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MEDIUM TERM FORECASTING OF ORCHARD FRUIT PRODUCTION IN THE EEC:
METHODS AND ANALYSES

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PREFACE

This study represents a summary of research carried out by the authors for EUROSTAT since 1974. The ultimate objective of this research was to produce a practical model by which routine forecasts of fruit production could be made with the maximum of objectivity and the minimum of computational difficulty. This involved the development of a computer program to handle the vast amount of data necessary to produce forecasts at Community level.

In Chapter 1 we present the background to the supply of orchard fruit in EUR-6 which we hope justifies the need for a study such as this.

In Chapter 2 we have attempted to outline the nature of the data available in terms of quality and quantity. It is these factors which govern the reliability of subsequent forecasts.

One of the tasks we were set in this research project was to fit curves to yield/age data using mathematical and statistical methods. A discussion of these methods is given in Chapter 3, which is a rather lengthy digression into the theory of curve fitting and perhaps should have been subtitled "Abandon hope all ye who enter here"! The inclusion of this chapter is justified, we feel, on the grounds that many of the techniques we describe are readily available in computer packages, and it is relatively easy for the non-statistician to use these methods and be unaware of the complexities and dangers involved. People are often impressed by the use of sophisticated techniques but we leave the reader to judge whether he considers there is much to be gained by their use.

In Chapter 4 we describe the forecasting model we have employed and, whilst we are fully aware of its shortcomings, we hope its simplicity will encourage its use. The model has been programmed in such a way that it can be easily modified and we should be pleased to hear of any improvements or difficulties that users encounter. Some modifications are indicated in this study but space has limited us to the more obvious changes.

The sensitivity of our forecasts have been investigated in Chapter 5 where various model assumptions have been tested. These represent but a few of many possible sensitivity analyses but our purpose is to illustrate principle rather than specific detail.

The results of over one thousand forecasts are summarized in Chapter 6. Detailed results for individual production zones, varieties and planting densities are held by EUROSTAT in Luxembourg.

It is impossible for us to record our thanks to all our many colleagues who have given freely of their time and advice over the last few years, but we would like to make special mention of the following:

Mr. T. Brian Wilson (EUROSTAT) for generating so much enthusiasm and for such assiduous guidance through the maze of data; Miss Lynda Mulley (EUROSTAT) for her patience and understanding during our periods of frustration and for keeping us up to date with data and information; Mr. Derek Peare (EUROSTAT) and Dr. Richard Kay (University of Sheffield) for helpful discussions relating to Chapter 3; Mr. Keith Teare, Dr. Martin Armitage and the staff of the Computing Laboratory, University of Salford; Miss Ann Orchard and Mr. Don Wise (University of Lancaster) for producing the finished line drawings and Mrs. Mary C. Heald for help with construction of some of the tables and other tasks too numerous to mention.

J.M.H. and P.J.V.

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CHAPTER 1
INTRODUCTION

1.1 Preamble

This study is a summary of the statistical research carried out by the authors for EUROSTAT(1) into the forecasting methods, problems and sensitivity of orchard fruit production in the EEC(2). Commercial top-fruit growing in the Community is subject to large climatic variations in production and relatively high price elasticity of demand. In seasons of surplus when prices would otherwise fall below the level to ensure satisfactory incomes to the efficient grower, including return on investment, large quantities, in absolute and relative terms, have been withdrawn from the market at considerable expense. However, seasonal market intervention will not be the most cost-effective method if the surplus arises from structural causes. It is, therefore, to the general problems of structural over-production for the Community as a whole that the authors have focussed their attention. In particular the analyses of production potential involved the following:

(i) – the mathematical determination of orchard yield curves from sample survey data

(ii) – to forecast in the medium term, the production potential of the major commercial varieties of dessert apples, pears, peaches and oranges

(iii) – to perform sensitivity analyses of the forecasts to types of yield curve and forecast assumptions.

1.2 The Supply Problem – some background information

The structural surpluses of some dessert species of fruit in commercial production in the Community has, on occasions in the recent past, reached considerable proportions. One such surplus was the so-called 'apple mountain' that was produced as a result of the excellent growing conditions during the 1975–76 season. In that year some 800 000 t of apples (10.6% of commercial production) were withdrawn from the market in order to maintain price levels. Excessive surplus production also frequently occurs in pears and to a lesser extent in oranges and peaches. During the 1970–71 season 642 215 t of pears were withdrawn and later, in 1974–75 some 187 954 t of oranges(3). In the light of such surplus production, forecasts of production potential are an important guide to the likelihood of such problems in the medium term. Details of the forecasting methodology and results are

(1) EUROSTAT – The Statistical Office of the European Communites.
(2) Our studies started prior to the availability of data for the enlarged Community and by Community we mean EUR–6, that is Belgium, France, FR Germany, Italy, Luxembourg and the Netherlands.
(3) The Agricultural Situation in the Community: Reports for 1971 to 1976, EEC, Brussels.

presented in later chapters. For the rest of this introductory chapter we shall describe briefly the main structural characteristics of commercial fruit production in the Community so as to put our results in perspective.

1.2.1 Fruit Area and Production in EUR–6

Tables 1.1–1.5 show the main features of area distribution and production of the four species of fruit discussed in this study.

1.2.1a Apples

France (26%) and Italy (33%) share the bulk of the Community apple-growing area and this is reflected in the production figures presented in Table 1.5. The largest single variety produced is Golden Delicious (42%) which forms 61% of the French commercial orchards. This variety is also very important in Italy where it forms some 37% of all apple orchards. Of the other important varieties listed in Table 1.1 it is evident that Red Delicious, Cox's Orange Pippin, Boskoop and Morgenduft, together with Golden Delicious comprise 70% of the EUR–6 production area.

TABLE 1.1

EUR–6: APPLES. AREA OF IMPORTANT VARIETIES

Variety	EUR–6 ha	%	Cum%	Germany	France	Italy	Netherlands	Belgium	Luxembourg
Golden Delicious	79 266	42.3	42.3	6 404	34 695	26 991	7 025	4 049	102
Red Delicious	21 795	11.6	53.9	4	6 164	15 490	137	:	:
Cox' Orange Pippin	11 773	6.3	60.2	6 162	129	:	4 279	1 191	12
Boskoop	10 156	5.4	65.6	3 238	402	:	4 850	1 623	43
Morgenduft	9 633	5.1	70.7	:	:	9 633	:	:	:
Reinette du Canada	7 306	3.9	74.6	:	3 188	4 118	:	:	:
Jonathan	5 872	3.1	77.7	846	123	3 731	808	361	3
Reine des Reinettes	3 923	2.1	79.8	1 689	2 198	:	:	:	36
James Grieve	3 511	1.9	81.7	1 486	37	:	1 784	181	23
Annurca	2 892	1.5	83.2	:	:	2 892	:	:	:
Granny Smith	2 883	1.5	84.7	:	2 883	:	:	:	:
Ingrid-Marie	2 080	1.1	85.8	1 956	:	:	124	:	:
Abbondanza	1 549	0.8	86.6	:	:	1 549	:	:	:
Gravenstein	1 498	0.8	87.4	318	4	1 176	:	:	:
Others	23 092	12.3	99.7	5 991	6 536	6 482	2 916	996	171
Total Apples	187 229	100.0	100.0	28 094	56 359	72 062	21 923	8 401	390

Source: Community Survey of Orchard Fruit Trees. EUROSTAT 1976

TABLE 1.2

EUR–6: PEARS. AREA OF IMPORTANT VARIETIES

Variety	EUR–6 ha	%	Cum%	Germany	France	Italy	Netherlands	Belgium	Luxembourg
Passe Crassane	16 618	18.7	18.7	:	4 071	12 547	:	:	:
Williams'	13 545	15.2	33.9	496	4 211	8 835	:	:	3
Jules Guyot	8 312	9.4	43.4	21	6 031	2 260	:	:	:
Abbe Fetel	8 189	9.2	52.5	:	:	8 189	:	:	:
Kaiser Alexander	5 581	6.3	58.8	:	40	5 541	:	:	:
Doyenne du Comice	5 506	6.2	65.0	:	1 595	1 735	1 342	834	:
Conference	4 892	5.5	70.5	201	780	1 013	1 812	1 081	5
Cosce	4 404	5.0	75.5	:	:	4 404	:	:	:
Beurre Hardy	2 565	2.9	78.4	95	1 533	:	760	175	2
Others	19 252	21.6	100.0	1 941	4 218	9 057	2 573	1 463	:
Total Pears	88 864	100.0	100.0	2 754	22 479	53 581	6 487	3 553	10

Source: Community Survey of Orchard Fruit Trees. EUROSTAT 1976

TABLE 1.3

EUR–6: PEACHES. AREA OF IMPORTANT VARIETIES

Variety	EUR–6			France	Italy	Germany Belgium
Yellow Flesh	ha	%	Cum.%			
Dixired Group	21 145	16.8	16.8	7 936	13 209	
Redhaven	17 111	13.6	30.4	5 845	11 266	
James Hale Group	9 610	7.6	38.0	2 955	6 655	
Vesuvio	6 782	5.4	43.4	:	6 782	
Fairhaven Group	6 362	5.1	48.5	3 692	2 670	
Merril Franciscan	2 979	2.4	50.9	2 979	:	
Blazing Gold	2 723	2.2	53.1	231	2 492	
Others	17 311	13.8	66.9	6 586	10 725	
Total Yellow Flesh	84 023	66.9	66.9	30 224	53 799	
White Flesh						
Springtime Group	7 122	5.7	5.7	3 577	3 545	
Morettini	4 057	3.2	8.9	:	4 057	
Michelini	3 665	2.9	11.8	1 014	2 651	
Amsden	3 032	2.4	14.2	2 783	249	
Others	9 240	7.4	21.6	4 436	4 801	
Total White Flesh	27 116	21.6	21.6	11 810	15 306	
Total Peaches*	125 664	100.0	100.0	42 034	83 136	494

**includes 14526 ha where skin type not determined 11.6%*
Source: Community Survey of Orchard Fruit Trees. EUROSTAT 1976

1.2.1b Pears

Within EUR–6 Italy has the greatest area of pear orchards (60% of the total) this being concentrated mostly in the traditional growing area of the Val Padana. Unlike apples, no one variety dominates the scene in the way that Golden Delicious does. Passe Crassane and Williams' are the two most important pear varieties and their production is very much concentrated in Italy and France.

1.2.1c Peaches

Owing to their favourable climate, France and Italy account for almost all the commercial peach orchards in the Community (see Table 1.3). About two-thirds of the area is found in Italy, particularly Val Padana.

1.2.1d Oranges

Apart from a minute amount grown in Corsica, the production of oranges occurs exclusively in Italy (96 688 ha). Production, which is mainly of the blood varieties, is concentrated in Sicily and Calabria.

TABLE 1.4

EUR–6: ORANGES. AREA OF IMPORTANT VARIETIES

Variety	Italy		
Blood Oranges	ha	%	Cum. %
Tarocco	34 645	35.8	35.8
Sanguinello	19 076	19.7	55.5
Moro	16 146	16.7	72.2
Others	2 648	2.8	75.0
Total Blood Oranges	72 515	75.0	75.0
Pale Flesh			
Ovale	4 514	4.7	4.7
Navels Group	2 989	3.1	7.8
Belladonna	1 544	1.6	9.4
Others	15 126	15.6	25.0
Total Pale Flesh	24 173	25.0	25.0
Total Oranges	96 688	100.0	100.0

Source: Community Survey of Orchard Fruit Trees, EUROSTAT 1976

TABLE 1.5

FRUIT PRODUCTION IN EUR–6 ('000 tonnes)

Species/Country	1972	1973	1974	1975	1976P
APPLES					
** Germany	1 224	1 980	1 266	*2 035	1 478
France	1 506	1 761	1 416	1 847	1 558
Italy	1 884	*2 002	1 844	2 078	2 091
Netherlands	400	450	385	430	380
Belgium	265	237	201	258	220
Luxembourg	6	5	5	6	4
EUR–6	5 285	6 435	5 117	6 654	5 731
PEARS					
Germany	336	403	322	* 386	388
France	386	423	375	357	421
Italy	1 538	*1 529	1 467	1 410	1 491
Netherlands	95	55	140	61	130
Belgium	51	30	88	44	71
Luxembourg	0.2	0.2	0.2	0.3	0.1
EUR–6	2 406	2 440	2 392	2 258	2 501
PEACHES					
Germany	20	34	34	12	17
France	515	542	406	99	503
Italy	1 273	*1 126	1 166	1 099	1 396
Netherlands	0.2	0.2	0.1	0.1	0.1
Belgium	0.8	0.7	2	0.2	1
EUR–6	1 809	1 703	1 608	1 210	1 917
ORANGES					
France	1.6	1.6	1.6	2.3	2.6
Italy	1 183	1 508	1 658	1 530	1 793
EUR–6	1 185	1 510	1 660	1 532	1 796

Source: Production of Vegetables and Fruit 1965-76, EUROSTAT, 1977

* *Break in comparibility*
** *Production figures for Germany include 'gardens'.*
p *Provisional — the 1976 figures for France are for harvested rather than marketed production*

1.3 How the Community deals with Surplus Production

In order to reduce production in those areas where there is a surplus, the Community has recourse to two primary control methods. In the short term, annual surpluses in production may be alleviated by the usage of an intervention system. In the longer term, it can encourage the reduction in the area planted under a specific variety of fruit by encouraging the clearance of orchards by financial inducements.

1.3.1 Market Intervention

The EAGGF[4] intervention system operated by the Commission aims to provide some stability to the market prices. Should market prices drop below certain levels the producers' cooperatives can withdraw produce from the market and compensate the producer for the unsold supplies. If the prices remain at an exceptionally low level, national governments undertake to buy supplies offered to them at the 'buying-in' price.

Member States may fix buying-in prices between 40% and 70% of the 'basic price' which is fixed annually by the Council of Ministers. The 'buying-in' prices are calculated from a three year average of market prices prevailing in the main Community producing areas, and are between 50% and 55% of the average prices for apples and pears, and between 60% and 70% for peaches and citrus fruits. Prices are seasonally weighted to discourage the 'buying-in' of fruit after the harvest. In addition, under the terms of the Common Agricultural Policy, if the market prices stay below the 'buying-in' prices on three successive days, a state of serious crisis is declared and Member States must intervene to stabilize the market.

The main drawbacks in operating an intervention system, such as the EAGGF, occur where intervention is necessary due to structural imbalance. In such a case there might well be substantial recurring costs and if the intervention price is fixed at too high a level this itself might also tend to encourage further plantings thus exacerbating the supply problem in the long run.

1.3.2 Expenditure

Both clearing and market intervention schemes are supported by the Community. In relative terms, intervention is the most expensive of the two in so far as it is an annual commitment whereas ad hoc clearing schemes are intermittent with a continuing effect. The total estimated cost of the 1976 clearing scheme to be supported by the EAGGF was 8.55 million

(4) EAGGF: European Agricultural Guidance and Guarantee Fund

units of account (u.a.) and that of the 1969/73 scheme 61 million u.a. It is useful to compare these figures with those in Table 1.6 which shows the EAGGF intervention expenditure over the last few years.

TABLE 1.6

EAGGF INTERVENTION EXPENDITURE (million u.a.)

	Apples	Pears	Peaches	Oranges	Total
1971/2	9.4	19.9	8.6	:	37.9
1972/3	0.2	2.5	3.0	:	5.7
1973/4	24.9	15.7	2.1	0.6	43.3
1974/5	2.3	12.2	9.4	18.5	42.4

Source: Schedules of Market Intervention operations carried out during the marketing seasons 1971-75., Brussels

1.3.3 Intervention as a Measure of Over-production

In a free market situation, production in excess of demand would tend to lower the market price. However, under the Common Agricultural Policy the interests of the grower are protected to some degree in that the market price is kept at a reasonable level by withdrawing surplus produce. The withdrawn produce provides, therefore, some measure of the level of surplus production. From an examination of intervention data we estimate that between 1968 and 1974, on average, some 165 000 t of apples and 200 000 t of French and Italian pears are surplus per annum.(5)

Table 1.7 shows the very large swings in the amount of fruit delivered to intervention during the six year period 1970/1 to 1975/6. The main varieties of fruit withdrawn under EAGGF are:

Apples — Golden and Starking Delicious, Morgenduft, James Grieve, Cox's Orange Pippin, Jonathan, Ontario, Renette du Canada and Boskoop

Pears — Passe Crassane, Jules Guyot, Conference, Beurre Hardy and Legipont

Peaches — Redhaven, Dixired and Fairhaven

Oranges — Moro, Tarocco and Sanguinello (group)

(5) Golden Delicious apples have accounted for 60% of intervention purchases of apples and Passe Crassane pears have accounted for 87% of intervention purchases of pears. (AGRAEUROPE 30.1.76).

TABLE 1.7

QUANTITIES OF FRUIT WITHDRAWN FROM THE MARKET (t)

Species	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76p
APPLES						
Belgium	4 550	5 695	2	11 091	131	14 237
Germany	4 830	8 066	-	10 812	98	38 135
France	85 643	99 559	-	250 162	-	400 000
Italy	41 644	40 105	1 623	116 424	41 846	323 629
Luxembourg	134	-	-	-	-	-
Netherlands	43 698	42 736	302	14 871	809	23 812
EUR–6	180 499	196 161	1 927	403 360	42 884	799 813
PEARS						
Belgium	12 663	2 319	515	26	4 944	314
Germany	198	43	40	-	23	18
France	19 280	37 923	1 246	18 323	5 061	1 468
Italy	554 253	360 221	48 007	241 819	182 612	172 656
Luxembourg	-	-	-	-	-	-
Netherlands	55 822	8 007	3 864	411	16 957	1 108
EUR–6	642 216	408 513	53 672	260 579	209 597	175 564
PEACHES						
France	15 583	69 354	16 196	20 360	4 547	-
Italy	31 466	28 249	15 695	737	75 360	33 170
EUR–6	47 049	97 603	31 892	21 097	79 907	33 170
ORANGES						
France	-	-	130	22	-	-
Italy	102	129	-	49	187 946	43 923
EUR–6	102	129	130	71	187 946	43 923

Sources: EEC Schedule of market intervention operations carried out 1970/75. Brussels.
The Agricultural Situation in the Community: 1976 Report, EEC, Brussels.

p *Provisional*

1.3.4 The Clearing of Fruit Trees

The clearing of orchards may be undertaken for several reasons. At the micro level, the grower may adopt a rotational scheme of replantings in order to maintain a balanced age distribution within his orchards. Also he may wish to achieve a varietal balance in order to spread the period of harvesting. Furthermore, he is likely to clear his orchards if they fail to produce a satisfactory economic return, either because of falling demand or because of declining productivity. At the macro level, the Community and/or national governments may introduce grubbing schemes in order to induce structural change within the fruit-growing industry.

Action by the Community to reduce the orchard area was first undertaken in 1969 when a system of premiums was established by which growers could, on application, receive a maximum of 500 u.a. per hectare of apple, pear and peach trees cleared(6). This applied to orchards which were planted before 1965. In order to qualify for this subsidy growers had to clear their orchards by the 1st March 1973 and were not allowed to replant the uprooted species for the first five years after clearance. The premium was payable in two instalments; one half to be paid on proof of uprooting and the other half three years later. To increase incentive, the subsidy was raised, in December 1970, to 800 u.a. per hectare, payable as a lump sum on completion of the clearing(7).

Table 1.8 shows the total areas cleared supported by premiums. These clearings represent a reduction of 20% on the previously reported area for apples, 12% for pears and 3% for peaches.

TABLE 1.8

ORCHARD CLEARING UNDER THE EEC CLEARING POLICY 1970-73

	Apples ha	Pears ha	Peaches ha	Total ha
Germany	24 091	1 802	198	26 091
France	15 705	3 692	2 520	21 917
Italy	6 285	10 368	3 278	19 931
Netherlands	5 206	1 369	2	6 577
Belgium	3 363	885	177	4 425
Luxembourg	226	2	:	228
EUR–6	54 876	18 118	6 175	79 169

Source: Community Survey of Orchard Fruit Trees, EUROSTAT, 1976

It is difficult to assess the effect on production of this clearing scheme as adequate data on varieties and ages of orchards are unavailable at Community level. However, a detailed study of 12 386 applications for grant in France has recently been carried out by FORMA(8). Their results indicate that substantial clearing took place especially in compact, commercially important holdings of above average size. The scheme had most effect on young orchards of, or still below, fully productive age. Clearing under grant accounted for 22% of the eligible 1969 area of apples, for 11% of the pear area but less that 5% of the peach area. A detailed analysis of the effect of this clearing policy was not made by FORMA.

(6) Regulation EEC No. 2517/69 of the Council

(7) Regulation EEC No. 2476/70 of the Council

(8) Fonds d'Orientation et de Régularisation des Marchés Agricoles

However, fruit production in France in 1974 and 1975 was still at a high level in relation to market demand. This was partially due to the increasing production of very young orchards which had not been eligible for clearing subsidies.

In 1976 it became apparent that further action should be taken at Community level to reduce the area of certain varieties of fruit which continued to be in surplus production. Council Regulation (EEC) No. 794/76 laid down details of a clearing scheme to run for one year under which premiums would be paid for the following varieties of fruit and their pollinators:

Apples — Golden Delicious, Starking Delicious, Morgenduft (Imperatore)
Pears — Passe Crassane

The total premium payable was limited to a lump sum payment of 1100 u.a. per hectare paid, at the latest, three months after the claimant had shown that clearing had actually taken place, which must have been completed by 1st April 1977. In order to asses the possible effects of this scheme we have been able to simulate additional clearings for this year in our forecasting experiments. The results of this exercise are given in Chapter 5.

1.4 The Planting of Fruit Trees

Much of the present supply and demand imbalance is due to the large area of orchards planted in the 1960's. Table 1.9 shows the planting trends in France and Italy of the most important variety of apple, pear, peach and orange. These trends are fairly typical of the trends in most varieties in EUR—6 as a whole. There have also been quite distinct trends in planting density of apples and pears which is clearly shown in Figures 1.10 and 1.11. There has, in recent years, been a tendency to change from the traditional planting densities to more intensive systems, the latter tending to give a higher yield per hectare at an earlier age.

1.5 The Yield/Age Relationship

The production of an orchard, growing at a known density, is related to its age, and for a given variety of fruit the yield/age response can be regarded as a smooth curve for the purposes of forecasting. Such curves, which are described in detail in Chapter 3, display the following characteristics. The curves for apples, pears and oranges usually comprise a sigmoid growth portion up to the age of about 16 years after which they may plateau or slightly ascend or descend.

The curve for peaches show a much shorter productive 'life-cycle' where a steeply rising sigmoid growth section is followed by a fairly quickly descending segment.

