done by a specialist based on field observations. Flora is recorded within a radius of 15 m, and includes an indication of abundance. Observation procedures have been reviewed and standardized. A major step forward was the creation of an ecological database, making it possible to use data that were not hitherto readily accessible.

Use of remote sensing by satellite

The abundance of **open forest** in natural and semi-natural Mediterranean environments makes mapping difficult, even when aerial photographs are used, and does nothing to facilitate the use of satellite images. However, experiments with the use of such images for forest-survey purposes are most often carried out in southern regions. A member of the NFS staff, Jean-Guy Boureau, has written a doctoral thesis entitled "Remote analysis of heterogeneous forest formations. Its use in the characterisation of lightly wooded Mediterranean areas". An experiment is currently under way in the Hérault to update the 1:25 000 map (compiled using aerial photographs) by means of satellite images rather than new photographs, which would be less expensive. This forms the subject of another paper at this workshop.



Operations on sample plots

The field installation of sample plots, which involves using simple survey tools (compass and measuring tape) to locate the exact position of a point marked on a photograph, takes up much of the survey time and thus accounts for much of the cost. There are often fewer access roads in southern France than in the rest of the country, and the often thorny scrub hampers progress. It was decided that, in the Corsican scrub, the plot could be placed at the point reached after an hour's walking, provided the vegetation was the same as around the point initially designated on the photograph. In open areas, the variance of measurements is high, meaning that results are not as accurate unless the sample is drastically increased. The trend is thus to investigate open forests using aerial photographs only. The map is drawn up as precisely as possible, and the first-phase sample investigated without carrying out field measurements. The results of the first two surveys give an indication of the characteristics of tree stands. Mapping is thus the most important aspect of work. The transition from heathland to open forest and then to dense forest is monitored in this way. Measurements begin at this latter stage.

Use of survey results

It is not possible to draw up a list of all the uses made of the survey products. The principal result is obviously knowledge of the extent of the forest. In the Mediterranean zone, successive surveys show an overall increase, although its geographical distribution is changing. In the Mediterranean zone, demand appears to be greatest for land-cover maps and maps of tree stands by type. This is because these maps are used for the prevention and control of forest fires. They make it easier to choose where to place firefighting equipment, and to predict the spread of a fire once started. An experimental software program has been drawn up to simulate fire spread based on digital map data and hypothetical weather conditions.

In the Gard, research work was done in 1994 with the following objectives:

- to incorporate NFS data into the geographical information system already being used by the forestry board;
- to map the extent of a fire that occurred in summer 1993 using a Landsat TM satellite image;
- to estimate fire damage using NFS data;
- to define a method for determining areas prone to fire;
- to define a method for helping redevelop burnt land.

More recently, maps were given to a body responsible for defining areas in which food products originated. The study related to goat's cheese.

Application of french experience abroad

In the past, the NFS has helped with survey work in the Taza province of Morocco. More recently, it helped the Tunisian survey department carry out a general survey (single operation) across the entire country, as well as set up and manage the database containing the results. Finally, using the results of a one-off survey carried out following an international call for tenders in Morocco, the NFS presented proposals for organizing a permanent survey, based on its own experience.

FORESTRY STATISTICAL INFORMATION SYSTEMS IN PORTUGAL

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Abstract

The authors briefly review Portuguese experience of the production, organisation and dissemination of forestry statistics and, in particular:

- the forestry statistical system as a reflection of activity in Portugal;
- its dependence on the importance attached to the forestry sector in the context of the economy as a whole, and the state of development of the various components of the sector;
- the acquisition and processing of information at the various stages of production and processing;
- experience hitherto and prospects for the future.

National forestry statistical information systems

1.

One of the more widely accepted definitions of the economy is "how, with or without money, individuals and societies use available resources to produce goods and services and to distribute them". Restricting the concept of resources to that of "forestry resources" brings a sound definition of forest economy. A forestry statistical system should constitute a continuous coherent flow of graphic and numerical information which enables the functioning of the economy of the sector and its links to the economy as a whole and with society to be represented, defined and analysed. It is therefore of the greatest importance as an instrument for defining strategic or tactical measures at national level and at the level of individual enterprises. Its constitution, organisation and efficiency at national level will depend on the importance attached to the forest economy and on the extent to which this is developed.

2.

In ideal conditions for the operation of the economy and action by its agents, the acquisition of information would of course be simple because it would entail no more than collecting existing information, processing and disseminating it. While the real picture differs from one country to another, even within a single country, or the different components of a branch of the economy, the effort and costs required to acquire information are generally substantial. Furthermore, the diversity of the goods and services produced by this type of resource further compounds the difficulty of collecting information on intangibles like soil and water conservation, or environmental protection as a whole, for example. It is, thus, difficult in practically any country in Europe to collect this information in standard form to comply with requests from various international bodies. The development of the technical means of collecting information has greatly reduced the time and the human resources needed to acquire process and circulate information.

3.

In very summary terms, where the material goods produced by forestry are concerned, the following may be considered to be the key points in collecting information on the system:

- assessing existing resources;
- characterising the activities pursued;

- raw material circuits and marketing; processing industries;
- internal consumption and external trade.

There follows an analysis of the Portuguese experience of collecting, processing and disseminating forestry information in the sequence defined above.

3.1. Assessing existing resources

The series of operations carried out to collect this information is usually described as the Forestry Inventory. Essentially, this refers to the assessment of areas covered by forests, their composition, spatial distribution and the collection of the data necessary to determine its production potential.

In Portugal, areas under forest and their composition have been assessed and mapped since 1874 (Estatísticas de Portugal e Colónias). The Carta Agrícola e Florestal (Farming and Forestry Map) dates back to the beginning of this century, and it forestry components were updated in the 1920s (Directorate-General of Forestry and Water Services) and, in the 1950s, a new Farming and Forestry Map was produced to a scale of 1:25 000 (agricultural reconnaissance and planning service). Since 1965, the Directorate-General of Forestry Services (DGSF and its successors) has carried out further forestry inventories, with updates approximately every 10 years. This work has been conducted on the basis of aerial photography to a scale of 1:15 000, using increasingly sophisticated films in successive flights (panchromatic, infrared black and white and more recently infrared colour).

Area estimation techniques moved from painstaking measurement once thematic maps were produced (1968-1978, scale 1:25 000) toward faster, less rigorous forms using methods involving direct sampling on aerial photography. Production potential is estimated by taking random or systematic sample forest plots, collecting information on volume and growth, species present and occupation by season, age or stage of development. This information is georeferenced to Administrative Division level (concelhos and distritos). The information obtained from summary inventories of the main lumber species conducted in 1986 and 1990 (DGF/ACEL) is georeferenced by large regions. Since 1985, specific inventories have been made of the areas occupied by cork-oak and holm oak, with particular attention to their state of health and natural regeneration.

As part of the third review of the National Forestry Inventory, the Instituto Florestal is going to use aerial photography carried out in 1995 (scale:1:40 000, infrared colour) with the aim, in the first stage, of compiling digital information on forestry areas broken down to NUTS level III. These areas will be estimated by sampling using a systematic network of points located on blow-ups to scale 1:10 000. In the second stage, the data necessary for assessing production potential will be collected and georeferenced to NUTS II level. The third stage will aim to produce a digital thematic map to 1:100 000. Since 1990, areas affected by forest fires have been surveyed every two years using Landsat TM satellite pictures.

In summary, the statistical data currently produced by the Forestry Inventory concern:

- forest areas by species and spatial distribution;
- stocks (tree volumes), and the structures and growth of standing crops of the main species.

3.2. Characterising activities

The data collection system for activities affecting forestry resources falls far short of the ideal, in that it is currently limited to a joint effort by the Instituto Forestal, Instituto Nacional de Estatística and the Instituto de Estruturas Agrícolas e Desenvolvimento Rural (IEADR) to use the surveys made of agricultural holdings to characterise the forestry activities associated with these. The aim is to determine the structure of forest husbandry in agro-sylvo-pastoral systems, from which it is hoped to obtain information on how forestry activity is organised and the working links between owners and forest, i.e. to answer the questions of who harvests how much, when, where and how. This task is hampered by the lack of any overall register of agricultural property, and of forests in particular.

3.3. Raw material circuits and marketing; processing industries

The information shortfall in this area, particularly concerning lumber and other products, is mainly the result of the lack of, or breach of, legal instruments for monitoring activities. While cork production reports have long yielded good statistical series, this type of information on other timber is sadly lacking, and the felling reports submitted bear no resemblance to the facts. Thus, indirect estimates are the rule in this field, based on industrial consumption and the volume of raw wood exported in an attempt to quantify the real volume of felling. The same holds for resinous products. These indirect processes were developed from the industrial statistics published by the INE when, in 1990, its published figures no longer cited values for materials consumed by the processing industries, whereupon the sole means of estimating the amount of annual harvests from Portuguese forests was lost.

3.4. Internal consumption and external trade

No specific information is available on internal consumption. Previous experiments by economic coordination bodies set up in 1973 within the Forestry Products Institute, which ceased to exist in 1989, highlighted the considerable difficulty of obtaining information on internal consumption, in that economic records allowed for no distinction between products for internal consumption and those intended for export. For external trade by products and markets of origin and destination, the custom has been to use the series published by the INE External Trade Statistics from data collected at customs offices. With the abolition of customs controls on intra-Community trade, accurate information is solely available on commercial flows with non-Member States, which account for a mere 10-20% of the total.

4.

Briefly, the national forestry statistics system has essentially operated on the following basis:

- forestry information disseminated by the National Forestry Inventory;
- overall statistics disseminated via the Forest Profile set up by the former Institute of Forest Products, which the DGF attempted to continue until 1991.
- specific external trade statistics compiled and disseminated by the INE.

For the future, the Instituto Florestal, in close cooperation with the INE, aims to consolidate systematic collection of data with a view to building up an adequate forestry database to lay the ground for a system of statistical information in the sector.

As already stated, since statistics and mapping are essential instruments for defining medium- and long-term strategies in the sector, they are, of course, indispensable for all concerned with the economic, social and environmental aspects of the forestry sector. Development technologies, from remote sensing to ever-improving computer resources, will enable that objective to be achieved if forestry and its multiple components are given due recognition by politicians, economic operators and public opinion.

ORGANIZATION OF FORESTRY STATISTICS IN SPAIN

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I. Introduction

I.1 Political and economic aspects

Forests play an important part, not only from the economic point of view but also with regard to the protection of the environment and the meeting of the demand for natural spaces, especially in countries with a high percentage of urban population.

Statistics on forests have traditionally taken a secondary place in the field of agricultural statistics and this, in principle, can be explained by the fact that forestry resources and their uses are of a permanent nature and affect fewer economic and social sectors. Nevertheless, this concept has recently been undergoing a radical change, both for economic reasons (growing imbalance in the balance of production-consumption of wood) and for reasons tied to the conservation of nature and the protection of the environment.

The drawing up of forestry statistics in Spain presents a series of specific problems of methodology arising from the extremely variable density which is characteristic of the Mediterranean forest and which, in fairly large areas of the national territory, is made up of pastures and meadows used for cattle and crops with varying degrees of intensity. This is a problem common to specific areas of Southern Europe which requires precise definitions within the overall scheme of land usage so that the information of the different types of forest areas in the 15 European Union countries can be compared. Another aspect peculiar to forests in Spain is that of the high risk of forest fires which has led, since 1956, to the drawing up of statistics specific to forest fires.

I.2 Legal aspects

Law 9/1989 dealing with Public Statistics, regulates the basic aspects of statistics to be used by the government in Spain. The methods and procedures used in forestry statistics are laid down in the Statistics Plan of the Ministry of Agriculture, Fisheries and Food, passed by Royal Decree 265/1985, 6 February. The Royal Decree states that, in order for the statistics contained in the abovementioned Plan to be carried out, the Ministry of Agriculture, Fisheries and Food may establish Treaties of Collaboration with the Autonomous Communities.

I.3 Functional aspects

Firstly, it is necessary to point that, independently of the statistics described below, which can be considered as purely pertaining to forests, the quantitative analysis of forestry activity uses information from the following statistical sources:

- Spanish Agricultural Census, carried out by the I.N.E. (National Institute of Statistics) theoretically every 10 years (the last being in 1989), which provides structural data on farmland in general (including forests and those with forest areas)
- Quarterly Survey on Active Population, conducted by the I.N.E., which provides data on the use of employment in forestry activity
- Spanish Foreign Trade, giving monthly statistics on imports and exports of forestry products and their by-products
- Spanish Industrial Statistics, prepared annually by the I.N.E., which provide data on the activity of the timber, cork and paper pulp industries.

Forestry statistics, in the strictest sense of the term (structural content and average production) are prepared by the Ministry of Agriculture, Fisheries and Food - General Subdirection of Statistics and the General Subdirection of

Natural Areas and Wildlife - either directly or with the collaboration of the Autonomous Communities, in application of the Treaties established to this end.

II.1 National forestry inventory

The need for complete and detailed information on the areas and stocks of forests in Spain led the government to plan and develop the first National Forestry Inventory, with the recording of data in the field carried out between 1965 and 1974.

This led the government, 10 years after the end of the abovementioned inventory and considering the important changes taken place in the forest areas during this period of time, mainly due to fires, reforestation, changes in the ownership of the land and variations in the use of the land, to carry out a second National Forestry Inventory, which began in 1986 and is due to finish in 1996. The second National Forestry Inventory has a double objective in mind: to provide up-to-date and continuous information on the composition and structure of forest areas in Spain to meet the statistical needs of Spain and the European Union and, on the other hand, to set up a database which is accessible and user-friendly with multiple applications: forestry legislation, planning, management, conservation, restoration of the environment and those applications directly related to the extension and size of the forests.

The National Forestry Inventory forms part of the Statistics Plan of the Ministry of Agriculture, Fisheries and Food in so far as it provides the basic statistics for the structural analysis of nature. It is carried out on a continuous basis, being repeated every 10 years, and the province is used as the geographic unit for the inventory. Areas, stocks and ecological and forestry indicators are the factors which have had an important influence on the design of the inventory and the Stratified statistical method has been chosen as the type of sampling to be used, with circular plots of multiple radii and sampling points on the kilometric vertexes of the U.T.N. grid which are found in areas classified as tree covered forests. Designing the way to process the data involved choosing the most appropriate software, preparing programmes to do the calculus algorithms and defining the output, both alphanumeric and cartographic.

There are four main phases inherent in the carrying out of the National Forestry Inventory: preparation of maps, field work, data processing and the publication of results.

The preparation of maps involves introducing both the information readily available and the information specifically gathered for the plan into a data bank. Protected areas, systems of ownership, altitudes, local government divisions and types of vegetation make up some of the input which is stored by means of digitizing the different areas.

The field work phase, which starts out with the analysis, sizing and distribution of equipment and the necessary auxiliary means, is based on the survey of plots which involves the location, implementation, identification, estimation of the age of the area, dendrometry and the identifiers of the ecological and forestry parameters.

Data processing, which brings together the phases of the preparation of maps and field work, enables dendrometric and dasometric information to be obtained.

The last phase, the publication of results, requiring the preparation of texts, the drawing up of tables and the filming of maps, is structured in three parts: general data, cartographic data and numerical data.

The situation of the National Forestry Inventory at present is as follows: 24 provinces published, 12 in process of publication, 5 at the data processing stage, 4 at the field work stage and 5 at the preparation of maps stage. The human resources available on the National Forestry Inventory amount to a team made up of approximately 140 people. The total working budget of the Inventory is around 4,000 million pesetas ($34 million), giving an average cost per province of around 80 million pesetas.

The third National Forestry Inventory, due to be carried out in the 10-year period between 1996 and 2005, will have as its main objectives the bringing up-to-date of information on forests, the evolution of the forest systems and the characterization of the ecosystems. It will be designed so as to take into account not only the structure of the forest systems but also that of the treeless areas, particularly those which are shrub, thicket and herbaceous, and it will evaluate the protective, productive, ecological and recreational aptitudes which are characteristic of these areas. This analysis will be carried out by means of greatly differing indicators such as composition, functioning, stability, fragility, forestry and phytosanitory state, erosibility, vulnerability to fire and others, with the main idea of providing the information necessary for the overall planning of forest systems in Spain.

II.2 Statistics on Forest Fires

The systematization of statistics on forest fires began in Spain in 1956 when the Forest Fire Service was set up to centralize the information gathered in the provinces, albeit in a rather irregular fashion. In this way, quantitative knowledge began to be acquired of the problem and this helped towards designing the tasks of prevention and extinction. In order to obtain information, a first Fire Report was used, processed manually and with the aid of calculators, and this gave rise to the first statistical data. In 1967 and after a new Fire Report was drawn up, the processing of data began using electronic computers. Nevertheless, statistics on forest fires by the Publication Service of the Ministry of Agriculture did not begin to appear until 1968 when the first volume was published. In the first part there was a summary informing about the forest fires from 1961 to 1967 inclusive and the rest referred specifically to data corresponding to 1968. Statistics on forest fires published annually from 1968 to date, an be divided into three periods: from 1968 to 1979, from 1980 to 1986 and from 1989 to present.

In the first period, the gathering of information was mainly directed towards causes, fire-fighting equipment, species affected and economic losses suffered in fires which mainly affected public land, especially those areas of reforestation, and, on many occasions, losses affecting private property were not reflected in the official accounting figures.

From 1980, and with the consolidation of a true fire-fighting structure, information began to be gathered on all the fires, regardless of ownership of the land and type of area affected and results were drawn up on a provincial level.

The last period of time, from 1989 to date, has seen the drawing up of a new Fire Report, designed to take into account the present-day characteristics of a phenomenon which has changed with respect to previous years, both as regards fire-fighting means and the social reality on which this phenomenon is based. Changes have been introduced such as the noting-down of times, the introduction of motivations of intentional behaviour, the use of aerial means, the segregation of forest areas and the qualitative evaluation of the ecological effects of the fires. As a result of this reform and given the development of information technology, the philosophy of the statistical system has been modified. On the one hand, it was necessary to meet the legitimate demand of the Autonomous Communities to have its own statistical data base and, on the other, it was necessary to have a national data base which included entries on previous intervals and improved the possibilities of obtaining results, reducing the minimum territorial area to municipalities and regions, enabling the introduction of intervals of dates to obtain results and giving access to a search for entries which met one or several conditions. The handing over of historical information on fires affecting their areas to the Autonomous Communities and the software necessary for the processing of all this information has resulted in decentralization which makes the handling and consulting of information in each province possible. Nevertheless, central government still gathers information on a national level to enable it to publish the Statistics on Forest Fires on an annual basis and to send information to the European Union in Brussels so that it can be integrated into the community data base, a necessary prerequisite to obtain financing from the European Union for fire-fighting plans.

II.3 Reforestation

Statistics on reforestation arise from a need to restock forest areas destroyed by fire. Spain has a historical series of statistics on reforestation going back to 1940. Due to administrative problems, the gathering of this information was interrupted for several years, but it was recently started again with a newly designed questionnaire which is more in tune with present-day needs. Basic information is provided by the Autonomous Communities, as agreed in the Treaties of Collaboration with the Ministry of Agriculture mentioned at the beginning of this paper. These statistics take into account the area reforested in the year, differentiating between that reforested for production and that reforested preferably for protection. The information is divided according to the 14 most important species in Spain and includes the cost of said reforestation: seed, seedlings, machinery, labour and other costs.

III. Statistics on forestry production

The general drawing up of statistics on forestry production is carried out every year and quarterly information also exists on licences for removals, which enables estimations of information for the year to be made in advance. The information necessary for these statistics is also provided by the Statistical Services of the Autonomous

Communities, by means of questionnaires designed by the Unit for Forestry Statistics of the Ministry of Agriculture, Fisheries and Food and which include the following sections:

III.1 Removals and use of wood

In Spain, in order to fell trees, it is necessary to have a licence issued by the Forestry Service of the Autonomous Community and, when the area of woodland to be felled exceeds certain dimensions, it is necessary to present a plan for the laying out of the forest area. The information gathered from these licences is compiled statistically in a questionnaire on Advances on Removals Licences which, on a quarterly basis, brings together the requests for these licences presented by the forestry workers and includes the following information:

- Cubic metres requested in the license, depending on whether the land is publicly or privately owned
- Distribution, depending on whether the main species are conifer or broad-leaf.

This information, aggregated on a provincial level, helps us to forecast annual removals. Nevertheless, these figures may not be exact as the licences can be used within a period of up to two years. Removals actually carried out is controlled by the Services of the Foresters (Forest Guards) and this enables the filling-in of a questionnaire summarizing annual removals. The annual volume of removals, divided into 25 species (conifer and broad-leaf), includes the value of the wood and its supposed end-use. Likewise, the following types of ownership are considered:

- State and Autonomous owned forests
- Consortium owned forests: public and private
- Public forests not belonging to a consortium and of free use
- Privately owned forests.

Despite the exhaustive control on removals, it has been proven that an important part of production escapes statistical control. Since the definition of the volume of removals is the most important concept in forestry activity, the idea has come about to draw up a balance sheet of production-consumption of wood to quantify exactly the amount of removals carried out. In this balance sheet, information on removals from the annual questionnaires is contrasted with information on the consumption of the processing industry (sawmills, boards, pulp, etc.) and with information on foreign trade. The result is a difference which represents the volume of production on a national level which does not figure in the basic information and which is reflected in the annual statistics as an additional term. The results of the statistics on removals, once they have been checked and approved, are published in the Monthly Statistical Bulletin and later in the Agricultural Statistics Yearbook published by the Ministry of Agriculture.

III.2 Forest nurseries

Statistics on forest nurseries have traditionally been carried out by the ICONA, by virtue of the control which this organization had over this type of farming and the results were published in the abovementioned Agricultural Statistics Yearbook. From 1986, and due to Spain joining the EEC, this task was assigned to the Autonomous Communities and so it was yet again necessary to make use of the aforementioned Treaties of Collaboration in order to assure the continuity of the information. Taking into account the increasing importance of reforestation, it is necessary to revitalize the annual statistics on forest nurseries and, to this end, a new questionnaire has been designed to renew this information with effect from 1994. Basic information has been divided on a provincial level and includes the production and value of seeds and plants - conifer and broad-leaf - both in private and public forest nurseries. Likewise, it also gives us information on the structure of the nurseries: number of nurseries, area planted - open-air and greenhouse - and costs.

III.3 Hunting and freshwater fishing

Hunting, apart from being a sport, is an important source of income for Spanish agriculture, not only for the monetary value of the specimens but also for the complementary income received by those involved in agriculture, regardless of whether the reserves are private or publicly owned. The same can be said for freshwater fishing, although in this case the fishing reserves are usually publicly owned. The practising of both hunting and freshwater fishing is totally regulated, with the Autonomous Communities holding the necessary power to ensure the rules are being enforced. Statistical information on hunting and fishing is provided by the corresponding

Services of the Autonomous Communities and is made up of: hunting and fishing licences, amount charged for specimens of the most important species and their value (all on a provincial level) and the complementary income received by the owners of the reserves.

III.4 Other mountain area products

Finally, statistics on forestry production cover a series of products, which, comparatively in Spain, are of lesser importance, even if, in certain regions, they take on greater importance. We are referring mainly here to the extraction of resin, cork and esparto, fruit (acorn, chestnut, pinenut, etc.) and recreational uses of the mountain areas. Statistical information on these products usually consists of estimations carried out by the Provincial Services, which, in some cases, is contrasted with government-held information, when, in order to make the best use of the corresponding information, it is necessary to go through official channels.

SESSION 3

THE IMPACT OF NEW TECHNOLOGIES IN AGRICULTURE /FORESTRY

THE MARS PROJECT: THE EUROPEAN APPROACH ADAPTABLE TO NATIONAL NEEDS

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Abstract

With the decision of the 26th of September 1988, the Council of Ministers of the E.C. approved the creation of a 10-year research and development Project for the Application of Remote Sensing to Agricultural Statistics in the European Union (E.U.). This Project is commonly referred to as the MARS Project, or "Monitoring Agriculture with Remote Sensing". Its main activities relate to the quantitative estimation of the acreage occupied by the various crops in a given region or country and the corresponding yield, vegetation and crop state monitoring, timely crop yield forecasting and the rapid estimation of the E.C.'s total production of the most important crops. In this presentation, the methods, results as well as examples of outputs of the MARS Project in the E.U. context are first briefly presented. It is then explained how the MARS approach is planned to be adapted to the Central European context. The framework for this activity is the MERA 92 and the future MERA 95 "Multi-country project for rapid monitoring of agricultural and environmental statistics", funded by PHARE. "MERA" stays for "MARS and Environmental Related Applications in the PHARE countries". If succesfull, this exercise may well turn out to be a major tep forward in the field of operational applications of remote sensing, as it integrates satellite derived information, ground survey data and surface meteorological data in one system for monitoring of agricultural and environmental statistics.

1. Introduction

A huge investment has been made by many countries in satellites for earth observation [Mc. Donald, 1994]. The possibilities of the technique are enormous, the number of scientific papers written about the use of satellite images to monitor vegetation is very large, but the operational applications for land use statistics remain relatively modest compared with the expectations developed in the 70's and 80's.

The MARS Project (Monitoring Agriculture with Remote Sensing) of the EC was conceived in part to help filling this gap, to develop operational tools using satellite images for agricultural information [Meyer-Roux and Vossen, 1994]. The targeted crops are the ones in which there is the biggest market: crops consumed on the farm, such as fodder crops are excluded for the moment. The scope is using existing research results and procedures to develop operational products at European scale, rather than carrying out new fundamental research. However some applied research is necessary.

The project is currently organised into 5 Activities and a number of extensions:

- Activity A: Regional inventories. Crop area and production estimation at national or regional level with area frame sampling and possible correction with high resolution remote sensing imagery, mainly SPOT and Landsat TM images [Gallego et al, 1994, Gallego et al, 1993, Perdigão, 1992].
- Activity B: Rapid estimates at the European scale of actual planted areas of the main annual crops, as compared to the previous season [Sharman and de Boissezon, 1994].
- Activity C: The Advanced Agricultural Information System, which combines the use of low resolution satellite indices (type NDVI and surface temperature derived from NOAA-AVHRR data) and ago-meteorological crop growth simulation model outputs [Vossen and Rijks, 1995, Supit et al., 1995].
- Activity D: The assessment of foreign agricultural production.

- Activity E: Development of new methods and techniques for image analysis and testing of the usefulness for agricultural purposes of new space born sensors such as ERS-1 [Kohl et al., 1993].

In addition, a support activity 'Area Survey Systems' deals with types of surveys to be used in conjunction with remote sensing.

For Activities A, B, C and E and for the support activity, major progress has been made to the extend that their (pre-) operational use or transfer to national or Community services has become possible. The Activity D started with the second Phase of the MARS Project and so, preparatory work has been done so far. Priority was indeed given to the implementation of a system that provides operation outputs at the scale of the European Union (EU). Geographic extensions are being launched in central Europe, countries of the former Soviet Union, and in northern Africa. In this paper, we shall deal mainly with the extension in central Europe.

Thematic extensions of the project are particularly important in the field of verification of farmer's crop declarations [Délince et al, 1994], water management in the Mediterranean region, the Hydre Project [Vogt and Vossen, 1995], soil maps [King et al, 1994]. Only the activities object of interest to be adapted and / or carried out at national level are developed in this paper.

2. Activity A : regional inventories

2.1 Objectives and methods

The aim of this action is to meet the need for accurate and objective annual information on acreage at regional level covering the main crops.

The method adopted is to establish close links between satellite data and observations on the ground. Development and evaluation focus on the so-called regression estimator method. The action comprises two components:

1. Component 1: objective observations in the field with a sample design established or enhanced by remote sensing;

2. Component 2: automatic classification of the satellite data in order to improve the estimates generated by the ground surveys, using the regression method.

Remote sensing also comes into play in providing the enumerator with documents enabling him to identify plots of land accurately on the ground. This component was developed as part of the support activity Area Survey Systems (see further).

Activity A was implemented, with the cooperation and joint financing of national and regional authorities, in administrative regions in Belgium, France, Germany, Greece, Italy, Portugal and Spain. Within the framework of the MARS Geographic Extension Activity, the same method of area frame sampling for regional inventories have been applied in Central and Eastern European countries.

The method used is as follows:

- stratification using satellite images and with existing topographical documents and maps as support;
- selection of a sample of square segments;
- survey on the ground on the basis of aerial photographs;
- if regression method is used:
  - simultaneous acquisition of full coverage of the region by both Spot and Landsat-TM;
  - automatic classification of the satellite data in order to improve the estimates generated by the above-mentioned ground surveys, using the regression method;
- analysis of the results.