If, therefore, the largest proportion of the orchard area is on an ascending part of the corresponding yield/age curve, then the production potential will rise throughout this period. A glance at Table 1.9 would seem to suggest that the production of the four selected varieties will continue to rise even though plantings have been considerably reduced since 1970.

TABLE 1.9

PLANTING* TRENDS OF THE MOST IMPORTANT VARIETY OF APPLE, PEAR, PEACH AND ORANGE

Date of Planting	Golden Delicious France and Italy ha	%	Passe Crassane France and Italy ha	%	Dixired France and Italy ha	%	Tarocco Italy ha	%
1973/74	1 265		37		280		311	
1972/73	1 203		178		471		724	
1971/72	1 302	13.21	107	3.47	875	25.42	999	19.30
1970/71	1 465		61		1 228		1 348	
1969/70	2 918		195		2 520		3 305	
1965-1969	19 327	31.33	3 549	21.36	8 879	41.99	7 887	22.77
1960-1964	23 092	37.43	8 619	51.86	5 216	24.67	8 500	24.53
1950-1959	9 300	15.08	3 318	19.97	1 627	7.70	5 899	17.03
<1950	1 814	2.94	555	3.34	47	0.22	5 672	16.37
Total	61 686	100.00	16 619	100.00	21 143	100.00	34 645	100.00

Source: Community Survey of Orchard Fruit Trees, EUROSTAT, 1976

* *These are not the actual areas planted during the specified time period but represent the area remaining as reported in the 1974 survey*

TABLE 1.10

TRENDS IN PLANTING* DENSITY OF APPLES IN FRANCE AND ITALY

Date of Planting	Density (Trees per hectare) Density 1 <400 ha	%	Density 2 400-799 ha	%	Density 3 800-1599 ha	%	Density 4 ≥1600 ha	%	Total ha	%
1973/74	520		548		1 111		577		2 756	
1972/73	679		531		944		533		2 687	
1971/72	753	30.79	680	27.75	849	28.44	511	13.02	2 793	100
1970/71	1 261		1 114		640		265		3 280	
1969/70	2 051		1 871		1 317		340		5 579	
1965-69	8 858	30.39	9 083	31.16	9 534	32.71	1 674	5.74	29 149	100
1960-64	12 850	34.10	10 704	28.41	11 840	31.42	2 285	6.06	37 679	100
1950-59	16 434	58.56	5 644	20.11	4 672	16.65	1 312	4.68	28 062	100
<1950	13 556	82.47	2 118	12.88	511	3.11	253	1.54	16 438	100
Total	56 962	44.35	32 293	25.15	31 418	24.46	7 750	6.03	128 423	100

Source: Community Survey of Orchard Fruit Trees, EUROSTAT, 1976

* *These are not the actual areas planted during the specified time period but represent the area remaining as reported in the 1974 survey.*

TABLE 1.11

TRENDS IN PLANTING* DENSITY OF PEARS IN FRANCE AND ITALY

Date of Planting	Density (Trees per hectare): Density 1 <400		Density 2 400-799		Density 3 800-1599		Density 4 ≥1600		Total	
	ha	%	ha	%	ha	%	ha	%	ha	%
1973/74	19	16.48	119	23.55	318	40.96	57	19.05	513	100
1972/73	34		39		154		281		508	
1971/72	100		132		246		135		613	
1970/71	221		274		338		123		955	
1969/70	344		462		728		234		1 767	
1965-69	1 646	9.06	3 938	21.68	8 920	49.11	3 661	20.16	18 164	100
1960-64	2 456	8.41	5 053	17.30	14 098	48.27	7 601	26.02	29 208	100
1950-59	3 073	18.62	3 023	18.32	6 143	37.23	4 264	25.84	16 502	100
<1950	3 274	41.82	1 313	16.77	1 336	17.07	1 904	24.32	7 828	100
Total	11 167	14.68	14 353	18.87	32 281	42.44	18 261	24.01	76 058	100

Source: Community Survey of Orchard Fruit Trees, EUROSTAT, 1976

* *These are not the actual areas planted during the specified time period but represent the area remaining as reported in the 1974 survey.*

CHAPTER 2

THE DATA

2.1 Introduction

It is conceivably possible to build a perfect forecasting model but we do not live in utopia where it might be possible to collect all the precise and necessary data. Some data are not, and never will be, available and one must fall back on less than perfect but, nevertheless, useful results produced by more realistic models. We know, for example, that the climate of a growing region is a vital control on the productivity of orchards and yet we cannot as yet forecast this variable with anything like the desired accuracy. Technological improvements and the development of management skills may also influence yields and forecasting accuracy. Even if this type of information could be measured one must question the effort required to obtain even a useful proxy for these variables in terms of costs and benefits. Notwithstanding these, and many other difficulties associated with forecasting, we shall, for the rest of this chapter describe in some detail the nature of the data we have used and which were made available by EUROSTAT for our medium term forecasting studies of fruit production.

The forecasting model developed by us is defined by four parameters:

(1) Area – the area under the crop at a given age in the base year.

(2) Yield – the expected normal yield at a given age.

(3) Plantings – the area planted each year during the forecast period.

(4) Clearings – the per cent per annum cleared during the forecast period.

2.2 Area Data

Member States were required by Directive 71/286/EEC to survey dessert fruit plantations. The concept of 'net' area planted with fruit was used by all countries although there were minor differences in the way this was defined or obtained. Net area of orchard excludes windbreaks, headlands and other non-planted areas necessary for working the orchard. A detailed breakdown of the area under orchards is shown in Tables 1.1 – 1.4. The more important features of the survey are described below and a full account is available in: **Community Survey of Orchard Fruit Trees, EUROSTAT, 1976.**

2.2.1 Coverage

The Directive referred to specified four species of dessert fruit for survey: apples, pears and peaches in EUR–6 and oranges in France and Italy. The survey was to cover all 'undertakings' or holdings having a planted area of at least 1 500 square metres where one of the above mentioned species was produced entirely or 'mainly' for sale.

2.2.2 Survey Methods

Member States were free to adopt an exhaustive or random sample survey. Complete enumeration of fruit holdings was carried out in Germany, Netherlands, Luxembourg and Belgium and sample surveys in France and Italy. An additional sample survey was carried out in Belgium in 1972 for updating purposes and also to obtain supplementary information on age and density of plantation. The sample surveys in Italy, France and Belgium were carried out as follows:

Italy – The 1970 Second General Census of Agricultural Holdings was used as a sampling frame for a stratified single-stage sample. Within each region, holdings with fruit as a predominant crop were stratified by the size of area under fruit of the four species. A total of 25 560 holdings (127 576 ha) were surveyed of which there was a complete enumeration of 9 806 holdings (103 433 ha) having at least 5 hectares of orchard.

France – The annual survey of land use served as a sampling frame for the 1974/5 orchard fruit survey which covered exhaustively the so-called 'exceptional orchards' and a random sample of all other orchards selected with probability proportional to orchard size. The area actually surveyed for apples, pears and peaches was 44 500 hectares.

Belgium – An exhaustive survey in 1970 was followed by a supplementary survey in 1972 which was based on a two-stage sample of 84 cantons. A sample of 55 squares was drawn from 400 squares, with a 5 km grid, covering the 84 cantons. Within each of the selected 55 squares a survey of all fruit orchards was carried out in one cell of 1 km radius centred on a reference orchard selected at random.

2.2.3 Time of Survey

The data used in our studies were collected on the following dates:

Belgium	–	May 1970, supplemented in 1972	Italy	–	June 1974
France	–	October 1974/January 1975	Luxembourg	–	May 1973
Germany	–	December 1972	Netherlands	–	May 1974

It will be noticed that the lack of synchronisation in the survey dates has meant a longer forecast lead time for Belgium and Germany. A further complication is brought about by the fact that some surveys took place in early summer whilst others were carried out from October to January. Autumn and winter surveys are likely to introduce errors of under-reporting of new plantings as new plantations are normally established between autumn and spring. Such under-reporting is not likely to be important in terms of forecast accuracy because the yield curves are relatively low until about the age of five. In the case of Belgium and Germany under-reporting may have more significance due to the longer forecast lead time. Furthermore, as orchards are normally cleared subsequent to crop harvest, a midwinter survey might also introduce errors of over-reporting in respect of older orchards, especially for late fruiting varieties. As a result of these national surveys the total area under dessert apples, dessert pears, peaches and oranges is estimated to be 498 686 ha.

2.2.4 Survey Characteristics

Article 2 of the Directive required the area under each species within each production zone to be recorded by:

(i) — variety

(ii) — age

(iii) — planting density

(iv) — irrigation of orchard if practiced regularly.

Irrigation is only practiced regularly in France and Italy but it was found difficult to define properly the 'regular use of irrigation' in their questionnaires. However, detailed survey results did not indicate, within each species, a higher percentage of irrigation for orchards of productive age or higher density. It was decided, therefore, to ignore irrigation at an early stage in our forecasting studies.

2.2.5 Variety

A detailed breakdown by variety was required for each species; in particular for all varieties which individually account for at least 3%, or collectively for at least 80%, of the species in question.

2.2.6 Age of Orchard

The Directive required that the survey assessed the age of the orchards from the period of planting on the site. The age categories were defined as follows:

Less than 1 year	5– 9 years
1 year	10–14 years
2 years	15–24 years
3 years	25 years and over
4 years	

In the case of the Netherlands different age groups for the 1974 survey were deliberately chosen. This was with the expressed intention of providing an age distribution which, three years later, will be directly comparable with those of the Directive for the subsequent 1977 survey. The age groups used in the 1974 Dutch surveys were as follows:

Less than 2 years	12–21 years
2– 6 years	22 years and over
7–11 years	

2.2.7 Planting Density

Increase in the number of fruit trees per hectare has been one of the most notable features of post-war fruit orchard management. The surveyors were required by the Directive to determine the class of the planting density according to the net area planted and the number of trees. The density classes are defined as follows:

Apples, Pears and Peaches

Density	1 –	less than 400 trees per hectare			
"	2 –	400–799	"	"	"
"	3 –	800–1599	"	"	"
"	4 –	greater than 1599	"	"	"

Oranges

Density	1 –	less than 250 trees per hectare			
"	2 –	250–499	"	"	"
"	3 –	500–999	"	"	"
"	4 –	greater than 999	"	"	"

2.2.8 Production Zones

The orchard area of the Community is subdivided into the following production zones, having broadly homogeneous ecological and agricultural conditions (see Figure 2.1):

Figure 2.1 EUR–6 Production Zones

Belgium	Forms a single production area	
Germany	1. Nord:	Schleswig-Holstein Niedersachsen, Hamburg, Bremen, Berlin
	2. Mitte:	Nordrhein-Westfalen, Hessen, Rheinland-Pfalz, Saarland
	3. Sud:	Baden-Württemberg, Bayern
France	1. Sud-ouest:	Limousin, Auvergne, Aquitaine, Midi-Pyrénées
	2. Sud-est:	Rhône-Alpes, Languedoc, Provence-Côte d'Azur
	3. Loire:	Pays de la Loire, Poitou-Charentes, Centre, Région parisienne
	4. Remainder of France	

Italy (i) Apples, Pears and Peaches

1. Val Padana, Alto Adige (peaches)
   (a) – Val Padana (apples and pears) Lombardia, Veneto, Friuli-Venezia, Giulia, Emilia-Romagna
   (b) – Trentino-Alto Adige (apples, pears)
2. Piemonte, Valle d'Aosta
3. Centrale: Liguria, Toscana, Umbria Marche, Lazio, Abruzzo
4. Meridionale: Campania, Calabria, Molise, Puglia, Basilicata, Sicilia, Sardegna

(ii) Oranges

1. Sicilia
2. Calabria
3. Puglia, Basilicata
4. Remainder of Italy

Luxembourg Forms a single production zone

Netherlands Forms a single production zone

2.2.9 Area Data Preparation

For forecasting purposes it is necessary to decide upon the manner of area distribution within the age groups and at what age to terminate the open-ended class. It was decided to adopt the usual statistical procedure and distribute the area regularly within the age groups. However, an examination of the forecast sensitivity to types of data distribution was carried out and is described in Chapter 5. The age class '25 years and over' was terminated at 35 years for apples, pears and peaches and at 40 years for oranges. This action was justified for two reasons. Firstly, the yield/age data provided by the national 'experts' rarely exceeded 35 years and tended to be rather sparce for these older orchards. Secondly, an examination of the survey data indicated that, for the most part, only a very small proportion of the crop areas fell within this last age group for apples, pears and peaches. Oranges have a larger proportion of orchards over 25 years and so it was considered desirable to have a longer data vector in this case.

New forecasts, to be made as a result of the 1977 Orchard Fruit Survey, will incorporate several changes, in particular to peaches and oranges. The new age groups and planting densities are shown in Table 2.1.

TABLE 2.1

CLASSES OF AGE AND DENSITY OF PLANTATION USED IN THE 1977 ORCHARD FRUIT SURVEY

	Apples, pears	Peaches	Oranges
Age of trees (years)	Under 1	Under 1	Under 1
	1	1	1
	2	2	2
	3	3	3
	4	4	4
	5 – 9	5 – 9	5 – 9
	10 – 14	10 – 14	10 – 14
	15 – 24	15 – 19	15 – 24
	25 and over	20 and over	25 – 39
			40 and over
Density of plantation (trees/ha)	Under 400	Under 300	Under 250
	400 – 799	300 – 399	250 – 374
	800 – 1 599	400 – 599	375 – 499
	1 600 and over	600 – 799	500 – 624
		800 and over	625 – 749
			750 and over

Member States may for high density plantations of apples and pears, subdivide the '15-24 years' age class into two age classes: 15 – 19 years
20 – 24 years

Source: Official Journal of the European Communities No. L285/35, 16/10/76

2.3 Yield Data

Data on 'normal' yields at different orchard ages were provided by Ministries of Agriculture and 20 private experts under contract. A list of these experts is given in Appendix 1. The data supplied in the form of yield/age curves were obtained from a variety of sources and by different methods.

2.3.1 Methods of Data Collection

Some yield curves appear to have been constructed in a subjective manner, the expert drawing heavily upon experience and data from experimental horticultural stations. In Val Padana a random sample of 2 630 holdings had been undertaken; elsewhere smaller purposive samples of between 50 and 300 commercial holdings had been surveyed.

In the majority of cases the experts collected time series data from each holding for as long as records were available thus using a mixture of cross section and time series data in the construction of their curves. Cross section data were collected in Belgium, Val Padana (for three different years) and the Netherlands.

2.3.2 The Data Provided by the Experts

In addition to providing EUROSTAT with yield/age curves, some of the experts were able to provide their raw data which we have been able to use in our statistical analyses described in Chapter 3. These data varied considerably both in quality and quantity so we felt that not all the data were adequate for use in our own curve fitting studies.

In all cases, as might be expected, there was sparcity of data in some varieties and density classes and for older orchards in general. This means that some curves are based, either partially or wholly, on very few observations. Of course no amount of investigation can provide sufficient data for a newly introduced variety or planting density and in such a situation the subjective judgement of the pomologist must be used to produce the most reasonable yield curve.

2.3.3 Curve fitting by the Experts

The objective was to obtain production yield/age curves not biological growth curves.

The biological growth curve refers to the growth in weight or size of an individual animal or plant through time, and can also refer to the growth of an animal or plant product during a growing season e.g. weight of wool per sheep or fruit weight per tree. An individual orchard fruit tree will have the following biological curve: zero production during the initial years; rapid rise to maximum yield, constant over a number of years, dependent on species and variety; with a final period of declining yield (or not, dependent upon the school of pomological thought). The yield/age relationship will not be a smooth curve since fruit trees exhibit wide between-year variations in yield due to annual climatic variation. For commercial production large numbers of fruit trees are planted together in individual orchard fields, the total production of which will give a similar growth curve through time, including between-year variations due to climate and between-tree variation due to vigour and situation. Records of such biological yield curve growth for individual fields are normally kept by research stations and some (the better managed) commercial holdings.

For forecasting purposes it is necessary to use production curves which reflect the yield/age relationship for the total population of orchards at the time of the basic survey. The national orchard consists of large numbers of fields planted in different years. To represent this population, a relatively large sample is ideally required to obtain adequate numbers of orchards in individual cohorts matched as to both age and time. In practice, the experts found it difficult to obtain large numbers of orchard data and most experts provided time-series data giving a large number of separate orchard/year observations for a relatively small number of orchard fields of the various varieties, planted in different years, often recorded over different lengths of time and even at different periods of time. If such data is only time-synchronised i.e. sorted into groups of yield observations referring to the same harvest years, it includes the between-age variations i.e. prevents examination of the yield/age relationship. If such data is only age-synchronised, i.e. sorted into yields for orchards of identical age groups, it includes between-year variation in yields, and also combines together orchards reaching that age group at different points in time between which technological changes may have occurred. Such changes may consist of improved bearing clonal material for grafting or of virus-free rootstock, and may considerably increase the yield of recent, say, 8-year-old plantations over other orchards which reached that age some time ago. Where time series data were limited to the most recent, say, 10 years of records for each orchard, the yield age curve tends to be plotted from different segments of the population; the early years are based on data from relatively young orchards and the older years on data from older orchards. This is quite different from the biological growth curve as defined above.

Some experts provided cross-section data from yield surveys recording observations from all ages of orchard existing in commercial production at one point in time. The resulting yield/age curve includes all variability due to age as well at to technological change. The younger orchards tend to give yields higher than older orchards now give (or gave formerly when they were of identical years) except where the latter have been selectively cleared (result of management practice of eliminating orchards of below average yield). Cross section data from yield surveys repeated over several years will provide data on the level of yields in "normal" years i.e. compensated for between-year variation. In both instances curves fitted to cross-section data will be production and not biological yield/age curves.

The methods used by the experts to obtain their curves seemed to vary considerably. Most based their curves upon mean yields for each age applying manual smoothing methods and sometimes using simple or repeated moving averages. One expert determined each of his curves in three segments; fitting two quadratic functions to obtain a sigmoid shape from the age of zero yield to the age of maximum yield, beyond which the curve was extended as a horizontal line.

In total 1 050 curves were received by EUROSTAT covering the main varieties and density classes of the four species of fruit under study. However, the shapes of the curves supplied by the different experts for the same variety and planting density often differed considerably. This is illustrated in Figure 2.2 which shows a composite plot of the experts' curves for Golden Delicious apples grown at density 1. Environmental variations between production zones, sampling errors and personal bias will be some of the factors creating these large differences in the shape and level of the curves.

2.4 Planting Data

During the forecast period orchards will be planted or replanted and so it is desirable to make provision for these new plantings in any forecasting model. In the absence of any actual planting data it was decided to use the area data recorded in the last survey for orchards aged 0–3 years. In the medium term it is not unreasonable to suppose that there are trends in plantings and so we decided to adopt a weighted moving average scheme to reflect such trends. In our studies we chose the following arbitrary scheme:

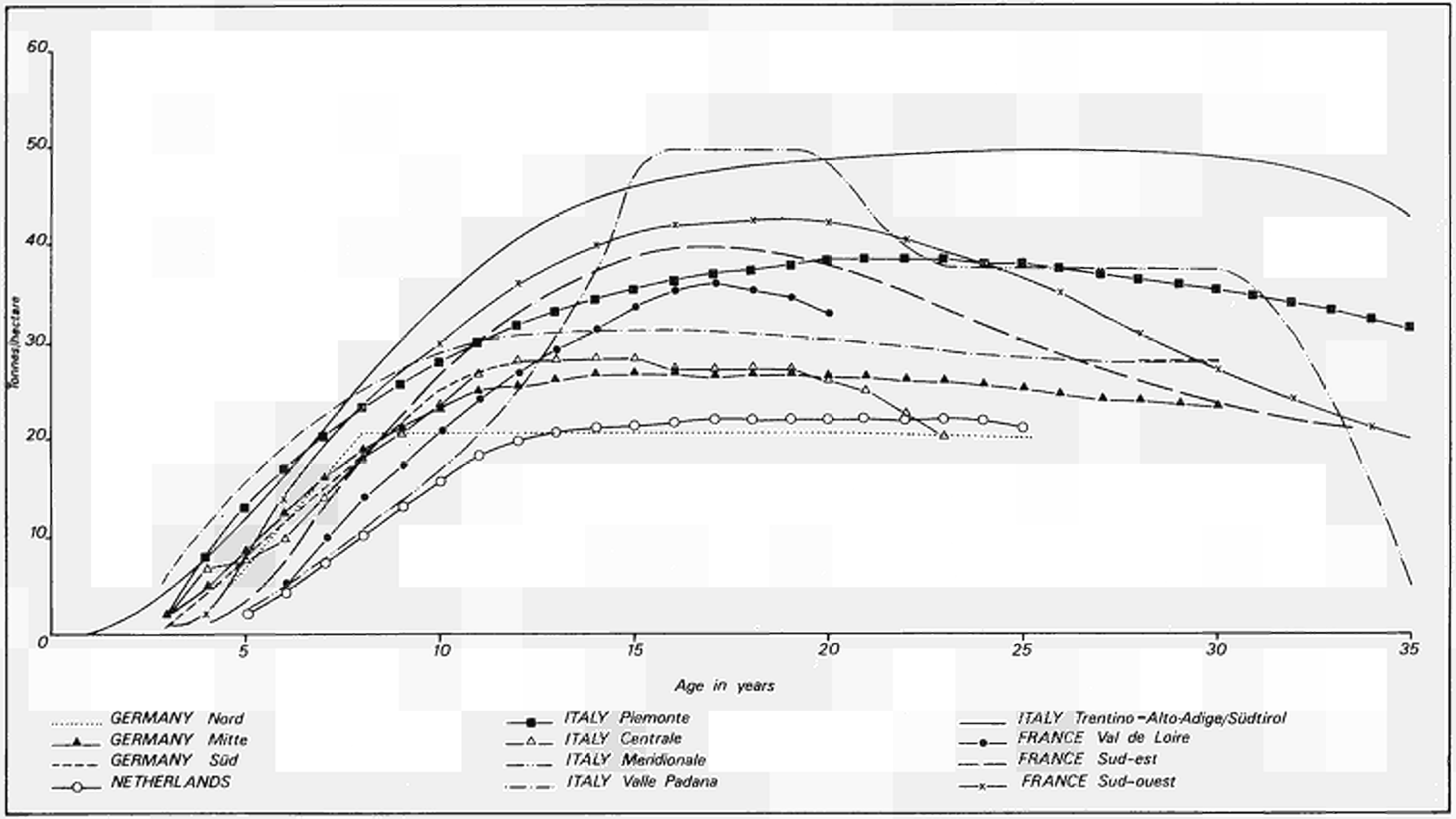
$$P(1) = 0.4A(0) + 0.3A(1) + 0.2A(2) + 0.1A(3)$$
$$P(2) = 0.4P(1) + 0.3A(0) + 0.2A(1) + 0.1A(2)$$
$$P(3) = 0.4P(2) + 0.3P(1) + 0.2A(0) + 0.1A(1)$$
$$P(4) = 0.4P(3) + 0.3P(2) + 0.2P(1) + 0.1A(0)$$
$$P(5) = 0.4P(4) + 0.3P(3) + 0.2P(2) + 0.1P(1)$$

where $P(i)$ is the calculated planting in the i^{th} year

$A(i)$ is the i^{th} element of the area vector

In view of the reporting errors discussed in section 2.2.3 it may have been better to exclude

Figure 2.2 Experts' curves for Golden Delicious – Density 1



the area A(0) from this scheme. However, the forecasts for a lead time as short as five years are relatively insensitive to planting assumptions.

2.5 Clearing Rates

The area under orchard fruit reported at the time of the last survey will be subject to clearings of some orchards over the forecast period, even in a stable situation when growers wish to maintain their mean orchard age.

Over the forecast period from the base year of the Orchard Fruit Survey, the area under fruit trees of the four species will be subject to increase from new plantings and to decrease from clearings. Even in a stable state situation when the total size of the orchard area remains constant, these increases and decreases will occur in order to maintain the same mean age of orchard and the same overall age/yield productivity. In practice, the timing of these new plantings and clearings will depend upon a series of exogenous variables (availability of capital, rates of interest, present and expected future earnings of fruit orchards, relative profitability of the orchard land and other inputs in alternative crops). Furthermore, the orchard fruit industry may not be in a state of equilibrium; there may be underlying trends for an increase or a decrease in the total area of certain species, certain varieties or density classes of plantation. As with new plantings, the experience over a previous period can be used as a starting point for making assumptions about the rate of clearings over the forecast period.

The data available for this initial calculation was limited to France (apples, pears and peaches) over a five year period between 1969/70 (the date of the first Orchard Fruit survey in France under the basic Directive) and 1974/75 (the date of a supplementing survey). Both surveys were conducted with identical definitions and survey coverage. It was possible to compare the area at the first survey with the area at the second survey for comparable age-groups (or combination of age groups) to calculate the annual compound rate of clearings with the formula:

$$\log(1 - r) = \frac{\log n F - \log n S}{n}$$

r = rate of clearing

n = number of years

F = Final orchard area

S = Starting orchard area

The calculation for white flesh peaches is given in Table 2.2 which indicates different clearing rates for the age groups according to the year of planting. Since both surveys were conducted by sampling, part of the difference in area between the two surveys could be due to sampling errors; but in all age groups the observed difference exceeds significantly the sampling error of the difference given by the formula:

$$S.E.(F - S) = \sqrt{[(S.E.\ F)^2 + (S.E.\ S)^2]}$$

The results of similar calculations for yellow flesh peaches, for apples and pears are given in Table 2.3. The percentage annual rates of change for both white flesh and yellow flesh peaches exhibited a similar pattern: high mortality levels in the older age groups of orchards falling rapidly among younger orchards. No such sharp fall was noticeable for apples and pears and the rates of change were generally high in respect of two species of considerable longevity compared with peaches.

TABLE 2.2

FRANCE: PEACHES (WHITE FLESH) – CHANGE IN AREA 1969/70–1974/5

Year of Planting	1969/70 Survey		1974/5 Survey		Change 1969/70–1974/5			
	Area ha	Sampling error ha	Area ha	Sampling error ha	Difference in area ha	Sampling error ha	Ratio difference ÷ S.E.	% annual compound rate
1950 and before	1 665	± 291	346	± 107	1 319	± 310	4,3	– 27,0
1951 – 3	996	± 219	205	± 84	791	± 235	3,4	– 27,1
1954 – 6	2 384	± 346	674	±155	1 710	± 379	4,5	– 22,3
1957 – 9	2 858	± 377	1 130	± 199	1 728	± 426	4,1	– 16,9
1960 – 2	2 455	± 351	1 436	± 224	1 019	± 416	2,4	– 10,2
1963 – 5	2 773	± 374	1 737	± 245	1 036	± 447	2,3	– 8,9
1966 – 8	3 048	± 384	2 445	± 293	603	± 483	1,2	– 4,3
1969 – 71	763		2 274					
1972 – 74			1 563					
All years	16 942	± 915	11 810	± 638	5 132	±1 115	4,6	– 7,1

Source: EUROSTAT (unpublished paper)

However, during the 5 year period 1969/70 to 1974/75, the additional clearings of fruit orchards in the Community had been induced by the EEC grant-aided clearing schemes under Regulation EEC/2517/69 terminating in 1973. A total of 21 917 "gross" hectares were so cleared in France. When these "gross" hectares are converted into approximately 18 000 "net" hectares to correspond to the definitions of the French Orchard Fruit survey, the areas cleared under grant in relation to the total survey area reported in 1969/70 were very important for apples (20%), important for pears (11%), but of minor importance for peaches (4%). The grant applied only to apple and peach orchards planted in 1965 or earlier and to pear orchards planted in 1968 or earlier. The clearings under grant accounted for three quarters of the decline in area of grant-eligible apple orchards over the five year period 1969/70 to 1974/75 but for only half in respect of pears and only 13% in respect of peaches.

TABLE 2.3

FRANCE: PEACHES, APPLES AND PEARS – RATE OF CHANGE OF AREA 1969/70–1974/5

Year of planting	1969/70		1974/75		Average age over period yrs	% Annual Compound Rate		
						PEACHES		APPLES
	Age group yrs	Average age yrs	Age group yrs	Average age yrs		White flesh%	Yellow flesh%	
1950 and before	19 +	?	24 +	?	?	27,0	20,9	10,6
1951 – 3	16 – 18	17	21 – 23	22	19,5	27,1	17,9	9,0
1954 – 6	13 – 15	14	18 – 20	19	16,5	22,3	15,2	7,4
1957 – 9	10 – 12	11	15 – 17	16	13,5	16,9	11,9	
1960 – 2	7 – 9	8	12 – 14	13	10,5	10,2	10,7	6,2
1963 – 5	4 – 6	5	9 – 11	10	7,5	8,9	9,7	5,8
1966 – 8	1 – 3	2	6 – 8	7	4,5	4,3	4,9	6,1
1969 – 71	0		3 – 5					
1972 – 76								
All years						7,1	1,8	4,5
						PEARS		
1948 and before	21 +	?	26+	?	?	8,9		
1949 – 53	16 – 20	18	21 – 25	23	20,5	8,3		
1954 – 58	11 – 15	13	16 – 20	18	15,5	5,5		
1959 – 63	6 – 10	8	11 – 15	13	10,5	4,0		
1964 – 68	1 – 5	3	6 – 10	8	5,5	4,3		
1969 – 73	0		1 – 5					
1974			0					
All years						3,7		

Source: EUROSTAT (unpublished paper)

It was therefore decided to regard the calculated rates of change for peaches as "normal", whereas those for pears and especially those for apples as abnormal having been greatly (even largely in respect of apples) induced by the EEC grant-aided clearing policy. It was further decided to modify the rates of change calculated over the previous 5 year period in order to establish rates of clearing for the future forecast period on the following assumptions:

(i) uneconomic orchards, especially of apples, would have been cleared by 1973 and the remaining modernised orchards would be subject to different clearing rates;

(ii) clearing rates would be low for orchards in full/substantial production as indicated by the yield/age curves, but would increase progressively with age;

(iii) clearing rates would be higher for the higher density plantations of apples and pears (but not of peaches and oranges where there is no apparent trend in planting practice);

(iv) clearing rates would be higher for white flesh than for other varieties of peaches (whereas no varietal differences were observed in the other species);

(v) the rates should be capable of reproducing the age distributions of the various species reported in the national surveys.

The actual clearing rates used in the forecasts were finally established on these principles by EUROSTAT after consultation with the Member States.

The clearing rates used in our forecasting studies are shown in Table 2.4. We are aware that it is perhaps unrealistic to apply these rates to all varieties and all regions but we must hope that these represent the average situation. However, when the results of the 1977 survey are available and can be compared with the earlier surveys in each Member State, it is hoped to be able to estimate clearing rates on a varietal and regional level.

TABLE 2.4

VECTORS OF CLEARING RATES (IN % p.a.–COMPOUND)

	Apples				Pears			Peaches		Oranges
	Density Class				Density Class			All densities		
Age	1	2	3	4	1	2 & 3	4	White	Yellow	
0	1	1	1	1	1	1	1	1	2	1
1	1	1	1	1	1	1	1	1	2	1
2	1	1	1	1	1	1	1	1.5	2.5	1
3	1	1	1	1	1	1	1	2.0	3	1
4	1	1	1	1	1	1	1	2.5	4	1
5	1	1	1	2	1	1	1	3.5	5	1
6	1	1	1	2	1	1	1	4.0	6	1
7	1	1	1	2	1	1	1	5.0	7	1
8	1	1	1	2	1	1	1	6.0	8	1
9	1	1	1	2	1	1	1	7.0	10	1
10	1	1	2	5	1	1	2	8.0	11.5	1
11	1	1	2	5	1	1	2	9.0	13	1
12	1	1	2	5	1	1	2	10.0	14.5	1
13	1	1	2	5	1	1	2	11.0	16.0	1
14	1	1	2	5	1	1	2	12.0	18.0	1
15	4	6	10	15	2	3	5	13.0	19.5	1
16	4	6	10	15	2	3	5	14.0	21.0	1
17	4	6	10	15	2	3	5	15.0	22.5	1
18	4	6	10	15	2	3	5	16.0	24.0	1
19	4	6	10	15	2	3	5	17.0	26.0	1
20	4	6	10	15	2	3	5	18.0	28.0	1
21	4	6	10	15	2	3	5	19.0	29.5	1
22	4	6	10	15	2	3	5	20.0	29.5	1
23	4	6	10	15	2	3	5	21.0	29.5	1
24	4	6	10	15	2	3	5	21.0	29.5	1
25	10	12	20	25	10	10	15	21.0	29.5	6
26	10	12	20	25	10	10	15	21.0	29.5	6
27	10	12	20	25	10	10	15	21.0	29.5	6
28	10	12	20	25	10	10	15	21.0	29.5	6
29	10	12	20	25	10	10	15	21.0	29.5	6
30	10	12	20	25	10	10	15	21.0	29.5	6
31	10	12	20	25	10	10	15	21.0	29.5	6
32	10	12	20	25	10	10	15	21.0	29.5	6
33	10	12	20	25	10	10	15	21.0	29.5	6
34	10	12	20	25	10	10	15	21.0	29.5	6
35	10	12	20	25	10	10	15	21.0	29.5	6
36										6
37										6
38										6
39										6
40										6

CHAPTER 3

YIELD CURVE FITTING

3.1 Methods of Fitting Equations

When fitting the various equations to the data, we use the criterion of least squares which says: 'find the values of the constants in the chosen equation that minimize the sum of the squared deviations of the observed values, or transformations of these values, from those predicted by the equation'.

We will consider models of two types; those whose constants are linear or can be linearized by simple transformations, and those whose constants are non-linear and cannot be linearized.

3.2 Least Squares Theory

Although we are concerned with only one independent variable

i.e. Yield = f (age of orchard)

it will be convenient to outline the general regression model involving several variables because many functional forms involve several terms in 'age', each of which must be counted as a separate independent variable in order to estimate the parameters of the equation.

The general regression model is of the form

$$y = f(\underline{x}, \underline{\theta}) + u \qquad (3\text{–}1)$$

where $\underline{x} = (x_1, x_2, \ldots\ldots, x_k)$ is a k-component vector of non-stochastic independent variables, $\underline{\theta} = (\theta_1, \theta_2, \ldots\ldots\ldots, \theta_k)$ is a k-component vector of population parameters to be estimated, y is the dependent variable, and u is an unobserved disturbance term.

Given n observations on y and the k x's denoted by

y_i and $\underline{x}_i = (x_{1i}, x_{2i}, \ldots\ldots, x_{ki})$ $\qquad i = 1, \ldots, n$

least squares estimates for $\underline{\theta}$ are those that minimize the expression

$$S(\underline{\theta}) = \sum_{i=1}^{n} (y_i - f(\underline{x}_i, \underline{\theta}))^2 \qquad (3\text{–}2)$$

The least squares estimates are denoted by $\hat{\underline{\theta}}$ and the minimum values of $S(\underline{\theta})$ by $S(\hat{\underline{\theta}})$. (It should be noted that if the disturbances in (3–1) are normally, independently and identically distributed, then the least squares estimates are identical to the maximum likelihood estimates.)

We first review briefly the essential details of estimation in the linear model and then examine the corresponding procedures in the more general model given in (3–1) and (3–2).

3.2.1 Linear Models

Linearity in the context of (3–1) will always be taken to refer to linearity in θ. Thus a model will be called linear if it can be written as

$$y = \sum_{i=1}^{n} \theta_i z_i + u \qquad (3\text{–}3)$$

after suitable redefinition of the original variables x,

where $z_i = g_i(x_1, x_2, \ldots, x_k) \qquad i = 1, \ldots, n$

In order to clarify this concept let us consider the following cases.

The Straight Line:

$$y = \theta_0 + \theta_1 x + u$$

This model is linear in θ and x.

The Polynomial:

$$y = \theta_0 + \theta_1 x + \theta_2 x^2 + \ldots\ldots + \theta_k x^k + u$$

This model is obviously non-linear in the x's but remains linear in terms of the parameter θ.

Intrinsically Linear:

$$y = \theta_0 \exp(\theta_1 x) u$$

This equation is non-linear in both θ and x but may be transformed into the following linear form

$$\ln y = \ln \theta_0 + \theta_1 x + \ln u$$

Intrinsically Non-linear:

$$y = \theta_0 + \theta_1 \exp(\theta_2 x) + u$$

This again is non-linear in both θ and x but cannot be transformed to produce a model which is linear in θ.

If the model is linear in θ as well as the original variables x, then we have

$$y_i = \theta_1 x_{1i} + \theta_2 x_{2i} + \ \ldots\ldots\ + \theta_k x_{ki} + u_i \qquad (3\text{–}4)$$

where x_{1i} is set to unity so that θ_1 defines the intercept term.

The n equations of the form (3–4) can be written in matrix form

$$\underline{y} = \underline{X}\underline{\theta} + \underline{u} \qquad (3\text{–}5)$$

where we assume:

(i) $E(\underline{u}) = \underline{0}$

(ii) $E(\underline{u}\underline{u}') = \sigma^2 \underline{I}$ i.e. the u_i are homoscedastic and pairwise uncorrelated.

(iii) $\underline{X}$ is a set of fixed numbers i.e. X is non-stochastic which means that in repeated sampling the sole source of variation in the y vector and the properties of our estimators and tests are conditional upon X.

(iv) $\underline{X}$ has rank $k < n$ i.e. no exact linear relations exist between any of the x variables.

The expression for the sum of squares (3–2) is

$$S(\underline{\theta}) = (\underline{y} - \underline{X}\underline{\theta})'(\underline{y} - \underline{X}\underline{\theta}) \qquad (3\text{–}6)$$

In order to minimize (3–6) we set the partial derivatives of $S(\underline{\theta})$ with respect to the elements of $\underline{\theta}$ equal to zero, yielding

$$-\underline{X}'\underline{y} + \underline{X}'\underline{X}\,\hat{\underline{\theta}} = \underline{0} \qquad (3\text{–}7)$$

and provided that $\underline{X}$ is linearly independent

$$\hat{\underline{\theta}} = (\underline{X}'\underline{X})^{-1}\underline{X}'\underline{y} \qquad (3\text{–}8)$$

These can be shown to be best linear unbiased estimators of $\underline{\theta}$.

Further Results:

(i) An unbiased estimate of the error variance σ_u^2 is obtained by

$$\hat{\sigma}_u^2 = \frac{S(\hat{\underline{\theta}})}{(n-k)} \qquad (3\text{–}9)$$

(ii) The variance-covariance matrix of the $\hat{\theta}$'s denoted by var($\hat{\underline{\theta}}$) can be shown to be

$$\text{var}(\hat{\underline{\theta}}) = \hat{\sigma}_u^2 (\underline{X}'\underline{X})^{-1} \qquad (3\text{–}10)$$

(iii) By making the further assumption that the u_i are normally and independently distributed we are able to perform statistical tests of significance and provide confidence intervals.

(iv) Goodness of Fit – The coefficient of determination, R^2, measures the explained sum of squares relative to the total sum of squares

$$R^2 = \frac{\text{Exp SS}}{\text{Total SS}}$$

Obviously, if one fitted regression fits the observations perfectly, the residuals will be zero and $R^2 = 1$. If, on the other hand, the estimated relationship completely fails to explain the behaviour of the dependent variable then $R^2 = 0$. A serious disadvantage with the use of R^2 is that as more explanatory variables are introduced into the model, the explained sum of squares will invariably increase (it will never decrease) even when the added variables do not seem to be particularly relevant. To overcome this we use an alternative measure,

$\bar{R}^2$, which involves a penalty weighting for the number of explanatory variables.

$$\bar{R}^2 = 1 - \left[\frac{(1 - R^2)(n - 1)}{n - k}\right]$$

N.B. For very poor fits $\bar{R}^2$ may become negative.

It is important to realise that in comparing the fit between two versions of a model in which the dependent variable enters in different forms that the R^2 values are not comparable. If in one case the dependent variable is Y, and in a different version it is ln Y, then the value of R^2 in the first case would represent the proportion of variation in the Y that is explained by the relationship. However, in the latter case R^2 measures the proportion of variation in ln Y that is explained.

3.2.2 Non-Linear Models

The general model (3–1) is estimated by minimizing the sum of squares

$$S(\underline{\theta}) = \sum_{i=1}^{n} (y_i - f(\underline{x}_i, \underline{\theta}))^2 \qquad (3\text{–}2)$$

with respect to the elements of θ, giving k normal equations of the form

$$\frac{\delta S}{\delta \theta_j} = 2 \sum_{i=1}^{n} \left[(y_i - f(\underline{x}_i, \hat{\underline{\theta}})) \frac{\delta f(\underline{x}_i, \underline{\theta})}{\delta \theta_j} \right]_{\theta = \hat{\theta}} = 0 \qquad j = 1, \ldots k \qquad (3\text{–}13)$$

When the model (3–1) is non-linear in the θ's the partial derivatives appearing in the middle of (3–13) will also involve the θ's and as a result the normal equations will be non-linear. In such cases the solution of the normal equations can be extremely difficult to obtain and iterative methods must be employed in nearly all cases. To compound the difficulties it may happen that multiple solutions exist corresponding to multiple stationary values of the function $S(\underline{\theta})$.

We now discuss some of the methods which have been used to estimate the parameters of the non-linear system. In general, each method begins with an initial guess of the values of θ, $(\theta_{1,0}, \theta_{2,0}, \ldots)$ called the starting point. Then a step size ϕ_0 is determined so that the value of $S(\underline{\theta})$ evaluated at $\underline{\theta}_1$ (where $\theta_{11} = \theta_{1,0} + \phi_{10}$ etc) is less than $S(\underline{\theta})$ at $\underline{\theta}_0$. The sequence of points θ_i is built up using information on the function values and in many instances any derivatives that can be calculated, but the precise formulation varies from method to method. If it happens that the method is unable to generate a new set of θ's that reduces $S(\underline{\theta})$ or if the percentage change in $S(\underline{\theta})$ reaches a small value, the process is terminated. Unfortunately, nothing can be said about how close this final solution is to the "true" solution (i.e. those θ's that produce the theoretical minimum of $S(\underline{\theta})$).

It is well known that when $f(\underline{x}, \underline{\theta})$ is linear in the θ's the contours of constant $S(\underline{\theta})$ are ellipsoids when plotted in the parameter space, while if $f(\underline{x}, \underline{\theta})$ is non-linear the contours are distorted according to the non-linearity. Typically, the contour surface of $S(\underline{\theta})$ is greatly attenuated in some directions and elongated in others so that the minimum lies at the bottom of a long curving trough. Furthermore, they may have multiple loops surrounding a number of stationary values and the resulting minimum may be local rather than global.

If we consider a two parameter example, Figure 3.1 illustrates the above problem.

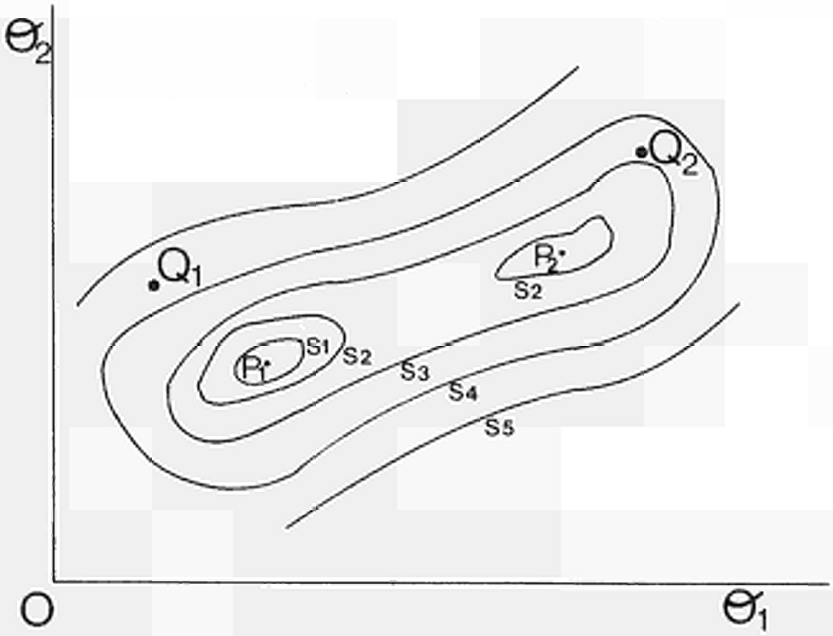


Figure 3.1 Contour surface showing a global and local minimum

The contours labelled $S_1, S_2, S_3, \ldots$ are isovalue contours of the sum of squares function and $S_1 < S_2 < S_3 < \ldots$. If the iterations were started at Q_1 then the search may terminate at P_1. But if we were to start at Q_2 rather than Q_1 then the search would terminate at P_2. The point P_2 is a local minimum and P_1 is the desired global minimum.

The problems are further complicated by the fact that the prediction function $f(\underline{x}, \underline{\theta})$, and hence the residuals, are not computed exactly. The $f(\underline{x}, \underline{\theta})$ is defined by computer language statements which, in turn, are evaluated using the finite precision of a computer. Thus the mathematical problem that the user has in mind is replaced by an approximate computational problem which is to be solved.