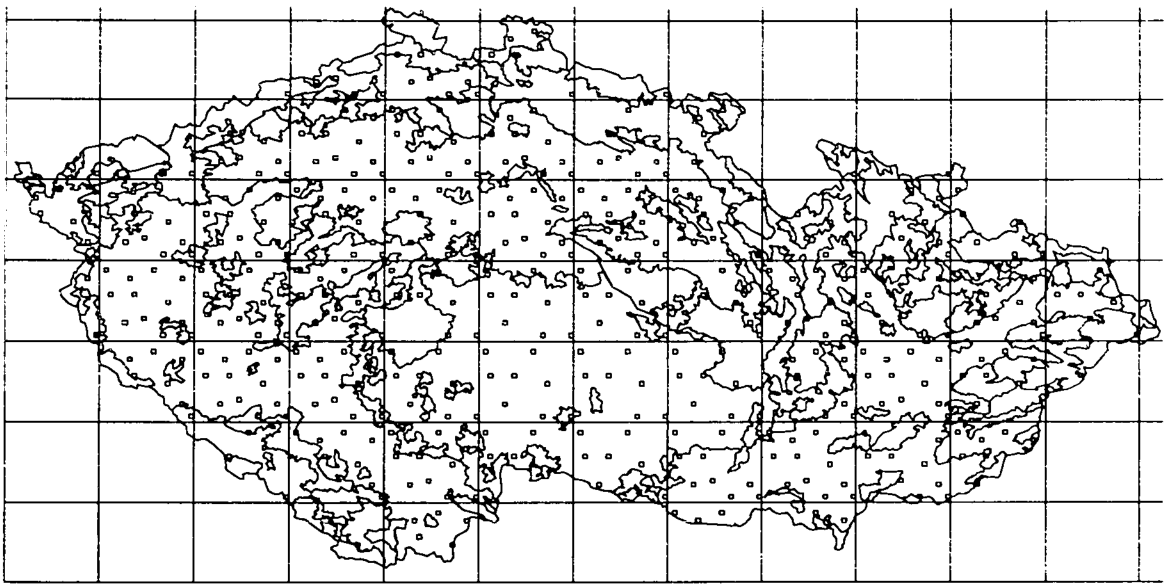
2.2 The results

Component 1 : stratification results

Stratification proves to be very economical as, generally speaking, it reduces the cost on the ground by a factor of two for the same degree of precision. It pays for itself in the first year and can be used for several years in a row. Satellite images appear to be the ideal means of detecting homogeneous areas of land use and physical boundaries, such as roads, rivers, paths and the edges of forests, for selecting segments and assessing in advance difficulties arising from the number of plots. Since the period in which the images are obtained is not critical, the method is applicable throughout Europe.

The square segments method is quick and effective. The best tool for the enumerator is an enlarged aerial photograph, but nearly everywhere the use of a 1/10 000 enlargement of the SPOT images of the segment have been used, together with the corresponding same scale topographic map. The identification of the farmer followed by a normal interview survey is carried out to provide a complete survey system not restricted to crop acreage. As an example, the stratification for the Czech Republic is given in Figure 1.

Figure 1: Stratification of the Czech Republic and sample of 417 segments (1992 survey)



Sample of 417 segments in the Czech Republic (survey 1992)

Component 2 : the regression estimator

The regression estimator method was applied in almost all the regions. The SPOT and LANDSAT resolutions are very suitable for automatic processing. However, this method is subject to strict constraints, both technical and financial, e.g. regarding the acquisition of the images. It was, in fact, not always possible to cover the whole of a region of 20.000 km2 within the optimum period, which was about 40 days, with a single type of satellite. It was nevertheless nearly always possible to cover the region by using both SPOT and LANDSAT, but this complicates processing, and by straying outside the optimum period for certain portions of the territory, but this reduces the efficiency. Table 1 gives as an example the results for Macedonia, in 1988 and 1989.

Table 1: Results for Macedonia (after stratification)

Crop	Official statistics (x 1000 Ha)	M.A.R.S. estimate (x 1000 Ha)		relative efficiency : without stratification		with TM stratification		Crop
	1988	1988	1989	1988	1989	1988	1989	
Common wheat	195.5	158.5 (11.7)	163.6 (11.0)	1.25	1.39	1.84	1.99	Common wheat
Durum wheat	150.3	175.4 (12.3)	161.1 (10.0)	1.17	1.49	2.17	2.13	Durum wheat
Barley		60.4 (6.4)	65.5 (5.5)	1.12	1.29	(*)	1.67	Barley
Dried pulses	5.0	0.6 (0.3)	2.2 (1.0)	1.44	1.72	3.56	(*)	Dried pulses
Maize	30.4	27.5 (3.3)	22.5 (2.0)	1.70	1.99	1.67	3.11	Maize
Sunflower	16.3	16.6 (3.5)	4.0 (1.2)	1.16	1.09	1.38	1.41	Sunflower
Potatoes	4.0	6.0 (3.0)	0.9 (0.7)	0.67	1.10	0.99	7.61	Potatoes
Sugar beet	10.3	15.9 (3.8)	13.9 (1.2)	1.36	1.99	1.23	7.16	Sugar beet
Rice	12.0	14.1 (1.1)	9.9 (0.5)	7.04	6.27	6.31	18.86	Rice
Cotton	57.7	73.9 (6.2)	60.5 (0.4)	2.26	2.47	1.54	3.19	Cotton
Tobacco	20.5	31.7 (4.7)	17.7 (2.2)	1.30	1.60	1.06	2.21	Tobacco

The figures between brackets are standard errors. (*) The regression correction has not been applied

When the data processing is done by professional service companies, no major problems are encountered with the technical aspect of the operation; however, such problems arise when national constraints affected the operations. The technique of automatic classification over a vast area is technically difficult for government agencies or services companies not specialized in remote sensing. For this reason, costs are high for results that are not reliable for all crops. Except in favourable conditions, and given the current state of technology and the cost of images, component 2 should not be recommended from an operational point of view for regional or national statistical services.

2.3 Conclusions, future developments

European statistical services are now fairly familiar with the potential of remote sensing in the area of crop inventories at regional or local level. The introduction of remote sensing entails the adoption of area sampling techniques, previously little used in Europe, where the prevailing method is surveys based on lists of farmers.

Putting the methods developed in Activity A into operational use means, in practice, supplementing structural surveys and compulsory censuses with an area survey generating more rapid, objective and accurate vegetation statistics. This appears to be an attractive alternative in countries where there are occasional weaknesses or where current systems do not fully meet the demands created by the new measures of the common agricultural policy. It is also in these areas that remote sensing is the most effective, and the system of area surveying is therefore to be recommended.

The regression estimator method is not to be recommended per se, not for reasons of technical feasibility, but because it requires too big an effort to implement, unless highly specialized services companies are brought in, for results that are not particularly outstanding from an economic point of view, except perhaps in certain region of the world. However, by using statistical systems based on lists of farmers or area systems based on either points or segments, through familiarity with the operational potential and limits of remote sensing, by stratification or automatic processing of satellite data, it is possible to select the method best suited to the case in point.

3. Activity C: the advanced agricultural information system.

This Activity consist of the following 3 components:

1. Component 1 : The assessment of vegetation conditions and yield indicators with low resolution meteorological satellite imagery
2. Component 2 : Yield prediction models
3. Component 3: The advanced agricultural information system

3.1 Component 1: Vegetation condition and yield indicators

Objective and methods

The objective of this component is to use satellite meteorological data for monitoring vegetation conditions and providing indicators of the yields of the main crops.

The method consists in processing the satellite data to generate two indicators: a vegetation index and surface temperature. Since these indices are directly related to the state of vegetation and crops, a spatial and temporal comparison of these data with other years or areas should make it possible to assess comparative yield levels. In addition to the objectivity of the method, the main attraction is the possibility of providing such indicators at various geographical levels: local, regional, national and European.

The methods developed so far cover only data from the NOAA-AVHRR satellite. Research work tends to demonstrate the importance of data from the METEOSAT satellites, which were left out of the project in order to simplify matters and avoid spreading efforts too thinly. This aspect will be added to the MARS activities as from 1996.

3.2 Component 2: Yield prediction models

Objectives and methods

The objective of component 2 is the development, testing and implementation of a system for timely regional crop state monitoring and yield forecasting of the following major E.U. crops: cereals, grain maize, rice, pulses, sunflower, soyabean, potato, sugar beet, colza, wine, olive oil, apple, pear and citrus. The quantitative yield forecasts should be accetapbly precise at the national scale and possibly also for large regions.

Some of the constraints of remote sensing techniques are for example the limited availability of sufficiently cloud-free images in the northern half of the E.U., the incompatibility between low resolution satellite imagery and the size of the fields, the incompatibility between the frequency of availability and the efforts required for the analysis of high resolution satellite data and the rate of change of crop conditions, and the non availability of proven models to relate satellite information to quantitative yield estimates on a regional scale.

On the other hand, methods that use 'surface' information, such as agrometeorological crop growth simulation models, drought indices and time trend extrapolation have proven to be useful for crop yield forecasting in various continents and different climatic conditions.

However, methods that use surface information have some major disadvantages, when they are applied at a regional scale: the required input information has often a limited precision and spatial resolution, the outputs do not always permit a correct assessment of the spatial extent of a fenomenon and some of the input information consists itself already of estimates derived from other parameters (solar radiation from cloud cover or sunshine duration). So far, yield prediction is done mainly by qualitative methods, or information from correspondents. Models exist based mainly on data from ground meteorological stations; however, they are not very satisfactory in practice. Locally valid prediction models do exist and have been developed by research bodies, but they cover mainly annual crops and the input data for the models are generally not available at European level. Existing prediction models using data from remote sensing have proved to be either unfeasible, or relatively complicated to implement.

The adapted strategy was therefore to work in two phases:

a) 1988-1993: development and implementation of a basic system for crop state monitoring and yield forecasting based on surface information, simultaneously with the development of the system for vegetation condition monitoring using low resolution satellite information.

b) 1994-1998: gradual improvement and possibly complete integration of both systems. Such improvements can for example be achived by the use of from satellite information derived solar radiation in agrometeorological models, by introducing improved techniques for the interpolation of rainfall data, by using remote sensing for the assessment of the spatial extent of (agro-) meteorological events, etc.

This component is therefore divided into two separate sub-actions:

a) the development of a semi-deterministic agrometeorological model for predicting annual crop yields;

b) the development of a model for the prediction of vine (and olive) yields based on pollen count methods.

Agrometeorological crop growth simulation of annual crops. Crop state monitoring and yield forecasting of the national and regional yields of annual crops are based on outputs obtained from a modified version of the WOFOST model (Supit et al, 1994) implemented according to the specific needs for the E.C.'s agricultural information system. The model is driven by a combined energy balance / waterbalance module which compares real transpiration with calculated potential transpiration through a light interception / CO2-assimilation / waterrequirements / water availability module. The model uses only those daily meteorological data that can be made available via the Global Telecommunications System: rainfall, vapour pressure (or relative humidity), 24-hour mean windspeed, sunshine duration or cloud cover (to estimate radiation and PET).

The **basic frame of the model** was adapted to accomodate the various annual crops of interest and the required input information (conversion factors, base temperatures, etc.) was made specific for the different large regions of the E.U., mainly on the basis of crop knowledge bases that were compiled on behalf of the MARS Project. The models are calibrated to make them region-specific (e.g., initial dry matter at emergence, mean planting date, calibration of the length of phenological stages as a function of sums of temperatures, etc.) on the basis of site specific field data available from various research institutes in the E.U. and on the basis of the crop knowledge bases.The general common outline of the models is given in the Figure 7. It is run once every 10 days. Model outputs are then available a few days after the end of a 10-day period

Historical **meteorological data** were obtained for stations that had kept records for a fairly long time (25 to 30 years). The data collected were those usually available through the GTS network and were used as input for the various models and sub-models.Such data were obtained for 400 European weather stations.The real-time data are identical but are obtained for a different group of ground stations, comprising some 600 stations. Finally, to make use of the meteorological data, it was also necessary to harmonize, at European level, sub-models such as potential and actual evapotranspiration.

Available actual meteorological data and their processing. The data are interpolated to both the network of the actually available meteorological stations, providing daily data in real time,and a 50kmx50km grid over the E.U. Only those stations are represented for which on a daily basis, the input data required for running the models can be obtained. The crop model runs (and the calculation of other derived parameters such as sum of temperatures, climatic water balance, etc.), both for the historical as for the actual data, performed at the level of each grid cell. To run the models at the level of each cell is necessary, because of the non-linearity of a majority of the relations between plant growth and agrometeorological growing conditions and because of the non-linearity of spatial evolution of many of the meteorological and pedological conditions.

As at present no proven techniques for the **interpolation of daily meteorological data** from the synoptic network and applicable to the E.U. as a whole exist (such techniques are only available for a limited number of variables and only for a few countries), a new technique had also to be developed for the interpolation of data from the existing network of meteorological stations on the regular grid.

The **crop knowledge bases** refer, for each major crop, to:

- suitable soil types;
- average planting (sowing), flowering and harvest dates;
- crop cycle length and relations between phenology and temperature and daylength
- initial dry matter after emergence (and, indirectly, crop spacing);
- crop specific parameters such as light interception as a function of leaf are index, energy convertion and the repartition of dry matter into the various plant parts;
- details of optimal, acceptable and harmful conditions for each phenological stage.

The available soils data and their enhancement. To permit the optimal use of the regional crop information, the existing 1:1.000.000 European soils data base was enhanced. Therefore, a cooperation with the National

Agronomy Research Institute (France) and a "Support group on soils and geographical information systems" was set up. The existing 1:1.000.000 soils date base (1985 version) was completed with information available in the original manuscript archives. The soils data base is mainly used in conjunction with the crop knowledge bases, to identify the areas where a given crop can possibly grow (crop suitability). From this version, a Profile Available Water Capacity Map has been derived.

The time trend component. Crop yields largely depend upon the farming practices and they may vary more or less rapidly or more or less drastically, according to newly adapted farming techniques and to innovations. However, this information is not timely available for crop monitoring and yield forecasting purposes at a regional or national scale. It must thus be assumed that environmental growing conditions other than weather are stable and do not change from year to year. This assumption is obviously not true for farming practices such as fertiliser application and variety choice. On the other hand, a correctly quantified possibly existing time trend, may to some extent be used as a replacement for part of the farming conditions that affect crop yield but that are not easily available at the time the crop yield forecasts are made. The use of a time trend includes also that, for a given year, changing farming practices from one site to another within the area, partly compensate each other.

The Crop Growth Monitoring System, CGMS: the meteorological data (and their pre-pocessing), the soils data base, the crop knowledge bases and the models themselves are integrated in one single system, called the Crop Growth Monitoring System (CGMS). CGMS is composed of 3 main modules:

i. The processing of daily meteorological data: quality control, formatting and replacement of missing values; calculation of derived parameters such as solar radiation (from cloud cover or sunshine duration), vapour pressure and potential evapotranspiration; interpolation to a regular grid of 50kmx50km; production of output maps of the meteorological conditions during a given 10-day period, month or season, both as actual values and as departures from the climatological normal conditions.

ii. The agrometeorological crop growth simulation, for each of the major annual crop types that, according to the crop knowledge bases, are likeley to grow in a given 50kmx50km grid. Since various soil types and crop varieties coexist in a grid, outputs for a basic square are produced for each of the major soil types and profile available water capacities, so as to reach a representativity of approx. 80% of the suitable soil coverage.

iii. The statistical module, relating the model outputs, through a regression analysis and possibly in combination with a technological time trend function drawn from historical yield data, to the series of regional yields available in EUROSTAT's REGIO data base. The regression analysis of past years is only used provided it gave satisfactory results in terms of significancy of the multiple determination coefficient, the partial correlation coefficients, the stability of the regression coefficients and the error anlaysis; if not, the time trend function only or previous year's yield are used as predicted values. A mean value per grid is the obtained by weighting the basic results of the model by the relative area occupied by these soil types. National outputs for a given crop are obtained by first weighting, within a given large region, the outputs at grid level by the area occupied by the various soil types suitable for that crop and then by weighting these regional outputs by the relative importance of the crop (in terms of mean regional planted area) within the country.

The heart of the system is the ARC/INFO geographical information system, around which the various data bases software modules and user-interfaces are constructed and which is the driver of the crop growth simulation modules and of the production of the map outputs. The data bases are stored in an ORACLE data base management system.

The **outputs of the system** are threefold:

a) Mapped outputs of agricultural season quality indicators. The main available modelled crop yield indicators are:
   - Biomass, under the actual rainfall conditions and as if all required moisture was available;
   - Grain production, under the actual rainfall conditions and as if all required moisture was available;
   - estimated actual soil moisture reserve; differences as compared to the previous decade or month;
   - state of advancement of the cycle during a given decade;

- percentages departure from the long term mean given decade or period within the growing season, for all of the previous indicators;

b) Alarm warning: Detection of abnormal weather conditions (during a given decade, or cumulated since the start of the season).

c) Tables, with calculated yield forecasts, including information on the quality of the regression equations such as the coefficient of multiple determination, the stability of the regression coefficients, the errors of the one year ahead predictions obtained for previous years, etc.

3.3 Component 3: The advanced agricultural information system

Objectives and methods

The objective of this component is to integrate the various actions and also incorporate conventional surveys in order to create a complete information system including the new methods described above. It therefore lies downstream of all the preceding Activities.

Synthesis work is another way of taking advantage of the various individual actions in order to integrate the results. This makes use of the results of Activity B for acreage and Activity C for yields. This activity covers also the link between area-type ground surveys and the analysis of high-resolution images from Activities A and B.

Results

At present, the NOAA-AVHRR processing chain *SPACE* generates the following products:

- daily mosaic of the Community generated from NOAA-AVHRR data (level 3);
- database for incorporating data for a homogeneous area or a given period, e.g. ten days, and for generating a more elaborate synthetic product (level 4). These can be time profiles for a given area or cartographical products for a given period.

Presently an archive of 7 years of daily European coverages is avalable: 1982 and 1989-1994. The agrometeorological Crop Growth Monitoring System *CGMS* is operational since 1993.

The *Advanced Agricultural Information System* produces, since 1993, the monthly *MARS Bulletin*. It is published from March to October and appears within 10 days after the acquisition of the raw satellite and meteorological data. It contains tables with forecasted crop acreages (at European level) and yields (at national level). The acreages are entirely derived from high resolution satellite imagery. The yields forecasts are established in three steps: first the raw outputs of the *CGMS* statistical module (national crop yield in kg/ha) are produced. This output, which is an automatic product, is then analysed by a team of agronomists and statisticians ("conjoncturists") as a function of the growing conditions indicated by the NOAA-AVHRR indicators NDVI and Ts. If necessary, the CGMS forecast is revised, according to the possible recent occurence of unfavorable conditions depicted by NOAA/AVHRR.

The MARS automatic processing of NOAA-AVHRR data in near real time and the complete Crop Growth Monitoring System, including the statistical module, are operational for all major annual crops and unique in Europe. The results are published in the Monthly MARS Bulletin, which is provided to the E.U.'s Directorate General Agriculture and to EUROSTAT within 10 days after data acquisition (SPOT and LANDSAT for Activity B, NOAA-AVHRR and meteorological data for Activity C). The MARS Bulletin appears from March to October. It not only contains the acreage estimates, but also quantitative yield forecasts based on the interpretation of the SPACE and the CGMS software outputs.

4. MARS extensions to central and eastern europe

Since 1991, the MARS Project has been extending some of its operational activities outside the European Union, at the request of a number of countries, where the agricultural structure is rapidly changing and updated statistics are required. The area frame sampling approach used for regional crop inventories of the MARS Project has been implemented. High resolution satellite data are used for the stratification of the surveyed region. Statistics on area and production have been obtained for the main crops, as well as information concerning ownership and exploitation structure of the land.

Romania and the Czech Republic were the first countries applying this method in 1992. The Romanian surveyed area covered six districts (judetz) with a total area of 26,733 Km^2. A sample of 339 segments was visited that year. In 1993, the surveyed area was increased to 11 districts (55,091 Km^2) and 425 segments. In 1995, estimates were produced for 17 districts (about 94,000 Km^2) with a more intense sample of 1800 segments. The activity has been carried out in co-operation with the Ministry of Agriculture and the National Commission of Statistics.

The entire national territory of the Czech Republic is surveyed since 1992 with the Ministry of Agriculture which took the activity in charge. The first year a sample of 417 segments of 400 ha was surveyed. The sample was later modified to 806 segments of 100 ha, with similar results. The results were evaluated as very useful by the national authorities and they lead to think on the adaptation of the sampling scheme to provide better results for potatoes and sugar beet, which are grown in quite localised areas. This is done in 1995.

The Statistical Office of Slovenia has started in 1993 the stratification of the territory based in high resolution satellite data. In 1994, the first results were obtained for 1/3 of the country, using the same method as MARS.

The fact that for several years the same sample has been surveyed and farmers enquired, permits a good monitoring of inter-annual changes in the agricultural domain like acreage, yields and production, land ownership and exploitation structure and their inter-relation. Possible trends are analysed. But also surface evolution of other land uses have been monitored with the same sample since the survey includes all categories of the extended CRONOS codes used by the MARS Project.

The extension of this activity to central and eastern Europe (CEEC) was increased in 1993/94 due to the growing request from the countries faced with an urgent need to improve or to adapt the agricultural and land use statistics to this phase of economic transition. The JRC co-operates with DG I (Directorate General I, External Relations) of the European Commission within the PHARE 1992 Regional Environmental Programme. The MERA Project (MARS and Environmental Related Applications) was formulated and it is now applied in Poland, Czech Republic, Hungary, Slovak Republic, Romania and Bulgaria.

Area frame sampling survey is giving in 1995 the first operational results in Poland, Slovakia and Hungary. Bulgaria should follow soon. The Ministries of Agriculture are involved and the results should be compared with the ones delivered by the Statistical Offices. Within the PHARE Multi-country Environmental Programme, MERA is foreseen to 1995 and 1996. At present, the surface covered by MARS Regional Inventories in CEEC is as follow:

Country	Surface - Km^2	%territory
Bulgaria	23 865	20%
Czech Republic	78 864	100%
Hungary	22 000	23%
Poland	31 308	10%
Romania	94 000	40%
Slovakia	6 760	13%

Other than this activity, each country is starting the implementation of the database necessary for the crop yield forecasting, as described before.

Two groups of countries are considered in the mera 95 Project. A first group is made up by the ones mentioned previously. In the second group, collaboration is being launched: Slovenia, where there is an operational segment survey, Estonia, Lithuania, Latvia, and Albania. This group will follow the strategy applied until 1995 by the first group. The sampling design and target of the MERA-95 activities in the first group of countries follows an approach combining:

- a sample of segments, with a homogeneous geographic distribution, for ground survey once a year (exceptionally twice), with a sample of farms related to these segments.
- a sample of sites for multitemporal satellite image analysis, with a sample of segments inside the sites wich is also surveyed on the ground.

Sampling of segments for Ground Survey

The sampling design of sites with segments inside will be complemented with sample of segments in the whole territory. The proposed sample size is about 2200 segments for the complete territory of approximately 880.000 Km^2 (1 segment per 400 Km^2) with the following approximate distribution (Table 2)

Table 2: Approximate size by country of a systematic sample by segments

Country	Segments
Poland	780
Czech Republic	200
Slovakia	120
Hungary	230
Romania	590
Bulgaria	280

This sample does not need to use a previous stratification because it is conceived as a systematic, preliminary sample. A ground survey on this sample will be conducted with only one visit per year (exceptionally two visits, because of the main crop associations). In non agricultural areas, the ground visit can be substituted by photo-interpretation of aerial photographs where available.

The above mentioned sample is to be conceived as a geographic enlargement of the existing one. Its segments must coincide with part of the current sample where possible, and be selected in a coherent way in the areas for which no sample has been yet set up. This sample is enough to approximately assess the necessary sample size and the optimal allocation of a complementary sample that meets as well as possible the needs of every single country.

In a further step, some pilot regions might be selected in the frame of national projects to assess the application of the regression estimator on classified satellite images. This method has not been found to be cost effective in western Europe at the current prices of satellite images and image analysis, but might yield a higher efficiency in central and eastern Europe with a larger field size.

A panel of segments for rapid estimates of crop changes at national level

The results of the ground survey will be used to compute an index of agricultural intensity for a probabilistic segment sub-sampling to set up a panel of segments. The probability of selection of each segment will be proportional to the agricultural intensity. The foreseen size of the panel is about 1000 to 1200 segments. The procedure to select the subsample out the systematic sample of 2200 segments is very similar to the one used to select a sample of 40 sites from the systematic sample of 58 sites across the region.

In the second year the segments of the panel may be visited 3 or 4 times along the agricultural season in order to provide estimates of the crop area change as well as crop rotation matrices and indications of the crop development state.

This panel of segments is likely to give more accurate estimates for a larger number of crops than the sample of sites for image analysis. But a longer delay can appear to have results because the larger number of ground surveyors involved is likely to result in organisational problems.

In this panel quantitative yield and production estimates will be obtained by "expert eye" of enumerators. The quality of the results is still to be assessed, since it depends very much on the crop and particular landscape of each area. A comparison with the estimates from the farm survey in the systematic sample of 2200 segments should give some indications.

Survey drawing fields or by points

Ground surveys have included so far an exhaustive visit of the segment, drawing every plot boundary larger than a certain threshold, and digitising later the drawings to compute the area for each land cover category in the sampled segments, that will lead later to area estimates to the region.

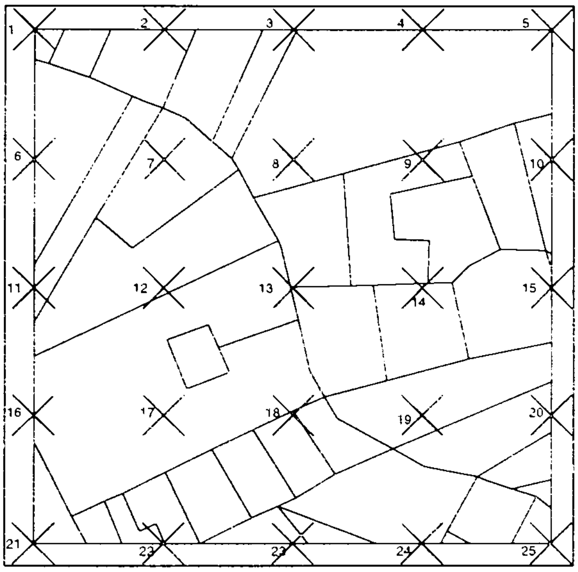


Figure 2 : Grid of 25 points in a square segment

An alternative approach consists of visiting only a sample of points inside the segment, possibly located on a regular grid (Figure 2). The point survey approach requires a set of rules to take decisions on points falling on the limit between two fields. This approach has some advantages and drawbacks compared with the full segment approach:

Advantages:

- The time to visit the segment is shorter, although the surveyor should expend some time the first year to write indications and possibly delineating a sketch to ensure that the same point will be visited the next time. The cost-efficiency ratio seems to be generally better than with the full segment approach.
- No digitising device is required.
- Point surveys can produce reliable figures for land cover categories that typically correspond to small or thin landscape elements, such as isolated hoses or trees, small roads or canals

Drawbacks:

- When there is a disagreement between the observations of a surveyor and a supervisor, it is more difficult to understand which is the origin of the problem: general wrong location, failure to detect a landscape change since the support aerial photograph was acquired or crop misidentification. This could lead to a less careful work by the surveyors.
- Combining ground information with satellite images is more difficult and less efficient.
- No information is obtained on the field sizes.

Since crop rotation matrices are one of the objectives of this panel of segments, the survey will be carried out by default by points.

Sites for satellite image analysis

The desired information on cultivated areas and potential yields will be obtained according to a method that is similar to the method that is presently used at the scale of the European Union (Rapid estimates of the MARS Project), and which contains two modules:

- A "Remote Sensing" module, with pre-processing and multi-temporal analysis of high resolution satellite images (SPOT or Landsat TM);
- A "Ground Survey" module, collecting ground data on the various types of land use.

The size of each site is 40 kmx40 km. It has been determined to ensure a high probability of multi-temporal satellite image acquisition on the whole site.

Sampling sites at regional scale (6 countries)

The purpose of this sample is to estimate *area changes* from year to year of main annual crops or other land cover classes. The notion of *"change"* is essential: the method is not able to assess crop acreages during a given year in absolute values with a satisfactory precision. The accuracy of this approach will be likely insufficient at national level for the requirements of national authorities.

A systematic sample of 58 sites of 40 km x 40 km has been selected over the region as a whole (6 countries). Within each site, a sample of 25 square segments of will be surveyed. For this sample, the SPOT grid was the reference, although the use of Landsat TM data is also possible for image analysis. The SPOT grid is related to the orbit projections on the ground. For each orbit there is a pair of tracks, one at each side of the orbit projection. North of 51°, only one orbit out of two is considered to avoid track crossing (Figure 3). Separate sampling is made north of the 51° parallel.