3.2.2a The Method of Steepest Descent

The gradient of the $S(\underline{\theta})$ surface is computed and the θ_i moved in the direction of steepest descent, i.e. along a vector direction $\underline{\delta}_g = -(\frac{\delta S}{\delta \theta_1}, \frac{\delta S}{\delta \theta_2}, \ldots \frac{\delta S}{\delta \theta_k})$. The process is repeated until it is not possible to move downslope any further. However, while the method will converge it is often extremely slow after the first few iterations. This is particularly true when the $S(\underline{\theta})$ contours are attenuated and banana-shaped, or when the path zig zags slowly along a narrow ridge. Nevertheless, various procedures exist for accelerating the descent.

3.2.2b The Gauss-Newton Method

The method is based upon expanding $f(\underline{x}, \underline{\theta})$ in a Taylor series and uses the results of linear least squares in a succession of stages.

Let $\underline{\theta}_0$ be a vector of initial values of the parameters. If we carry out a Taylor series expansion of $f(\underline{x}, \underline{\theta})$ about $\underline{\theta}_0$ and curtail the expansion at the first derivatives, we can say that approximately, when $\underline{\theta}$ is close to $\underline{\theta}_0$

$$f(\underline{x}_i, \underline{\theta}) = f(\underline{x}_i, \underline{\theta}_0) + \sum_{j=1}^{k} \left[\frac{\delta f(\underline{x}_i, \underline{\theta})}{\delta \theta_j}\right]_{\theta=\theta_0} (\theta_j - \theta_{j0}) \tag{3–16}$$

If we set

$$\begin{aligned} f^0 &= f(\underline{x}, \underline{\theta}_0) \\ \beta_j^0 &= \theta_j - \theta_{jo} \\ Z_{ji}^0 &= \left[\frac{\delta f(\underline{x}_i\, \underline{\theta})}{\delta \theta_j}\right]_{\theta=\theta_0} \end{aligned} \tag{3–17}$$

we see that (3–1) is approximately

$$y_i - f_i^0 = \sum_{j=1}^{k} \beta_j{}^0 Z_{ji}^0 + u_i \qquad \begin{matrix} i = 1, \ldots n \\ j = 1, \ldots k \end{matrix} \tag{3–18}$$

We can now estimate the parameters by linear least squares,

giving

$$\hat{\underline{\beta}}_0 = (\underline{Z}_0{}' \underline{Z}_0)^{-1} \underline{Z}_0{}'(\underline{y} - \underline{f}^0) \tag{3–19}$$

which will minimize the sum of squares

$$SS(\underline{\theta}) = \sum_{i=1}^{n} (y_i - f(\underline{x}_i, \underline{\theta}_0) - \sum_{j=1}^{k} \beta_j^0 Z_{ji}^0)^2 \tag{3–20}$$

with respect to β^0.

Let us write $b_j^0 = \theta_{j1} - \theta_{j0}$ then the θ_{j1} $j = 1, \ldots, k$ can be thought of as the revised best estimates of $\underline{\theta}$. We can now place the revised estimates in the same roles as were played above by the values θ_{j0} and go through exactly the same procedure described above but replacing all the zero subscripts by ones. This will lead to another set of revised estimates θ_{j2} and so on. This iterative procedure is continued until the solution converges, i.e. until the successive iterations $q, (q+1)$,

$$\left| \left\{ \theta_{j(q+1)} - \theta_{jq} \right\} / \theta_{jq} \right| < \text{eps} \qquad j = 1, \ldots, k$$

where eps is some prespecified amount, say 0.000001. At each stage $S(\underline{\theta}_q)$ can be evaluated to see if a reduction in its value has actually been achieved.

The drawbacks of this method are that it may not converge and even if it eventually does it may do so very slowly and may even oscillate widely, continually reversing direction. Several methods have been devised in an attempt to combat the deficiences of these two methods, the most widely used are based on the method developed by D. W. Marquardt (1963).

3.2.2c Marquardt's Maximum Neighbourhood Method

This method represents a compromise between the other two methods we have described.

Suppose we start from a certain point in the parameter space θ. If the method of steepest descent is applied, a certain vector direction $\underline{\delta}_g$, is obtained for movement away from the initial point. However, this may be the best local direction in which to move to attain smaller values of $S(\underline{\theta})$ but may not be the best overall direction. The best direction must be within 90° of $\underline{\delta}_g$ or else $S(\underline{\theta})$ will get larger locally. The Taylor series method leads to another correction vector $\underline{\delta}_t$ given by a formula like (3–19); Marquardt found that for a number of practical problems he studied, the angle, ϕ say, between $\underline{\delta}_g$ and $\underline{\delta}_t$ fell in the range $80° < \phi < 90°$. In other words the two directions were almost at right angles. The Marquardt algorithm provides a method for interpolating between the vectors $\underline{\delta}_g$ and $\underline{\delta}_t$ and for obtaining a suitable step size as well.

This latter method appears to combine the best features of the Gauss-Newton and Steepest Descent methods while avoiding their most serious limitations. It is good in that it almost always converges and does not "slow down" as the other methods often do.

3.2.2d The Simplex Method of Nelder and Mead

The simplex method of Nelder and Mead (1965) is widely accepted as more robust, though rather less efficient, than many available methods for unconstrained optimization.

We will briefly describe the iterative method for the minimization of a function, $S(\underline{\theta})$, of k variables. The method depends on the comparison of the function values at the $(k+1)$ vertices of a general simplex, followed by the replacement of the vertex with the highest value by another point. The simplex adapts itself to the local landscape, elongating down long inclined planes, changing direction on encountering a valley at an angle and contracts on to the final minimum.

Let $P_0, P_1, P_2, \ldots\ldots P_k$ be the $(k+1)$ points in k-dimensional space defining the current simplex.

We write S_i for the function value at P_i and define

h as the suffix such that $S_h = \max_i(S_i)$

l as the suffix such that $S_l = \min_i(S_i)$

Further we define $\bar{P}$ as the centroid of all vertices *excluding* P_h, and write $[P_i\, P_j]$ for the distance from P_i to P_j.

Initially, P_h is reflected in $\bar{P}$ to give a new point P_r, where

$$P_r = (1 + \alpha)\,\bar{P} - \alpha P_h$$

in which α is a positive constant termed the **reflection coefficient.**

Thus P_r is on the line joining P_h and $\bar{P}$, on the side of $\bar{P}$ opposite P_h with

$$\alpha = \frac{[P_r\,\bar{P}]}{[P_h\,\bar{P}]}$$

If $S_h > S_r > S_l$ then P_r replaces P_h and the basic iteration continues with the new simplex.

If $S_r < S_l$, i.e. if reflection has produced a new minimum, then we expand P_r to P_e by the relation

$$P_e = \gamma P_r + (1 - \gamma)\,\bar{P}$$

in which the **expansion coefficient**, γ, is given by

$$\gamma = \frac{[P_e\bar{P}]}{[P_r\bar{P}]}$$

If $S_e < S_l$, the expansion has been successful and we replace P_h by P_e and restart the process. Otherwise the expansion has been a failure and P_h is replaced by P_r before restarting.

If on reflecting P_h to P_r we find that $S_r > S_i$ for all $i \neq h$, i.e. if reflection has produced a new maximum, then a contraction of the simplex is called for.

This takes the form

$$P_c = \beta P_h + (1 - \beta)\,\bar{P}$$

where the **contraction coefficient**, β, is given by

$$\beta = \frac{[P_c\bar{P}]}{[P_h\bar{P}]} \qquad o < \beta < 1$$

If $S_c < S_h$ the contraction is considered successful and P_c replaces P_h and the basic process recommenced. If the contraction is not successful we replace all the P_i's, $i \neq 1$, by $(P_i + P_1)/2$ and restart the process.

The criterion used for halting the procedure is that

$$\sqrt{\frac{1}{k}\sum(S_i - \bar{S})^2} < \text{eps}$$

where eps is a parameter which is set according to the accuracy required.

A failed expansion may be thought of as resulting from an inroad into a valley (P_r), but at an angle to the valley so that P_e is well up on the opposite slope.
A failed contraction is much rarer, but can occur when a valley is curved and one point of the simplex is much farther from the valley bottom than the others; contraction may then cause the reflected point to move away from the valley bottom instead of towards it. Further contractions are then useless.

The basic steps of reflection, expansion and contraction are illustrated in Figure 3.2 for a problem with two variables and, therefore, a simplex with three vertices.

Nelder and Mead found that useful values for the operational coefficients were $\alpha = 1$, $\beta = ½$, $\gamma = 2$, corresponding to a simple reflection, halving when in difficulty and doubling when a useful direction is located.

All these non-linear procedures require the user to provide initial values of the parameter $\underset{\sim}{\theta}$. All available prior information should be used to make these values as reliable as possible. Good starting values will often allow an iterative technique to converge to a solution faster than it would otherwise do. Also poor starting values may result in convergence to unwanted local minima or the inability to find any solution (usually due to "overflow" in the computer arithmetic).

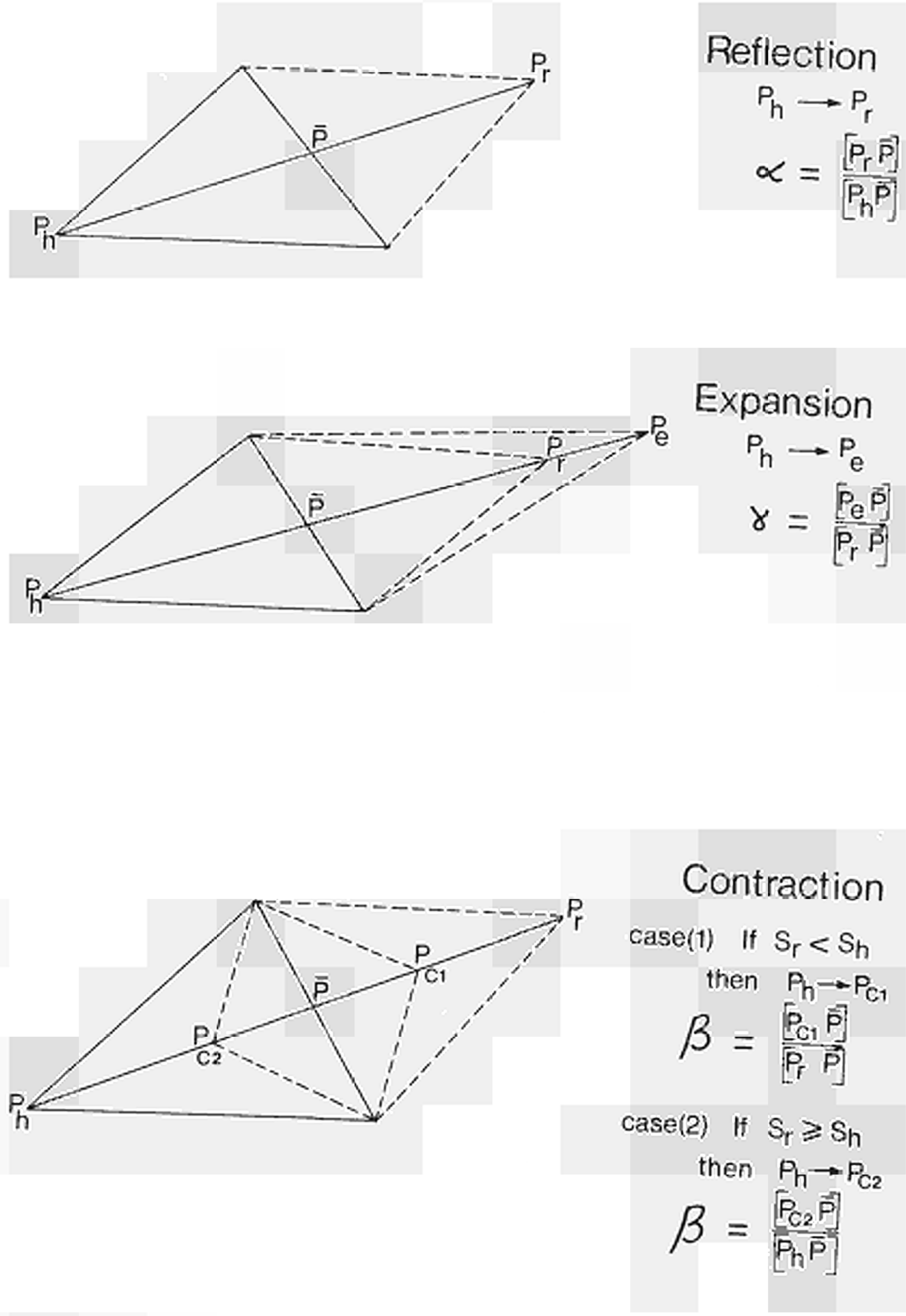


Figure 3.2 The basic operations of the simplex method

In the non-linear case the variance-covariance matrix of the parameter estimates possesses asymptotic properties allowing approximate confidence limits to be calculated. The usual tests of significance are also approximate, the approximation improving as we increase the sample size. However, very little is known about sampling properties in the small sample case.

3.3 Curve Fitting applied to Orchard Yield/Age Data

In fitting curves to the yield data described in Chapter 2, our objective is to obtain production yield/age curves using the methods discussed in this chapter and to compare them with those provided by the experts. From the data available we selected those we considered adequate in terms of both quality and quantity. For the remainder of this chapter we shall outline our method of approach and findings.

3.3.1 Exploratory Stage

The first step in the analysis was to obtain a few scatter plots of yield against age in order to get a "feel" for the data. From these we were able to gain a visual portrayal of, (a) the general form of the relationship, (b) the variability of the data, and (c) the sparcity of the data at certain ages.

3.3.2 Variability of the Data

An inspection of the scatter plots would suggest that variability tends to increase with age of orchard. This is particularly true with apples and pears and to a lesser degree with peaches. This variability is due to several factors; the most important are probably climate and management (use of improved rootstocks, pruning, use of pesticides and fertilizers etc.). A further source of variation is the grouping of density of orchard. For example, Density 2 may have 401 trees per ha. at one extreme and 799 at the other, and denser plantations tend to have higher yields per ha. than the less dense.

We have no information on these important omitted variables and even if we had it is difficult to see how many of them could realistically be incorporated into our forecasting model. It is for this reason that we are concerned only with establishing 'normal' yields and forecasting production potential in terms of percentage change.

We are left, therefore, with the problem of fitting equations to extremely variable replicate data which show strong evidence of heteroscedasticity (a breakdown in the assumption of constant variance of the disturbance term).

The usual theoretical approach for dealing with heteroscedasticity is to weight each of the observations so the less reliable the information, in terms of its associated variability, the less it contributes to the estimate.

Suppose we postulate $\underline{y} = \underline{X}\,\underline{\theta} + \underline{u}$ in the usual way but $E(\underline{u}\underline{u}') = \sigma^2 \underline{\Omega}$ instead of the ordinary least squares assumption that $E(\underline{u}\underline{u}') = \sigma^2 \underline{I}$. The variance-covariance matrix of the residuals takes the form

$$E(\underline{u}\underline{u}') = \sigma^2 \underline{\Omega} = \sigma^2 \begin{bmatrix} 1/k_1 & 0 & 0 \ldots\ldots & 0 \\ 0 & 1/k_2 & & . \\ 0 & & 1/k_3 & . \\ . & & . & . \\ . & & . & \\ 0 & 0 \quad . & . \quad . & 1/k_n \end{bmatrix} \tag{3–21}$$

where k_i is the weight associated with observation i.

The resulting minimum variance estimator of $\underline{\theta}$ is

$$\underline{\theta} = (\underline{X}'\underline{\Omega}^{-1}\,\underline{X})^{-1}\,\underline{X}'\underline{\Omega}^{-1}\underline{y} \tag{3–22}$$

which is known as the generalized least squares estimator of $\underline{\theta}$.

It is also appropriate to consider an alternative model with a multiplicative, as opposed to an additive, disturbance term.

$$\underline{y} = f(\underline{x}, \underline{\theta})\underline{u} \tag{3–23}$$

where $E(\underline{u}) = \underline{i}$, $E(\underline{u}\underline{u}') = \sigma^2 \underline{I}$

However, although the disturbance term, u, is assumed to have constant variance, the conditional variance of the dependent variable can be shown to be porportional to its conditional expectation.

i.e. $\mathrm{Var}\,(y|X) = E(y|X)^2\,\sigma^2$

This 'heteroscedasticity' across the conditional variance of y in the multiplicative model may be ameliorated by a logarithmic transformation of the equation (Goldberger, 1971).

To study changes in the conditional variance of y we plotted within each age group, the square of the mean yield against the variance. We illustrate this in Figure 3.3. It can be seen that the results, though often widely scattered, show some evidence of a linear relationship emanating from the origin. In such cases a logarithmic transformation of the yield data

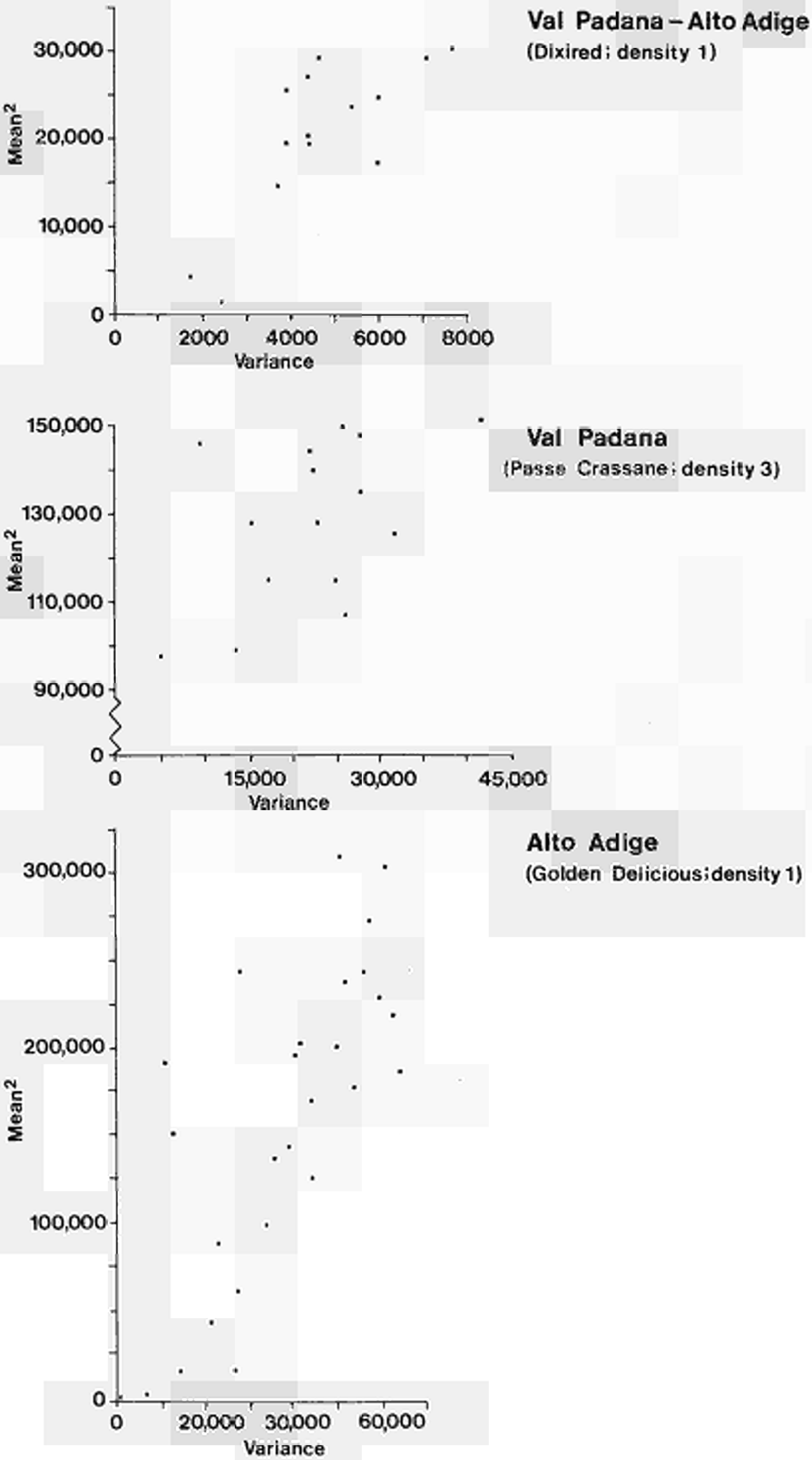


Figure 3.3 Examples of the relationship between the conditional variance of yield and the square of the conditional mean.

will help to stabilize the variance. However, heteroscedasticity by itself is not sufficient justification for adopting a particular transformation. It is more natural to investigate the form of the function independently. The results of such an investigation are given below.

3.3.3 The Equations Fitted

An extensive search by the authors resulted in a short list of the following functions:

QUADRATIC $y = a + bx + cx^2$ (3–24)

LOG QUADRATIC $y = Ae^{bx + cx^2}$ (3–25a)

$\ln y = a + bx + cx^2$ (3–25b)

LOG RECIPROCAL $y = Ae^{b/x}$ (3–26a)

$\ln y = a + b/x$ (3–26b)

HOERL'S SPECIAL FUNCTION

$y = Ax^b e^{cx}$ (3–27a)

$\ln y = a + b \ln x + cx$ (3–27b)

The above are all intrinsically linear in the parameters and can be fitted using linear least squares with the appropriate assumptions about the residual variance.

MODIFIED GOMPERTZ[(1)]

$y = Ae^{-be^{-cx}} e^{dx}$ (3–28a)

$\ln y = a - be^{-cx} + dx$ (3–28b)

GENERALIZED LOGISTIC – we use the form suggested by Nelder (1962)

$$y = \frac{A}{(1 + \phi e^{-b - cx})^{1/\phi}} \qquad (3\text{–}29a)$$

$\ln y = a - 1/\phi \ln(1 + \phi e^{-b - cx})$ (3–29b)

When $\phi = 1$ we have the 3-parameter logistic curve

$\phi = -1$ we have the Mitscherlich (diminishing returns) curve

$\phi \rightarrow 0$ we have the standard Gompertz curve

We also found it necessary to fit the standard Gompertz and the 3-parameter logistic independently of the modified Gompertz and generalized logistic.

(1) The modified Gompertz curve was suggested by biometricians at Long Ashton (Bristol). In their work with English orchard data they found that in the majority of cases d was not significantly different from zero, implying the standard Gompertz to be sufficient.

The generalized logistic provides a family of asymptotic 'growth' curves where A defines the level of the asymptote. The Mitscherlich or monomolecular curve has no point of inflexion, its growth rate declining linearly with increasing Y.