The sampled area was divided in blocks containing 4 Spot KJ (North of 51° after fusion of the scene centres) or 8 Spot KJ (in the south of Europe, without fusion of the scene centres).

The approximate size of the block is thus 150 km x 100 km, i.e. 15.000 km^2 in the centre of Europe. The block size is slightly decreasing with higher latitudes. One site was selected per block with the same relative position (systematic sampling). The initial sampling rate was thus higher than 10%. Candidate sites are located in digital maps. In the case of sites on the borders of the region, a site was kept in the sample if more than 50% is inside the region (Figure 4)

All 58 sites will be ground surveyed, by visiting 25 segments per site located on a regular grid. A within-site stratification can be made to improve image analysis or estimation accuracy as a post-stratification.

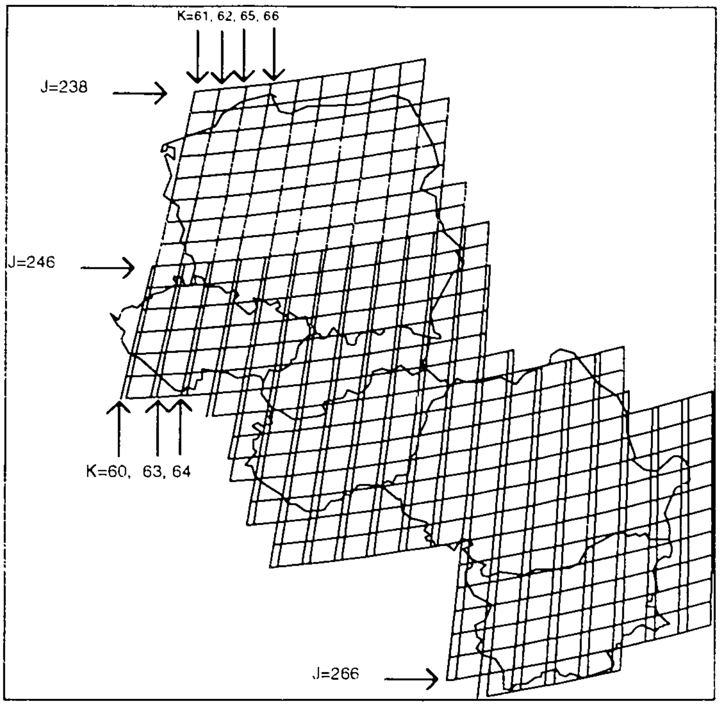


Figure 3: SPOT reference grid on central European countries

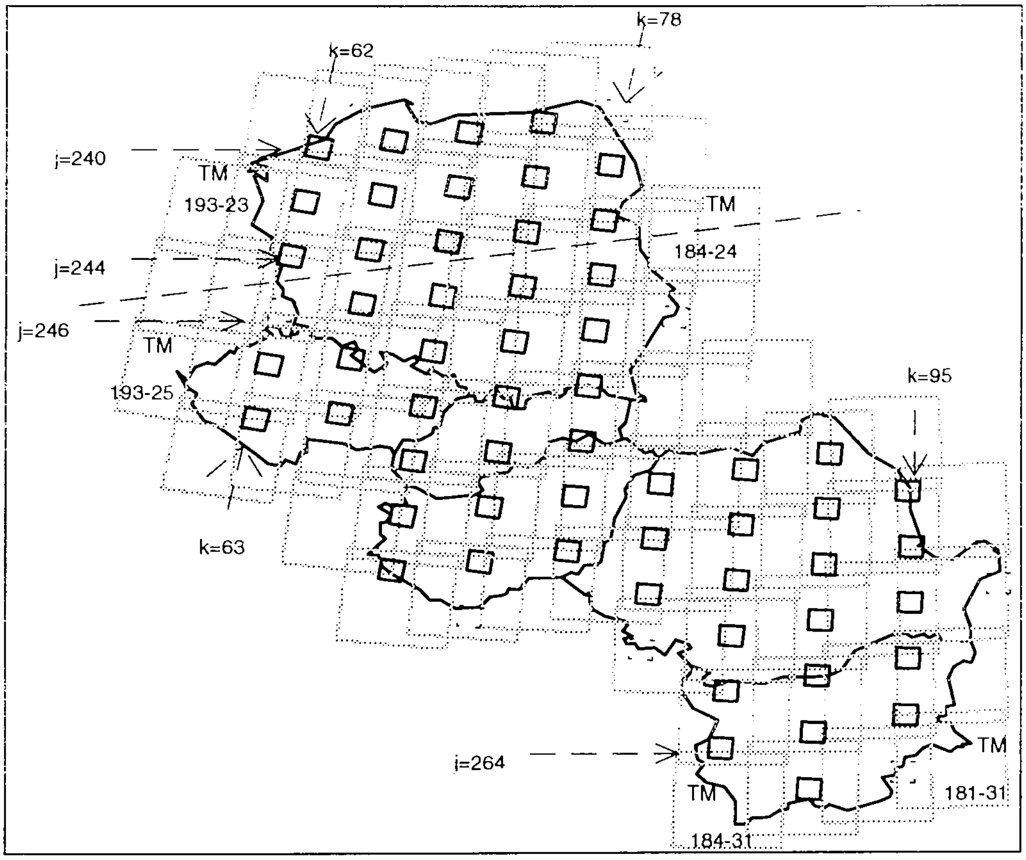


Figure 4: Systematic sample of sites based on the SPOT reference grid.

Subsample of sites for satellite image analysis

Not all 58 sites will be analysed with high resolution satellite images, since the cost of analysing each site is quite high. A subsample is selected trying to concentrate the sample on more intensive agricultural areas and keeping at the same time the possibility of a correct statistical extrapolation. A suitable stratification for this scale is not yet available, so subsampling by strata was discarded as an option at short term. The solution adopted was a subsampling with a probability proportional to the percentage of agricultural land in each site of the systematic sample of 58 sites.

Spot XS digital quick-looks of the pre-selected scenes were analysed for a rough visual estimation of the percentage of agricultural land. Digital quick-looks contain 1/36 of the pixels of the complete SPOT-XS image (1/6 of the rows, 1/6 of the columns), so it behaves like an image with a resolution of 120 m. Digital quick looks are available for images acquired since 1990, and they could be obtained for 49 sites out of the 58 in the sample. For the other 9 sites, a visual interpretation of Landsat TM 1:100.000 scale photographic products was performed.

Let us see with more detail the subsampling procedure. We call

A_s : Agricultural index in site s of the first phase sample (systematic sample of 58 sites).

P_s . Probability assigned to site *s* for the second phase sampling

Y_s . Value of a target variable in site *s* of the sub-sample.

$\eta_{lat(s)}$: Distance between the centres of two contiguous sites in the first phase sample at a constant latitude.

n : Number of sites in the subsample

The index A_s has to be known for all the 58 sites in the first phase sample. It does not necessarily equal the percentage of agricultural land. There is some freedom to select an index adapted to the objectives of the survey or restrictions imposed by the require sample. In our case we have selected A_s= min (40, % of agricultural land). This means that any site with an estimated % of agricultural land above 40% is considered as "intensive agriculture" with the same index A_s=40.

If we have a point inside the region for which we know the latitude, the probability that it lays inside a site of the first phase sample is proportional to $1/\eta_{lat(s)}$. The probability that it belongs to a site in the second phase sample is proportional to the index $P_s / \eta_{lat(s)}$. If we want the final sub-sample to be selected with a probability proportional to the agricultural intensity A_s, we have to perform the subsampling with a probability proportional to $P_s = A_s * \eta_{lat(s)}$. Subsampling is preferred without replacement to avoid one site entering twice in the estimate computations.

The subsampling has been carried out with a systematic procedure to ensure some kind of homogeneity in the geographic distribution: the first phase sites are sorted by country and latitude inside each country. P_s and cumulated rates $\Pi_s = \sum_{s'=1}^{s} P_{s'}$ are computed for each site. The total sum Π_{58} is divided by the wished number of sites n: $\Lambda = \Pi_{58}/n =$ and a random number λ is selected between 1 and Λ. The sample is determined by the numbers λ, $\lambda+\Lambda$, $\lambda+2\Lambda$, ...$\lambda+(n-1)\Lambda$. A site s is selected if one of these number falls in the interval between Π_{s-1} and Π_s. The maximum possible value of n for a sampling without replacement, i.e. to ensure that no site is selected twice is $n_0 = \Pi_{58}/\max(P_s) = 40$ $\max(P_s) = 63.8464000$ $\Pi_s = 2545.61$

The remote sensing module will be implemented only on the subsample of n = 40 sites (figure 5). The other 18 sites in the sample are only ground surveyed. The ground survey will permit to obtain information on crop acreages and expected yields, independently from the satellite images. This module makes it possible to identify soil occupations with a more detailed nomenclature than with remote sensing, and hence to assess the land cover change with a better accuracy and to verify a aposteriori the satellite image interpretations.

This second stage sampling will allow for future estimates with a Horvitz-Thomson estimator.

It must be mentioned that the implementation of a regional sample that at the same time would be representative at the national scale, is technically almost impossible and extremely expensive. Present satellite technology does indeed not (yet) permit the acquisition of sufficient images for a large sample of sites. At the level of a single country in western and central Europe, the required investments, training, etc. are prohibitive and, in addition, do not guarantee that results are available within reasonable time after image acquisition.

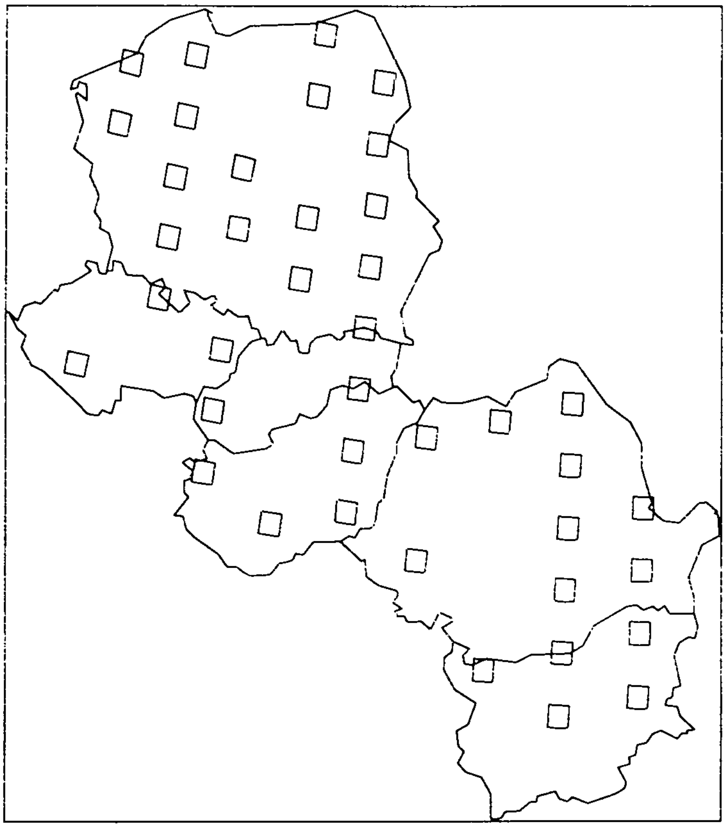


Figure 5 :Sample of sites for image analysis

5. Conclusions

From the beginning, the MARS Project was able to translate the results of research into a programme that meat the needs of clients- DG VI and EUROSTAT. Operational methods have been developed that can provide the reliable and consistent information necessary at the European level. An harmonisation of methods at the country level, facilitates the comparability of data and the transfer of scientific results achieved, not only in the E.U., but also to the countries in an approximation process.

By doing this, new requests and needs appears and further developments take place. The environmental applications of the methods and systems implemented by MARS are getting importance nowadays. The manifested interest demonstrated by the national authorities and other sector to adapt MARS approach to their specific conditions, not only in CEEC, but also in the new Member States and Norway is a prove. In that sense, MARS is taken as an example of sound research in Europe.

Table 3: Pre-sample of sites

Country	SPOT K	SPOT J	% agr.	distance $\eta_{lat(s)}$	Index P_S	Sample
PO	62	240	70	127.2	50.87	yes
PO	66	240	20	127.2	25.43	yes
PO	70	240	40	127.2	50.87	no
PO	74	240	30	127.2	38.15	yes
PO	62	242	60	130.0	51.99	yes
PO	66	242	60	130.0	51.99	yes
PO	70	242	80	130.0	51.99	no
PO	74	242	20	130.0	26.00	yes
PO	78	242	60	130.0	51.99	yes
PO	62	244	20	132.8	26.56	no
PO	66	244	60	132.8	53.12	yes
PO	70	244	80	132.8	53.12	yes
PO	74	244	30	132.8	39.84	no
PO	78	244	70	132.8	53.12	yes
PO	67	246	40	135.6	54.23	yes
PO	71	246	70	135.6	54.23	yes
PO	75	246	50	135.6	54.23	yes
PO	79	246	40	135.6	54.23	yes
PO	71	248	50	138.3	55.33	no
PO	75	248	90	138.3	55.33	yes
PO	79	248	40	138.3	55.33	yes
PO	75	250	10	141.1	14.11	no
PO	79	250	10	141.1	14.11	yes
CZ	63	248	70	138.3	55.33	no
CZ	67	248	10	138.3	13.83	yes
CZ	63	250	70	141.1	56.43	yes
CZ	67	250	60	141.1	56.43	no
CZ	71	250	30	141.1	42.32	yes
SK	71	252	30	143.8	43.14	yes
SK	75	252	10	143.8	14.38	no
SK	79	252	30	143.8	43.14	yes
HU	71	254	60	146.5	58.61	yes
HU	75	254	20	146.5	29.30	no
HU	79	254	60	146.5	58.61	yes
HU	71	256	20	149.2	29.83	no
HU	75	256	70	149.2	59.67	yes
HU	79	256	40	149.2	59.67	yes
RO	83	254	50	146.5	58.61	yes
RO	87	254	30	146.5	43.95	yes
RO	91	254	30	146.5	43.95	yes
RO	83	256	10	149.2	14.92	no
RO	87	256	20	149.2	29.83	no
RO	91	256	10	149.2	14.92	yes
RO	95	256	40	149.2	59.67	no
RO	83	258	30	151.8	45.55	yes
RO	87	258	10	151.8	15.18	no
RO	91	258	10	151.8	15.18	yes
RO	95	258	80	151.8	60.73	yes
RO	87	260	30	154.4	46.33	no
RO	91	260	80	154.4	61.78	yes
RO	95	260	90	154.4	61.78	yes
RO	91	262	80	157.0	62.81	yes
BU	87	262	80	157.0	62.81	yes
BU	95	262	70	157.0	62.81	yes
BU	87	264	10	159.6	15.96	no
BU	91	264	20	159.6	31.92	yes
BU	95	264	50	159.6	63.85	yes
BU	91	266	10	162.2	16.22	no

THE IMPACT OF REMOTE SENSING ON THE AGRICULTURAL INFORMATION SYSTEM IN ITALY

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1. Introduction

In every sector, the impact of new technologies has always been found to depend on the operational context. This determines the length of time necessary for their acceptance in practice. This type of consideration, which is more of a statement of fact, is a constant feature in every operational phase in which there is a sudden increase in technical quality. The subject under consideration, namely the use of satellites for collecting data in the agricultural and forestry sectors, falls into this context and, in my opinion, a preliminary assessment should now be made. The existing potential for using remote sensing must not be disregarded, but it is even more important not to overlook the considerable scope for development, which in some cases has already begun to be investigated. The whole question should be given due attention and it should not be forgotten that for the time being, as has been pointed out many times at various meetings, remote sensing cannot meet all the statistical requirements in the agricultural, environmental and forestry sectors. Account should also be taken of the fact that remote sensing can do more than just meet the need for economic and statistical information, which may not, in fact, constitute priority areas.

2. The statistical context

It would make good practical sense to make a general assessment of all the various aspects of remote sensing, from the technical elements to operational and economic ones, before going on to the question of implementation time, and so on. Obviously, all the Member States at present have extremely different statistical structures, which have to fulfil a series of information requirements at both European Union and national levels. This workshop will therefore restrict its examination of new technologies to the impact that they may have in the countries of Southern Europe and their potential use in developing countries. As regards Italy, an analysis of the structure of the agricultural information system was already presented, so I shall assume that everyone is already aware of the information given by Dr Manfroni. I shall simply draw attention to those points which are of particular relevance to my report. Nor should we disregard the constant changes in the information requirements for agriculture, which also affect developments in possible statistical surveying systems. I feel it is suitable, at this point, to examine and analyse what has been said on several occasions in the past and to make a series of points and assessments.

- This workshop may be considered as a follow-up to the work carried out at Villefranche, the purpose of which, I believe, was to investigate the situation inside and outside Europe. The most important conclusion of a statistical nature that emerged was the extreme importance of "*forecast data*" in the major countries of the world, including the EU;

- In Italy, as was made clear in Dr Manfroni's report: there is a National Statistical System with related public institutions set up under Italian legislation; responsibility for agriculture, like health, is in the hands of regional authorities;

- The difficulties in acquiring funds for the agricultural statistical system at a time when other sectors, in which information is still limited, require ever greater funds to meet the new information requirements, are a fact which cannot be changed. The most important point, therefore, is that such difficulties occur both at Community level and at the level of many Member States, including Italy, where they occur at regional level too;

- The general problem of the excessive burden of statistical surveys has been observed at national level. This led the Union to hold a series of meetings, beginning in 1992, which dealt with the question of screening. At these meetings, a series of interesting observations were drawn up on operational aspects. A working document has been produced by the EU Statistical Office in close cooperation with the department responsible for DG VI (agricultural policy) which has submitted it to the Member States for detailed discussion. The document pinpointed the sectors in which, according to the EU, information requirements should be reduced and those in which they should be increased. In some other cases, the situation was extremely varied, inasmuch as there was a total lack of information in some sectors while in others the information available was always modest and often presented in an obsolete way from the surveying point of view.

- At present all the countries have extremely different statistical structures, i.e. surveying systems, some of which are more suitable than others to meet information requirements at Community and national levels. Within the EU there are various approaches. There are the advocates and users of administrative types of data, those which, on the other hand, focus mainly on data gathered from sample surveys carried out using various methodologies, e.g. satellites, holdings, etc., and finally, the possible combinations of these two approaches.

- The final assessment that I feel it is important to reiterate at this workshop on remote sensing is that I do not consider remote sensing as the general solution for all information requirements either in my country or in any other, but simply as a method which may help to meet many of them.

The Member States have provided information and assessments on these subjects which, of course, are based on national problems. The work has resulted in a draft decision on the improvement of Community agricultural statistics.

3. The situation in Italy

The structural approach to agricultural statistical surveys is to a large extent still the same as the one drawn up by a few eminent agricultural economists in the thirties and subsequently updated in the fifties.

The whole approach is based on a statistical methodology which basically takes account of two fundamental points:

- the existence of a territorial breakdown,
- the existence of a pyramid structure within that breakdown.

A considerable number of agronomic experts worked on this. Their tasks included developing "estimation statistics". Gradually, over the years, a series of surveys was compiled to meet legal and non-legal Community obligations. These surveys, which involve the collection of data directly from the farmers, are in most cases carried out entirely by the regional experts working on estimation statistics.

In the eighties, Italy restructured its system of agricultural statistics on the basis of Directive 518/81. The results of this restructuring became more apparent at the operational stage of data collection than in a new survey methodology. Efforts to broaden the sample surveys at the level of the agricultural holding by means of direct contacts between the Statistical Institute and holdings, thus reducing data collection costs, have failed. It has not been possible to find a statistically suitable solution to make such surveys feasible. The response rate of holdings, after being very high, fell sharply, making the samples unrepresentative and the results therefore unacceptable from the statistical point of view.

At the beginning of the nineties, a series of ever more pressing and difficult problems meant that a study had to be carried out without delay with a view to a genuine restructuring of the whole system of agricultural surveys. This conclusion was reached after a certain amount of reflection resulting from a period in which all the Community and national obligations had been fulfilled. The starting point was the results of the survey on the structure of agricultural holdings in Italy in 1993, to which Dr Calò has drawn attention.

I would like, at this point, to remind you of just some of the figures presented by Dr Calò, in particular those concerning specific aspects of the agricultural situation in Italy, which refer only to those holdings which are included in the EU field of observation. 34.3% of the total holdings in the EU (EUR 12) are in Italy, while the Utilised Agricultural Area (UAA) in Italy accounts for only 12.4% of the EU total.

- 77.5% of holdings in Italy have a total area of less than 5 ha, yet these account for 45.1% of all holdings in the EU.

- Another point of particular interest is that only 34.1% raise livestock.

According to the last census of 1990, there were over three million holdings in Italy, of which only around 2 665 000 were covered by Community surveys. In Italy, therefore, there were over 300 000 very small holdings which are constantly being included in national sample surveys. A universe of this size means that any sample survey on crops conducted by interviewing farmers personally always involves a very large number of units to survey. The interviewers responsible for gathering the data are usually people from the region concerned and they have increasingly reported that farmers tend to become uncooperative if they are involved in more than one sample survey in the course of any one year.

This reluctance to cooperate may also be explained by the age of the farmers. Again according to the data quoted by Dr Calò, the average age of Italian farmers is very high:

- in 1993, 32.8% of Italian holdings were run by farmers aged over 65 years, while at EUR 12 level 45.2% of such holdings were in Italy.

Given these few but fundamental figures, sample surveys, like remote sensing, clearly do not appear to be able to meet all the information requirements. This statement may be logically extended to estimation statistics. The solution which at present appears the most logical is that an integrated set of statistical surveys should be created by adopting the most suitable survey method for the purposes in question. This is the approach which is being followed in Italy, and this methodology could - indeed should - also be used in other countries. To put it more simply, the idea of an *integrated statistical system* should be used as both a point of departure and a point of arrival. This concept should therefore be used as a basis for all the analyses needed to create the point of departure. To put it much more simply, we are faced with the construction of a theorem in the mathematical sense.

4. Problems to be examined

The analysis of what can generally be described as the problem benefits considerably in Italy from the fact that for over ten years the Ministry of Agriculture, Food and Forest Resources and Fisheries has been carrying out an experimental type of survey of considerable technical and organisational depth. The first line of research focused on developing provisional and definitive data for certain crops. This was followed by an analysis of the various uses of the Utilised Agricultural Area (UAA) for the major items, with a final attempt to go down to the smallest territorial level, i.e. the province (NUTS 3). The institute is therefore operating in close contact with the Ministry of Agriculture, Food and Forest Resources in order to study the possibilities in sectors of production which have not yet been studied in detail. A Study Committee has been set up, again by ISTAT, to lay down guidelines for the restructuring of agricultural statistics. The thinking behind the suggested work is described in the summary, so I would like to draw attention to only a few aspects.

5. Methodological approach

The last aspect to be dealt with is the finalisation of all the elements necessary for constructing a sound methodological system. In my opinion, a series of analyses and checks should be carried out for this purpose:

5.1 Classification

The basic element in a parallel analysis of two or more different methodologies, is a detailed study of the definitions underlying the "concepts" used. The focus of the whole operation, which at first sight may appear relatively insignificant but which is in fact very important, consists of drawing up a complete list of the concepts defining all the sectors to be surveyed, and subdividing them into the following categories:

- in perfect agreement
- possible to assimilate, i.e. easy to correlate
- totally different.

5.2 Determination of the sectors which can be surveyed using remote sensing

The next point involves the determination of all the sectors of the statistical survey on agriculture and forestry in which this sampling method can be used at present. This operation may appear superfluous, but in fact it is fundamental inasmuch as most agricultural experts are not yet fully aware of the practical possibilities provided by satellites.

5.3 Needs

The third element in this not unimportant work is trying to determine what information needs are considered attainable using this surveying method. This should logically be done by studying information on requirements at the national and regional levels, since, as I have already mentioned, the Italian Government has conferred competence in agricultural and health matters to the regions.

5.4. Integration of present and future

The fourth point consists of drawing up a list of all data-collection methods taking the form of surveys based on statistical criteria. In other words, a "census" should be carried out of statistical collection methods based on criteria with minimum acceptable technical characteristics. This will unquestionably permit the theoretical establishment of the bases for all possible forms of integration.

5.5 System of agricultural statistics

On the basis of the "census" of surveys which can be carried out using the old and new systems, as many agricultural statistics systems as possible should be set up to meet national and regional requirements. Personally I am convinced that in Italy, the system that will finally be adopted will comprise statistical information gathered using various surveying techniques, namely:

- evaluations by sectoral experts
- collection of data on specialised panels of agricultural holdings
- surveys carried out using satellite images, possibly in conjunction with interviews at agricultural holding level,

which could be integrated by means of statistical methodologies such as matrix type analyses and data extrapolation.

The Committee set up by the Institute to make a proposal on the restructuring of agricultural statistics will have to carry out an analysis of this kind so that it can subsequently inform the president and the directors of ISTAT of the best practical solutions from the technical angle, with a view to the future rather than the present.

5.6 Economic analysis

The final basic point concerns the evaluation of the costs which each system involves, in order to arrive at a single potential combination with various possible alternatives:

surveying system - production costs

I believe it will be the question of cost that will determine which system is applied.

SIMULATION OF THE USE OF SPOT 5-6 DATA IN AGRICULTURAL STATISTICS PORTUGAL 1994/95

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1 Aim and scope of the project

1.1 Aim

The basic aim of this project was to evaluate the potential impact of the new SPOT 5-6 high resolution satellites on the agricultural statistics system in Portugal. In particular, the purpose was to assess the possible advantages in comparison with the sensors available at present.

In order to make this assessment possible, a simulation flight was carried out in three areas of mainland Portugal which were regarded as representative of the real national agricultural situation, and two sets of data were produced by synthesis, corresponding to the present SPOT resolution (P=10m, XS=20m) and the resolution of SPOT 5-6 (P=5m, XS=10m). In addition, all the characteristics actions of image processing and interpretation were carried out with a view to obtaining statistical indicators of agricultural land use.

The project was directed towards comparative studies of the two sets of data, with the aim of bringing out the contributions of new technologies in a clear and representative manner.

1.2 Scope

The aspects connected with agricultural information are the common concern of all countries. The ever-growing requirements of the users of statistical data have led to discussions about the present agricultural statistical models with regard to the relationship between costs, quality and the suitability of the information produced. Although countries display very different characteristics in aspects connected with organization, they are nevertheless very similar and conservative as far as collection methods are concerned.

In Portugal the system of annual agricultural statistics is fundamentally based on the **collection of data from farm surveys**, the exploitation of **administrative sources** and assessments made by **regional or national experts** connected with the sector.

In each of the cases a large proportion of the information comes from that provided by farmers, and this requires a constantly updated file of farmers. The updating of agricultural files is a very sensitive aspect, in view of the difficulty of maintaining an updated base, especially in periods, such as the present one, in which agriculture is undergoing rapid structural changes. On the other hand, many of the problems associated with the quality of the information produced by surveys are connected with the difficulty experienced by farmers in interpreting and understanding the questions, which makes it necessary for a large proportion of the operations to be carried out by direct interview, entailing financial costs which it is often difficult for the countries to bear.

In Portugal the system of agricultural statistics has developed in the direction of better integration of these various vectors: surveys, administrative information and experts, with a view to increasing the production of agricultural information both at regional level and as regards thematic coverage. However, the present system of annual agricultural statistics still has limitations as regards both product coverage and regional breakdown. On the other hand, the need for an annual monitoring of agricultural (UAA) and other land use in accordance with a framework of requirements laid down by Eurostat in Regulation (EEC) No. 959/93 made it possible to start a national discussion on these subjects involving a rethinking of the methods used and consideration of the possibility of integrating alternative methods with a view to making the systems more flexible and better suited to the requirements as regards agricultural information.

The use of area surveys in agricultural information systems, supplemented more recently by the integration of satellite images, especially high resolution images (SPOT P+XS, Landsat TM), may lead to an improvement of the present system. Although the mere use of satellite images is at present still subject to serious limitations for complex agricultural systems such as those which exist in Portugal, it has nevertheless brought significant advantages in improving the organization of field work, in the development of methods of determining statistical parameters and in the effort to systematize procedures. Furthermore, the technical improvements introduced in the new SPOT 5-6 sensors, connected with the degree of spatial and spectral resolution (the latter through the introduction of the MIR channel), are opening up new prospects of application in agricultural systems as difficult and complex as that of Portugal.

1.3 Previous experience

Portugal has since 1989 integrated the work relating to action 4 of the MARS (*Monitoring Agriculture by Remote Sensing*) Project, subsequently extending its participation to include action 1 - *Regional inventories*. The overall balance of this experience is positive, since it has enabled Portugal to gain access to and learn about a set of techniques, and has also mobilized synergies around multidisciplinary teams which are proving very useful in the development of future work.

Nevertheless, this experience has brought to light a set of problems which can basically be summarized as follows:

- logistic difficulty of coordination,
- reduced endogenization of scientific and technical knowledge,
- systematization gaps from the point of view of methodology and processing of results,
- technical problems connected with the characteristics of the actual sensors of the Landsat TM and SPOT satellites and the excessive fragmentation of land use in some of the country's regions.

1.4 Institutional organization

The project team consists of four national organizations, which cover all of the technical/scientific areas envisaged. The work was programmed and shared out prior to the implementation of the project, enabling the responsibility levels and duties of each to be determined.

Instituto Nacional de Estatística : Project Coordinator and body responsible for the presentation of the intermediate and final reports.

Instituto de Estruturas Agrárias e Desenvolvimento Rural - Ministério da Agricultura : Body responsible for carrying out the land inventories.

Centro Nacional de Informação Geográfica : Body responsible for processing and classification of the satellite images.

Universidade de Lisboa : Body responsible for the preparation of the ground documents and methodological support in all the phases of the project.

2 Development of operations

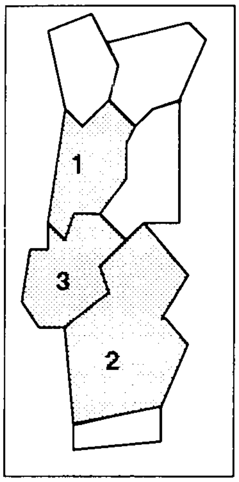
2.1 Selection of study regions

The choice of the study regions was made in two phases. In the first phase three agricultural regions were chosen, and in the second phase the places which would be the subject of study in each region were defined. The agricultural regions were chosen on the basis of the following criteria:

- experience gained within the framework of actions 1 and 4 of the MARS project

- agricultural importance of the regions at national level
- production systems with different natural and structural characteristics

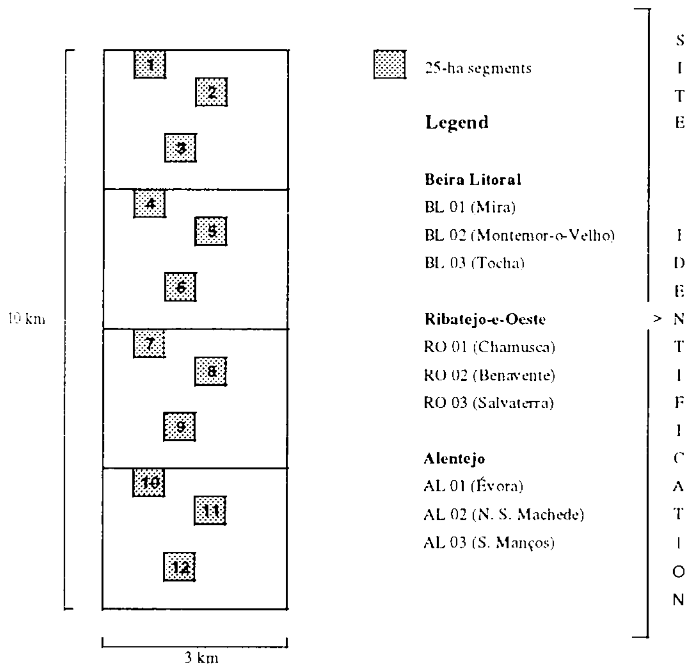
Integration of these criteria led to the choice of the agricultural regions of **Beira Litoral, Ribatejo e Oeste, Alentejo**



These are three very different regions from the view point of agriculture and specific production systems.

- Beira Litoral **(1)** is manifestly a region of holdings of minimal size, with a predominance of small-scale farming and intensive land use systems.
- Alentejo **(2)** , the southernmost region in this study, stands out in contrast owing to the marked predominance of winter cereals and industrial crops (tomatoes and sunflowers) which are characteristic of extensive systems with a predominance of large farms.
- Ribatejo e Oeste **(3)** occupies an intermediate position in terms of geographical location and land use characteristics, and also in terms of structural agricultural characteristics.

2.2 Sampling plan



Three observation sites were chosen in each agricultural region, resulting in a total of nine sites for the whole study. The sites were located in accordance with the same criteria as were applied for the choice of the regions. At the suggestion of the CNES (Centre National d'Etudes Spatiales - National Space Research Centre), the area of each site was 3 x 10 km, in the directions E-W and N-S. Then observation segments of 25 ha each, were defined at each site in accordance with a square lattice measuring 500 x 500 m. Sampling was random and systematic, with the preparation of a sampling plan common to all the sites. On each site, 12 observation segments were selected; this represents a sampling rate of 10%. It was decided to use such a high sampling rate because the size of the study sites was relatively small. The segments were then plotted on the maps of Portugal to the scale of 1:100 000 and on the military map to the scale of 1:25 000.

2.3 Preparation of the ground documents

The purpose of the preparation of the ground documents is to provide the field teams with the elements necessary for locating the work areas, delimiting the parcels observed on the ground and making notes describing the respective agronomic characteristics. The ground documents were produced from archive aerial photographs (scale 1:15 000) of the IPCC (*Instituto Português de Cartografia e Cadastro - Portuguese Cartographical and Cadastral Survey Institute*). For locating and identifying the segments in the field, enlargements of aerial photographs to the scale of 1:5 000 were used, with the limits of the segments drawn in, as well as military maps (scale 1:25 000) of the Army Geographical Institute (Instituto Geográfico do Exército - IGeoE) and maps of Portugal (scale 1:100 000).

2.4 Simulation flight

In response to a request to the competent national authorities, the Fokker F-27 ARAT (*Avion de Recherche Atmosphérique et de Télédétection*) of France's IGN (*Institut Géographique National*) was authorized to overfly Portuguese airspace during the period between 24 May and 28 June 1994, its mission being the simulation of data of the SPOT 5-6 high resolution satellite. The whole mission was performed from the Portela airport in Lisbon. Prior to that, a mission coordination meeting was held between the CNES/IGN team and the national authorities of the CCTAL (Centro de Controlo de Tráfego Aéreo de Lisboa - Lisbon Air Traffic Control Centre) and the EITA (Esquadra Independente de Tráfego Aéreo de Lisboa - Lisbon Independent Air Traffic Squadron). This extremely important meeting enabled the entire mission to be better planned and coordinated with the responsible national bodies. The work was done between 24 May and 30 May 1994. However, owing to bad weather conditions, the image acquisition did not take place until 27 May for the Ribatejo e Oeste and Alentejo regions and 29 May for the Beira Litoral region. These missions were accompanied by the technicians responsible for the execution of the project, and were a unique and very interesting experience.

2.5 Ground surveys

The ground surveys are of the greatest importance in remote sensing studies. Their basic purposes are:

- to provide an estimate of the crop areas directly and rapidly;
- to enable a start to be made on the progress of classification of the satellite images, representing the "field truth";
- to help to improve the results of the estimates, when thematic maps resulting from the classification of satellite images are used.

2.5.1 General principles

Making the land inventory consists in drawing the land use parcels on transparent paper placed on top of an aerial photograph on which the observation segment has been previously marked and describing the parcels as faithfully as possible. The parcels are given a code, with which, in the present work, the Cronos nomenclature is associated. With a view to the subsequent processing and use of this information by means of the TTS (Television Tracking System), the drawing of the parcels of the segments must meet the following requirements:

- The parcels must be clearly delimited and closed off
- The parcel number must be shown in such a way that it cannot be confused with the area of the parcel itself.

2.5.2 Material

For this work the field teams were given orientation documents to enable them to locate the segment unmistakably, and also documents to help them draw and identify the parcels on the ground. The documents used were:

- aerial photograph (contact proof), scale 1:15 000
- an enlargement of the aerial photograph of each segment to the scale 1:5 000
- tracing paper for drawing the field "sketch"
- tracing paper for the clean-copy drawing
- a questionnaire for completion of the description and coding of the parcels of the segment
- pens for drawing on acetate; black and red

2.5.3 Observation principles

The following observation principles were employed in the ground surveys:

- ***Parcel*** This is a homogenous land use zone, whether or not agricultural. Attention is paid only to the part of the parcel which is inside the segment. Roads and tracks in forest and/or urban areas are given special treatment (see further on).

- ***Minimum observation detail*** In view of the spatial resolution of the new SPOT 5-6 sensors, i.e. 10 metres, corresponding to 0.5 mm on the aerial photograph enlarged to the scale of 1:5 000, linear elements less than 10 metres wide - very narrow fields, roads, tracks, fences (border hedges), railway lines, watercourses - **are not observable in terms of "parcels"**. Similarly, compact elements less than 100 m2 in area (scattered trees, pools, houses or isolated structures, etc.) will not be taken into account for drawing purposes. However, if a group of such elements constitutes a linear element more than 10 m wide (in the example: a railway line or a road lined with trees or an irrigation ditch with sloping banks), or a compact element more than 100 m2 in area (e.g. a pool or lake, or a small copse), even though it is heterogeneous, it will be drawn and coded with the code most appropriate to the situation. In the case of fields which are adjacent to each other but each less than 10 m wide, a single parcel should be created, and coded as accurately as possible, with **a clear description of the type of land use**.

2.5.4 Delimitation of the land use categories

The most important elements used in the delimitation of the land use groups are the following:

- ***Roads with tarmac surfaces, railways, rivers and streams*** These are elements which in themselves play an important role as topographical references and borders of parcels. They are generally less than 10 m wide. They are shown as single elements and by **only one line**. They will be shown as parcels if they are more than 10 m wide (motorways, important railway lines, rivers, etc.). In these cases, descriptive assessment of the reality is very important, since the Cronos nomenclature does not allow them to be clearly and accurately identified.
- ***Country roads*** These are generally parcel borders and must be shown by a single line even though they appear to be larger in the enlargement of the aerial photograph. However, a road, even if tarmac-surfaced, which ends within a parcel **is never shown**.
- ***Copses, woods and forests*** The whole body of trees of a forest, wood or copse represents only a single parcel. No account must be taken of the parcel division established by cadastral survey by the various forestry enterprises. However, a forest or forest area may contain clearings (or islands) which are coded and described according to their use (waste land, grassland, fallow ground, lakes or swamps, forest houses, etc. which constitute parcels if their size warrants it). If a tarmac-surfaced road runs through a forest area, it is important to reference the roads as a single element represented in the drawing by a single line, because they will be the only reference which will make it possible to find a forest segment on the satellite image. On the other hand, forest tracks and firebreaks less than 10 m wide are not shown. If there are tarmac-surfaced roads which necessitate the division of a forest parcel, the resulting parcels are identified by different numbers on the drawing, although they use the same Cronos code.
- ***Urban zones and other artificially created zones (rural structures)*** A farmhouse or office, vehicle yard, cattle shed and recreation area are regarded as belonging to this category. They are regarded as a single entity if they are isolated in an essentially agricultural or forest environment and if, in total, they represent an area greater than 100 m^2 they must be referenced in the land inventory.
- ***Urban and other artificially created zones*** The urban unit is regarded as a single entity, whether it consists of built-up areas or parking areas, streets, etc. Towns, villages or hamlets are delimited globally on the field drawing.

All the zones in this group were coded as urban zones.

- **Agricultural area (arable land)** It is to these that the greatest attention is paid in this study. Adjacent parcels which have the same crop but are visibly different owing to the variety or cultivation methods or phenological status **are dissociated from each other and shown independently**. Parcels which have the same crop but are separated by a road or track **are separated**. The road or track is regarded as the parcel boundary and will be shown by a single line.
- **Horticultural crops/kitchen garden** The whole parcel occupied by these crops is shown if of a size greater than the minimum observation detail.
- **Orchards** Their treatment is exactly the same as that described under the preceding point. Whether it is a single crop or one associated with other (permanent or temporary) species is always mentioned.

2.5.5 Organization

For carrying out the land inventories, teams of Ministry of Agriculture technicians who had already taken part in similar work in the MARS Project, actions 1 and 4, were formed. Three work teams, one for each agricultural region, were formed, involving altogether 13 technicians.

2.5.6 Training of the field teams

During the last week of April and the first fortnight of May, training and familiarization programmes were carried out among the regional teams involved in this work. The main aims of these programmes were to impart information on the methodology to be employed in making the inventory of the segments and also to draw attention to the criteria regarding observation detail required by this study.

2.5.7 Execution period

The dates for the land inventories were governed by the dates on which the simulation flight was made. With this in mind, it was initially planned that the inventory work should take place simultaneously with the image acquisition. This aspect of the work programming is extremely important because, if the ground work and the passage of the sensor were too far out of phase interpretation errors might be made when the images were compared with the "ground truth".

However, the weather conditions encountered during the month of June, marked by heavy rainfall, prevented field work during that month. Thus all the field work was done in July. With the delay which occurred the photographic coverage, to the scale of 1:15 000, provided by the CNES during the simulation flight, was however available. These photographs were a great help to the ground teams, particularly in the areas where the available national air coverage was very out of date. With a view to correcting possible classification problems due to the lack of synchronization of observation dates, the regional teams were present at some of the phases of the image processing work, thus clearing up all doubtful points.

2.5.8 Quality control

The work was monitored by the responsible officials of the central services of the Ministry of Agriculture; this ultimately led to a reassessment of some of the sites.

2.6 Processing of the ground surveys

2.6.1 Acquisition by TTS

The segments were digitized with the aid of the TTS. This system makes it possible to digitize the ground documents on the basis of the acquisition of the image by a video camera. The image is then displayed on a monitor and the codes corresponding to the different land uses entered in accordance with the Cronos nomenclature. The TTS produces the areas of the various agricultural parcels according to the Cronos codes, in digital format, as well as a number of statistical indicators.

2.6.2 Georeferencing

The segments used in the ground surveys were georeferenced on the basis of the military maps (scale 1:25 000) of the IGeoE and the aerial photograph used (enlargement to scale 1:5 000).

After the segments relating to each site had been digitized and the codes for the crops observed in the field had been entered, it was necessary to prepare these data so that they could be superimposed upon the images. For this purpose a program was run in which the files with the digitized segments were georeferenced and converted into a format compatible with ARC/INFO (files with .out extension). In ARC/INFO (version 6) a series of operations were performed on the segments. In a first phase polygons corresponding to the parcels in each segment were generated and a topology was created to associate the codes of the crops observed on the ground with the polygons generated in the preceding stage. It was necessary to correct some codes which had been incorrectly entered in the digitization phase.

As the object was to superimpose the twelve segments of each site on the corresponding image, a single file, consisting of the twelve segments, was generated for each site. In some segments cases were observed where adjacent polygons had the same codes. In these cases the polygons were joined together - in other words, the border between adjacent polygons with the same number was eliminated. When the files, with the segments corresponding to each site, had been processed, they were converted into the IGDS format and transferred to the Microstation (Intergraph).

2.7 Image classification

2.7.1 Image characteristics

The sensor used in the simulation flight (push broom) displays the following spectral and spatial characteristics:

Table 1 : Spectral and spatial characteristics of the SPOT sensors

BAND	SPECTRAL RESOLUTION (mM)	SPATIAL RESOLUTION (m)
1	0.50 - 0.59	10 (5/6) - 20 (present)
2	0.61 - 0.68	10 (6/5) - 20 (present)
3	0.79 - 0.89	10 (5/6) - 20 (present)
Pan	0.51 - 0.73	5 (5/6) - 10 (present)

The images were originally captured with a spatial resolution of 1.67 metres. They were later resampled for 10 and 20 metres. The information about the images was stored in CD ROMs in LUM format. Intergraph IS12 software was used for digital processing of the images.

2.7.2 Combination of spectral channels

The images acquired with the sensors to be installed on board the SPOT 5-6 satellite consist of a set of four simultaneously obtained spectral channels for the wavelengths corresponding to green, red, infrared and panchromatic. The colour composition consisted of the creation of a composite RGB image by the allocation of three spectral bands - Band 3, Band 2 and Band 1 - to the colours red, green and blue. It should be noted that the MIR (mid-infrared) channel was not simulated.

2.7.3 Geometrical correction

The digital images show a series of distortions which prevent their direct use for cartographic purposes, making it necessary to perform a geometrical correction. The geometrical correction consisted of adjusting the image to the existing cartography by locating control points and applying a mathematical transformation. Entities which are precisely identifiable and which do not undergo changes over time were used as control points. The entities most used were road and track crossings, and railway lines. The control points used were digitized from the military map (scale 1:25 000) in the International Ellipsoid zone 29 UTM projection system. Efforts were made to make these points visible on the images, so as to minimize the error obtained in the geometrical correction.

Table 2 :Geometrical correction indicators of the simulated SPOT images

SITE	SPATIAL RESOLUTION	NÚMBER OF POINTS OF CONTROL	MEAN SQUARE ERROR (m)
Chamusca	10 m XS	10	13.57
	20 m XS	9	11.30
Benavente	10 m XS	16	6.19
	20 m XS	15	13.96
Salvaterra de Magos	10 m XS	13	7.55
	20 m XS	14	9.92
Mira	10 m XS	13	9.46
	20 m XS	13	18.62
Tocha	10 m XS	17	7.14
	20 m XS	15	9.25
Montemor-o-Velho	10 m XS	22	3.69
	20 m XS	18	9.63
Évora	10 m XS	10	6.21
	20 m XS	10	5.75
N.S.Machede	10 m XS	12	7.11
	20 m XS	12	9.86
S.Manços	10 m XS	15	8.99
	20 m XS	18	12.77

The mean-square error obtained in the geometrical correction of each site varied greatly, as can be seen from the values. This variation is generally due to the out-of-date 1:25 000 military maps and the actual symbols used in their preparation. However, the mean-square error obtained was not greater than one pixel (10 or 20 m, depending on the spatial resolution of the image) except at the Chamusca site, at 10 m resolution. A mathematical transformation expressed by a first-degree polynomial was carried out. The coefficients of the polynomial were calculated by the least-square method from pairs of points of known coordinate (UTM coordinates for the points digitized from the military map and line/column coordinates of the image). The interpolation of the values of the pixels resampled to 10 and 20 m was done by the nearest-neighbour method.

2.7.4 Supervised automatic classification

Classification methods are traditionally divided into two types: **supervised** and **unsupervised**.

The ***unsupervised*** method consists in grouping the pixels with similar values in a set of spectral bands, this similarity being determined on the basis of a notion of "distance" defined by the processing system and independent of its correspondence with the actual land use. Themes which are assumed to exist on the ground are subsequently attributed to these groups. This method is often used in delimiting different land uses. However, this method has been found to be inefficient when the aim is to identify agricultural crops, because the spectral signatures of the various crops may be very similar.

The ***supervised*** classification method presupposes prior knowledge of the study zone and the "ground truth". On the basis of the "ground truth", groups of pixels representative of each theme (training areas) are selected, and the information needed for classification is obtained from these. Supervised classification entails recourse to mathematical tools specific to decision theory. When a pixel is associated with a predefined class, a statistical decision is being taken, and this entails a specific error probability which must be minimized. One the ways of minimizing this error when a large number of pixels is being classified is by using the maximum verisimilitude classifier based on Bayes' theory.

2.7.5 Selection and delimitation of the training classes

The spectral signatures of the themes to be classified were obtained from the ground survey parcels ("ground truth") through the definition of training classes. It was however necessary to define in advance what themes it would be possible to identify on the image. The table 3 shows the crops identified on the ground, by region.

Table 3 : Identification of land use - Ground survey

BEIRA LITORAL	RIBATEJO E OESTE	ALENTEJO
1) Cereals Oats Wheat Maize Rice	**1) Cereals** Rice Wheat Maize Oats	**1) Cereals** Barley Oats Wheat Triticale Mixture of cereals
2) Potatoes	**2) Potatoes**	**2) Potatoes**
3) Industrial crops Sunflowers	**3) Industrial crops** Sunflowers	**3) Industrial crops** Sunflowers
4) Dry pulse crops Bean	**4) Dry pulse crops**	**4) Dry pulse crops**
5) Fodder crops Fodder Perennial ryegrass Fodder oats Beet	**5) Fodder crops** Fodder sorghum	**5) Fodder crops** Perennial ryegrass Associated crops
6) Horticultural crops Turnips Pumpkins Kale Broad beans	**6) Horticultural crops** Tomatoes Melons Pumpkins Beans Carrots Water melons Sweet peppers	**6) Horticultural crops** Melons
7) Permanent crops Vines Vines + citrus fruit Olive trees Olive trees associated with vines Orchards Pears Walnuts Apples + pears Citrus fruits Citrus fruits + kitchen garden Kiwi fruits	**7) Permanent crops** Vines Olive trees Orchards Citrus fruits Plums Pears Peaches	**7) Permanent crops** Olive trees Orchards
8) Permanent grassland and meadow	**8) Permanent grassland and meadow**	**8) Permanent grassland and meadow**
9) Forest Mixed forest Coniferous forest Deciduous forest Eucalyptus	**9) Forest** Mixed forest Eucalyptus Hispanic oak Pine trees (Scotch and Italian) Deciduous trees Shrubs	**9) Forest** Eucalyptus Poplars
10) Other Set aside Fallow Uncultivated Social area Kitchen garden Woods	**10) Other** Set aside Fallow Social area Prepared area Inland water Island Kitchen garden Shrubs Woods Natural pastureland	**10) Other** Fallow Social area Reefs Set aside Uncultivated Brook Inland water

One of the criteria adopted in the selection of the themes to be identified in the training class definition phase was the representative nature of this theme in the land inventory. From among the themes identified in the land inventories, the following groups **were not considered** in the training class definition:

- Social area: although this theme is defined by a very characteristic spectral signature, it was not representative in the regions/sites being studied;
- Kitchen gardens: a very heterogeneous theme with a low degree of representativeness;
- Swamps/pools: although these present a spectral signature which is quite clearly distinguished from the others, it is not a representative theme;
- Olive grove: theme for which it is difficult to obtain a spectral signature owing to the cultivation characteristics;
- Reefs: although this theme is identified on the ground, it is not visible in the images with a spatial resolution of 10 or 20 metres.

When the themes to be classified had been defined, the training classes were selected. The ground surveys for each site, composed of 12 segments each, were superimposed on the corresponding images with a spatial resolution of 10 and 20 metres. The training classes were chosen in two different ways:

- Automatic selection of training classes;
- Manual selection of training classes.

In automatic selection, all the pixels existing in the parcel identified in the ground survey were taken as the training area.

In manual selection, the spectral signatures of each class was obtained by choosing the training areas pixel by pixel. It was thus possible, when necessary, to separate two or more spectral classes within the same parcel of the ground survey.

The process of automatic selection of the training areas, although very rapid and free of subjectivity, does not enable different spectral signatures to be distinguished within the same parcel of the ground survey.

In the analysis of the statistics of the automatically-selected training classes, it was found that there were crops which were not distinguishable from each other and which had similar statistical characteristics (mean, standard deviation, mode and median). It was therefore decided to select the training areas manually, delimiting them pixel by pixel and sometimes subdividing the parcel identified on the ground into two or more areas.

The heterogeneity of some of the crops identified in the land inventories is obvious from observation of the images in colour composition. It will be seen that different shades occur within the same colour or different colours within the same parcel corresponding to a certain crop or between parcels existing in the remaining segments. Situations of this type were found with sunflower and barley crops and also with fallow land. In these cases the parcels corresponding to sunflower crops, for example, were separated into different training classes (sunflower 1 and sunflower 2). Thus, two spectral signatures were obtained for the sunflower crops, producing better results in supervised classification.

During the phase of delimitation of the training areas to obtain the spectral signatures of the themes to be classified, various doubts arose regarding the crops identified in the land inventories. In order to overcome this problem, meetings were held between the team responsible for classifying the images and the teams responsible for carrying out the ground surveys.

In the Alentejo region doubts often arose about the parcels identified as fallow, wheat, oats and barley. The technicians responsible for this identification concluded that sometimes the parcels identified as fallow contained stubble from wheat, oats or barley from the previous year or were covered with natural vegetation. On the other hand, the variety of natural vegetation existing in these parcels and the occurrence of animals which flatten this vegetation produce heterogeneity in the radiometric signature of these parcels. Thus, despite the fact that parcels of fallow land are generally relatively large, it was decided to delimit two or more training classes which would be as homogeneous as possible.

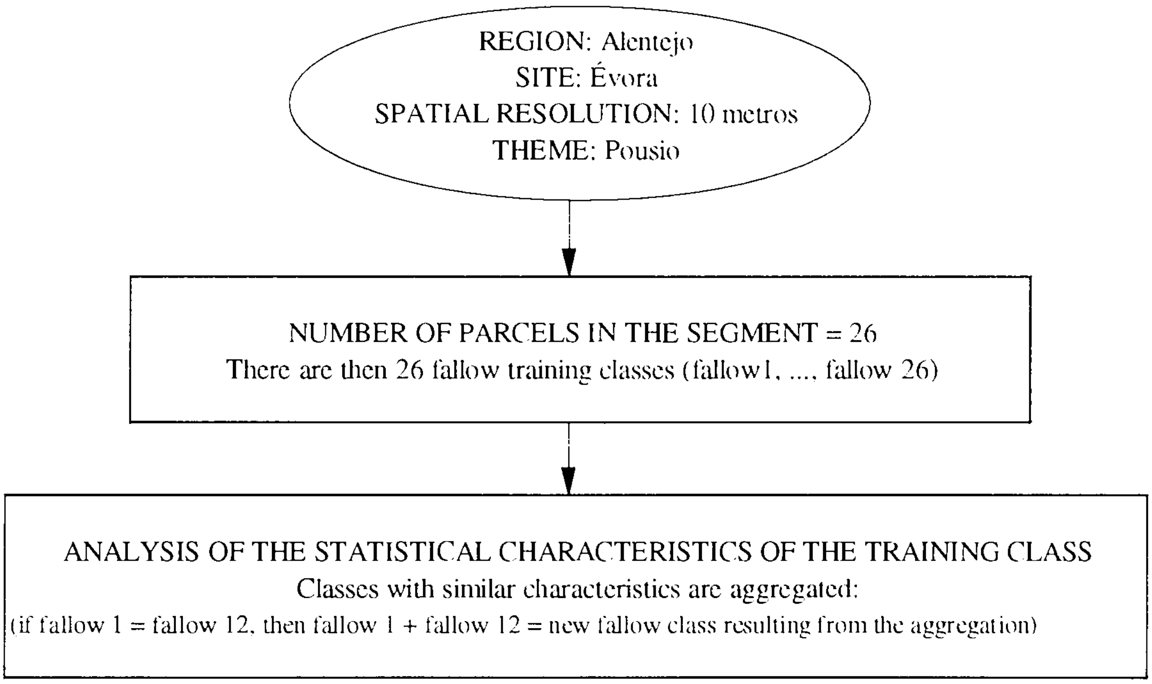
With regard to wheat, oats and barley, it is difficult to distinguish these three themes with the spectral resolution of the sensor used. It was however possible in some cases to separate wheat and barley. Where this was not possible, these themes were aggregated and classified as cereal.

In the Ribatejo and Oeste region, where spring crops predominate (except at the site - Chamusca - which consists almost exclusively of forest and crops under cover), problems of a different nature arose.

Owing to the image date it was not possible to distinguish between the spectral signature of some of the spring crops, particularly tomatoes, sunflowers and maize. On the other hand, the sunflower crop was characterised by a great diversity of spectral signatures owing to the existence of parcels of sunflower at different phenological stages.

With regard to vines, there were also differences in spectral characteristics at the Benavente and Salvaterra de Magos sites. In this case, too, the technicians responsible for carrying out the ground surveys explained the differences by the crop management methods at the two sites.

To enable the process of manual delimitation of the training classes to be better understood, the following diagram shows an example for the Alentejo region.



This process was carried out in two phases. In the first phase the parcels corresponding to each theme were identified, the number of training classes delimited being equal to the number of parcels of this theme in the segment. In the second phase the statistics of each training class were analysed, the classes with very closely similar spectral characteristics being aggregated.

After the aggregation of classes by theme, the training classes of all the themes were analysed simultaneously. It was found that certain crops were defined by similar spectral signatures, and it was decided to aggregate these.

The assessment of the increase in the spatial resolution of the images of the future SPOT 5-6 satellite involves a comparison between the results obtained in the supervised classification of the images with a spatial resolution of 10 and 20 metres. This comparison is possible only if the training classes defined for each of the resolutions are exactly the same. Thus, the classification of the images with a spatial resolution of 20 metres was carried out using the training classes defined at 10 metres.