The logistic curve is symmetrical about its point of inflexion, its relative growth rate declines linearly with increasing Y. The Gompertz is similar to the logistic but is asymmetrical, inflecting at $A/e = (0.36A)$.

The modified Gompertz and generalized logistic are intrinsically non-linear and are fitted by non-linear least squares methods. (They may, of course, be fitted using maximum likelihood methods as an alternative procedure).

In all the preceding equations, except the quadratic, we were able to perform logarithmic transformations of the dependent variable. The only aspect of the transformation that requires careful attention concerns the stochastic disturbance. The use of the least squares criterion for fitting equations requires that the disturbance term is ADDED to whatever form is fitted. Let us look at this requirement in more detail.

3.3.4 Transformations of the Dependent Variable and its implications on the Stochastic Model

The specification of the model, including the manner in which the disturbance term is introduced, should not be dictated by mathematical or computational convenience. It is important to keep in mind that such a specification represents a commitment on our part concerning our prior knowledge and beliefs about the relationship that is being modelled. Since the stochastic disturbance determines the distribution of the dependent variable for any set of fixed values of the explanatory variables, its role in the regression model is quite crucial. Clearly, we need to be aware of the implications of the particular specification put forward. For instance, in the case of the Hoerl's function described in the last section, if we assume a multiplicative disturbance in the pre-transformed equation this implies that the distribution of yields for any given age of orchard is log normal, i.e. skewed. This must be our view of the world if we wish to insist on that specification.

Suppose we specify

$$y = Ax^b e^{cx} u \qquad (3\text{–}30a)$$

where u is a multiplicative disturbance.

Taking logs

$$\ln y = a + b\ln x + cx + \ln u \quad (3\text{–}30b)$$

which is linear in the parameters and suitable for solution by linear least squares.

However, suppose we specify

$$y = Ax^b e^{cx} + u \quad (3\text{–}31a)$$

where u is an additive disturbance.

Taking logs

$$\ln y = \ln(Ax^b e^{cx} + u) \quad (3\text{–}31b)$$

produces a rather intractable expression which is non-linear in the parameters and is unsuitable for solution by linear least squares methods. However, we could find a non-linear solution to the form (3–31a). It is important to note that the application of least squares to (3–30b) results in minimizing $\sum(\ln\epsilon)^2$ whereas applying least squares to (3–31a) results in minimizing $\sum\epsilon^2$, where ϵ_i represent the observed disturbances.

In view of our observations with respect to the variability of the yield data in section 3.3.2, we consider a multiplicative disturbance specification to be preferable to an additive one. This means that least squares methods can be applied to the transformed equations. This being so we should look further at the implications of this assumption.

In the model

$$\ln y = a + b\ln x + cx + \ln u \quad (3\text{–}30b)$$

assuming $\ln u \sim N(0,\sigma^2)$ then u is log normally distributed with mean $e^{\frac{1}{2}\sigma^2}$ and variance $e^{\sigma^2}(e^{\sigma^2} - 1)$ and median 1.

The conditional mean of y in (3–27a) is

$$E(y|x) = Ax^b e^{cx} \cdot E(u)$$

$$= Ax^b e^{cx} e^{\frac{1}{2}\sigma^2}$$

and the conditional median of Y is

$$M(y|x) = Ax^b e^{cx} M(u)$$

$$= Ax^b e^{cx}$$

We may conclude, therefore, that

$$M(y|x) = E(y|x)e^{-\frac{1}{2}\sigma^2} \leqslant E(y|x)$$

The two central tendency functions differ in level although not in shape.

The usual approach of estimating functions involving the logarithmic transformation of y implicitly estimates the conditional median function rather than the conditional mean function.

In contrast, the systematic part of (3—30b) is at the same time the conditional mean and conditional median and the parameter estimates are best linear unbiased.

However, because our initial interest lies in the conditional distribution of y rather than ln y there are some problems which arise with respect to the level and value of the original function.

A, the level of $M(y|x)$ is equal to e^a and it is natural to estimate it by $e^{\hat{a}}$ which is the estimate customarily reported for the level of the original function. Since $\hat{a}$ is normally distributed then $e^{\hat{a}}$ is log normally distributed and thus

$$E(e^{\hat{a}}) = e^{E(\hat{a}) + \frac{1}{2}var(\hat{a})} = e^a . e^{\frac{1}{2}var(\hat{a})}$$

Thus $e^{\hat{a}}$ is biased as an estimate of A; the bias is upward and vanishes asymptotically.

One might attempt to adjust for the bias using

$$e^{\hat{a}} . e^{-\frac{1}{2}var(\hat{a})}$$

which would reduce but not eliminate the bias, although again it is asymptotically unbiased.

If interest is in estimating the level of the conditional mean function, i.e. $Ae^{\frac{1}{2}\sigma^2}$, clearly $e^{\hat{a}}$ is biased even asymptotically.

One might consider using

$$e^{\hat{a}} . e^{\frac{1}{2}\hat{\sigma}^2} \text{ or } e^{\hat{a}} . e^{\frac{1}{2}\hat{\sigma}^2} . e^{-\frac{1}{2}var(\hat{a})}$$

both are biased with bias vanishing asymptotically.

Goldberger (1968) presents a method for obtaining minimum variance unbiased estimators using a series expansion involving the gamma distribution, where the magnitude of successive terms tend to drop-off so rapidly that these unbiased estimators are of little difference to the simpler asymptotically unbiased estimators quoted above.

Goldberger's method is summarized as follows:

Let $\frac{\nu w}{\sigma^2}$ be distributed as χ^2_ν, where w is a random variable, ν a positive integer, and σ^2 a positive parameter. For a given constant c, an unbiased estimator of $\exp(c\sigma^2)$ is given by the function

$$F(w;\nu,c) = \sum_{j=0}^{\infty} f_j (cw)^j / j!$$

where

$$f_j = \frac{(\frac{1}{2}\nu)^j \, \Gamma(\frac{1}{2}\nu)}{\Gamma(\frac{1}{2}\nu+j)}$$

An unbiased estimator of the conditional median function is $\hat{A}_M = e^{\hat{a}}F_M$, where $F_M = F(w;v,c)$ with $\nu = n-k$, $w = \hat{\sigma}^2$ and $c = -\frac{1}{2}m^{00}$ such that $cw = -\frac{1}{2}\text{var}(\hat{a})$

An unbiased estimator of the conditional mean function is $\hat{A}_E = e^{\hat{a}}F_E$, where $F_E = F(w;v,c)$ with $\nu = n-k$, $w = \hat{\sigma}^2$ and $c = \frac{1}{2}(1-m^{00})$ such that $cw = \frac{1}{2}(\hat{\sigma}^2 - \text{var}(\hat{a}))$

We illustrate the results of this section using data for South West France; Golden Delicious, Density 1. A Hoerl's function is fitted to the 351 observations using linear regression and a summary of the results is given in Table 3.1.

TABLE 3.1

EXAMPLES OF LOGARITHMIC REGRESSION

$\ln y =$	$0.7512 + 2.7800 \ln x - 0.1514\,x$		
	(0.2956) (0.2039) (0.0166)		
$\bar{R}^2 =$	0.56	$\hat{\sigma}^2 = 0.2384$	$\nu = n-k = 351-3 = 348$

Alternative Estimates of Levels

Level of Median Function:	$A_M = e^a$		
(i)	$e^{\hat{a}} = 2.1195$		
(ii)	$e^{\hat{a}} . e^{-\frac{1}{2}\text{var}(\hat{a})}$	= 2.1195 x 0.9570	= 2.0284
(iii)	$e^{\hat{a}} . F_M$	= 2.1195 x 0.9569	= 2.0282
Level of Mean Function:	$A_E = e^a . e^{\frac{1}{2}\sigma^2}$		
(i)	$e^{\hat{a}} . e^{\frac{1}{2}\hat{\sigma}^2}$	= 2.1195 x 1.1266	= 2.3879
(ii)	$e^{\hat{a}} . e^{\frac{1}{2}(\hat{\sigma}^2 - \text{var}\hat{a})}$	= 2.1195 x 1.0781	= 2.2851
(iii)	$e^{\hat{a}} . F_E$	= 2.1195 x 1.0781	= 2.2851

3.3.5 Regressions on Means vs All Data

In many instances it is tempting to simplify the curve fitting by finding the average yield for each age of orchard and then to fit a curve through the means. However, considerable care must be taken if this is to be done.

The replicate data have generally different numbers of observations at each age and this should be accounted for if a biased curve fit is to be avoided. An ordinary least squares fit through the means gives equal weight to each observation thus attaching equal reliability to means calculated from a small number of observations with those calculated from a larger number. Figure 3.4 shows the bias that can result in this case. To overcome this problem either a weighted (generalized) least squares program must be used (where the

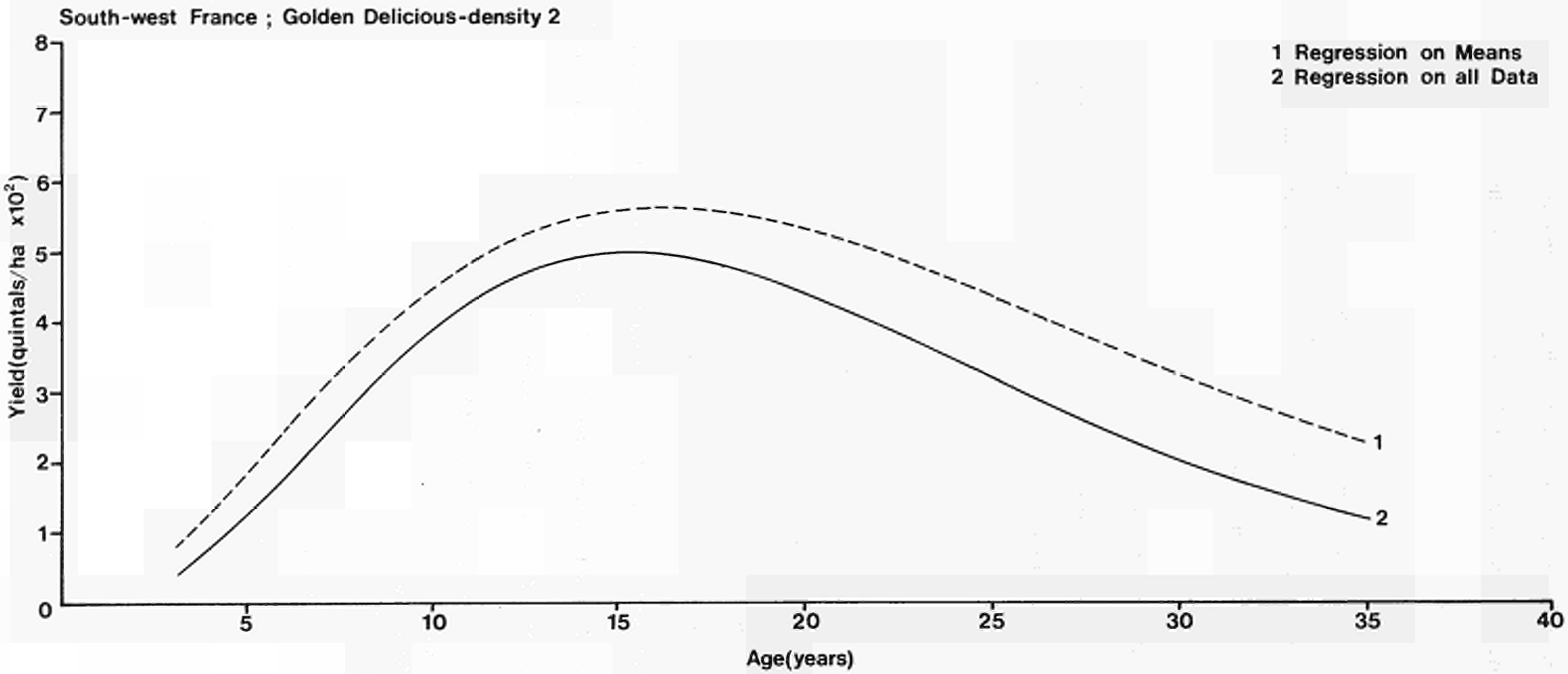


Figure 3.4 A comparison of regression curves fitted to data means and all data

weights correspond to the number of observations at each age), or an ordinary least squares fit must be applied to all the raw data where the differing number of replicate values is automatically taken into account.

3.3.6 Some Examples

We illustrate our approach to the curve fitting problem with some selected examples and present the results together with an account of the problems we encountered, particularly with regard to the non-linear least squares fitting.

3.3.6a Peaches

We found that asymptotic curves were unsuitable for peaches and so only the quadratic, log. quadratic, Hoerl's and modified Gompertz were considered. However, in the case of the quadratic we are assuming an additive disturbance specification whereas in the other three functions we assume a multiplicative disturbance.

Figure 3.5 a and b show plots of the residuals against age using data from the Val Padana and Alto Adige regions of Italy. It can be seen that the pattern of the residuals from the quadratic equation indicate a more widely dispersed and non-normal distribution than those from the Hoerl's equation. Furthermore, the shape of the quadratic is theoretically inferior to the other functions in that it has no point of inflexion and its rate of growth is linear throughout. We decided, therefore, to eliminate the quadratic from our list of curves. Table 3.2 gives a summary of the results and Figures 3.6 and 3.7 show the graph plots of these functions together with the curve provided by the 'expert'.

TABLE 3.2

RESULTS OF FITTING ALTERNATIVE CURVES TO PEACH DATA

Log Quadratic: $\ln y = a + bx + cx^2$

Hoerl's: $\ln y = a + b \ln x + cx$

Modified Gompertz: $\ln y = \ln a - be^{-cx} + dx$

		Log Quadratic	Hoerl's	Modified Gompertz
Val Padana and Alto Adige				
J. H. Hale – density 2	a	3.356	1.265	136.897
n = 96	b	0.234	2.660	116.198
	c	–0.008	–0.237	1.264
	d			–0.011
	$\bar{R}^2$	0.123	0.218	0.330
Val Padana and Alto Adige				
Dixired – density 1	a	2.132	0.075	134.510
n = 524	b	0.521	3.701	33.054
	c	–0.023	–0.351	0.883
	d			0.003
	$\bar{R}^2$	0.278	0.330	0.365

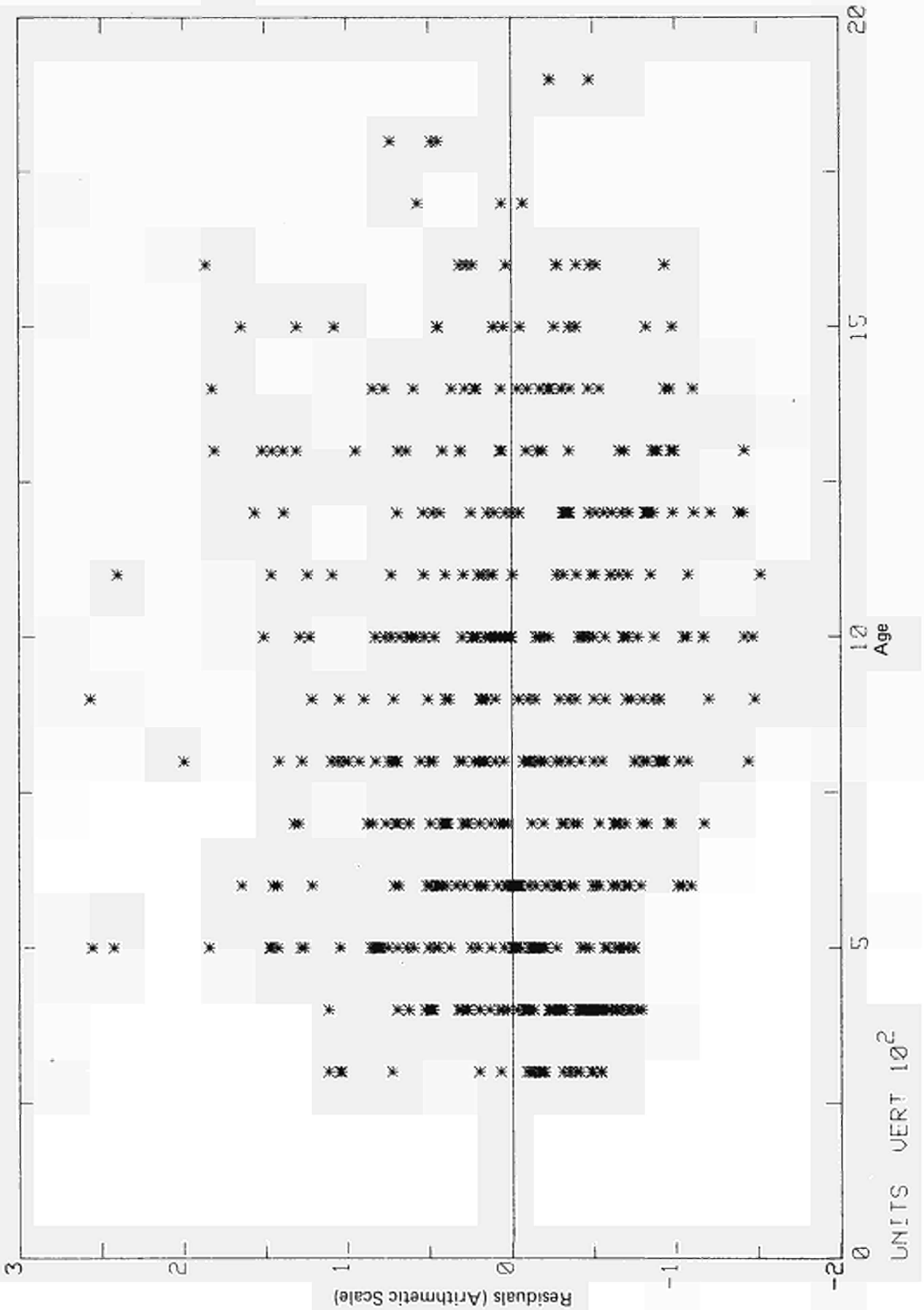


Figure 3.5a Plot of residuals from fitting a quadratic curve to Dixired – Density 1 yield/age data (Val Padana and Alto Adige)

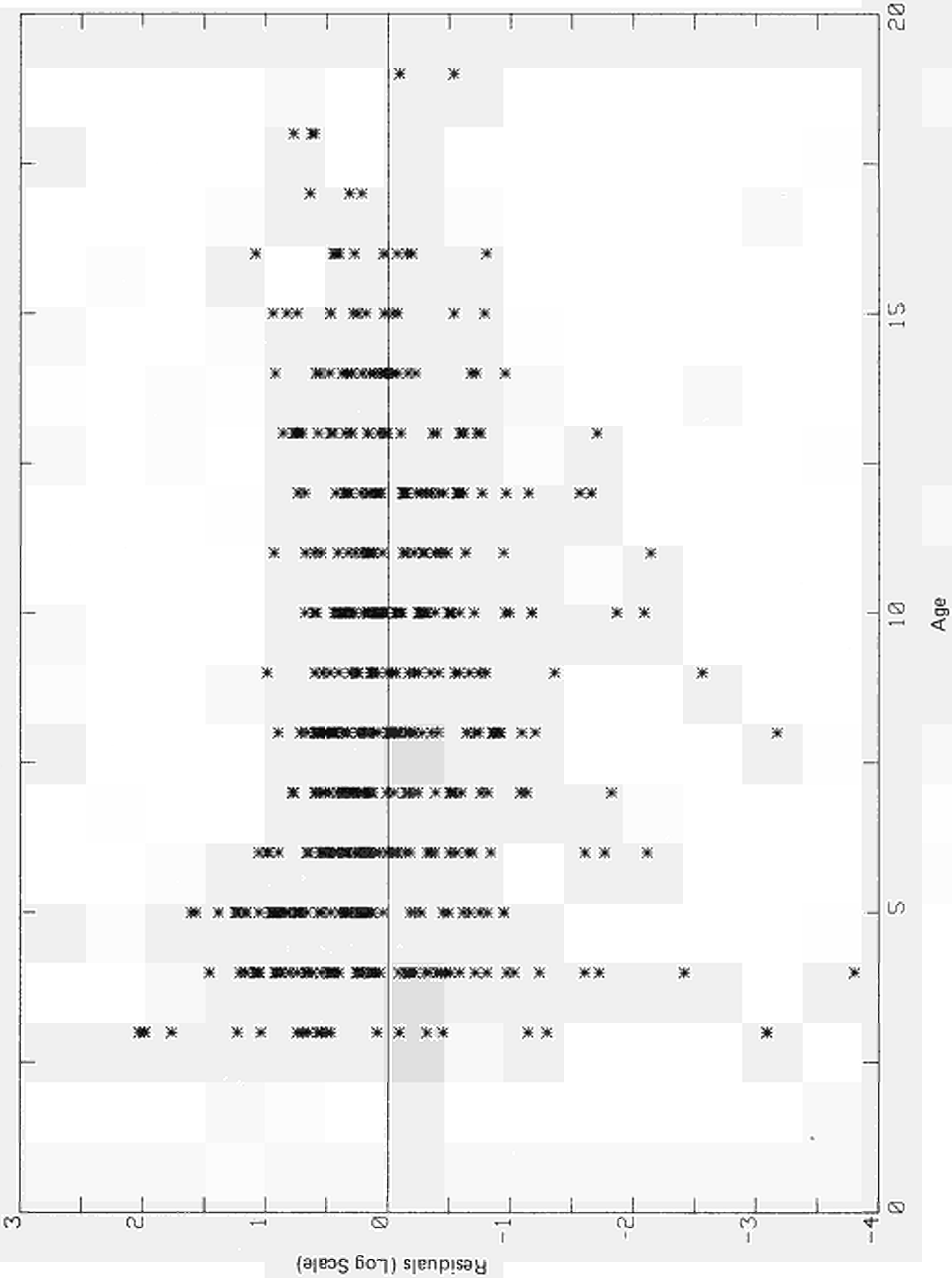


Figure 3.5b Plot of residuals from fitting a Hoerl's curve to Dixired – Density 1 yield/age data (Val Padana and Alto Adige)