The training classes digitized on the basis of the parcels of the segments superimposed on the images with a spatial resolution of 10 metres were converted into a vectorial file. On the basis of this file, the training areas were defined for supervised classification of the images with a spatial resolution of 20 metres. It was thus ensured that the training classes used in the classification of the images at 20 metres were exactly the same as at 10 metres.

However, as some of the training areas defined at 10 metres were small, it was not possible to use them in the 20-metre classification, especially in the Beira Litoral region.

3. Analysis and discussion of results

3.1 Programming of image acquisition dates

The choice of the image dates to be used in assessment studies of land use by means of remote sensing is an essential aspect, as it is a condition governing all the information that can be gained from the images. On the other hand, the growing cycle of the crops and the farming methods employed have a strong conditioning influence on the choice of the image date, and must therefore be taken into account in planning work of this type.

Usually, when the aim is to identify crops with very different growing cycles - winter and spring - recourse is had to images with different dates.

The use of images relating to two different dates would have made it possible to achieve, by comparison, a better separation of crops, especially in the case of spring crops and of fallow land. It was therefore necessary to aggregate certain crops in the phase of delimitation of training classes, so that far fewer themes were defined in the image than were identified in the ground surveys.

This aspect, which is considered critical in all remote sensing projects, where the multitemporality of the images forms the basis for a large proportion of the classification mechanisms, is, in the context of this project, a limitation which was assumed from the outset. However, the aim of this study is to compare two SPOT sensors, and at present it is impossible to carry out simulation flights at a rate similar to that at which these images will become available in future.

3.2 Preparation of the ground documents

The most important aspect of the preparation of ground documents relates to the use of aerial photography in the ground surveys, instead, as would be desirable - and is usually done - of documents produced from satellite images from the sensor. Recourse to satellite images during the field work would make it possible to identify clearly the origin of the variability found in the spectral signature of one and the same class of land use. In future this must be systematically done, even by recourse to SPOT images with a resolution of 20 m available on the necessary dates.

3.3 Ground surveys

As already explained in 2.5, the ground surveys took place in accordance with a methodology similar to that defined by the MARS project, which uses the Cronos nomenclature for allocating the land use categories. There is, however, a systematic difference between the aggregation of land use classes according to this nomenclature and the legend which can be obtained through classification of the satellite images. As the aims of this project are statistical, it becomes necessary to establish, objectively, a compromise between the observation/classification/economic interest components which will make it possible to optimize the effort made (and the cost entailed) in a manner which is technically realistic and efficient from the socio-economic point of view.

The land use themes identified in the ground survey were presented in point 2.7.5. On average, about 30 themes were considered by the teams; however, in the legend produced by the image classification, only ten or so thematic classes were distinguished. In future work this question will have to be reconsidered, although the direct use of documents prepared on the basis of satellite images will contribute greatly to matching the ground survey to the classification procedures.

The levels of breakdown of land use achieved by means of the ground surveys, classification and thematic aggregation are compared in the following figures:

Region : Beira litoral
Site : Montemor-o-velho

Thematic classes	Supervised classification spectral classes	Ground survey classes
Spring crop	Sunflowers + Maize + Rice	Sunflowers Maize Rice
Maize	Maize 3 Maize 5 Maize 10	Maize
Rice	Rice 1 Rice 3 Rice 49 Rice 29 Rice 18 Rice 33 Rice 45 Rice 47 Rice 53	Rice
Sunflower	Sunflower 5 Sunflower 5a	Sunflowers
Fallow	Fallow 1 Fallow 3 Fallow 4 Fallow 5 Set aside 1	Fallow Set aside
Fodder	Fodder 1 Fodder 2	Fodder
Forest	Forest 1 (deciduous + coniferours) Forest 2 (deciduous) Forest 3 (deciduous + coniferous)	Deciduous forest Coniferous forest

Region : Ribatejo-e-Oeste
Site : Benavente

Thematic classes	Supervised classification spectral classes	Ground survey classes
Fallow	Fallow 1 Fallow 2 Fallow 3	Fallow
Wheat	Wheat 1 Wheat 2 Wheat 3	Wheat
Spring crops	Spring crop 1 (tomatoes + sunflowers) Spring crop 2 (tomatoes + sunflowers + maize) Spring crop 3 (tomatoes + sunflowers + maize) Spring crop 4 (tomatoes + sunflowers)	Tomatoes Sunflowers Maize
Sunflower	Sunflowers 1 Sunflowers 2	Sunflowers
Melons	Melons 1 Melons 2	Melons
Maize	Maize 1 Maize 2	Maize
Rice	Rice 1 Rice 2	Rice
Vines	Vines 1 Vines 2 Vines 3	Vines
Grassland	Grassland 1 Grassland 2 Grassland 3	Grassland
Pine	Pine 1	Scotch pine
Water	Water 1	Water

Region : Alentejo
Site : N.S. Machede

Thematic classes	Supervised classification spectral classes	Ground survey classes
Fallow	Fallow 1 Set aside 1	Fallow Set aside
Cereal	Oats + triticale + mixture of cereals + barley	Oats Triticale Mixture of cereals Barley
Wheat	Wheat 1	Wheat
Sunflowers	Sunflowers 1 Sunflowers 2	Sunflowers
Fodder	Fodder 1	Fodder

Table 4 : Levels of thematic breakdown of land use by different sources of information

3.4 Analysis of classification

3.4.1 Spectral signatures

The supervised classification is carried out on the basis of the radiometric response of the objects (in this case, agricultural crops) existing on the ground. Identification of spring crops in June creates various difficulties. Sometimes these crops are still in the germination or plantlet phase, which prevents effective separation of crops via the radiometric values in the three wavebands of the SPOT sensor. Thus the spectral response will be similar to that of ploughed land, or fallow land, for all these.

Figures 1 and 2 show some examples of spectral signatures obtained for the training classes as a result of 10 m and 20 m classification. It should be noted that in some situations, for example for sunflowers on the N.S. de Machede site in the Alentejo region, it was necessary to consider subclasses within the same thematic class which presented different spectral signatures and partly reflect the aforesaid variability. This question has already been discussed in point 2.7.5.

Figure 1 : Spectral signatures - Alentejo - N.S. Machede, 10 m

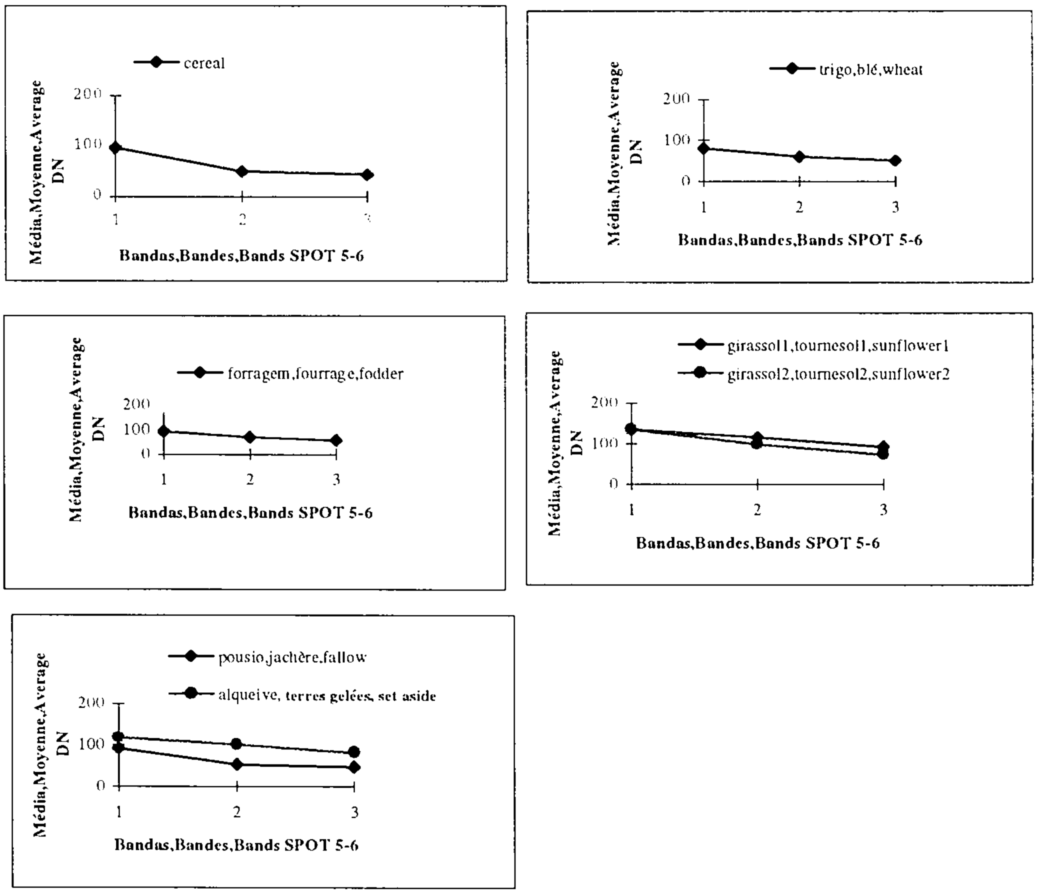
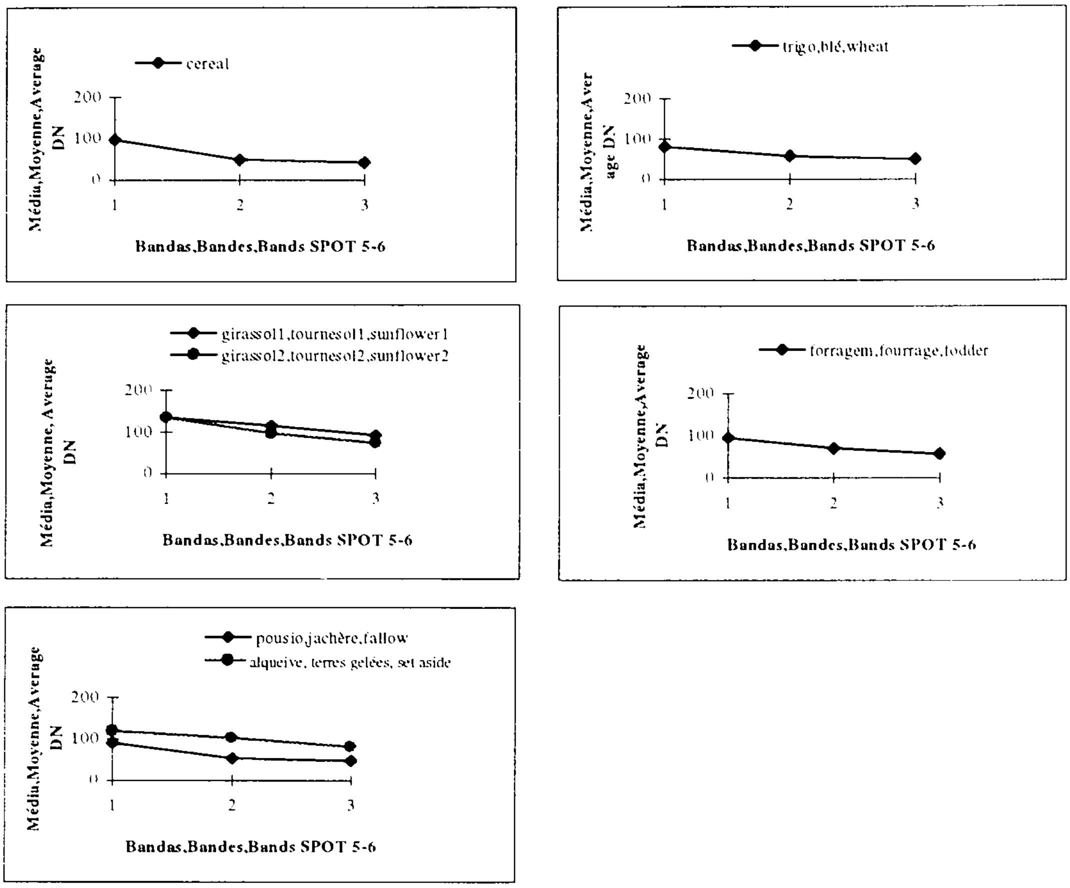


Figure 2 : Spectral signatures - Alentejo - N.S. Machede, 20 m



3.4.2 Classification quality

In this study supervised classification was carried out, using the maximum verisimilitude classifier, on images with a spatial resolution of 10 m and 20 m, on each site. The ground surveys - 12 segments of 25 ha per site - were used as the "ground truth". In order to assess the reliability of the classification results, it is possible to use various statistical approach criteria. In many remote sensing studies preference is given to approaches with reference to the regression model or the analysis of contingency tables or confusion matrices.

In this study recourse was had to analysis of the **confusion matrices**, because the size of the observation units was too small for a study of the first type. Thus the information concerning two or more variables was cross-plotted in contingency tables in order to evaluate the degree of coincidence or association. The purpose of these tables was to compare the results obtained in the supervised classifications with the information relating to the "ground truth". In addition to the calculation of the confusion matrices, the distances (Euclidian and Jefferies-Matsusita) between the various classes of land use were also determined for each site. These indicators make it possible to evaluate the separability between the classes and are presented in point 3.4.4.

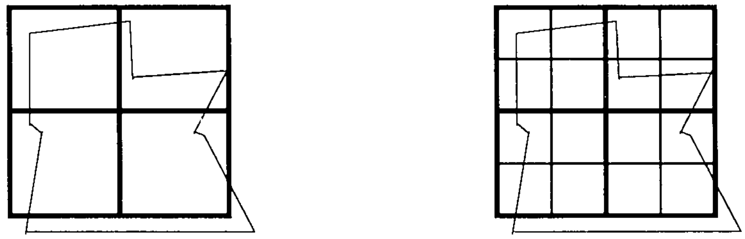
3.4.4 Analysis of error matrices

The relationship between the spatial resolution of 20 and 10 metres is 1:4, i.e. one 20-metre pixel corresponds to four 10-metre pixels. It could thus be expected that the number of pixels of each training class with a resolution of 20 metres would be four times smaller than that of each training class with a resolution of 10 metres. However, this proportion was not encountered in all situations in which the confusion matrices obtained for the two classifications are presented.

The training areas which constitute the various training classes were carefully delimited on the images with a spatial resolution of 10 metres, attention being paid to the border pixels. When these same areas were superimposed on the images with a resolution of 20 metres, it was found that in most cases the border of these areas passed through the centre of the pixel and not through its edge, as was the case with the 10 metre resolution. In these cases the pixel was not taken into account in counting the number of pixels constituting the training area, so that the number of pixels in this training area was reduced. The following figure illustrates a situation where the proportion 1:4 does not occur in the number of pixels in the training area.

Spatial resolution: 20 m — Number of pixels: 0

Spatial resolution: 10 m — Number of pixels: 5



Example of non-occurrence of the proportion 1:4 in the number of pixels in the training classes.

In the example shown in this figure a training area with five pixels was delimited for a 10 metre image. When this area was superimposed on the 20 metre image the number of pixels was zero, because this area did not contain any entire pixels.

In the tables of results presented below (tables 5 to 10), the confusion matrices were constructed on the basis of selected sets of pixels for each training class. These matrices are the result of the classification of the training classes defined for each theme, pixels relating to the "ground truth" being presented on the line, while the pixels actually classified by the classifier as belonging to each theme are presented in the column.

The evaluation of the performance of the training classes classification was made on the basis of overall accuracy, errors of omission and commission and the accuracy of each training class, calculated as follows:

- Overall accuracy: sum of the elements of the main diagonal, to be divided by the total number of pixels.
- Errors of omission: sum of the elements outside the main diagonal (on the line), to be divided by the total of pixels of this class on the ground (on the line).
- Errors of commission: sum of the elements outside the main diagonal (in the column), to be divided by the total number of pixels classified in this class (in the column).
- Accuracy of each training class: number of pixels correctly classified in each theme, to be divided by the total number of pixels used in this theme (total on the line).

The value obtained in the calculation of the **accuracy** of each training class provides an estimate of the accuracy of each training class, i.e. of the accuracy with which a certain training class is classified in this theme.

The **error of omission** indicates the quantity of pixels which are being classified as other themes, and the **error of commission** indicates the probability that a pixel classified as a certain theme will actually represent this theme on the ground.

The analysis of the confusion matrices (for the 10 and 20 m cases) varies greatly from region to region.

At the **Alentejo** sites the accuracies achieved are very high (always above 80%) and the omission/commission errors are few (always between 10% and 20%, with a few exceptions). These are zones where the final classification legend is small (5-6 classes), which is natural in a region where extensive crops (winter cereals and sunflowers) predominate.

In the sites in **Ribatejo e Oeste** the accuracies achieved are even greater, as the errors of omission and commission are even smaller. In this case the legend used is more extensive (as a rule), including as it does the classes of vines, rice, etc. This situation is probably connected with the lesser importance of winter cereals (in comparison with Alentejo), which leads to a decrease in the importance of interpretation errors generated by areas of stubble, whose spectral response is confused with fallow/set aside areas, as was found to be the case in Alentejo.

At the sites in **Beira Litoral** the accuracy is lower and varies more between sites. Errors of omission and commission are generally higher, reaching very significant values (e.g. above 70% for fodder at the Mira site), This is an area with very small parcels and a great diversity of crops.

This situation is similar both for the 20 m XS images and for the 10 m XS images.

Table 5 : Confusion matrix: Beira Litoral Site: Montemor-o-Velho

Resolution: 10 m (Unit : pixel)

Land	Classification								Total	Errors of omission (%)	Errors of commission (%)	Accuracy (%)
	1	2	3	4	5	6	7	N/C				
1. Spring crop	2 828	106	588	70	0	0	0	52	3 644	22,4	3,8	77,6
2. Maize	1	356	31	0	0	0	0	3	391	9,0	38,7	91,0
3. Rice	112	117	2 758	5	3	0	11	31	3 037	9,2	18,4	90,8
4. Sunflowers	0	0	2	153	0	0	0	4	159	3,8	32,9	96,2
5. Fallow	0	2	0	0	203	13	18	1	237	14,3	45,0	85,7
6. Fodder	0	0	0	0	8	59	0	0	67	11,9	23,4	88,1
7. Forest	0	0	1	0	155	5	2 280	29	2 470	7,7	1,3	92,3
TOTAL	2 941	581	3 380	228	369	77	2 309	120	10 005			

Overall accuracy (%) = 87,53

Table 6 : Confusion matrix: Beira Litoral Site: Montemor-o-Velho

Resolution: 20 m (Unit : pixel)

Land	Classification						N/C	Total	Errors of omission (%)	Errors of commission (%)	Accuracy (%)
	1	2	3	4	5	6					
1. Spring crop	465	9	64	0	0	0	17	555	16,2	4,1	83,8
2. Maize	0	38	0	0	0	0	0	38	0,0	22,4	100,0
3. Rice	20	2	579	0	0	0	11	612	5,4	10,0	94,6
4. Sunflowers	0	0	0	16	0	0	0	16	0,0	0,0	100,0
5. Fallow	0	0	0	0	18	0	0	18	0,0	0,0	100,0
6. Forest	0	0	0	0	0	469	7	476	1,5	0,0	98,5
TOTAL	485	49	643	16	18	469	35	1 715			

Overall accuracy (%) = 94,46

Table 7 : Confusion matrix: Ribatejo e Oeste Site: Benavente

Resolution: 10 m (Unit : pixel)

Land	Classification													Errors of omission (%)	Errors of commission (%)	Accuracy (%)
	1	2	3	4	5	6	7	8	9	10	11	N/C	Total			
1. Spring crop	3 653	36	6	0	8	0	0	35	68	0	0	97	3 903	6,4	1,1	93,6
2. Melons	14	365	0	0	0	0	0	0	0	0	0	1	380	3,9	9,0	96,1
3. Maize	2	0	246	0	0	0	0	0	0	0	0	6	254	3,1	3,9	96,9
4. Sunflowers	1	0	4	323	0	0	0	0	0	0	0	8	336	3,9	0,0	96,1
5. Rice	2	0	0	0	573	0	0	0	1	0	0	26	602	4,8	5,4	95,2
6. Wheat	0	0	0	0	0	190	6	10	11	3	0	2	222	14,4	20,5	85,6
7. Vines	0	0	0	0	0	2	529	57	57	0	0	3	648	18,4	11,2	81,6
8. Fallow	1	0	0	0	0	0	15	129	1	0	0	0	146	11,6	45,1	88,4
9. Grassland	19	0	0	0	0	17	46	4	380	0	0	12	478	20,5	26,8	79,5
10. Pine	0	0	0	0	0	30	0	0	1	535	0	11	577	7,3	0,6	92,7
11. Water	0	0	0	0	25	0	0	0	0	0	1 491	51	1 567	4,9	0,0	95,1
TOTAL	3 692	401	256	323	606	239	596	235	519	538	1 491	217	9 113			

Overall accuracy (%) = 94,71

Table 8 : Confusion matrix: Ribatejo e Oeste Site: Benavente

Resolution: 20 m (Unit : pixel)

Land	Classification													Errors of omission (%)	Errors of commission (%)	Accuracy (%)
	1	2	3	4	5	6	7	8	9	10	11	N/C	Total			
1. Spring crop	724	3	7	0	0	0	0	3	14	0	0	23	774	6,5	0,8	93,5
2. Melons	3	63	0	0	0	0	0	0	0	0	0	1	67	6,0	6,0	94,0
3. Maize	1	1	49	0	0	0	0	0	0	0	0	2	53	7,5	12,5	92,5
4. Sunflowers	0	0	0	45	0	0	0	0	0	0	0	0	45	0,0	0,0	100,0
5. Rice	0	0	0	0	124	0	0	0	1	0	0	8	133	6,8	7,5	93,2
6. Wheat	0	0	0	0	0	42	0	0	1	0	0	0	43	2,3	10,6	97,7
7. Vines	0	0	0	0	0	1	123	15	9	0	0	1	149	17,4	12,1	82,6
8. Fallow	0	0	0	0	0	0	2	34	0	0	0	0	36	5,6	35,8	94,4
9. Grassland	2	0	0	0	2	4	15	1	77	0	0	1	102	24,5	25,2	75,5
10. Pine	0	0	0	0	0	0	0	0	1	108	0	1	110	1,8	0,9	98,2
11. Water	0	0	0	0	8	0	0	0	0	1	331	10	350	5,4	0,0	94,6
TOTAL	730	67	56	45	134	47	140	53	103	109	331	47	1 862			

Overall accuracy (%) = 94,90

Table 9 : Confusion matrix: Alentejo Site: N.S. Machede

Resolution: 10 m (+ 1 class) (Unit : pixel)

Land	Classification								Errors of omission (%)	Errors of commission (%)	Accuracy (%)
	1	2	3	4	5	6	N/C	Total			
1. Cereal	2 761	2	134	0	36	339	90	3 362	17,9	20,4	82,1
2. Wheat	0	677	0	0	26	76	9	788	14,1	31,1	85,9
3. Barley	1	0	71	0	1	2	0	75	5,3	79,0	94,7
4. Sunflowers	0	0	1	1 800	8	395	33	2 237	19,5	6,4	80,5
5. Fodder	0	186	0	0	733	67	9	995	26,3	38,2	73,7
6. Fallow	707	117	132	123	382	5 157	36	6 654	22,5	14,6	77,5
TOTAL	3 469	982	338	1 923	1 186	6 036	177	14 111			

Overall accuracy (%) = 80,62

Table 10 : Confusion matrix: Alentejo Site: N.S. Machede

Resolution: 20 m (Unit : pixel)

Land	Classification							Errors of omission (%)	Errors of commission (%)	Accuracy (%)
	1	2	3	4	5	N/C	Total			
1. Cereal	717	4	0	2	54	17	794	9,7	18,5	90,3
2. Wheat	8	132	0	3	25	2	170	22,4	39,7	77,6
3. Sunflowers	0	0	389	5	88	12	494	21,3	5,6	78,7
4. Fodder	0	26	0	195	5	1	227	14,1	21,7	85,9
5. Fallow	155	57	23	44	1 212	8	1 499	19,1	12,4	80,9
TOTAL	880	219	412	249	1 384	40	3 184			

Overall accuracy (%) = 84,33

3.4.4 Separability analysis

The separability analysis was carried out on the basis of the calculation of the Jeffries Matsutita distances. This indicator varies between 0.0 and 2.0 and can be taken as a quantitative measure of the separability achieved between the different classes in the classification process. The values obtained, shown in the tables 11 to 16 pages for a significant set of land use classes, illustrate the quality of the classification carried out.

It should be noted that for different types of land use the values are all very close to 2.0. Nevertheless, in this case too the Beira Litoral region was the one which showed for some classes (e.g. vines/maize at the Mira site) JM distances below 1.0, which illustrates the difficulty of spectral separation of these classes in the Beira Litoral region.

Table 11 : Jefferies-Matsusita distance
Beira Litoral region Site: Montemor-o-Velho
Resolution: 10 m

	1	2	3	4	5	6	7
1. Spring crops	0.0000	1.8921	1.8376	1.9957	2.0000	2.0000	1.9975
2. Maize	1.8921	0.0000	2.0000	1.9889	1.9994	2.0000	2.0000
3. Rice	1.8376	2.0000	0.0000	2.0000	2.0000	1.9999	1.9998
4. Rice	1.9957	1.9889	2.0000	0.0000	1.9984	2.0000	2.0000
5. Set aside	2.0000	1.9994	2.0000	1.9984	0.0000	2.0000	2.0000
6. Fodder	2.0000	2.0000	1.9999	2.0000	2.0000	0.0000	1.9968
7. Forest	1.9975	2.0000	1.9998	2.0000	2.0000	1.9968	0.0000

Table 12 : Jefferies-Matsusita distance
Beira Litoral region Site: Montemor-o-Velho
Resolution: 20 m

	1	2	3	4	5	6
1. Spring crops	0.0000	1.8009	1.9192	2.0000	1.9999	1.9968
2. Maize	1.8009	0.0000	2.0000	2.0000	2.0000	2.0000
3. Rice	1.9192	2.0000	0.0000	2.0000	1.9991	2.0000
4. Sunflowers	2.0000	2.0000	2.0000	0.0000	2.0000	2.0000
5. Fallow	1.9999	2.0000	1.9991	2.0000	0.0000	1.9890
6. Forest	1.9968	2.0000	2.0000	2.0000	1.9890	0.0000

Table 13 : Jefferies-Matsusita distance
Ribatejo e Oeste region Site: Benavente
Resolution: 10 m

	1	2	3	4	5	6	7	8	9	10	11
1. Spring crops	0,0000	2,0000	2,0000	2,0000	2,0000	2,0000	1,9260	2,0000	1,9978	2,0000	2,0000
2. Melons	2,0000	0,0000	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000
3. Maize	2,0000	2,0000	0,0000	1,9114	2,0000	1,9999	2,0000	2,0000	2,0000	2,0000	2,0000
4. Sunflowers	2,0000	2,0000	1,9114	0,0000	2,0000	1,9999	2,0000	1,9999	2,0000	2,0000	2,0000
5. Rice	2,0000	2,0000	2,0000	2,0000	0,0000	2,0000	2,0000	2,0000	2,0000	1,9976	2,0000
6. Wheat	2,0000	2,0000	1,9999	1,9999	2,0000	0,0000	1,7547	1,8513	1,6178	1,9674	2,0000
7. Vines	1,9260	2,0000	2,0000	2,0000	2,0000	1,7547	0,0000	1,9764	1,4634	2,0000	2,0000
8. Fallow	2,0000	2,0000	2,0000	1,9999	2,0000	1,8513	1,9764	0,0000	1,9995	2,0000	2,0000
9. Grassland	1,9978	2,0000	2,0000	2,0000	2,0000	1,6178	1,4634	1,9995	0,0000	1,9985	2,0000
10. Pine	2,0000	2,0000	2,0000	2,0000	1,9976	1,9674	2,0000	2,0000	1,9985	0,0000	2,0000
11. Water	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000	2,0000	0,0000

Table 14 : Jefferies-Matsusita distance
Ribatejo e Oeste region
Site: Benavente
Resolution: 20 m

	1	2	3	4	5	6	7	8	9	10	11
1. Spring crops	0,0000	2,0000	1,9989	2,0000	1,9998	2,0000	1,8631	1,9999	1,9967	2,0000	2,0000
2. Melons	2,0000	0,0000	1,9963	2,0000	2,0000	2,0000	2,0000	1,9998	2,0000	2,0000	2,0000
3. Maize	1,9989	1,9963	0,0000	1,9815	2,0000	2,0000	2,0000	1,9910	2,0000	2,0000	2,0000
4. Sunflowers	2,0000	2,0000	1,9815	0,0000	2,0000	2,0000	2,0000	1,9946	2,0000	2,0000	2,0000
5. Rice	1,9998	2,0000	2,0000	2,0000	0,0000	1,9871	1,9999	2,0000	1,9827	1,9896	1,9993
6. Wheat	2,0000	2,0000	2,0000	2,0000	1,9871	0,0000	1,9029	1,9491	1,8380	1,9767	2,0000
7. Vines	1,8631	2,0000	2,0000	2,0000	1,9999	1,9029	0,0000	1,9123	1,6874	2,0000	2,0000
8. Fallow	1,9999	1,9998	1,9910	1,9946	2,0000	1,9491	1,9123	0,0000	1,9999	2,0000	2,0000
9. Grassland	1,9967	2,0000	2,0000	2,0000	1,9827	1,8380	1,6874	1,9999	0,0000	2,0000	2,0000
10. Pine	2,0000	2,0000	2,0000	2,0000	1,9896	1,9767	2,0000	2,0000	2,0000	0,0000	2,0000
11. Water	2,0000	2,0000	2,0000	2,0000	1,9993	2,0000	2,0000	2,0000	2,0000	2,0000	0,0000

Table 15 : Jefferies-Matsusita distance
Alentejo region
Site: N.S. de Machede

Resolution: 10 m

	1	2	3	4	5	6
1. Cereals	0,0000	1,8340	1,9985	1,8877	1,0073	1,9991
2. Wheat	1,8340	0,0000	1,9937	1,3311	1,2849	1,9993
3. Sunflowers	1,9985	1,9937	0,0000	1,7546	1,9858	0,8287
4. Fodder	1,8877	1,3311	1,7546	0,0000	1,4778	1,6194
5. Fallow	1,0073	1,2849	1,9858	1,4778	0,0000	1,9876
6. Set aside	1,9991	1,9993	0,8287	1,6194	1,9876	0,0000

Table 16 : Jefferies-Matsusita distance
Alentejo region
Site: N.S. de Machede
Resolution: 20 m

	1	2	3	4	5	6
1. Cereals	0,0000	1,5542	1,9970	1,9287	1,1947	1,9994
2. Wheat	1,5542	0,0000	1,9869	1,5553	0,8752	1,9996
3. Sunflowers	1,9970	1,9869	0,0000	1,7243	1,9729	0,7342
4. Fodder	1,9287	1,5553	1,7243	0,0000	1,5620	1,6783
5. Fallow	1,1947	0,8752	1,9729	1,5620	0,0000	1,9865
6. Set aside	1,9994	1,9996	0,7342	1,6783	1,9865	0,0000

3.5 Comparison between the 20 m and 10 m images

The central aim of the project is to compare ways of using SPOT sensors in agricultural statistics and to evaluate the advantages of the new sensor in relation to the present generation of satellite images. This comparison was however impaired by the non-availability of the MIR channel in the simulation flight and by the aforementioned limitations with regard to the multitemporality of the images.

On the other hand, the experiments previously carried out in Portugal in this field revealed logistic and technical inadequacies which have already been described and which we believe have been overcome in this project through the combination of teams and experience. It is thus important to emphasize that, although the central question of this project has been the comparison between the SPOT sensors, it has also made it possible to assess the actual feasibility and suitability of remote sensing techniques in Portugal.

With regard to the last-mentioned aspect, integration between the various work phases was achieved, with transmission of information being effected in a simple manner and with automation of many of the processes carried out. As for suitability, it was concluded that it is possible to use remote sensing by satellite in the regions being studied within the limits of the legends obtained. Nevertheless, only regional extrapolation of the results obtained and an objective comparison of these with conventional statistics and (if possible) the exhaustive ground truth (the universe) will enable the performance of the method to be assessed.

With regard to the comparative advantages of the new sensor, the results obtained do not warrant the conclusion that the 5-6 sensor is clearly an improvement on the present sensor. In areas with small parcels, spatially smaller crops can be distinguished more clearly by the SPOT 5-6, and this should enable them to be included in the land use legends. However, this advantage will probably be reduced through the loss of spectral homogeneity brought about by the increase in spatial discrimination, as can be seen from the decrease in accuracy encountered for these classes.

Thus, the conclusion to be drawn is that the information provided by the SPOT 5-6 satellite will have to lead, in order to be fully used, to the development of more advanced classification techniques which are not based solely on the radiometric homogeneity of the different types of land use.

3.6 Future prospects

The elements at present available thus do not permit a final conclusion on the comparative advantages of the new sensor.

From among the aspects previously described we can indicate a set of lines of work which it would be interesting to pursue in the near future as a natural continuation of this project. These would be:

- An exhaustive study of the 3x10 km sites, comparing the actual land use (obtained by a combination of photo-interpretation and ground survey) with the extrapolation produced on the basis of the area survey and the image classification. This study will have to provide answers to the problems of the size and location of the segments and of the relative efficiency of classification based on satellite images.
- Use of the MIR channel in the classification procedures.
- A comparative study of non-spectral satellite image classification methods.
- A reassessment of legends for the different phases of the work (preparation - field - classification - statistics).
- Finally, the carrying out of a SPOT 5-6 coverage (simulation) in an administrative unit for which conventional statistics corresponding to an agricultural area (Zona Agrária) are available.

THE TERRITORIAL PANEL FOR THE STATISTICAL MONITORING OF CROP TRENDS

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I. Introduction

It was at the end of the 19th century and the beginning of the 20th century that methodological criteria and practical applications were developed in order to obtain a series of quantitative data on agriculture as a basis for decision-making concerning not only shortages and the cost of foodstuffs and of raw materials for industry but also surpluses. To these traditional economic problems must be added those resulting from the new concepts of budgetary, social and environmental policies which have emerged in recent years. In these initial developments [1], it was recommended to compile periodical statistics on the state of crops and forecasts of future harvests as a means of obtaining sufficiently consolidated annual estimates and of facilitating public and private decision-making in the markets for each product. At the time it was already felt that the most important aspect was the measurement of areas, and it was even stated in writing that "the quality of a country's agricultural statistics is in direct proportion to the care and accuracy with which areas are measured".

The above-mentioned basic ideas are contained in the EU legislation on crop statistics (Regulation 837/90 concerning statistics on cereals, Regulation 959/93 concerning statistics on crop products other than cereals. Directive 76/625 concerning statistics on fruit trees, and Regulation 357/79 concerning statistics on areas under vines).

Agricultural statistics are especially important in the countries of Southern Europe, particularly Spain, since the social and economic importance of agriculture in the national economy, the highly perishable nature of a large part of agricultural production (fruit and vegetables) and the variability of the climatic conditions - which considerably affect crops and expected harvests - are factors which call for agricultural statistics with the necessary coverage, reliability and timeliness and which ultimately explain the large body of statistics kept by the Spanish Ministry of Agriculture, Fisheries and Food (MAPA). This body of statistics is traditionally obtained by the following two major surveys:

- The annual crop survey (areas, production and yield), carried out at national, regional and provincial levels.
- "Monthly data on crop areas and production". This operation involves monthly estimates, on the basis of timetables previously drawn up according to the biological cycle of each crop, for the main crops in terms of quantity (55 arable crops and 19 tree crops), which are compiled and disseminated monthly at national, regional and provincial levels.

In order to improve the reliability of these two operations, the MAPA has developed during recent years (since 1990) the area frame system/surveys of territorial segments, which is also designed as a system for integrating all crop statistics and which can be used for collecting data on land use and for carrying out environmental studies with the desired intensity and frequency.

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[1] See the work of Prof. Pilat M. Thadée and Prof. Umberto Ricci and the publications of the International Statistical Institute and the International Institute of Agriculture.

II. Brief description of the area frame system/surveys of territorial segments

II.1. The organization of the area frame

Since the monthly statistical bulletins of the MAPA[2] give a sufficiently detailed description of the area frame, we shall just summarise it briefly. Drawing up an "area frame" involves dividing the territory concerned into N small sections, which are called "segments" and completely cover the territory in question without overlapping. The area frame can be used for a number of purposes (statistical surveys, administrative checks, assessment of damage to land or crops, assessment of urban development, etc.). The use of the area frame for statistical purposes involves recording on the ground the specific characteristics of a sample n of previously selected segments (sub-set of N) and evaluating these characteristics for the whole territory by means of statistical estimators which allow the values of N to be deduced from the values of n.

The area frame drawn up by the MAPA currently covers 87.6% of the country, and its basic characteristics are the following:

- The map used is the National Topographical Map, scale 1:50.000 and UTM projection, which is published by the Army Geographical Service and has a basic grid pattern of 10 km x 10 km and another secondary grid of 1 km x 1 km, running N-S and E-W.
- For the purposes of the area frame, each of the squares of the basic grid is called a "block" and each square of the internal grid is called a "cell"; thus each block comprises 100 cells.
- In principle, the basic statistical unit is the cell (a square of 1 km x 1 km = 100 ha). Owing to considerations of the cost of carrying out the work and the coverage and reliability to be achieved in the general investigations of land utilisation, a systematic sample of 3% of the cells in each block (those with coordinates 3-2, 2-6 and 6-7 in the SW corner) was selected. For work requiring more thorough research, the sampling rate may be increased (as was the case in the 1992 basic survey on fruit trees, for which the sample was increased by adding a further 6 elements in each block).
- Owing to the fragmentation of agriculture in Spain, field surveys of the cell (100 ha) may be very complicated, so the cell has been replaced by the "segment", which is a square 700 m x 700 m (49 ha) in the SW corner of the cell.
- The area frame documentation compiled by the Statistical Unit of the MAPA consists of the following:
  - A 1:1 000 000 general map of each Autonomous Community on which the sheets of the 1:50 000 National Topographical Map (NTM) which are covered by it have been marked.
  - 1:200 000 provincial maps on which the sheets of the NTM, the blocks and the approximate positions of the sample segments have been outlined.
  - Sheets of the 1:50 000 NTM on which the sample segments have been outlined and numbered.
  - Aerial photographs with a scale of approximately 1:18 000, comprising the segment and its surroundings. On each of these photos the segment has been outlined with the square corresponding to it.
  - A 1:5 000 enlargement of the part of the above-mentioned photograph where the segment is. The segment is outlined on this enlarged photograph by a 14 cm square.
  - A database containing data enabling each segment to be identified.

II.2. MAPA annual crop survey

Since, like the area frame, the MAPA annual crop survey is described in sufficient detail in the above-mentioned statistical bulletins, we shall give here only a brief summary of the methodology and results of this survey. The area frame is used as a sampling basis for the annual crop survey, which was initially carried out in 1990 in the Castile and León region and has been gradually extended to other areas, so that in 1995 it covered all the territories belonging to the regions of Castile and León, Madrid, Castile-La Mancha, Andalusia, Extremadura, Aragón, La Rioja, Murcia, Valencia and Galicia. This survey meets the statistical requirements of EU Regulations

[2] N° 12/1990, 6/1991 and the monographs published in May 1992 and April 1993

837/90 and 959/93. In order to obtain data on areas and yields, the survey is based on two operations carried out simultaneously or in succession: the area survey and the yield survey.

The **area survey** involves the following work:

- Situating the segments in the field by using the area frame material: an up-to-date drawing on transparent paper of the plots in the segment, with the help of the 1:5 000 enlarged photographs; numbering each plot on a drawing, identifying the crop or use of each plot and transferring these data to an ad hoc questionnaire.

- Processing all the data obtained in the n segments of the sample (11 938 in 1994), including checking the quality of the field work; devising estimators to obtain results at the necessary geographical levels and computer programs for obtaining the results; calculating the results and their margin of error.

The final product is an estimate of the area under each crop in the zone in question (total, regional and provincial) and of the appropriate coefficient of variation (in %), which is the parameter defining the reliability of the result obtained; for example, for the total area of application of the 1994 survey (78.7% of the country), the system used determines the area under grain cereals (14.2% of the geographical area) with a coefficient of variation of 2.8%, while a coefficient of variation of 2.3% is obtained for the area under vines (2.7% of the geographical area). The field work involved in the area survey requires staff specialised in handling maps and photographs and in identifying crops and types of land use. On the other hand, the desk work is equally complicated. The results obtained since 1990 prove that the organisation, equipment and drawings used are correct.

The yield survey has so far only covered the quantities of Spain's main autumn-winter cereals: wheat, barley, oats and rye. This survey is carried out immediately before the harvest on a sub-sample of the segments used for the area survey. The field work is extremely complicated, since the yield of the plots of the sub-sample must be determined by means of objective methods (counting the ears of grain, weighing the grain, evaluation, etc.); the results obtained on each plot are transferred to an ad hoc questionnaire and then processed by computer. The yield data supplied by those who farm certain plots have been compared with our results; a field data/farmer's data regression was calculated, and the results were encouraging. In any case, it should be pointed out that even in the countries with broader experience of this type of procedure, the results of the yield survey, although positive, are less conclusive than those of the area survey. In view of this fact, methodological experimentation must be continued with a view to the objective determination of the yields of the various crops.

III. The territorial panel

III.1. Design

The territorial panel project is designed like a repetitive survey (several times a year) for providing statistically reliable data on crop trends, even several months before the harvest. The following requirements were taken into consideration when designing the territorial panel:

- The methodology must be the same as for the area frame system/surveys of territorial segments, so that the panel results are consistent with those of the annual surveys.
- It must be based on NUTS level 3 (provinces). This requirement is imposed by the prior existence of the MAPA's project "Monthly data on crop areas and production", which is in great demand and for which the panel is to serve to improve reliability and to meet the requirements of the regional authorities.
- It should be developed in line with the biological cycle of the various crops in the areas surveyed and geared to collecting area data and to estimating the yields, at least of the main crops, from a quantitative point of view in each area.
- It must be possible to obtain estimates of early and late crops, which are perhaps not well determined by the annual survey, and of multiple cropping (on the same plot).
- The project should be implemented in order to obtain timely results (within appropriate deadlines) at reasonable cost to the budget.

III.2. Sampling plan

The panel's sample of segments is a sub-sample of the sample used for the annual survey, designed in accordance with the two following basic objectives: the monitoring of crops - at least the main crops in terms of quantity - during the farming year and at NUTS level 3, and monitoring the representative results within a technically acceptable period and at reasonable cost. In view of the above-mentioned restrictions, the sampling procedure consists of the following stages:

- Prior stratification of the segments of the annual survey according to 5 classes (segments without crops, non-irrigated arable crops, non-irrigated tree crops, irrigated arable crops and irrigated tree crops) and 9 size strata (according to the percentage of the segment occupied by crops in a particular class). This stratification makes it possible to classify unambiguously each segment in the class-size typology, to direct the panel sample towards areas under crops (most important for the project) and to reduce the size of the sample to a minimum.
- After the stratification of the segments of the survey sample (10 745 for the six Autonomous Communities studied in 1993), and depending on the area occupied by the type of crop in each class, a distinction is made between the "extensive" segments (those with a small proportion of the type of crop in the class and for which the total of this type does not exceed 10% of the total area of the segment) and "intensive" segments (the rest).
- The panel sample (sub-sample of the annual survey) is fixed for each Autonomous Community (NUTS 2) at 20% of the "intensive" segments.
- The panel sample corresponding to each Autonomous Community is distributed according to provinces (NUTS 3) proportionally to the arithmetic mean of the number of intensive segments in the provinces and to its square root.
- After the number of segments making up the panel sample of a province has been allocated, the distribution is made by classes (non-irrigated arable crops, non-irrigated tree crops, irrigated arable crops and irrigated tree crops) proportionally to the square root of the number of intensive segments in each class present in the province in question.
- After the total of the panel sample for each province and for each class of segments has been determined, a systematic and independent selection is made for each class from a listing of each class present in the province. The order of this listing affects the selection procedure. Up to four types of sequencing were envisaged, and of these the one termed S has generally been adopted (sequencing the segments of each class according to districts and blocks).

The sampling system described above is a technically acceptable compromise between the overall budgetary limitations, the requirements of the Spanish regional authorities and the ultimate objective of the project: to measure trends in the areas under crops throughout the year at provincial, regional and national levels. For all the Autonomous Communities covered by the annual survey in 1993 and the territorial panel in 1994 (Castile and León, Castile-La Mancha, Extremadura and Andalusia - in all 59.8% of the national territory), the number of segments in the annual survey and the territorial panel is as follows:

Segments per class	1993 survey	1994 panel
Total	9 077	735
uncultivated	3 336	---
non-irrigated arable crops	3 520	308
non-irrigated tree crops	1 289	205
irrigated arable crops	730	162
irrigated tree crops	202	60

III.3. Field work

The field work/data collection for the territorial panel project is similar to that for the annual survey; the following special points should be mentioned:

- Timetables for successive visits to the segments (3 per year) are proposed by the technicians of the provinces in the light of the phenological state of the main crops in each zone.
- During the first visit to each of the panel segments, a descriptive sheet is completed giving the main geographical data, the access routes and the basic infrastructure in order to facilitate subsequent visits.
- The drawing of the plots in the panel segments shows a primary or basic network on the basis of more or less permanent features (roads, buildings, woodland, etc.). In addition to the drawing of the plots, there is a secondary network and which may have changed to a greater or lesser extent between the time of subsequent visits.
- Crops and land use are codified according to the system set up for the annual survey (approx. 80 crop codes, with 7 additional codes, 10 codes for land occupied by permanent pasture and 13 codes for other types of use, including woodland and non-agricultural areas).
- For all the plots of the panel segments, the yields of all the crops grown on them are evaluated. This evaluation is scheduled and carried out at stages close to the harvest (usually during the second and third visits, depending on the crops).

III.4. Methods for obtaining results

In view of the conditions which must be met by the territorial panel, the procedure for obtaining results is fairly complex. In order to obtain results from the data collected during the successive visits to the segments, the following methods have been tried:

- **Direct expansion**: this procedure regards the field information as if it was obtained during an isolated visit to the segments. The results are obtained by extrapolating the field data according to the selection probabilities ij of the segments.

$$\Pi_{ij} = \frac{P_{ij}}{\sum_{j=1}^{N_i} P_{ij}}$$

- **Estimation of differences between successive visits:** the calculation of results is based on the determination of the differences

$$Y_{i;j;c;t} - X_{i,j,c;t-n}$$

of the percentages of occupation of crop c in segment i;j; between visits t and t-n.

- **Ratio estimator**: the estimation is based on the ratio R_c between the percentages of occupation of crop c in each segment of the sample during the two temporally homogeneous visits in successive years and the value of the characteristic in question, obtained by means of a high-precision mass operation (annual survey). This method offers the most reliable results: the algorithms for calculating the estimator and the variance are as follows:

$$\hat{Y}_c = R_c \bar{X}_c = \frac{\bar{\bar{Z}}_c}{\bar{\bar{V}}_c} \bar{X}_c = \frac{\sum_{i=1}^{h} \sum_{j=1}^{n_i} \frac{y_{ijc}}{n_i \Pi_{ij}}}{\sum_{i=1}^{h} \sum_{j=1}^{n_i} \frac{x_{ijc}}{n_i \Pi_{ij}}} \bar{X}_c$$

as per P_{ij} is the probability of selection, in the annual survey, of the segment j of class i, where j varies from 1 to N_i

$$v(\hat{Y}_c) = \sum_{i=1}^{h} \frac{N_i^2}{N^2} \frac{1}{n_i(n_i - 1)} \sum_{j=1}^{n_i} [z_{ijc} - R_c V_{ijc}]^2$$

N_i and n_i are the number of segments in stratum i of the population and of the panel respectively.

v and z are the variables derived from x and y respectively.

The processing of data must be simplified as far as possible so that the regional statistical services can carry it out directly and thus save time in obtaining results. To this end, the estimator formulas have been converted and reduced to a simple sum of the products of the percentages yijc occupied by the crop in question in each segment ij, by previously calculated coefficients which are called Value per Unit (VPU) and signify the geographical area represented by each of the panel segments. Thus the expression [1] is simplified as follows:

$$\hat{Y}_c = \sum_{i=1}^{h} \sum_{j=1}^{n_i} \frac{V.P.U.}{100} Y_{ijc}$$

The VPU is characteristic of each segment of the sub-sample. If the areas y_{ijc} are determined by counting the points, e.g. of a model of 196 points (0.25 ha/point), instead of as a percentage of the segment, it is necessary merely to replace 100 by 196.

III.5. The development and the current situation of the territorial panel project

The Statistical Unit of the MAPA began the territorial panel project in 1993 as a pilot project in three Spanish provinces (Guadalajara, Palencia and Seville) with the assistance of the agricultural administrations of the Autonomous Communities concerned(3). The encouraging results of this pilot project, together with the numerous statistical and non-statistical applications of the project, meant that the territorial panel, in 1995, was extended to cover all the 31 provinces of the 7 Autonomous Communities of Castile and León, Castile-La Mancha, Extremadura, Andalusia and Valencia (24 provinces and 64.5% of the national territory) during 1994, and that the Autonomous Communities of Aragón and Murcia were incorporated into this project in 1995, thus covering 76.1% of the national territory(4). The MAPA and the regional agricultural authorities are firmly in favour of the consolidation of the territorial panel project, but it requires methodological developments so that the results obtained have the necessary coverage, reliability and timeliness within the cost limits imposed by the budget.

IV. Possible applications of the territorial panels

IV.1. Statistical applications

IV.1.1. Evaluation of crop areas and yields

The panel provides evaluations of crop areas at NUTS level III (and by integration at more highly aggregated geographical levels) which are directly usable in the MAPA programme "Monthly data on crop areas and production", which is in great demand from researchers in agricultural trends. In view of the small size of the panel sample, yields in the field are determined for all the plots occupied by the crop. The average production estimator is calculated by means of direct extrapolation. One of the direct uses of the project is the above-mentioned application of the panel in the statistical monitoring of crop trends during the farming year. Given its detailed geographical breakdown (NUTS 3), this alone justifies the project.

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(3) The description and results of this pilot project were published in the "Boletín Mensual de Estadística" N° 8-9/1994.

(4) The results of the 1994 territorial panel are published in an MAFF monograph in the "Boletín Mensual de Estatdística", August 1995.

IV.1.2. Incorporation of data on early and late crops into the annual statistics

The annual survey (carried out in application of Regulations 873/90 and 959/93) is like a "snapshot" taken on the spot at a given date. This is why early and late crops (potatoes, maize, sunflowers, sugar beet, etc.) cannot be totally monitored by this operation. The panel project provides for three of four visits per year. Thus the trends in the various crops can be quantified and analysed at different points during the year. Consequently, the results of the overall survey can be supplemented by correcting the figures calculated for certain crops on the basis of the panel results, thus providing complete results. The territorial panel also offers the possibility of quantifying the scale of multiple cropping, which in certain cases means the double or even triple use of agricultural land.

IV.1.3. Design of samples for carrying out specific surveys

For carrying out surveys on the specific technical and economic aspects of agricultural activity (e.g. the economic effects of fertilisation or of the use of certain systems of cultivation), it is necessary to design a sample which achieves the double objective of being able (a) to consult the farmer on the doses or systems used and (b) to note on the spot - in the plots under crops - the effects of these applications or systems. In this type of design, the use of the territorial panel frame may be appropriate, since it enables the two units under observation (farmer - plot) to be clearly linked.

IV.2. Non-statistical applications

IV.2.1. Global recording of administrative data

The regional, national and EU authorities produce various sources of information in the course of their activities of administration and economic management. Normally these authorities obtain results on areas, production, trends and behaviour concerning various crops, either from data supplied directly by respondents or by means of methods involving rapid determination by experts. There may therefore be instances of bias resulting from non-response, private interest in declarations and subjective assessments, and this leads to errors which are difficult to quantify. By devising a methodology to determine the "confidence intervals", in which the true values must figure, it is possible to contrast the reliability of data obtained from other sources as well as to ensure objectivity, staggering, repetitiveness and speed at reasonable cost. The panel results are obviously useful for recording declarations of areas under crops eligible for premiums.

IV.2.2. Uses of the matrices of change

The work carried out in the panel segments involves recording the crops which occupy each of the plots of these segments during successive visits. By incorporating the changes recorded in the various plots of a segment between an annual survey and each of the subsequent visits, and by allocating to these changes weighting coefficients calculated as a function of the "weight" of the segment, we obtain a "matrix of change" which provides information on trends in the crops over time. This system enables us to determine the **crop options** adopted by farmers. We can also determine the extent to which these actual farming practices tally with those which are theoretically indicated by agricultural science. By means of additional data, it is also possible to look for the reasons for apparently irrational behaviour. Similarly, the **grubbing-up** and **planting of certain varieties** are detected and their areas of contraction or expansion are monitored.

The territorial panel and the matrices of change (at provincial, regional, national and even supranational levels) derived from it may be decisive elements in drawing up **timetables for sowing and harvesting various crops**.

IV.2.3. Environmental applications

Studying the environmental aspects of farming and land use is becoming an increasingly important concern - and will be even more so in the future - of European society and institutions. The territorial panel may be of considerable help in the quantitative determination of these aspects, since the territorial frame on which it is based may be objectively applied to analyse, among other things, the following aspects:

- determining, at detailed geographical levels, the effects of disasters caused by unusual climatic conditions, such as drought, hail, heat waves, etc., and evaluating existing prevention systems;

- determining the effects of phytopathological diseases or accidents and, alternatively, measuring the effects of possible overdoses of plant-protection products and analysing the residues of such products after application;
- monitoring the implementation and results of the afforestation plans for agricultural areas, which the Community institutions - and those of some Member States - regard as very important as a means of regenerating plant cover;
- monitoring soil erosion on agricultural land and damage to such land (pastures, brushwood, disused pastures, etc.) caused by climatic changes or human activity;
- detecting losses of agricultural land as a result of its use for non-agricultural purposes such as urbanization, industrialization, construction of roads, railways, etc.

EXPERIENCES OF REMOTE SENSING IN FRUIT MONITORING

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Abstract

Over the 10 years the Italian Ministry of Agriculture has conducted a series of experiments addressed to assessing the performance of remotely-sensed data in updating vineyard and olive tree inventories and in mapping orchards. These studies pointed out the difficulty of mapping orchards through the use of SPOT and TM multitemporal data. This difficulty is particularly evident when attempting to map different types of orchards : apple, pear, kiwi, peach etc. It appears therefore that accurate mapping of these land use classes is presently impossible. In fact, the maximum accuracy achieved was 55-60%, much too low for maps of practical utility. Results were more encouraging for utilization of SPOT-XS and TM satellite data in updating olive tree and vineyard inventories. The studies conducted so far have shown a good performance of satellite-acquired data in identifying explants. Major difficulties occur instead in the identification of new plantings. We will illustrate the results achieved in development of agricultural statistics on orchards, vineyards and olive trees based on the AGRIT statistical system, which is presently being applied by the Ministry of Agriculture. We will conclude our presentation by analyzing the presence of mixed crops that could hinder the use of remote sensing techniques in countries such as Italy, Portugal, Greece and Spain

EXPERIENCE OF REMOTE SENSING IN FORESTRY

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Reliable information on forestry resources today appears an essential ingredient in defining forestry policy and rational management of this resource. Pinpointing certain events regionally or nationally gives a better picture of their possible repercussions on forest development. The need is often expressed for information to localize burnt areas (particularly in the Mediterranean countries) and storm damage and to monitor afforestation and deforestation, etc. Each country obviously has its own priority concerns. However, many countries possess neither regularly and frequently updated forest maps nor accurate estimation methods for their forestry resources.

Remote sensing by satellite is an instrument that has its place alongside the traditional tools of forestry statistics and can also meet the more recent demands of mapping. However, few countries are already using this tool for compiling inventories and monitoring forestry resources. In order to gain a fuller understanding of the potential and limitations of introducing remote sensing into inventory procedures, we will first look at the forest data and information this technique yields. We will then consider the factors that can help us to define the place of satellite images in forest inventory methods. Last, we will present the individual case of the French National Forest Inventory and the reasons for which this agency has come to take an interest in satellite images and consider using them in response to a new state of affairs.

I. Characteristics of forestry information in satellite images

1 - Remote sensing: general

Satellite remote sensing studies the waves in the electromagnetic spectrum emitted or reflected by objects on the earth's surface. Satellite-borne sensors record the intensity of the energy emitted or reflected at a given time in one or more wavelengths by a portion of the earth's surface. The information is transmitted to users in the form of images, usually in digital form. Analysis of satellite images is based on the principle that the radiation measured relates to the object observed. As the data are in digital form, they can be processed by computer, which can facilitate the extraction of useful thematic information. The images can also be geometrically rectified and thus related to map coordinates. They can then be combined with other geographical data via GIS (Geographical Information System), with all the related advantages.