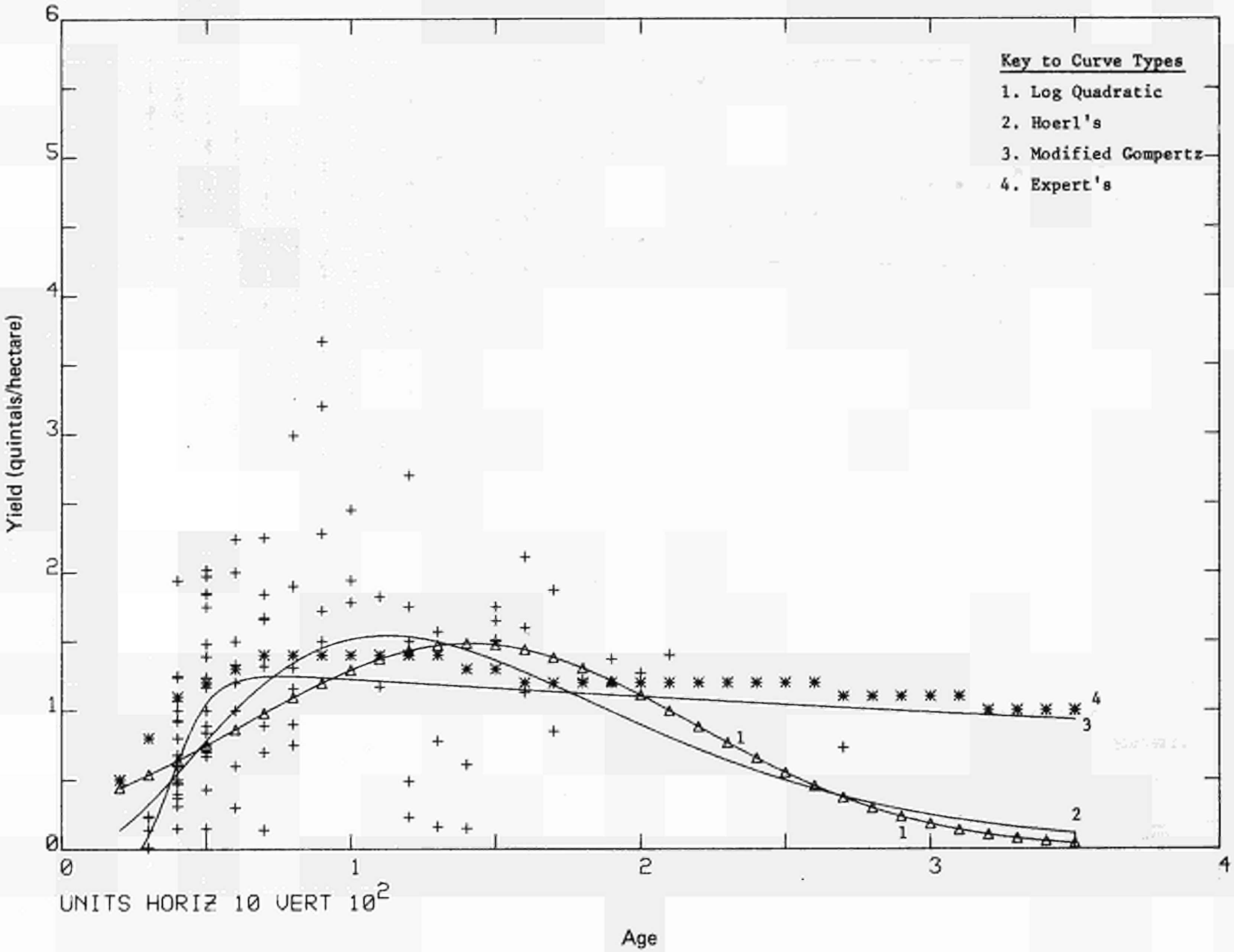


Figure 3.6 Alternative yield curves : J. H. Hale – Density 2 (Val Padana and Alto Adige)

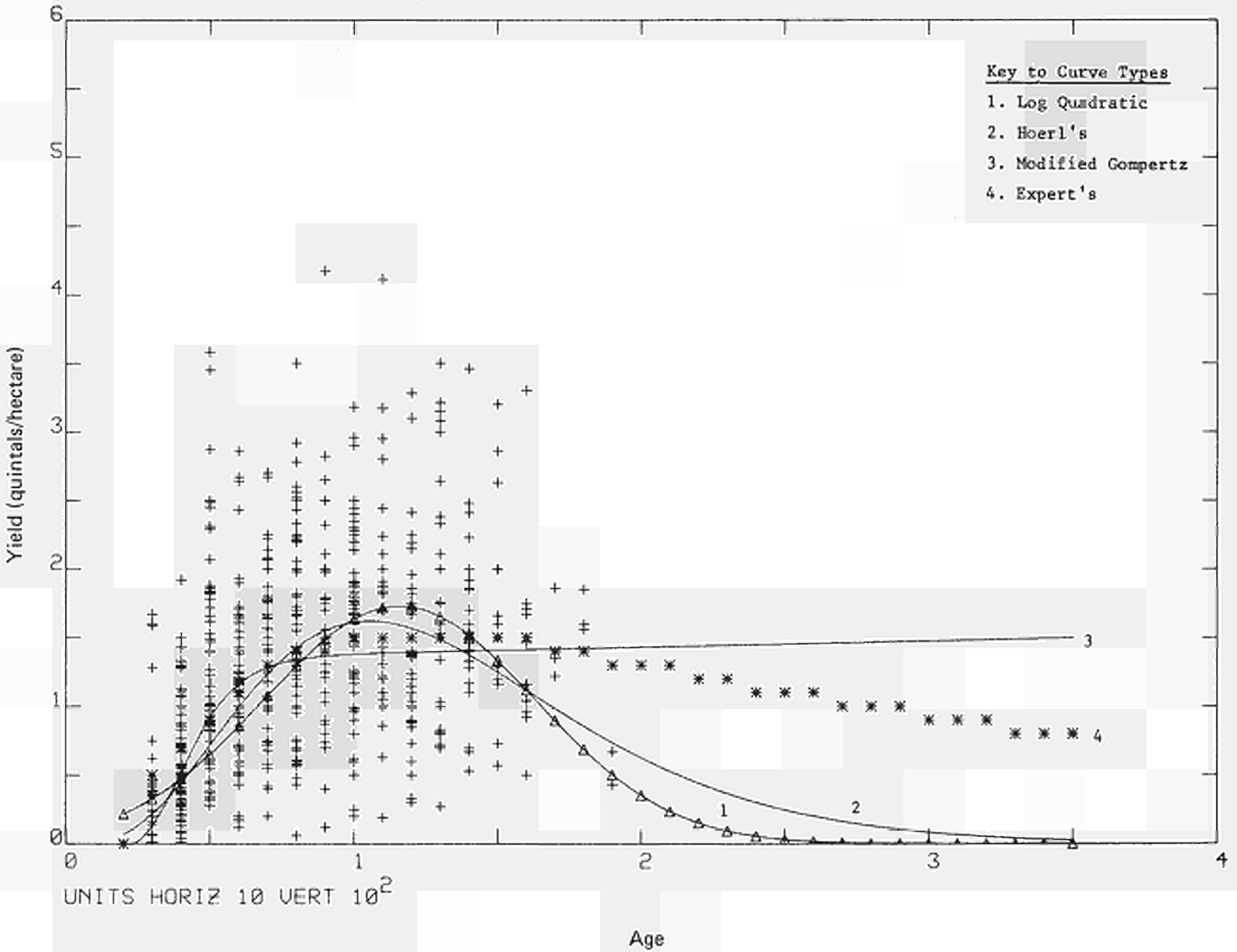


Figure 3.7 Alternative yield curves : Dixired – Density 1 (Val Padana and Alto Adige)

3.3.6b Apples and Pears

We group apples and pears together as the production curves for these two species are very similar. The only difference between them is one of level, i.e. pear yield is generally lower than apple yield.

TABLE 3.3

RESULTS OF FITTING ALTERNATIVE CURVES TO APPLE AND PEAR DATA

Log Reciprocal:	$\ln y = a + b/x$
Hoerl's:	$\ln y = a + b \ln x + cx$
Modified Gompertz:	$\ln y = \ln a - b \exp(-cx) + dx$
Standard Gompertz:	$\ln y = \ln a - b \exp(-cx)$
Generalized Logistic:	$\ln y = \ln a - {}^1\!/\!_d \ln(1 + d \exp(-b-cx))$
3-Parameter Logistic:	$\ln y = \ln a - \ln(1 + \exp(-b-cx))$

		Log Reciprocal	Hoerl's	Modified Gompertz	Standard Gompertz	Generalized Logistic	3-Parameter Logistic
S.W. France	a	6.555	1.486	492.773	314.199	297.892	287.167
Williams – Density 3	b	−13.624	3.904	9.947	10.765	−3.504	−5.388
n = 115	c		−0.220	0.280	0.328	0.464	0.682
	d			−0.022		0.386	
	$\bar{R}^2$	0.523	0.565	0.573	0.574	0.573	0.574
S.W. France	a	6.559	0.751	687.005	422.619	412.286	404.518
Golden Delicious – Density 1	b	−9.900	2.780	6.128	6.471	−2.647	−3.847
n = 351	c		−0.151	0.225	0.281	0.366	0.491
	d			−0.022		0.405	
	$\bar{R}^2$	0.542	0.560	0.561	0.560	0.560	0.560
S.W. France	a	6.888	0.761	450.721	517.238	490.106	468.442
Golden Delicious – Density 2	b	−9.985	3.155	7.002	6.799	−2.756	−4.122
n = 546	c		−0.206	0.335	0.312	0.423	0.597
	d			0.007		0.398	
	$\bar{R}^2$	0.478	0.488	0.484	0.486	0.486	0.486
Alto Adige	a	7.285	−0.066	769.933	565.497	526.890	488.380
Golden Delicious – Density 3	b	−9.999	4.843	10.961	11.141	−3.434	−6.508
n = 93	c		−0.472	0.466	0.503	0.722	1.375
	d			−0.027		0.284	
	$\bar{R}^2$	0.855	0.860	0.862	0.864	0.863	0.862
S.W. France	a	6.278	−0.220	441.396	324.093	318.145	317.691
Red Delicious – Density 1	b	−8.466	3.522	9.537	10.333	−4.554	−4.879
n = 231	c		−0.226	0.351	0.401	0.670	0.709
	d			−0.018		0.879	
	$\bar{R}^2$	0.254	0.348	0.334	0.317	0.321	0.324

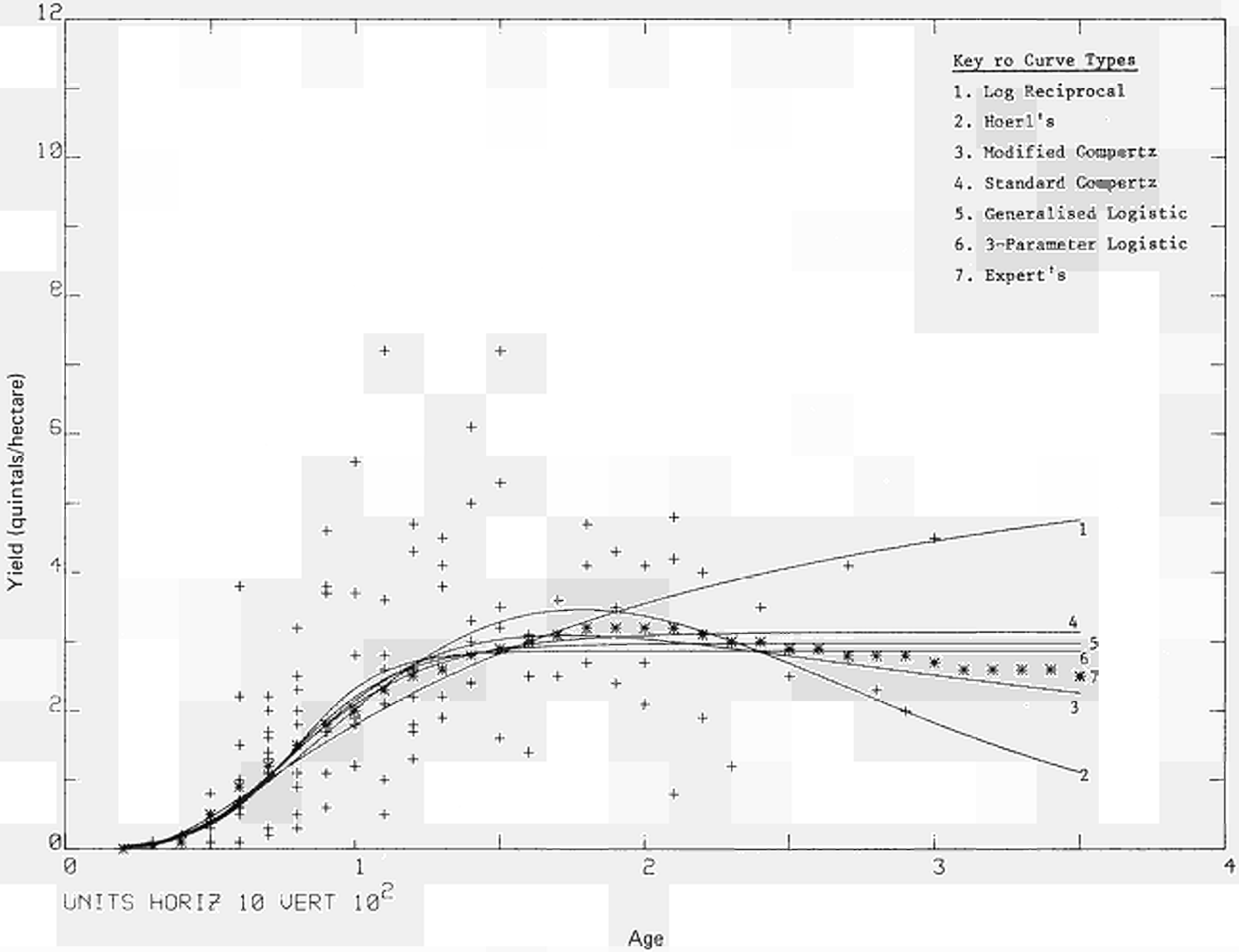
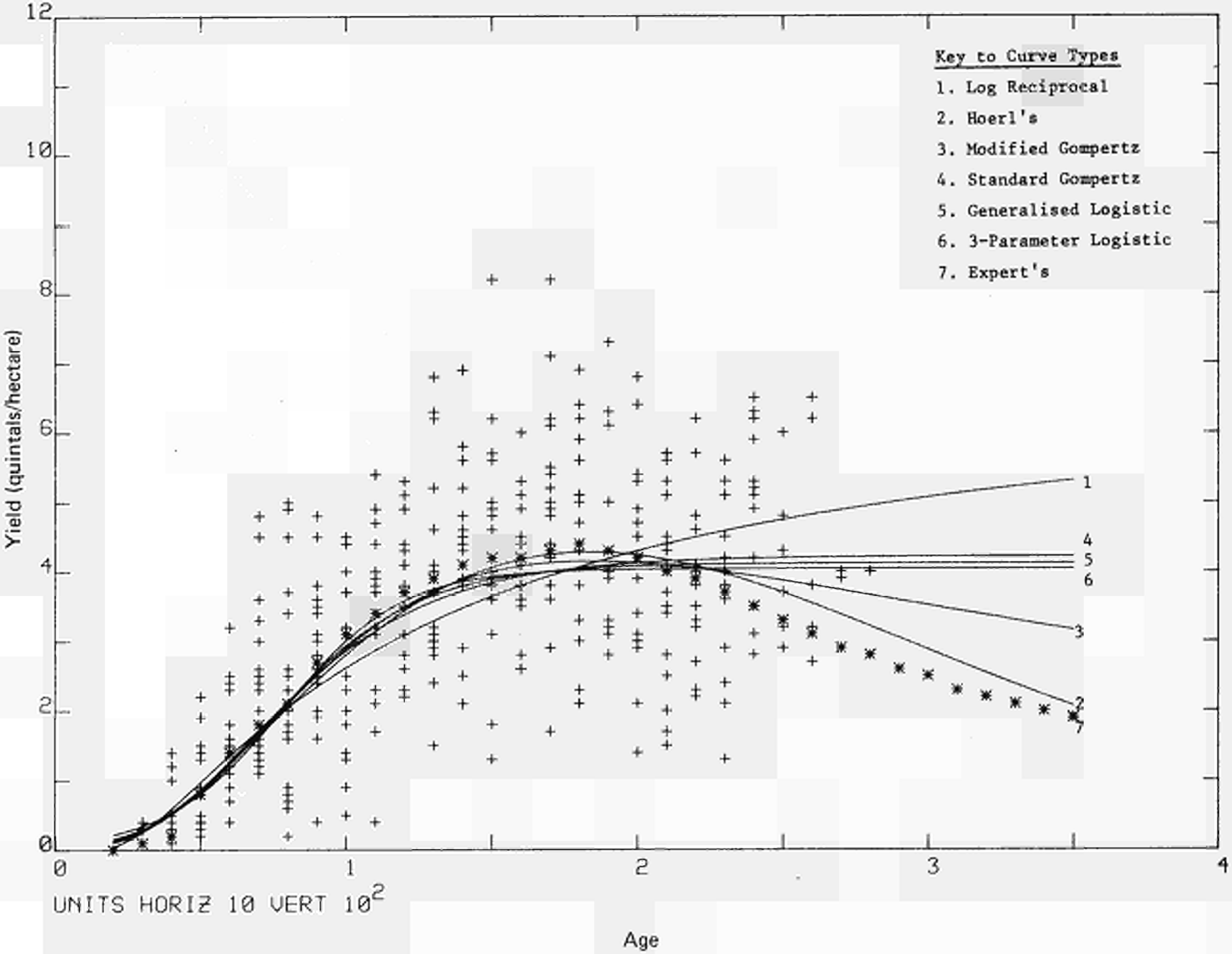


Figure 3.8 Alternative yield curves : Williams' – Density 3 (S.W. France)

Figure 3.9 Alternative yield curves : Golden Delicious – Density 1 (S. W. France)



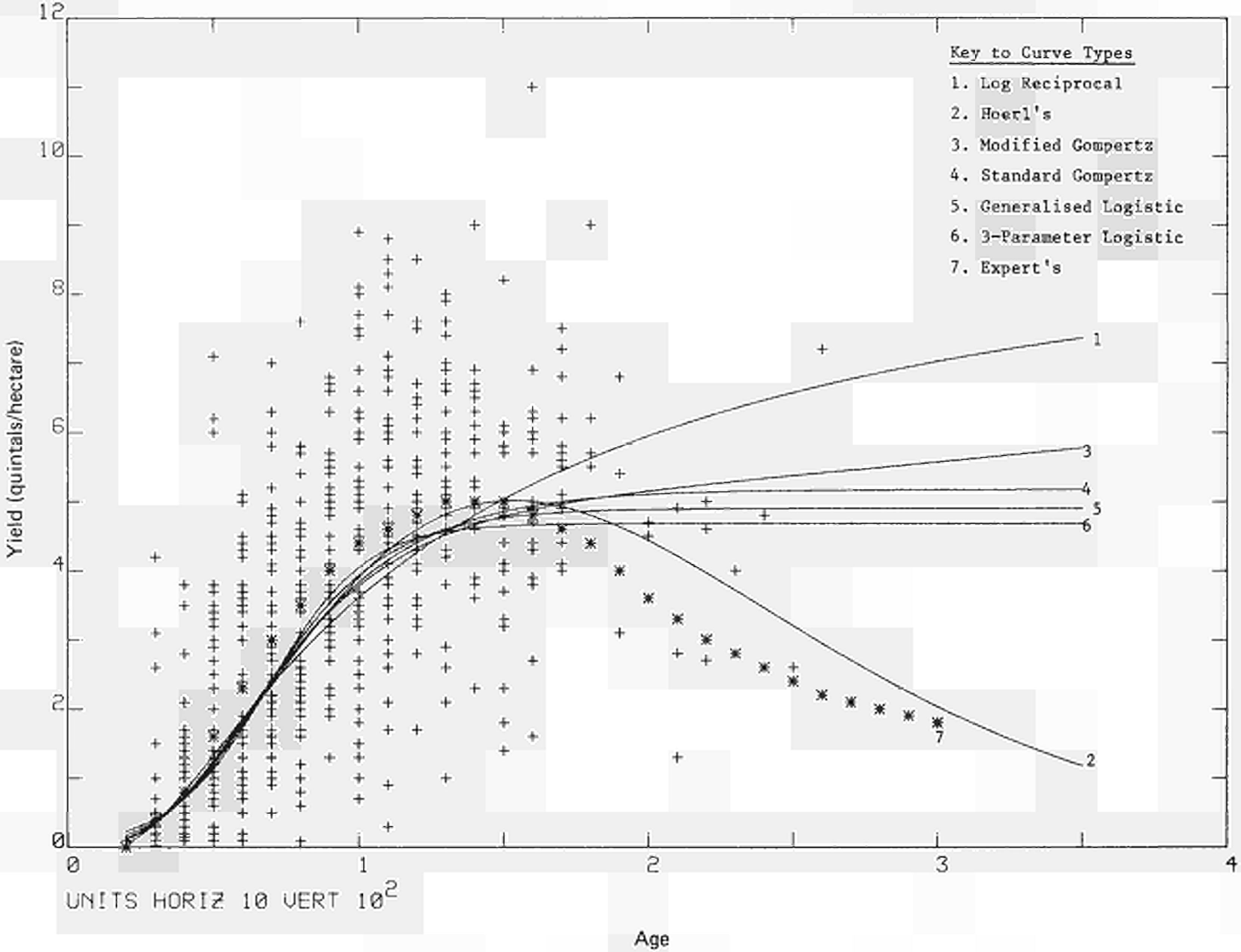


Figure 3.10 Alternative yield curves : Golden Delicious – Density 2 (S. W. France)