The sensor, which enables the measurements to be made, is characterized by its spatial, radiometric and temporal resolution. Depending on its characteristics, a sensor is more or less suitable for analysing a given phenomenon. For forestry, the images used come mainly from the MSS (Multispectral Scanner) or the Landsat TM (Thematic Mapper) sensors, or from the SPOT HRV (Haute Résolution Visible) sensor. Another sensor that is sometimes used is the AVHRR (Advanced Very High Resolution Radiometer) on board the NOAA (National Oceanic and Atmospheric Administration) satellites. The images it produces are more suitable for studies of very large areas and global vegetation monitoring. It is felt that the data recorded by radars that have only recently been installed on some satellites may become a valuable source of forestry information, however, too little is known about them for such information to be integrated into an inventory approach. We will concentrate mainly on the use of images from the earth observation satellites SPOT and Landsat.

2 - SPOT and Landsat images

2.1 Characteristics of the SPOT and Landsat sensors

Table 1: Principal characteristics of Landsat TM and MSS images and SPOT XS multispectral and P panchromatic images

	Landsat TM image	Landsat MSS image	SPOT XS (multi-spectral) image	SPOT PAN (panchromatic) Image
Dimension of image	185 km x 185 km	185 km x 185 km	60 km x 60 km	60 km x 60 km
Pixel size	30 m	79 m	20 m	20 m
Wavebands	TM1 (blue): 0.45-0.52 µm TM2 (green): 0.52-0.60 µm TM3 (red): 0.63-0.69 µm TM4 (NIR*): 0.76-0.90 µm TM5 (MIR*): 1.55-1.75 µm TM7 (MIR): 2.08-2.35 µm TM6 (TIR*): 10.4-12.5 µm	MSS4 (green): 0.5-0.6 µm MSS5 (red): 0.6-0.7 µm MSS6 (NIR): 0.7-0.8 µm MSS7 (NIR): 0.8-1.1 µm MSS8 (TIR): 10.5-12 µm (Landsat 3)	XS1 (green): 0.50-0.59 µm XS2 (red): 0.61-0.68 µm XS3 (NIR): 0.79-0.89 µm	P (panchromatic): 0.51-0.73 µm
Interval between passages of the satellite	16 days	18 days	26 days (vertical view)	
Repositioning capability	no	no	+ or - 27m - increases probability of obtaining images; - ability to produce stereoscopic pairs	

* NIR: near infra-red, MIR: medium infra-red, TIR: thermal infra-red

The geometric resolution is defined by the pixel size[1] which is the basic unit area imaged on the ground by the satellite.The radiometric resolution is determined by the number and breadth of the spectral wavebands recorded by the sensor. The frequency of the images is, generally speaking, compatible with the objectives of forestry studies, except in areas with heavy cloud cover (humid tropical areas). So we can now concentrate on the impact of the other two characteristics: radiometric and geometric resolution.

2.2 Information from the various wavebands

It is fairly difficult to establish hard and fast rules about the thematic content of the various bands in the electromagnetic spectrum (visible, near infra-red, medium infra-red, thermal infra-red), owing to the complex composition of the radiometric signal from each pixel.

The factors influencing the radiometry of a forested area fall into two groups [1] (see Figure 1):

- Endogenous factors, naturally including the radiometry of the vegetation, which is a mixture of the spectral responses of its various constituents (leaves, trunks and branches). We know that the reflectance of leaves varies according to their anatomical structure, age, water content, state of health, etc. [2, 3]. In addition to this, there is the influence of the structure and geometry of the tree cover (inclination of the leaves, leaf-area index, shape of the canopy, etc.) and the ground cover ratio, as the ground has its own spectral characteristics.
- Exogenous factors include the scale of observation (see Section 2.3), the effect of viewing angles and lighting, which is closely related to topography.

1 Pixel (picture element): area in the image corresponding to the instantaneous field of view below the scanner (mechanical or optical) or the sensor in the case of a linear-array sensor system.

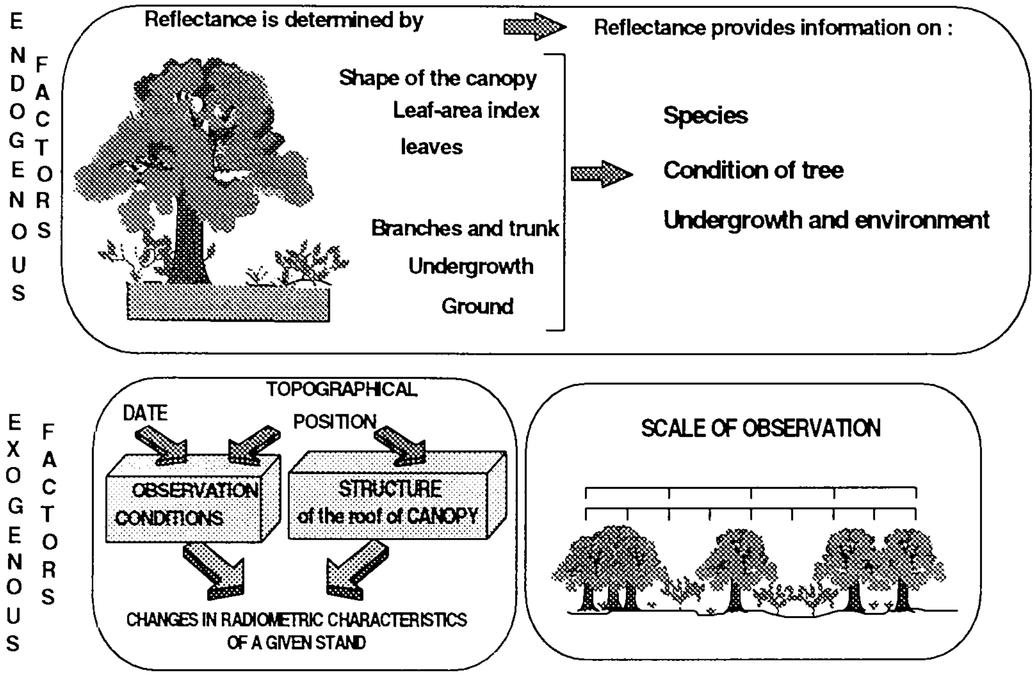

***Figure 1**: Endogenous and exogenous factors influence radiometry and provide a key to thematic information contained in satellite images.*

Satellite images do not allow for direct observation of the optical properties of a species, but provide more general information deriving from a series of characteristics of the vegetation cover, the environment in which it is located and the observation conditions. Thus, the radiometry of a pixel can provide information on:

- the type of cover (species and structure);
- the condition of the cover, in particular its state of health and water content [4, 5, 6, 7, 8];
- the nature of undergrowth [9,10];

This accounts for the many fields of application that are being explored, sometimes with only limited success. In order to study a given theme (e.g. mapping stand types), the other factors (e.g. undergrowth, ground and state of health) are sources of interference. Radiometric information is fairly rich, but very complex.

To simplify, it is usually felt that visible wavelengths, which relate directly to the chlorophyll activity of the plant, and near infra-red wavelengths, which are abundantly reflected by vegetation, are suitable for vegetation identification. Variations in the medium infra-red spectrum are more difficult to interpret. However, most authors agree on the usefulness of medium infra-red wavelengths to supplement information from the near infra-red band [12, 14, 15]. Some studies conclude that these wavelengths are a good indicator of the state of health, others an indicator of humidity. Thermal infra-red wavelengths can be related to the surface temperature, which appear to be a good indicator of the water content of the vegetation, and hence its propensity to catch fire. From this derive potential applications in monitoring fire risks and fire prevention. [16]

2.3 Information relating to geometric resolution

Geometric resolution determines the texture of the image. The textural quality of the information is determined by the relationship between the size of the objects and the spatial resolution [17].

In working with a fairly large scale aerial photograph (under 1/25 000), the structure of the roof of the canopy and the shape of the crowns are criteria that enable the photo-interpreter to identify certain forest types (species and stand structure). This information is not directly accessible on satellite images (see Figure 2). In a closed-canopy forest, each pixel covers a certain number of crowns. Several authors agree that above a resolution of 10 metres, the images contain very little textural information on the stand.

In open-canopy woodlands, the situation is slightly different. The arrangement of the cover, which may be assimilated to a mosaic of trees, bushes, elements of the herbaceous layer and bare ground, gives rise to a local structure that one appears to be able to define using texture indicators, such as variograms, even for a resolution in the order of about twenty metres [18].

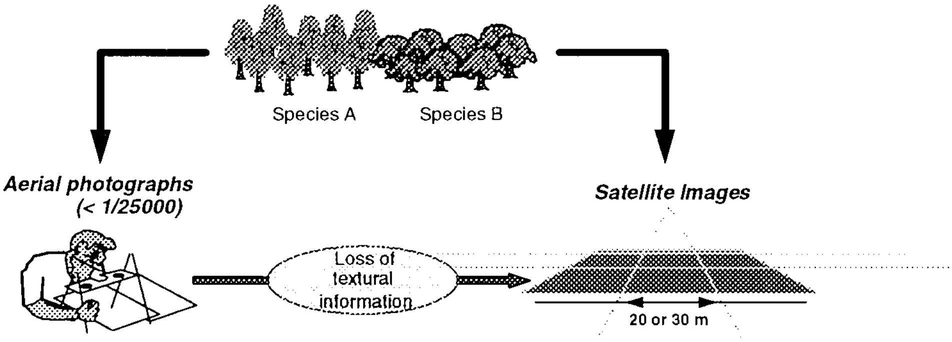

Figure 2 : Illustration of the loss of textural information in the transition between interpretation of aerial photographs and the analysis of satellite images. This reduces the capacity for species recognition.

What is more, because of their size, two pixels may have the same radiometry, but a completely different content. Figure 3 illustrates the case, in the near infra-red band, of two adult stands of different composition but with the same global reflectance (average of the reflectances of the various elements composing each pixel).

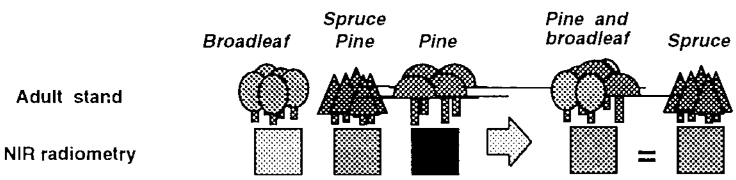

***Figure 3**: Illustration of the radiometric confusion arising from the size of each pixel, which may contain several trees of different species.*

This first part, which draws attention to the importance, but also the complexity of the information contained in satellite images, should enable us to gain a better understanding of the results obtained from remote sensing of forest resources.

II. Results of experience in the study of forest resources by remote sensing

We shall now look more closely at the results obtained in three fields of application that are of particular interest to forest inventory services: mapping stand types, estimating resources and mapping forest changes.

1 - Species mapping; estimation of forest area

Satellite images are known for their capacity to provide rapid mapping of major forest types, but are less suitable for the detailed mapping required by forest managers [19]. There are several levels of mapping:

- Distinction between forest and non-forest: this is generally achieved satisfactorily. However, certain types of forest, in particular young stands and scattered woodland can be confused with moorland or agricultural land.
- Distribution of the major species groups: the distinction between broadleaf and coniferous is the most reliable [15]. In comparison with the preceding level of mapping, there is further scope for confusion, particularly between young coniferous and broadleaf stands.
- Species recognition: several studies have led to distinctions between species or species groups [20, 21, 22], even in hilly areas, by applying appropriate methods and adjustments. The images also appear to enable the various stages of maturity of a given species or species group to be distinguished [9, 23, 24]. However, these results are not applicable across the board, and the quality of the mapping will depend on the type of forest studied. The use of series of images recorded at different times of the year (and therefore at different phenological stages) increases the ability to distinguish between species [25], but also the cost of the study.

2 - Estimating forest resources

Several authors have attempted to establish relationships between forest mensuration and radiometric data. For a certain number of selected sample plots, the average radiometry is taken from the images and mensuration data is collected on the ground. The mensuration parameters are usually land area, hight, density and age, and more rarely leaf biomass, or indices descriptive of the overall structure of the stand [26]. The analytical tool generally used to build a model of the relationships between the two types of data is linear regression. However, even though in certain study areas significant correlations are observed between radiometry and one or more parameters descriptive of the stand, results vary considerably from study to study and cannot be generally applied. Even for simple stands (conifer forest), not all authors succeed in establishing clear and significant relationships between mensuration data and reflectance [15, 27].

There are differences in the spectral waveband that gives the best estimate of mensuration parameters. In different studies, the best wavelengths were found to be the visible spectrum [12, 29], the near infra-red band [30, 31] or the medium infra-red band [27, 28]. Other authors find ratios or certain combinations of wavebands are more suitable [26, 29, 32], particularly in hilly areas, as they reduce the radiometric interference linked to topographical effects. The presence of hills is sometimes an advantage where composition and production conditions correlate strongly to topographical position [27, 32]. It is also worth mentioning the correct results obtained using winter images for broadleaf woodland [31] or texture wavebands from SPOT panchromatic images (10 m) [26].

Thus, the quality of the relationships established varies considerably according to the area studied and its biogeographical characteristics, the image chosen and the forest parameters studied. What is more, even where there are identifiable trends, they are often felt to be insufficient to build models for estimating forest mensuration quantities on the basis of satellite images [15, 27, 29]. In estimating forest resources, radar data are undoubtedly more promising than optical data, but processing them is still at the research stage.

3 - Mapping changes

The ability to produce time series of images for a given region makes remote sensing a suitable tool for monitoring an area and studying forest changes. To be detectable, changes in cover must generate radiometric changes, and these must be greater than the radiometric variations due to exogenous factors (differences in atmospheric conditions, observation conditions, etc.), unless adjustment is made for such effects [33].

From a thematic point of view, the results of change mapping obviously coincide with those obtained from single-date mapping. If a clear-felled plot can be identified in one image, it follows that it is possible to detect the change from an adult stand to a clear-felled plot by comparing two images. The various methods of analysis used to localize changes fall under one of the following approaches: independent analysis of two images and comparison of the results; analysis of the latest image while taking account of the results of previous analysis or existing maps (of whatever origin); and simultaneous analysis of multi-date data. The quality of the results depends on the approach adopted. The first mentioned is the least effective. On the other hand, direct comparison of two images can reveal a wide range of radiometric changes than one can then attempt to relate to an event on the ground. Comparing an existing map with an image can reveal disparities within mapping units, which may correspond to a change or discontinuity in the stand that one can attempt to interpret.

Whichever method is used, the detection of major changes, such as clear felling or forest fires yields good results [15, 34, 35, 36, 37, 38]. The detection rate for incidences of clear felling is close to 100%, though the quality of the estimate of the area felled depends on the size of the individual cut [36]. The detection of more subtle changes, such as tending activity or damage (due to parasites, pollution or climatic change), entails mastering the effect of exogenous factors (atmosphere, lighting and observation angles, etc.). Results have been obtained in the detection of thinning (detection rate of 60% to 70% and more) and other tending activities [37, 39, 40, 41, 42]. However, it can be difficult to distinguish between tending operations and health problems, which often display similar characteristics to thinning [37, 39, 40].

4 - Summing-up

Analysis of satellite images does not enable one to identify a wide range of types of stand for the purposes of forest mapping. Further, in countries like France, where there is fairly detailed forest information, the production of forest maps from satellite images is of little interest to users and managers, who are used to a more detailed description of forested areas. The best results to date have been obtained by traditional image processing methods in the study of fairly simple forest types (small variety of species and structures, as in Scandinavian or certain North American forests). More recent image analysis methods are a promising source of useful information on more complex forest types and open-canopy forests, such as open Mediterranean woodland. These are based on a spectral breakdown of the pixel [44, 45] or the use of variograms to categorize the stand structure [18, 43]. Lastly, it should be pointed out that the use of information from sources other than the image analysed (digital model of the terrain, ecological data, etc.) or from earlier images generally enhances the radiometric information.

Current images cannot be used systematically to estimate forest mensuration data for large areas. Future sensors, with higher resolution, will undoubtedly be more suitable for handling such problems, but hopes ride above all on the use of radar data.

In both stand mapping and resource estimation, the poorness of the results is unquestionably linked, in part, to the considerable spatial variation in the radiometry of a stand, as defined for forestry purposes, which leads to considerable confusion between different forest types. Analysis of radiometric variation over time allows one to overcome the spatial variation to a certain extent and yields promising results (detection of clear felling, as well as more subtle changes such as thinning and forest decline). Study of forest changes and the resulting updating of forest maps is an area in which satellite images appear a valuable source of information. This type of data should facilitate the rapid updating of information on forested area, particularly over large areas, at reasonable cost in terms of time and manpower.

III. Integrating satellite remote sensing into forest inventory procedures

The results obtained in forest mapping and map updating are such that one can envisage integrating satellite images into forest inventory methods at various levels. A few examples will serve to illustrate the more theoretical considerations we will address first.

1- Potential contribution of satellite images to forest inventory procedures

It should be borne in mind that the term "forest inventory" can cover a number of objectives: general inventory for framing forestry policy, forest management inventory, inventories for special purposes, etc. The objectives one wishes to attain must first be clearly defined so that a suitable inventory methodology can be selected and the necessary resources (technical, human and financial) devoted to meeting it. Objectives must sometimes be revised downwards in view of the resources actually available. In this context, satellite remote sensing is a tool among others, suitable for certain purposes. In view of the wide variety of cases one is likely to encounter, it is difficult to give a list of the situations in which the use of satellite images is a valuable means of attaining the objective set. We have therefore opted to define the demand for forest information according to a number of criteria and look at the potential contribution of satellite images in each area.

1.1 Defining the objectives of a forest inventory

The following criteria were selected as a means of defining objectives:

- The kind of information sought: does one want a general overview of the forest (types of stand) for management or other purposes, or study a particular phenomenon (special inventory, such as inventory of burnt area or inventory of areas of ecological interest.
- The characteristics measured in order to describe the forest: sometimes information on the area by forest type is sufficient. Often other information is sought: mensuration, age, ecological interest, etc.
- Localization of the information: is it necessary?
- What level of accuracy is sought? On this question, a distinction can be made between cartographic accuracy, if the information is localized, and statistical accuracy, if non-localized data are obtained from information relating to a number of sample points.
- Frequency: how often is the information needed?

1.2 The place of remote sensing in defining an inventory methodology

For each of the criteria used to define objective, on the basis of the results presented in Part II, we can look at the strengths and weakness of remote sensing and gain some understanding of the role it may play.

- The kind of information sought: while, for most inventories, detailed mapping is required for estimating areas, the advantage of satellite images depends largely on the on the degree of complexity of the forest one is working on. Only certain special-purpose inventories (e.g. localization of burnt areas) are feasible in most cases. It therefore seems preferable, especially where the type of environment has not yet been extensively studied, to carry out tests on a limited area before launching a project on regional or national scale.
- The characteristics measured in order to describe the forest: with very few exceptions, satellite images do not appear particularly suited to the direct collection of mensuration-type data. For such purposes, statistical inventories remain the most appropriate solution. On the other hand, where one wishes to estimate the area under major forest types, remote sensing can be a useful tool, particularly for fairly uniform forest cover (e.g. Scandinavian or Boreal forest).
- Localization of information: satellite images can be used to localize certain types of stand, as well as major disturbances affecting a forest stock (clear felling or fires) and even more subtle changes, using the appropriate image processing techniques.
- Accuracy of information: here, there is a close link between mapping methods based on remote sensing and statistical methods (see Figure 4).

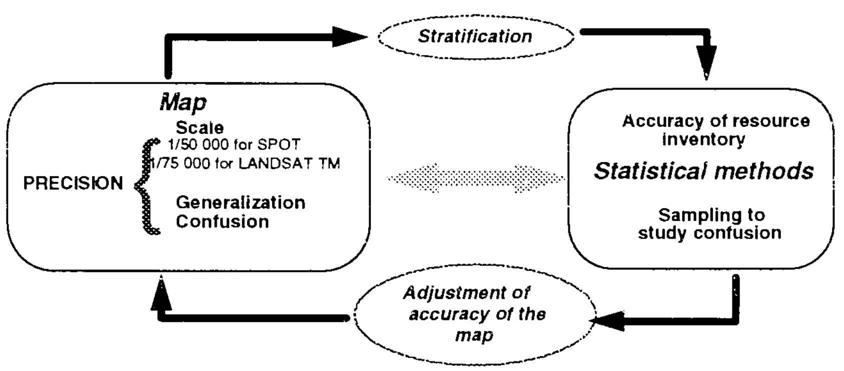

***Figure 4**: Diagram showing the links between cartographic accuracy and statistical methods. More accurate maps allow for better stratification and lead to improvements in resource estimates. Moreover, certain statistical methods attempt to arrive at more reliable estimates of the area of the strata by reducing errors due to confusion between strata.*

In a cartographic approach, the scale of representation of the information depends on the image used. It is in the order of 1/50 000 with SPOT XS and 1/75 000 with Landsat TM. The accuracy of the map also depends on the generalization threshold adopted and, ultimately, the amount of confusion between stand types. The accuracy of area estimates can nevertheless be improved by analysing the nature of the confusion using information obtained by sampling on the ground. Adjustment can thus be made for bias. Moreover, in a statistical inventory, remote sensing can play a unique role in stratifying the territory. An inventory of forest resources can indeed be produced by statistical methods alone via systematic sampling of the whole territory. However, stratification based on purely forestry criteria can increase the reliability of estimates for a given number of plots to be visited on the ground. The more detailed the stratification, the more accurate the results. However, a sophisticated stratification (species x forest resource criteria) is difficult to obtain from satellite images.

The advantages of using remote sensing increase with the planned frequency of the inventory. Where regular information is required, two approaches are possible: compiling a new inventory each time or updating the preceding inventory. If an updated inventory approach is adopted, satellite images become a valuable source of information. Firstly, satellite data are less costly when it comes to covering a large area exhaustively than the aerial photographs sometimes used. Secondly, the information collected in the past facilitates the extraction of useful thematic data from a satellite image. Both area data and resource estimates can be updated (see Figure 5).

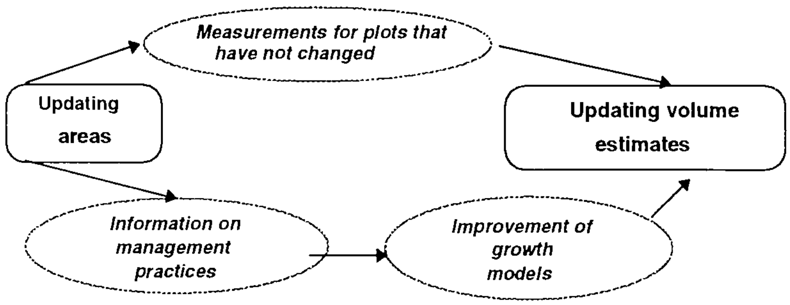

Figure 5: The advantages of remote sensing grow when it is applied to an up-datedd inventory approach. The images are suited to the frequent updating of maps, and facilitate the updating o volumes by limiting the number of visits on the ground and improving the growth models that can be applied to inventory plots that have not changed stratum.

In practice, by detecting radiometric changes, for example in the case of a statistical inventory based on permanent plots, it is possible to identify plots that should be remeasured. Detection of clear felling and certain thinning operations is another way of regularly monitoring the development of resources starting from a given benchmark state. This type of information can also be used to improve simulation models of the development of stands applicable between two inventories, by giving access to more information on the management methods used.

To illustrate the various points covered here, we will look at a few examples of inventory methods incorporating remote sensing.

2- Examples of the use of satellite remote sensing in forest inventory procedures

For each of the examples given in this sections, we will first describe the objectives before attempting to show how remote sensing has contributed to achieving them.

2.1 Forest inventory of Californian forest estates

a) Context and objectives

The traditional method features a stratification of forest stock on the basis of aerial photographs. Groups of plots are then distributed fairly uniformly among the various strata. The objective here was to replace aerial photographs with Landsat TM images for stratification purposes in order to estimate the volume of standing conifers in two forests (total area 8 400 km2).

b) Method

The method is called FOCIS (FOrest Classification and Inventory System). Four original wavebands in the Landsat MSS image and a synthetic texture wavebands are processed with the aid of ecological information on species and a digital model of the terrain. The classification of the image by regional forest types serves as a basis for the stratification.

c) Results

The accuracy of this stratification has been measured as 84%. Measurements on the ground have led to final volume estimates that were only 3.4% off those obtained by the traditional method. These estimates are consistent with the level of accuracy required by the US Forest Service. Moreover, there are considerable time savings with respect to the old procedure: the inventory was produced in one year instead of the usual two to three years. As the method worked well with the first two forests, inventories of other areas have since been produced.

2.2 Forest inventory in Finland

a) Context and objectives

To date, the Finnish Forest Research Institute has practised only extensive ground-based sampling on a systematic basis. The results are therefore reliable only for areas of at least 150 000 ha. The aim of introducing stratification based on satellite image processing is to enhance the accuracy of the inventory data.

b) Method

A Landsat TM image is used to define uniform forest strata. The distinction between forest and non-forest is made with the help of exogenous information. The same goes for peat bog localized in the forest, which are excluded before the classification is made in order to limit confusion. The classification is of the supervised type, the testing areas correspond to plots that are measured on the ground.

c) Results

The volumes estimated by stratum have the lowest variance. And, it is possible to estimate volume with the same degree of accuracy for an area three times smaller (50 000 ha).

2.3 Minnesota inventory of forest resources

a) Context and objectives

There were two stated objectives:

- to produce estimates of forest area by species group to a pre-set level of accuracy (5% at state level with a degree of confidence of 95%, and 10% at county level with a degree of confidence of 90%);
- to set up a continuous forest inventory based on satellite images in order to improve the traditional inventory compiled every 15 years. The latter is based on measurements made via a network of sample plots. These plots are grouped together by stratum and their distribution among the various strata serves as a basis for estimating the respective areas. Between each inventory, forest growth models are applied to the plots. However, this updating is imperfect, as it does not account for any changes in the area of the various strata. To remedy this, Landsat TM images were used. A test was carried out on 3 million hectares, roughly half the forested area of the state.

b) Method

Area estimates:

This is based on the use of full satellite coverage and sample coverage by aerial photograph (consisting of parallel flight lines 50 km apart). Sample plots were defined at regular intervals along the bands of aerial photographs and were used to define some one hundred forest types (land cover x height x density) by photo-interpretation and visits on the ground. For classifying the Landsat image, the forest types were grouped into 11 classes (6 classes of forest and 5 of non-forest). The areas estimated from the classified images were corrected using regression estimators based on a comparison between the situation on the ground and the classification, with the aid of sample plots.

Continuous inventory updated annually:

The Landsat image was classified into 5 major classes of ground cover: water, agricultural land, other non-forest land, deciduous forest and coniferous forest. The land cover of the plots visited on the ground during the last inventory was compared with the new land cover given by the image. The plots that had changed land cover, and had therefore changed stratum, were remeasured, as well as a certain percentage of unchanged plots. Growth models were applied to the unvisited sites. All the data are used to produce the results of the new inventory.

c) Results

The area results were little different from those of traditional US Forest Service statistics: +0.8% for conifers, -6% for deciduous and -3% for forest. The area updating method improves the accuracy of the interim results. On the whole, remote sensing allows for more frequent updating at lower cost.

2.4 Updating of the forest map of British Columbia

a) Context and objectives

A forest map was produced by photo-interpretation of aerial photographs. Some 6 600 1/20 000 scale maps were produced. The results were incorporated into a GIS and satellite images were used to update the maps every two years for the intensively managed forest area and every five years for other areas of the province.

b) Method and results

The detection of certain changes (clear felling, new roads, burnt areas, wind damage) is achieved by on-screen photo-interpretation of geo-referenced and enhanced Landsat TM images. The colour composites used depend on the type of change sought. The results are cross-checked on the ground and distributed among the various levels of GIS information (roads, felled areas, etc.).

These three examples demonstrate that satellite images can be integrated into inventory methods or inventory updating procedures at several levels and with varying degrees of complexity. However, it should be pointed out that the three cases in question concern fairly uncomplicated forests. We will now go on to look in more detail at the case of the French National Forest Inventory and see how this agency plans to use satellite images to fulfil its mission in a complex forest environment.

IV. - Remote sensing in the French National Forest Inventory (NFI)

1- The NFI's remote sensing activities

The NFI has a long-standing interest in remote sensing, which it considered from the very start to be a promising source of information on the forest environment, and has followed the development of this instrument. This interest has been reflected in its participation in data evaluation projects [48, 49, 50] and the assessment of a number of image analysis techniques (such as testing automatic image segmentation software [51]). A number of research projects have been completed or are under way (work on open woodland [18], updating of maps by image comparison [52], analysis of usefulness of future data sources: high resolution, medium infra-red, radar, etc. In addition to its on-going contact with research institutes, the NFI's remote sensing unit engages in projects at the request of users, such as the mapping and monitoring of fallow land in a department in central France to monitor the decline of farming activity. A forest map updating project was carried out for and in cooperation with Russian partners. Lastly, the NFI acts as consultants in many projects, some of which have a remote sensing component (e.g. in Morocco). In addition to these projects, the NFI devotes considerable effort to basic research aimed at addressing new situations that may arise in the course of its mission. In this it employs its expertise in the areas of forest inventory, remote sensing and GIS. In this perspective, a project was launched with the aim of updating maps of stand types for the French national forest inventory with the aid of satellite images.