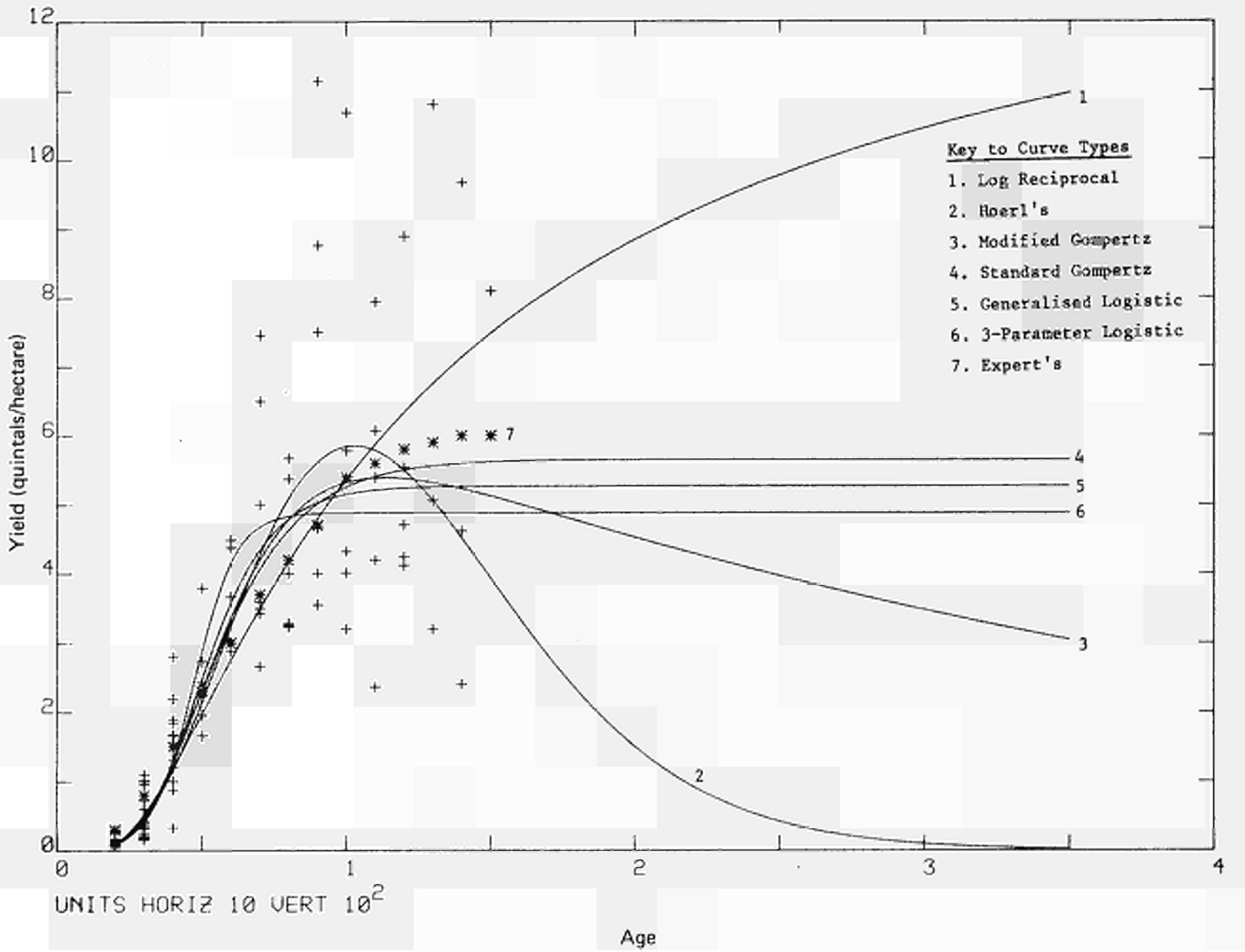


Figure 3.11 Alternative yield curves : Golden Delicious – Density 3 (Alto Adige)

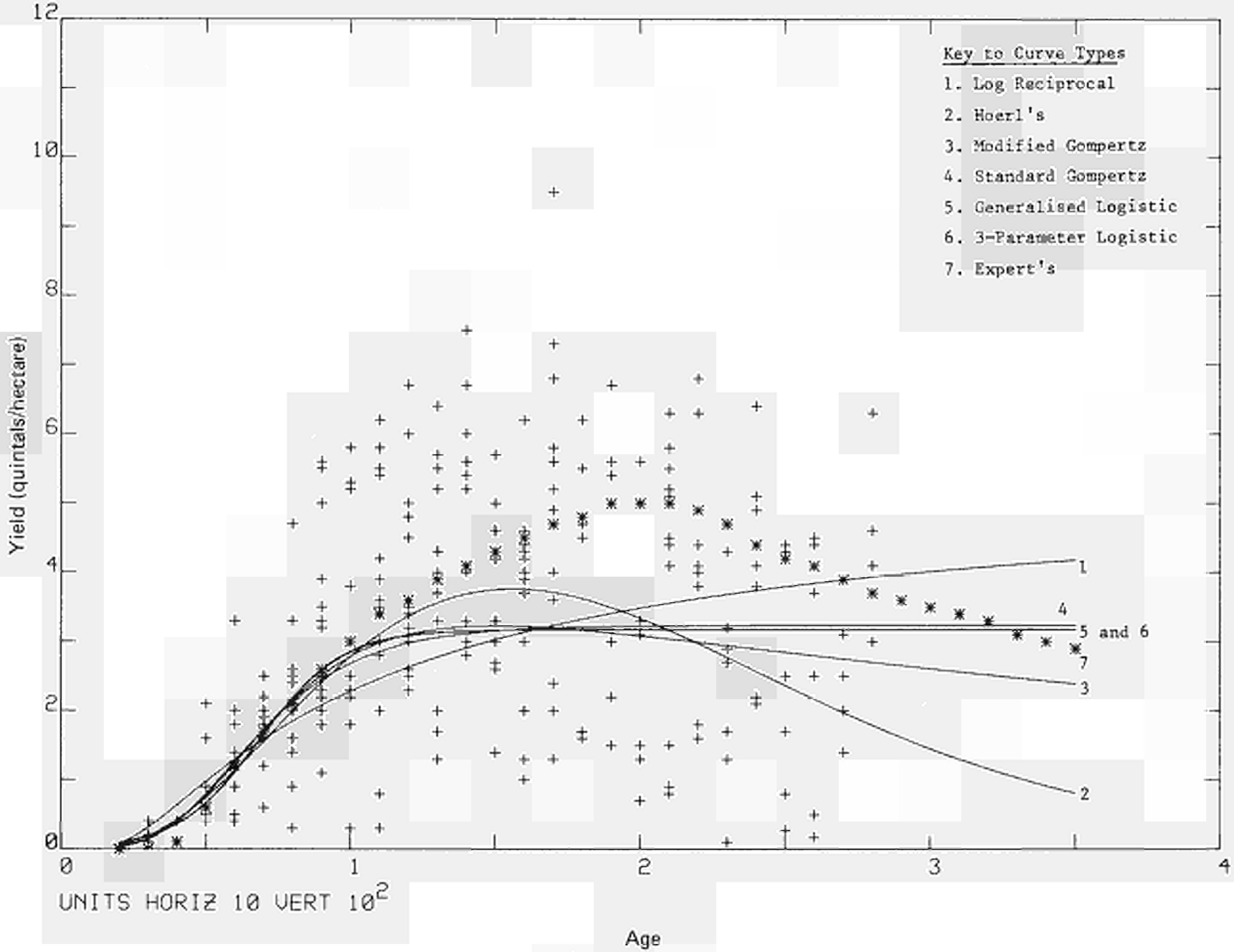


Figure 3.12 Alternative yield curves : Red Delicious – Density 1 (S. W. France)

In our original work for EUROSTAT we fitted the following functions:- Log. reciprocal, Hoerl's and 3-parameter logistic. We have since extended our investigations to include:- modified Gompertz, standard Gompertz and generalized logistic. Table 3.3 gives a summary of the results of fitting the above six equations to some selected apple and pear data and Figures 3.8 to 3.12 show graph plots of the results.

Golden Delicious – density 3 for Alto Adige (Italy) was selected to give some indication as to the effect of extrapolating the curves where data is available for young orchards only. The value of $\bar{R}^2$ shows that all equations fit the data almost equally well, but on extrapolation the curves differ widely.

3.3.7 Some Computational Aspects of Curve Fitting

The linearizable curves are simple to fit using an ordinary linear least squares regression package. However, the fitting by non-linear least squares presents many problems and the use of these routines requires caution and an awareness of the difficulties involved.

The results of the non-linear fits quoted in the previous section were obtained using one or other of the two routines; either the Marquardt method adapted by Powell (1968) or the simplex method of Nelder and Mead (1965).

We encountered the following problems:

(i) Limitations in the size of computer in terms of word length. Failures on one computer sometimes succeeded on another with a larger word-length.

(ii) The results were highly sensitive to the starting values, and different values often converged to different local minima.

(iii) The same starting values used in both routines often produced, (a) different minima, and (b) a successful solution for one method but a 'failure' by the other, for the same set of data.

We experienced greater success with the Nelder and Mead routine than with the Powell but the former often required many more iterations to converge than the latter.

The 'success' of the routines is to some extent dependent upon the number of parameters to be estimated, thus the 3-parameter equations generally produced fewer failures than the

4-parameter.

3.3.8 Confidence Intervals and Tests of Significance

The 95% confidence interval around the fitted equation is so wide, because of the high variability of the data, that we considered it to be of little use in this exercise.

Tests of significance of the parameters of the equations were not performed for the following reasons:

(i) Our non-linear fitting procedures did not provide us with standard errors of the estimates and so we were unable to attempt significance tests on the non-linear equations.

(ii) The usual tests of significance would not be strictly valid because of the lack of independence of the disturbance term (e.g. where we have time series data on the same orchards the disturbance will be autocorrelated).

(iii) Quite apart from the previous reasons, we believe that such tests of significance are not particularly relevant in this exercise. Our main concern is to fit equations to data which produce theoretically plausible curves. The fact that a parameter may not be significantly different from zero is no justification for its omission. For instance, in the modified Gompertz, if we were to omit the term in e^{dx} simply because it is frequently insignificant, we would be imposing the asymptotic rigidity of the standard Gompertz a priori.

3.3.9 Choice of Curves

Of the non-linear curves, as one would expect, the 3-parameter logistic, the standard Gompertz and the generalized logistic often give almost identical results and so it is unnecessary to fit all three. The generalized logistic has the obvious advantage of incorporating the other two functions but has the disadvantage of containing an extra parameter.

It is perhaps worth mentioning that after repeated failures fitting the generalized logistic we had to resort to fitting the simpler 3-parameter logistic in order to substitute the results as starting values in the generalized form.

The modified Gompertz has an advantage over the generalized logistic in that it is more flexible, allowing an increasing or decreasing 'tail'.

The Hoerl's function, although extremely versatile, does not allow the same flexibility in this context as the modified Gompertz, in that whilst maintaining a sigmoid 'growth' section it does not allow an increasing 'tail' section. However, it has the important advantage of being fitted by linear least squares and as such avoids all the real problems of non-linear fitting.

Nevertheless, the choice between curves must be made with reference to the forecast sensitivity, the results of which are given in Chapter 5.

CHAPTER 4

THE FORECASTING MODEL AND COMPUTER PROGRAM

4.1 Introduction

One of our major concerns in this study was to develop a procedure whereby forecasts of normal production of orchard fruit could be made. However, we had in mind the need to develop a model which is much more general and which could be readily adapted for use in forecasting production of any permanent crop. We hope, therefore, that the program outlined in this chapter will be found useful to anyone who may have the need to forecast the annual output of any commodity which follows a similar 'life-cycle' to that of orchard fruit.

4.2 The Forecasting Model

In mathematical terms the forecasting model developed by us for EUROSTAT may be stated as follows:

$$\mathrm{Prod}_b = \sum_{i=0}^{n} Y_i A_i$$

$$\mathrm{Prod}_{b+r} = Y_o P_r + \sum_{\substack{i=1 \\ r>1}}^{r-1} Y_i P_{r-i} \left(\prod_{j=1}^{i} C_{i-j,r-j}\right) + \sum_{i=r}^{n} Y_i A_{i-r} \left(\prod_{j=1}^{r} C_{i-j,r-j}\right)$$

where,

Prod_b	Estimated production in the base year	
A_i	Area under the crop at age i	$i = 0, \ldots\ldots n$
Y_i	Yield of crop at age i	$i = 0, \ldots\ldots n$
P_h	New planting in year h	$h = 1, \ldots\ldots r$
$C_{k,h}$	Clearing factor $(1 - c_{k,h})$	
	$c_{k,h}$ = clearing rate of area at age k in year h	$\begin{cases} k = 0, \ldots\ldots n \\ h = 1, \ldots\ldots (r-1) \end{cases}$
	n = upper limit of orchard age	
	$r = 1, 2, 3 \ldots$ is the forecast lead time	

4.3 The Forecasting Program – 'FORECAST'

Although the forecasting model described in section 4.2 is relatively simple it would be an enormous, if not impossible, task to produce a series of forecasts without the aid of a computer. Here we shall briefly describe the main points of interest in the Fortran IV computer program we have written for this purpose. The results presented in Chapter 6 of this study were obtained with the program or with a minor variation of it.

As presented here, the forecasting program FORECAST is written so that it may be easily understood and modified by other users. This basic version of FORECAST is, therefore, written in a fairly flexible style and as it stands runs with moderate efficiency. The latter may be easily improved and is very much dependent on the individual forecasting project being tackled. For routine analyses, many values are most efficiently assigned within the program rather than being 'read in' repetitively at run time.

FORECAST has been run successfully on a variety of computers including a CDC 7600 an ICL 1904S and an IBM 370, the latter machine being the main machine at the Community's headquarters in Luxembourg. On the CDC 7600 it compiled in 0.74 seconds and required 12k of memory. Total run time for a typical job producing four forcasts was 1.1 seconds, and each forecast produces about 120 lines of output. A complete listing of the Fortran source is to be found in Appendix 2.

4.3.1 The Variable List

To facilitate a study of the details of FORECAST the more important variable and constants used in the program are described below:

A (36,10)	a real array storing the area at each age, after clearings and plantings have taken place, for the whole forecast period JT
AGE (36)	a real vector holding the crop age values from 0 to 35
APLAN (10)	a real vector containing the calculated weighted plantings
APRODN (36,10)	a real array containing the production at each age of the crop for the forecast period JT
AREA (36)	a real vector holding the areas, in hectares, under the crop corresponding to ages 0 to 35 years AREA (1) would thus contain the crop area at age 0, AREA (4) at age 3, and so on
AREAB (36)	a real vector storing the area after clearing for the JTth year in the forecast
ARES (10)	a real vector holding the aggregated areas for the JT years and NU forecasts

ATP (10)	a real vector containing the total area under the crop for each year of the forecast
ATTP (10)	a real vector holding ATP in percentage form
B (36,10)	a real array containing the production forecasts broken down by age groups for JT years
BA (36,10)	a real array containing the area forecasts broken down by age group for JT years
BAP (36,10)	contains BA in percentage form
BP (36,10)	contains B in percentage form
BPROD (36)	a real vector containing the base year production
BRES (10)	a real vector containing aggregated production results for JT years and NU forecasts
CLEAR (36,10)	a real array containing the clearing vectors corresponding to ages 0 to 35 years for the forecast period (Clearing data are in per cent per annum)
D (10) and DD (10)	real vectors containing intermediate calculations to be stored in APLAN
ID	an integer constant in the range 1 – 4 representing the density class (This controls the selection of the appropriate clearing rates)
IYEAR	the calendar year representing the base year of the forecast
JT	the forecast lead time in years (In the version of the program listed in Appendix 2, JT is limited to a maximum value of 10)
NU	an integer between 1 and 98 inclusive indicating the number of data decks which follow (Results from NU data decks are summed and the results summarized by the program)
PARES (10)	holds ARES in percentage form
PBRES (10)	holds BRES in percentage form
TITLA (20)	a real vector holding alphanumeric information to be printed out as a header on the tables
TP (10)	a real vector holding the total production under the crop for each year of the forecast
TPP (10)	a real vector holding TP in percentage form
V (5)	a real vector holding the base year production by age groups
VV (5)	contains V in percentage form

VVV (5) — a real vector holding the contents of XV in percentage form

YIELD (36) — a real vector containing the yield information in tonnes corresponding to the expected normal yield (i) at age (i)

XV (5) — a real vector holding the base year areas by age group

4.4 Program Structure and Linkage

To run the program as listed in Appendix 2 of this study the user must supply the job control cards and the data deck. The complete deck structure of a typical job is shown in Figure 4.1

4.4.1 Job Control

No details of the job control cards are given here as these vary from installation to installation.

4.4.2 The Data Deck

Card input to FORECAST is as follows:

CARD 1 — IYEAR,JT

Read the base year and forecast lead time.

FORMAT (I4, I2)

CARD 2 — NU

Read the number of data decks to follow for which a grouped summary table is to be calculated. If NU is punched as 99 the program will terminate.

FORMAT (I2)

CARD 3 — ID

Read the density class.

FORMAT (I2)

CARD 4 — TITLA

Read in a title.

FORMAT (20A4)

CARDS 5, 6, 7 — AREA

Read the area data corresponding to ages of orchard 0 to 35 years.

FORMAT (13F6.0)

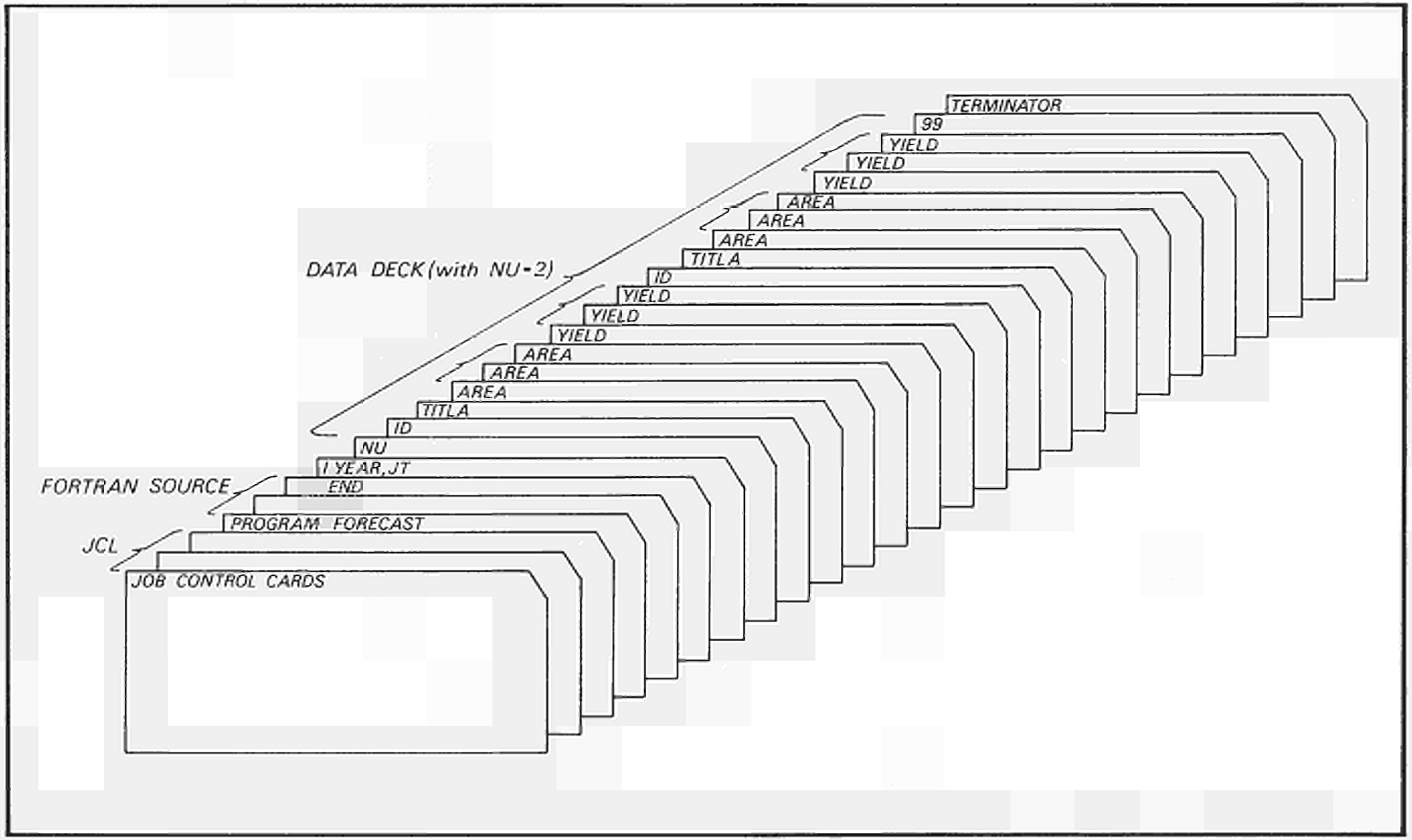


Figure 4.1 Layout of typical program deck

Figure 4.2 Coding form showing typical data set

Fortran Coding Form

NAME JEAN HAWORTH	PROGRAM TITLE FORECAST TEST	DATE 16/11/77
ADDRESS BSØ2	JOB NUMBER 1	Page 1 of 1

```
1974 5
 2
1
FRANCE-S.W. AMERICAN RED D1
     Ø     1     Ø     1     1     5    13     5    1Ø     7    4Ø    4Ø    4Ø
    40    4Ø    35    34    34    34    35     4     4     4     4     4     2
     2     2     2     2     2     2     2     2     2     1
     Ø     Ø     Ø     Ø     1     6    12    17    21    26    3Ø    34    36
    39    41    43    45    47    48    5Ø    5Ø    5Ø    49    47    44    42
    41    39    37    36    35    34    33    31    3Ø    29
2
FRANCE-S.W. AMERICAN RED D2
     Ø    22    13    1Ø     5    35    91    35    72    66    82    82    82
    82    82    38    39    39    39    38     1     1     2     1     1     5
     5     5     4     4     4     4     4     4     4     4
     Ø     Ø     Ø     2     6    12    16    20    24    26    28    30    32
    33    34    35    36    36    36    35    34    33    32    31    29    27
    25    24    22    21    2Ø    19    18    17    17    16
99
```

W.M. Ltd., London, S.W.1. 35858 — Form 20/2

CARDS 8, 9, 10 YIELD

Read the yield data corresponding to ages of orchard 0 to 35 years.

CARD 11 NU

To terminate the deck punch 99.

FORMAT (I2)

Repeat cards 3 to 10 NU times. Figure 4.2 shows a typical data deck as it might appear on coding forms prior to being punched on to cards.

4.5 Some Suggested Program Modifications

There are several simple modifications which may be made relatively easily without major alteration to FORECAST. A few possibilities are suggested below.

i) Because the authors' prime concern was the calculation of medium term forecasts the forecast lead time, JT, in the version of the program presented here is limited to 10. Should longer forecasts be desired (or indeed be desirable) the dimensions of the main variables should be suitably extended.

ii) Until recently fruit data were collected and recorded in one of four density classes, hence the present limit on the value of ID. However, it would be a very simple matter to incorporate more density classes. The statement

```
GOTO (20, 21, 22, 23), ID
```

on line 116 of the program should be altered together with the addition of a set of assignments to fix the new clearing rates, if any.

iii) The data provided by EUROSTAT comprised area and yield information, mostly corresponding to the ages of orchards in the range 0 to 35 years. For this reason the data vectors have 36 elements. Most vector and matrix operations in FORECAST have an upper range to the index corresponding to this number of elements. To deal with greater ages of permanent crops the Dimension statement must be modified together with all the DO loops involving the data vectors. These changes may easily be generalised by reading the length of the AGE, YIELD and AREA vectors at run time as an integer constant which would define the appropriate upper ranges for the index of the DO loops.

iv) Planting information can either be calculated from trends in the area data or can be read in directly. In our studies planting information was not available and trends were calculated as simple weighted moving averages as in line 108 of FORECAST. This scheme can be modified in a number of ways. For example, the weights may be altered and the length of the moving average may be changed by modifications to loops DO 16, 17 and 18 and the dimensions of D and DD.

v) In order to keep the program flexible the clearing data have been programmed as a matrix. In the present version of FORECAST the percentage clearings for the various age groups are part of the main program — lines 114 to 139. Because the same rates of clearings have been retained throughout the forecast period in our studies, only the first row of CLEAR is in fact used. Two modifications are possible.