2- The Hérault project[2]

2.1 Context and objectives

In order to understand why the NFI has devoted its efforts to such a projects, it is necessary to examine certain stages in traditional resource inventory methods and look at the way aerial photographs are used. The

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[2] Project part-financed by the CNES (Centre d'Etudes Spatiales - Space Studies Centre)

photographs, generally IRC photographs with a scale in the region of 1/17 000 or 1/20 000, are used for two separate purposes:

- Via photo-interpretation backed by cross-checking on the ground, they serve to identify the stand types that are the basis for mapping the "study areas" (stand type x type of estate x forest region). This map, which is the basis for stratifying the territory, contributes to defining the number of points in each stratum that will compose the final sample and will be visited on the ground.
- They also constitute the background for the sample. They are used to describe, by photo-interpretation, some 15 000 to 20 000 points in each department (1 per 30-40 ha). Among these points, a certain number will be checked and surveyed: mensuration parameters and ecological data are recorded for 20-are plots. The photographs are used to localize the point accurately on the ground.

The photographs are perfectly suited to the requirements of the traditional method. However, the result of this work is that there are digital maps covering over two-thirds of the French territory accurately localizing the various types of forest stand. So, the problem is now one of updating the map, rather than of making it. Updating on the basis of aerial photographs is an arduous, time-consuming and costly task. However, there is a large body of information in digital form, which, combined with satellite images - providing exhaustive coverage of the department at lower cost - can be used to achieve the desired result. The aim of the pilot project is to ascertain the feasibility of updating the NFI map via satellite remote sensing. It should be borne in mind that if the map can be updated to a satisfactory level of accuracy for the purposes of the NFI, other problems will have to be solved, such as the question of the image as background for the sample. The introduction of satellite images into the French NFI approach would entail a number of adjustments, particularly as regards the localization of the sample.

As regards the updating aspect, we opted for a pre-operational approach. This entails:

- working at forest region or department level;
- combining image processing techniques with the flexibility of visual interpretation;
- bearing in mind the need to be able to reproduce the approach, which led us to choose a study area with a wide variety of stands and topographical conditions.

The aim of the study is also to determine the quality of the results obtained using a single image coverage of the department (minimum data). We then plan to assess the marginal contribution of other types of data (smaller geometric resolution, stereoscopic images, series of images taken at regular time intervals). The cost of additional information can thus be evaluated with respect to updating using minimum data. The result of the updating must satisfy the accuracy standards set for the inventory.

2.2 Study area and data

The southern French department of Hérault on the Mediterranean coast was chosen, as meeting the desired requirements of variety (see Figure 6).

Heavily forested in the west, it presents a wide variety of forest types with both Mediterranean and mountain-type stands. Moreover, the most recent aerial photographs were taken in 1992 (Third inventory of the department) and will enable us to compare the results obtained by traditional methods (production of a new map) with those obtained by updating the old map using satellite images.

Figure 6 *: Situation of the department of Hérault (in black) in the South of France on the Mediterranean coast*

The following data are available:

- 1981 map of stand types;
- the aerial photographs that were used to make this map (IRC scale 1/17 000 from 1981);
- a series of SPOT images:
  - 2 multi-spectral images (XS) from 13/09/1992 (west) and from 18/08/1992 (east) covering the whole study area;
  - for the western area: a panchromatic image from 06/09/1992 and a series of multi-spectral images dating from 03/09/1990, 05/09/88 and 22/06/86;
- a digital model of the terrain useful for geometric rectifications, image processing and analysis of the results;
- for the final assessment of the results, the map obtained at the same time by traditional methods will serve as a benchmark.

2.3 Method

The updating of the map involves identifying all the changes and retaining only those that give rise to a change of type according to the NFI classification. The first stage therefore consists in establishing some sort of classification of changes taking account of the type of change and its source. There are a number of possible methods for mapping the changes. The ones that appear most promising when used in conjunction are:

- analysis of the radiometric characteristics of the uniform plots defined on the old map according to forestry criteria;
- radiometric comparison pixel by pixel.

The identification of changes is therefore based on comparing information from the 1981 digital map in vector form and the enhanced images or the radiometric changes between the years. Interpretation of the information contained in the images is visual. This approach requires that the following conditions be met:

- high-quality image-to-map registration, hence the need for accurate geometric rectification of the images;
- finding the optimum colour composite for identifying changes and calculating differences between wavebands;
- a suitable tool for cross-mapping matrix and vector data and the interactive adjustment of the latter;
- -checks on the ground.

a) Geometric rectification

This is carried out on a work station[3] using software that can produce orthoimages where a DTM is available. The error in rectification between map and image is less than a pixel.

b) Choice of colour composites

The colour composites must be simple and capable of being reproduced in another study area, while highlighting as clearly as possible the information on the presence of changes.

c) Recording the information obtained from the images

The tool selected for recording the changes identified is a GIS (Geographical Information System) called ALLIANCE developed by ICARE INTERNATIONAL, which has a computer-aided photo-interpretation module (CAPI). The polygons composing the map are adjusted on screen and a number of characteristics relating to the changes are recorded: probable source, colour composite in which the change was detected. For each sector interpreted (marked out on the basis of IGN 1/25 000 scale maps), it is important to scan the images in a pre-set order so that the importance of the various sources of information can be analysed. The order is as follows: (see Figure 7)

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3 IMAGINE (new version of ERDAS, a work station marketed by ESRI) installed in the CEMAGREF/ENGREF Joint Remote Sensing Laboratory)

1.- The colour composites produced from the XS 1992 image for analysing the information to be obtained from the minimum data.

2.- The panchromatic image to assess the contribution of a closer geometric resolution. This image is analysed second because the results, combined with those from the XS 1992 image, give an idea of the type of information that can be obtained from data recorded by the future SPOT sensors (multi-spectral images with a resolution of 10m).

3.- The contribution of time series.

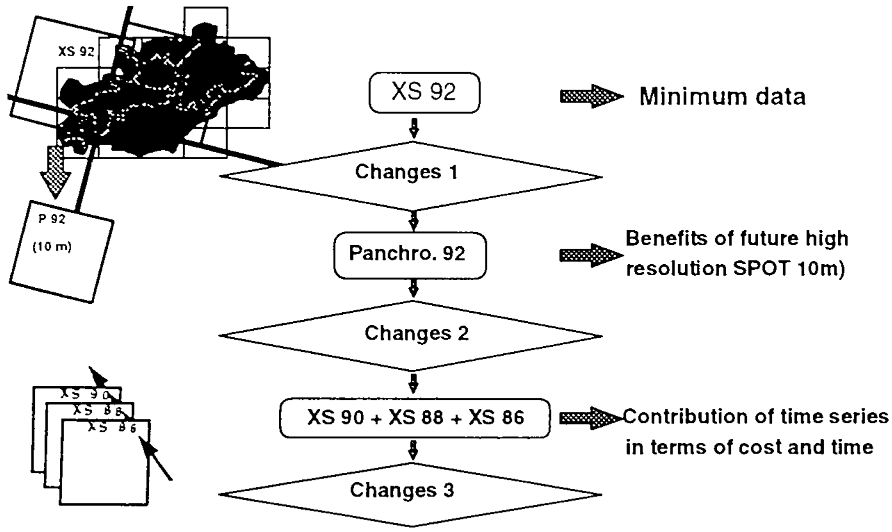

***Figure 7** : Order of interpretation of the images in order to find the minimum information necessary to attain the result most closely in line with NFI specifications*

There are two approaches to the latter: the analysis of a colour composite comprising wavebands from different dates, or the calculation of waveband differences following standardization of the images. The second approach, though the most time-consuming in terms of data-processing, should yield information that can be easily interpreted. The aim is to eliminate the influence of factors that cause radiometric variation between dates (relief, differences in atmospheric conditions, differences in global behaviour between stands, etc.): a radiometric change must reflect only a change in the state of the stand. We thus obtain simple images in which the information highlighted is an increase or decrease in the radiometry on each waveband considered in pairs. This method is capable of revealing small changes in stands because the lack of spatial uniformity in the radiometric characteristics of pixels, which often hinders the identification of a change, does not come into play. This method concentrates on analysing the change in the radiometric signature over time.

d) Checks on the ground

Ground checks should not be overlooked and are an integral part of the method. Even the interpretation of transitional aerial photographs entails large-scale ground checks in order to identify the type of a large number of units defined using aerial views. Similarly, it is intended to identify a significant proportion of the changes localized using satellite images by field visits.

e) Assessment

The map updated by remote sensing will be compared with the one produced by traditional photo-interpretation of the 1992 aerial views. The comparison with be first visual then digital.

2.4 Results

The results are not yet complete (about 30 000 ha photo-interpreted) and have so far only been subjected to a quality analysis. It is worth noting the importance of the 1981 aerial photographs for understanding the radiometric discontinuities observed in a polygon and deducing probable changes or natural evolution in part of the polygon. The single 1992 XS image provides a considerable quantity of data. The panchromatic and multi-temporal colour

The single 1992 XS image provides a considerable quantity of data. The panchromatic and multi-temporal colour composites yield little additional information. However, the waveband differences between years have not yet been calculated and analysed. The final objective of the results is to achieve an understanding of the contribution of the various images in detecting a change according to the various scenarios that may be defined by type of stand subject to the change and topographical situation. Another aim is to quantify the contribution of the various layers of information in relation to the accuracy criteria set by the NFI. If it is observed that the accuracy of the update is compatible with NFI objectives, this will raise the question of the use of the images as back-up for the sample.

V. - CONCLUSION

The attraction of using satellite remote sensing to obtain forest information depends on a large number of factors. The complexity of the radiometric signal accounts for the limitations of this tool when analysing images alone. The information obtained is sometimes of a low level of detail, particularly when a complex environment is studied. The use of exogenous data generally makes it possible to obtain more detailed information from the images, and to a certain extent resolves confusion between themes. However, in all cases, satellite remote sensing can provide a means of answering certain questions currently raised in the area of forest inventories. It has proved suitable for mapping disturbances affecting forest areas and this play an important role in certain specific inventories (inventory of burnt areas, clear cutting, storm damage, etc.). Satellite images can also be used to improve resource inventories. They cannot be used for the direct estimation of forest resources, but have a role to play in stratification. Stratification improves the precision of resource estimates for a given number of sample plots. Lastly, remote sensing seems particularly suitable in update approaches: namely, updating of forest areas, which can be incorporated into resource inventory updating procedures. Some countries already use remote sensing to enhance their inventory procedures. However, these are generally ones that have relatively uncomplicated forest areas.

The French National Forest Inventory (NFI), which deals with a forest marked by diversity of its geographical environments and species, has acquired over many years a certain expertise in the use of remote sensing. This body is today examining the ways in which it can integrate satellite images into its inventory methods in order to meet new requirements. This involves, in particular the updating of its digital map of stand types. A project covering a department in southern France has recently been launched to assess the contribution of remote sensing. Even if the results do not prove conclusive for all types of stand, the NFI feels that it is important to devote attention to this type of approach at this stage. New data soon to become available will undoubtedly yield information that will enable us to take the process a stage further, in particular the future high-resolution SPOT data (10m multispectral and 5 m panchromatic images) which will make it possible to produce or update maps in more detail, and radar data which promise to provide localized resource information.

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SESSION 4

THE POSSIBLE IMPACT OF NEW TECHNOLOGIES IN AFRICAN COUNTRIES

THE ORGANISATION OF AFRICAN STATISTICAL SYSTEMS

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Background

This is intended to identify international support for statistical development in the African countries by the United Nations System. In the period from 1983 to 1989, aid expenditure totalled USD 45 764 million (excluding Algeria, Djibouti, Egypt, Libya, Morocco, Sudan and Tunisia). The expenditure was distributed as follows:

- 56.5% - censuses, population surveys and social statistics;
- 21.6% - assistance for economic statistics;
- 11.1% - multi-sectoral statistics covering projects of institutional support for statistical services.

I. Where african statistics stood in 1990

1. Organisation of the national statistical systems

Most national statistical systems (NSSs) are centralised. Central Statistical Services are responsible for producing data of all kinds. Central Banks produce data, and technical ministries have small units. Central statistical services form part of the civil service and are supervised or managed by the ministry responsible for planning (exceptions: Ghana, where the central statistical service is not part of the civil service; Nigeria, where it has the same standing as a Secretariat-General within a ministry). The status of the central statistical service within the civil service varies from one country to another. The legal bases for the central statistical services vary. In the English-speaking countries, laws lay down their duties, penalties for not cooperating with their officials, for the destruction of documents, for providing false information, etc., and no separate laws are required for conducting a census of the population. In the French-speaking countries, even when a general legal basis does exist, decrees and additional regulations are required. The Portuguese-speaking countries have specific laws and decrees concerning statistics (Angola has specific decrees concerning the census of the population).

Most central statistical services are organised in three large organic divisions:

- economic statistics;
- demographic and social statistics;
- data processing.

Mali and Zambia both have an Agricultural Statistics Division.

2. Statistical infrastructure

Fewer than half of the central statistical services had all the basic infrastructure (decent furnished accommodation with equipment such as word processing facilities; transport; means of printing publications and photocopiers; means of communication and a statistical library or bibliographical reference unit and adequate staff).

3. Mechanisms for coordination between producers and between producers and users

There is a total lack of formal mechanisms for coordination between producers in many countries. There is often no scope for coordination within a single service, and no harmonised concepts, definitions and classifications within single bodies; data on the same field reveal discrepancies between different data producers. General

Committees of Producers and Users have seen scant success. Specific committees, such as early warning system (EWS) and Population Committees have enjoyed greater success. The level of coordination between producers and users is poor.

4. Statistical themes covered

The national statistical services usually produce the following:

Economic statistics. Agricultural statistics (in some countries the Ministry of Agriculture is responsible for collecting data); industrial statistics; price statistics; foreign trade statistics; construction statistics; distribution statistics; employment and earnings statistics and national accounts statistics.

Demographic and Social Statistics. Population (fertility, mortality, migration, population traits) statistics, housing and nutrition statistics. Health and Education Ministries produce the corresponding statistics.

Surveys are conducted of output, consumption and expenditure. The informal sector has begun to attract particular attention (Zambia, data from the labour force survey, Mali, Tanzania and Angola).

5. Data production

Central statistical services have not been able to keep up with the constant rapid developments in software and hardware design. They have experienced problems with hardware and software provided by some donors (compatibility, inappropriate software, maintenance etc.). Many professional statisticians have received adequate computer training. Available packages enable reliance on computer specialists for analysis and calculations to be reduced. The FAO strategy for processing the World Agriculture Census enables statisticians to take on responsibility for a large part of the process. Data dissemination follows the traditional pattern of distributing published material, with delays in the publication of results. Central statistical services have not yet adopted data dissemination policies. The presentation of results does little to attract users. Few central statistical services have adopted the use of short summary reports for presenting the results of their surveys.

6. Timeliness and quality of data

Desktop publishing techniques were not widespread in 1990, and delays between the processing and publishing of results are considerable (e.g. the 1975-1984 population census results have not been published). Data dissemination is rarely timely

Data quality showed some minimal improvements in 1990. Age and outputs continue to pose problems, as does the use of expenditure as estimators (proxies) for disposable income. The introduction of household diaries etc. has not yielded sufficient results.

7. The use of statistical data

There is consensus on the greater use and critical analysis of statistical data in the 1990s. However, most users are university researchers and bilateral and multilateral agencies. Policy makers and planners have made little use of the data. Multilateral agencies (UNDP/WB) are encouraging the revitalisation of the process of planing and macro-economic management in some countries. In this context, the conduct of long-term forward studies implies the availability of statistical data and perhaps greater care in the production of data.

8. Low political and status or priority of statistics

Management and planning methods make little use of numerical data. Little responsibility is assumed for economic policies and management in a non-democratic institutional framework. Low and, in some cases declining, budgets are being compounded by a climate of budget cutbacks in the context of structural adjustment policies. A non-democratic atmosphere does not encourage the development of statistical information. Furthermore, methods of reaching decisions and accompanying policies do not favour the implementation of data-response mechanisms (feedback), which means that information systems are given low priority.

II. The main challenges in the 1990s

These challenges are as follows :

- Statistical information to support democratic development.
- The financial sustainability of the central statistical services (a greater commitment by the African States to central statistical services' budgets).
- Competition between internal (national) and external data sourcing; the choice of a minimum set of topics and thematic areas for central statistical services. A balance has to be struck between resources and information requirements.
- Management of central statistical services (introducing modern management methods).. Central statistical services should apply business management methods, and be led by prospects and objectives. Project leaders and the heads of organisational divisions should be given management training.
- Preparing work programmes so that activities are tailored to budgets and financial resources.
- Staff motivation, with training to reduce the turnover of skilled staff. Questions concerning the turnover of qualified staff should be set in the broader context of the reform of the civil service, and the scope for reducing turnover explored.
- Development of analytical capacity. Central statistical services should increasingly assume data analysis functions. This may serve to educate and attract users, in that pre-interpreted information may be obtained which is to some extent immediately useful.
- Developing information marketing policies. The publication of statistical information should be approached from a marketing point of view. An integrated approach should be adopted at the levels of product design; of obtaining funding for the product, of user acceptance and the degree to which the product is useful to the user, and forms of disseminating and presenting information.
- Improved statistical coordination.
- Improved producer/user communication.
- Improved output quality (graphics, reliability, timeliness, concision, incorporating analysis). Priority should be given to introducing graphic design techniques, along with central statistical services' capacities for reproducing documents.
- Increased female involvement in statistical development.

III. The impact of new technologies on the organisation of statistical services : GIS (Geographical Information Systems) Technology

1. The objectives of a system for monitoring the living conditions of the population (Nutrition, gender, food security and poverty).

1.1 Greater accessibility and databases

Data bases should have the following elements :

- Provision for quick consultation of existing information on poverty, the lack of food security, difficult living conditions for women and other indicators broken down by the smallest geographical units.
- Geographical location of population groups at risk, the number of persons at risk and the sex-ratio of heads of households.
- Economic activity: occupation; women's workloads.
- Production: Standard diets (kg per month of main foodstuffs), time series for production fluctuations in recent years if possible; the gap between production and consumption in an average year and in drought conditions; survival diets and requirements in times of emergency; main crops;
- Migration: anticipated migratory movements and alternative sources (male and female).
- Institutional projects: development projects under way; existing and potential food aid projects; programmes to combat poverty; projects financed by the UN, NGOs and bilateral agencies;

- Gender: women's involvement in development projects
- Climatic and environmental data.

1.2 Instrument for forecasting the impact of disasters, intervention and policies

GIS data base is potentially an instrument for managing disaster scenarios and shaping emergency intervention : how to react to ecological disasters? what to do in cases of reduced food output in a given region? Which impact on adjacent regions in terms of migratory movement and pressure on local resources ? Can information contained in the GIS database and underlying models developed therefrom enable food safety policies to be revised?

1.3 An instrument for monitoring projects and leading to cost/benefit analysis

GIS data bases may assist managers in monitoring the impact of local and regional projects. These are a useful monitoring tool, enabling time series to be built up and development trends or those changes over time and in one region which are specifically linked to projects and policies to be compared.

2. Increased analytical capacity

The use of GIS technology to monitor a number of pertinent indicators of food safety, questions of gender and parameters linked to poverty increases information managers intervention and forecasting capacity. In Africa, specifically, the need to anticipate scenarios where food, equipment and social and economic services are in short supply is of great importance in planning projects. Using this type of technology it will be possible to strike a better balance and improve the effectiveness of the whole range of information collected by the various information services.

3. Reducing operating costs

By enabling a more integrated approach to be adopted and incorporating the space variable on its full scale, GIS technology will allow data collection policy to be reoriented. The trend in the future may be towards a more selective data collection policy, requiring soley what information is necessary and making better use of what is available. The fundamental idea will be to aim for greater integration. Substantial advances will be made in processing and analysis, and it will be possible to begin a process of greater decentralisation of information systems, moving away from the institutional and power centres towards the periphery (regions and provinces).

THE USE OF NEW TECHNOLOGIES IN AFRICA AND THE ROLE OF COOPERATION

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An approach on four levels

1) the operational level:

New technologies, and remote sensing in particular, are gradually being integrated into the process of compiling information for statistical information systems. This integration is the result of advances and retreats, of often critical analysis of advantages and disadvantages but, first and foremost, it attests to the recognition of the clear benefits for traditional production systems when these technologies are properly applied and duly geared to users' needs.

In every African country, and in the Portuguese-speaking countries in particular, these new techniques may be seen not as new working tools but often as the only means available. Their usefulness therefore has to be assessed in the context of statistical systems which do not combine the basic conditions necessary for producing reliable, timely information. Let us look at a few examples of when new technologies offer clear working benefits:

- when no basic, up-to-date, traditional records are available;
- when administrative information is scarce and hard to press into service;
- when no regular statistical operations are carried out;
- when no up-to-date cartographic base exists;
- when middle managers are in scant supply;
- when no forward data is available on aspects with a direct impact on food balances and the environment.

Remote sensing not only covers most of these situations, it provides definitive geocoded references and lays the ground for the implementation of Geographical Information Systems (GIS).

2) the strategic level:

The Portuguese-speaking countries of Africa are witnessing profound changes in the structures of education, medical assistance, politics and virtually all social structures. Statistical information systems have links and considerable responsibilities vis-à-vis the rest of society, and statisticians are sorely tried each and every day by the lack of reliable up-to-date statistics. One of the clearest and specific signs of the changes under way in the Portuguese-speaking countries of Africa is their integration into the process of competition. The globalisation of markets has led to the geographical specialisation of production as a whole (and of the information market, for various reasons) so that, while head offices remain at the "centre" of the system and the higher ranks of marketing have stayed close to the centre, production has drifted out to the periphery. In this context, statistical information systems which fail to modernise by implementing and managing technological change will be relegated to the very edge of the periphery, at the mercy of subcontracted systems for carrying out field work and data collection.

New technologies should therefore be seen as the key to survival for statistical information systems by virtue of the interactions they trigger off:

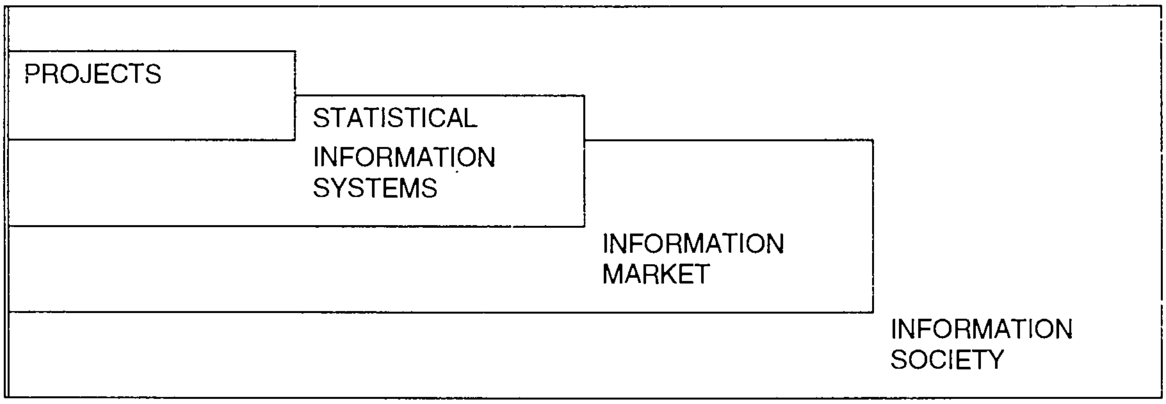
- in coordinating the process of producing information;
- in harnessing the catalytic effects of change;
- in assigning a leading role to statistical information systems.

3) the conceptual level:

Statistical information systems are systems in the traditional sense of a set of interacting elements marshalled to achieving specific objectives. In this light, each component project of the system comprises of a set of elements which enable an appropriate response to be brought to each specific requirement identified by users. This is, therefore, a set of information organised to provide timely, reliable, workable responses to society as a whole and to users (customers) in particular. Information which satisfies these conditions is a product, and the whole should be seen as an asset, and a public asset at that, with its own costs and value; and it can also be marketed. Accepting this fact, statistical information systems should take the extent to which their costs are covered by the revenue from the sale of their products as one of the most important indicators for evaluating their potential.

New technologies, seen as a collection of knowledge applicable to the production of information but above all in the light of extraordinary degree to which they slash the lead time between a given product being ordered and being delivered, emphasise the tangible and intangible aspects associated with a certain industrial thinking which has to permeate the whole process of producing information.

New Technologies



4) scope for cooperation

As signatories to the Lome Conventions, the EU Member States and the ACP countries agree that the former need technology to maintain their international competitive position, while the latter need technology to achieve adequate levels of competitiveness. What separates the two sides is an immense gap in their ability to produce and harness technological innovation as a motor for growth and restructuring. In this context, cooperation may provide the ideal area for striking a fair balance in the dichotomy between the current production capacity of the statistical information systems of the Portuguese-speaking countries of Africa and the extent to which they are virtually obliged to obtain new means of production abroad. A warning has nevertheless to be sounded against seeing cooperation as a panacea or the search for partners as some kind of life insurance for the partners. For cooperation to be the most effective means of transferring know-how and technology and thus breaking down the barriers on the periphery it has to be seen as a watershed in the competition process which involves risks for both parties, and the parties have to formalise their willingness to establish and maintain certain links in specific clauses in any such agreements.

Cooperation which can generate synergies and complementarities and underpin the will jointly to pursue a specific objective has to be based on cooperation agreements which clearly define the objectives, the duration, the links between the parties, the internal organisation of these agreements and their potential as well as the material form this cooperation is to take.

We may consider that the European Community has a well-defined, consistent research and development policy following the summits of heads of state and government in Paris and Copenhagen on 20 October and 15 December 1972. These summits explicitly stated not only a common will to promote the development of a policy in the field of science and technology but the recognition that this policy implies substantial coordination, specifically at the level of the activities pursued in international organisations.

The creation of the Joint Research Centre (JRC) as a vehicle for action now affords the EU permanent access to vast scientific and technological potential in terms of both human and equipment resources. Increasing cooperation between Eurostat and the JRC, with particular emphasis on the Institute for Remote Sensing Applications, has allowed these new technologies gradually to be tailored to the specific requirements of statistical information systems.

The experience acquired in the meantime of different statistical products and in various parts of the world such as South-East Asia, Central and West Africa and Central and South America has built up considerable maturity and potential for cooperation by the EU. As a member of the European CESD network, the CESD Lisbon has the specific aptitude and sufficient flexibility to undertake effective dialogue between the EU and the Portuguese-speaking countries of Africa in the specific area of training and support for statistical information systems. We are available and interested in such a process.

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0 Sekalaista (vaaleanpunainen)
1 Yleiset tilastot (yönsininen)
2 Talous ja rahoitus (violetti)
3 Väestö- ja sosiaalitilastot (keltainen)
4 Energia ja teollisuus (sininen)
5 Maa- ja metsätalous, kalastus (vihreä)
6 Ulkomaankauppa (punainen)
7 Kauppa, palvelut ja liikenne (oranssi)
8 Ympäristö (turkoosi)
9 Tutkimus ja kehitys (ruskea)

SARJA

A Vuosikirjat ja vuositilastot
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DA Klassifikation af Eurostats publikationer

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2 Økonomi og finanser (violet)
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7 Handel, tjenesteydelser og transport (orange)
8 Miljø (turkis)
9 Forskning og udvikling (brun)

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EN Classification of Eurostat publications

THEME

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3 Population and social conditions (yellow)
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5 Agriculture, forestry and fisheries (green)
6 External trade (red)
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8 Environment (turquoise)
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NL Classificatie van de publikaties van Eurostat

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8 Milieu (turkoois)
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SV Klassifikation av Eurostats publikationer

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DE Gliederung der Veröffentlichungen von Eurostat

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FR Classification des publications d'Eurostat

THÈME

0 Divers (rose)
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3 Population et conditions sociales (jaune)
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7 Commerce, services et transports (orange)
8 Environnement (turquoise)
9 Recherche et développement (brun)

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PT Classificação das publicações do Eurostat

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5 Agricultura, silvicultura e pesca (verde)
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7 Comércio, serviços e transportes (laranja)
8 Ambiente (turquesa)
9 Investigação e desenvolvimento (castanho)

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