(a) If the clearings are to remain constant throughout the period JT, and if the user wishes to employ many different rates in a large data deck, the clearing rates are best read in at run time.

(b) Variable clearing rates throughout the forecast period are simply achieved by reading in a matrix of clearing data and by modifying the CLEAR (1,I) statements to read CLEAR (J,I) where J and I are the indices of the DO loops.

vi) Since July 1976 Member States have had guidelines published in the Council Directive (76/625/EEC) as to how to submit census data to EUROSTAT in machine readable form. Annex 1 of this Directive gives details of the Fortran statements which describe the formats of identification codes, age classes and areas. Input of data to FORECAST in this format requires a number of modifications. In the form that EUROSTAT will use in future forecasts the modifications to FORECAST are as follows:

(a) add GAREA (10) to the Dimension statement.

(b) remove cards 76 to 88 and insert the following lines.

```
C......FILL THE CENSUS RECORD
       READ (5,3) IC, IP, IS, IV, ID, (GAREA (I), I=1,9)
       DO 130 I=1,9
130    GAREA (I) = GAREA (I) /100.0
C......FILL THE AGE VECTOR
       AGE (1) = 0.0
       AK = 0.0
       DO 131 I=2,36
       AK = AK+1.0
131    AGE (I) = AK
C......FILL THE AREA VECTOR
       DO 132 I=1,5
```

```
132     AREA (I) = GAREA (I)
        DO 133 I=6,10
133     AREA (I) = GAREA (6)/5.0
        DO 134 I=11,15
134     AREA (I) = GAREA (7)/5.0
        DO 135 I=16,25
135     AREA (I) = GAREA (8)/10.0
        DO 136 I=26,36
136     AREA (I) = GAREA (9)/11.0
```

(c) remove FORMATS 3 and 4

(d) insert the following card in the format section

```
3       FORMAT (I1, I2, I1, I3, I1, 9F7.0)
```

To print out the coded information as a title sequence the following lines should be inserted after the coded data has been read in:

```
        WRITE (6, 700)
700     FORMAT (1H1, 7X, 28 ('*') )
        WRITE (6, 701) IC, IP, IS, IV, ID
701     FORMAT (8X, '* COUNTRY', 13X, I1, 4X, '*' /, 8X, '* PRODUCTION ZONE',
       14X, I2, 4X, '*' /, 8X, '* SPECIES', 13X, I1, 4X, '*' /, 8X, 'VARIETY',
       211X, I3, 4X, '*',/, 8X, '* DENSITY', 13X, I1, 4X, '*')
        WRITE (6, 702)
702     FORMAT (8X, 28 ('*') )
```

4.6 Program Output

For each forecast two pages of results are output. Table 4.1 illustrates the first output page which lists the complete input vectors for yield and area in the base year of the forecast and the calculated base year production, both in total and for each age of orchard. In addition the area vector is also printed for the forecast year together with the production vector. So as to keep the program flexible the clearing vectors for each year in the forecast have had to be printed out as rows at the bottom of the first page. Given that the forecast length is variable, the paper width might easily be exceeded if the clearing vectors were output as columns although this latter method would have visually been more satisfactory. The second output page (Table 4.2) summarizes production and area data for each year of the forecast. In addition to percentage conversions and the printing of the weighted plantings, each year of results is further grouped into age class categories to provide an insight into the changing demographic structure of the orchards in question.

At the end of a group of forecasts a short summary table is printed giving details of the area and production for the group throughout the forecast period.

TABLE 4.1

FIRST OUTPUT PAGE FOR A FORECAST

FRANCE S.W. AMERICAN RED 01

AGE	BASE YEAR 1974 YIELD(T/HA)		AREA(HA)	PRODUCT	**	EXTRAPOLATION FOR1979 AREA(HA)	PRODUCT(T)
0.	0.0	**	1.0	0.0	**	0.85	0.0
1.	0.0	**	1.0	0.0	**	0.84	0.0
2.	0.0	**	0.0	0.0	**	0.85	0.0
3.	0.0	**	1.0	0.0	**	0.80	0.0
4.	1.0	**	1.0	1.0	**	0.77	0.8
5.	6.0	**	5.0	30.0	**	0.95	5.7
6.	12.0	**	13.0	156.0	**	0.95	11.4
7.	17.0	**	5.0	85.0	**	0.00	0.0
8.	21.0	**	10.0	210.0	**	0.95	20.0
9.	26.0	**	7.0	182.0	**	0.95	24.7
10.	30.0	**	40.0	1200.0	**	4.75	142.6
11.	34.0	**	40.0	1360.0	**	12.36	420.3
12.	36.0	**	40.0	1440.0	**	4.75	171.2
13.	39.0	**	40.0	1560.0	**	9.51	370.9
14.	41.0	**	40.0	1640.0	**	6.66	272.9
15.	43.0	**	35.0	1505.0	**	38.04	1635.7
16.	45.0	**	34.0	1530.0	**	36.89	1659.9
17.	47.0	**	34.0	1598.0	**	35.77	1681.1
18.	48.0	**	34.0	1632.0	**	34.69	1664.9
19.	50.0	**	35.0	1750.0	**	33.63	1681.7
20.	50.0	**	5.0	250.0	**	28.54	1426.9
21.	50.0	**	4.0	200.0	**	27.72	1386.1
22.	49.0	**	4.0	196.0	**	27.72	1358.4
23.	47.0	**	4.0	188.0	**	27.72	1303.0
24.	44.0	**	4.0	176.0	**	28.54	1255.7
25.	42.0	**	2.0	84.0	**	4.08	171.2
26.	41.0	**	2.0	82.0	**	3.06	125.4
27.	39.0	**	2.0	78.0	**	2.87	111.8
28.	37.0	**	2.0	74.0	**	2.69	99.4
29.	36.0	**	2.0	72.0	**	2.52	90.7
30.	35.0	**	2.0	70.0	**	1.18	41.3
31.	34.0	**	2.0	68.0	**	1.18	40.2
32.	33.0	**	2.0	66.0	**	1.18	39.0
33.	31.0	**	2.0	62.0	**	1.18	36.6
34.	30.0	**	2.0	60.0	**	1.16	35.4
35.	29.0	**	1.0	29.0	**	1.18	34.2
TOTALS			458.0	17634.0		387.5	17319.3

CLEARING VECTORS ARE AS FOLLOWS

```
1974  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.10.10.10.10.10.10.10.10.10.10.10.
1975  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.10.10.10.10.10.10.10.10.10.10.10.
1976  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.10.10.10.10.10.10.10.10.10.10.10.
1977  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.10.10.10.10.10.10.10.10.10.10.10.
1978  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.10.10.10.10.10.10.10.10.10.10.10.
```

TABLE 4.2

SECOND OUTPUT PAGE FOR A FORECAST

PRODUCTION BY AGE GROUP

	WEIGHTED PLANTING	PRODUCTION	AS PER CENT OF1974	0-4	5-9	10-14	15-24	25+
YEAR 1974		17634.00	100.0	1.T (0.)	663.T (4.)	7200.T (41.)	9025.T (51.)	745.T (4.)
1975	0.80	17981.85	102.0	1.T (0.)	645.T (4.)	6148.T (34.)	10405.T (58.)	782.T (4.)
1976	0.82	18083.96	102.6	0.T (0.)	496.T (3.)	5075.T (28.)	11724.T (65.)	789.T (4.)
1977	0.87	18033.48	102.3	1.T (0.)	458.T (3.)	3825.T (21.)	12957.T (72.)	792.T (4.)
1978	0.85	17763.88	100.7	1.T (0.)	167.T (1.)	2721.T (15.)	14082.T (79.)	792.T (4.)
1979	0.85	17319.28	98.2	1.T (0.)	62.T (0.)	1378.T (8.)	15053.T (87.)	825.T (5.)

AREA DISTRIBUTION BY AGE GROUP

	WEIGHTED PLANTING	AREA	AS PER CENT OF1974	0-4	5-9	10-14	15-24	25+
YEAR 1974		458.00	100.0	4.H (1.)	40.H (9.)	200.H (44.)	193.H (42.)	21.H (5.)
1975	0.80	445.64	97.3	4.H (1.)	34.H (8.)	165.H (37.)	221.H (50.)	22.H (5.)
1976	0.82	431.79	94.3	4.H (1.)	25.H (6.)	134.H (31.)	248.H (57.)	22.H (5.)
1977	0.87	417.49	91.2	4.H (1.)	19.H (5.)	99.H (24.)	273.H (65.)	22.H (5.)
1978	0.85	402.72	87.9	4.H (1.)	8.H (2.)	72.H (18.)	297.H (74.)	22.H (5.)
1979	0.85	387.50	84.6	4.H (1.)	4.H (1.)	38.H (10.)	319.H (82.)	22.H (6.)

CHAPTER 5

SENSITIVITY ANALYSES

5.1 Introduction

In this chapter we shall look at the sensitivity of the forecasts, in percentage terms, to some of the parameters described in the previous chapters. In particular to:

(i) different yield curves as described in Chapter 3

(ii) the method of distribution of the data within the vector AREA

(iii) a simulation illustrating the possible effects of the 1976 grubbing policy.

The forecasting model has four parameters and it is an easy matter to determine the sensitivity to any one of them by controlling the other three.

5.2 Sensitivity to the Yield/Age Curves

Forecasts were made using the same sample of curves described in Chapter 3 and using the clearing and planting schemes outlined in Chapter 2. The results are presented in Tables 5.1 and 5.2 where it will be seen that four types of curves were used for peaches and seven for apples and pears.

5.2.1 Apple and Pear Forecasts

Forecasts based on the experts' curves produce no consistent pattern vis à vis other curves. The log. reciprocal often gives a reasonably good fit to the data but does not produce a plausible curve if it has to be extrapolated over ages 20-35 years as it continues to rise quite steeply (see Figure 3.11). On the other hand, when the curve needs little or no extrapolation, i.e. when the data spans 35 years, the sigmoid part of the curve tends to be too low compared with that suggested by the experts. When the log. reciprocal has required extrapolation we have continued the curve horizontally beyond the last data point (age).

Furthermore, the results in Table 5.1 show that this curve, in terms of fit, is marginally the worst and that the forecasts are, on the whole, extreme.

One logical way of assessing the remaining curves is to regard them as being of two types:

(i) asymptotic – generalized logistic, 3-parameter logistic and standard Gompertz

(ii) non-asymptotic – modified Gompertz and Hoerl's.

As to be expected there is very little difference in the forecasts based on the asymptotic curves with the generalized logistic representing the 'average' of the three.

We also observe a very close correspondence between the Hoerl's and modified Gompertz.

We may also conclude that there is no appreciable difference in the forecasts between the two groups of curves thus implying that there is little difference between the forecasts based on the linear (Hoerl's) and non-linear curve types.

During the period 1974-1976 we examined a great many curves and subsequently forecasts but these did not include plantings and clearings. However, the results of these analyses are strongly in accord with our present findings.
We have, however, reduced the potential sensitivity to the curves by the fact that we have narrowed our initial selection to those which are very similar in terms of shape and statistical explanation. Forecasts will obviously be sensitive to curve type per se but are not, in general, sensitive to the curves in our final selection.

TABLE 5.1

FORECAST SENSITIVITY TO CURVE TYPE FOR APPLES AND PEARS

	Williams' — D1		Red Delicious — D1		Golden Delicious — D1		Golden Delicious — D2		Golden Delicious — D3	
Curve Type	1979 as % 1974	$\bar{R}^2$	1979 as % 1974	$\bar{R}^2$	1979 as % 1974	$\bar{R}^2$	1979 as % 1974	$\bar{R}^2$	1979 as % 1974	$\bar{R}^2$
Log Reciprocal*	125.1	0.52	97.8	0.25	106.9	0.54	115.0	0.48	203.0	0.86
Hoerl's	119.9	0.57	85.8	0.35	103.2	0.56	102.2	0.49	195.6	0.86
Modified Gompertz	114.7	0.57	86.9	0.33	101.7	0.56	107.7	0.48	204.4	0.86
Standard Gompertz	115.2	0.57	90.0	0.32	102.5	0.56	107.0	0.49	204.8	0.86
Generalized Logistic	112.7	0.57	89.2	0.32	101.8	0.56	104.8	0.49	207.7	0.86
3-Parameter Logistic	110.3	0.57	88.9	0.32	100.5	0.56	102.4	0.49	212.0	0.86
Expert's	115.5		98.2		99.3		92.0		197.4	

* adjusted

5.2.2 Peach Forecasts

Without a completely exhaustive analysis of all the peach data we cannot come to any universal conclusions. However, the results presented in Table 5.2 are probably typical of the behaviour of the peach forecasts in general. It is immediately obvious that, in the case of Dixired, the forecasts are insensitive to the curve types used. It is not so easy to come to such a positive conclusion in the case of J. H. Hale. In this case the forecast based on the expert's curve is lowest and there is a difference of 10 percentage points between the mathematical curves. The modified Gompertz produce the best curve fit ($\bar{R}^2 = 0.33$) but it can be seen in Figures 3.6 and 3.7 that the curve comes to a very early peak, which might be unlikely. One conclusion that may be drawn is that there appear to be two types of curve; the expert's and modified Gompertz versus the log quadratic and Hoerl's, but there is no substantial difference in the forecasts.

TABLE 5.2

FORECAST SENSITIVITY TO CURVE TYPE FOR PEACHES

	J.H. Hale – D2		Dixired – D1	
Curve Type	1979 as % 1974	$\bar{R}^2$	1979 as % 1974	$\bar{R}^2$
Log Quadratic	84.8	0.12	57.9	0.28
Hoerl's	87.5	0.22	61.7	0.33
Modified Gompertz	77.9	0.33	59.8	0.36
Expert's	72.1		59.8	

5.3 Sensitivity to Data Distribution within the Area Vector

In Chapter 2 the area data were described as having been collected in a number of age classes and it was thought that the forecasts might well be influenced by the method chosen to distribute this grouped data into the 36 element vector AREA. To assess this sensitivity four experiments were performed on each of the following data sets:

(a) **Apples** – Golden Delicious, density 1 – Alto Adige (Italy)

(b) **Pears** – Passe Crassane, density 3 – Loire (France)

(c) **Peaches** – Morettini, density 1 – Val Padana (Italy)

All forecasts were made using the experts' yield curves and clearing vectors described in Chapter 2.

On each data set the four experiments were:

(i) **Experiment R** – Grouped area data distributed **rectangularly** within the corresponding portion of the area vector.

(ii) **Experiment C** – Grouped area data placed in the **central** element of the corresponding portion of the area vector.

(iii) **Experiment S** – Grouped data placed at the **start** of the corresponding portion of the area vector.

(iv) **Experiment E** – Grouped data placed at the **end** of the corresponding portion of the area vector.

To illustrate these designs consider a situation in which 100 ha are recorded in age class 5-9 years. The assignment of the data amongst the five elements of the area vector for the four experiments is as follows:

Age	Experimental Designs R	C	S	E
5	20		100	
6	20			
7	20	100		
8	20			
9	20			100

There are many designs which could have been chosen but these four we selected for the following reasons. Without any prior knowledge it is reasonable to distribute the data evenly within the corresponding portion of the area vector which is, of course, the usual statistical procedure when dealing with grouped data. On the other hand forecast extremes could be achieved by placing all the data either at the beginning or the end of each group.Experiment C was performed to assess the forecast differences between it and experiment R. A considerable amount of effort was initially required to distribute all the area data according to design R (although this is easily done by computer – see section 4.5 (vi)) and should experiment C provide similar forecasts, method C would have the advantage of simplicity.

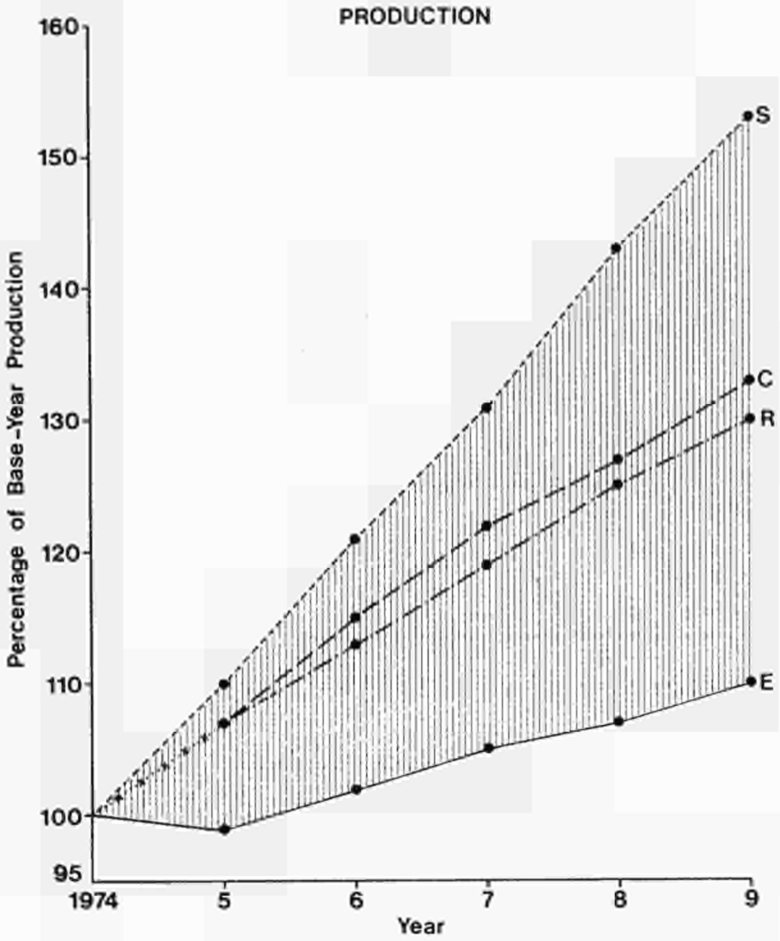
5.3.1 Experimental Results

The forecast results for both production and area are shown in Figures 5.1 to 5.3. To some extent it was possible to predict these results on purely theoretical grounds. For example, all four designs will obviously produce the same forecast if the yield curve is horizontal, and on an ascending or descending yield curve extreme data assignments will have the effect of either raising or lowering the forecast.

In practice complications to the simple theoretical model suggested above occur because yield curves generally have ascending, descending and plateau-like segments which may combine with a very uneven demographic structure. One must also remember that the movement of the area data within the area vector also changes the effect of the clearing vector; it may be, for example, that one might expect experiments R and C not to differ in terms of area forecast but slight differences will develop over the forecast period because of the influence of the same clearing vector on two slightly different area vectors.

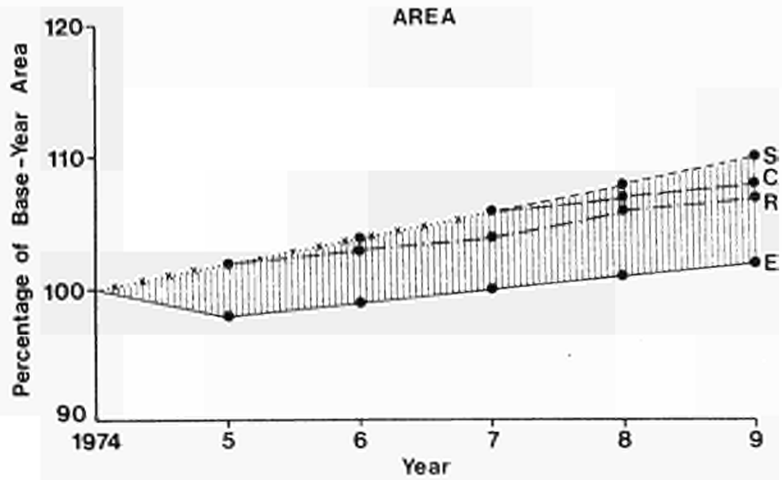
5.3.1a Apples

In Figure 5.1 the largest forecast production was obtained in experiment S, the smallest in experiment E and very similar results in C and R. These results are very much as expected



Percentage of Base--Year Production

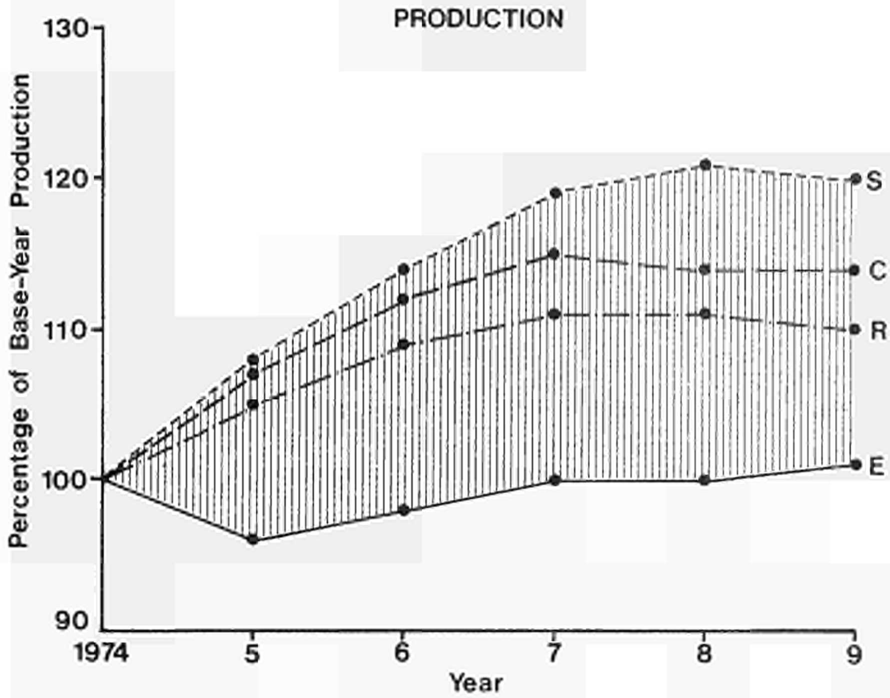
Year	S	R	C	E
1974	100	100	100	100
1975	110	107	107	99
1976	121	113	105	102
1977	131	119	122	105
1978	143	125	127	107
1979	153	130	133	110



Percentage of Base--Year Area

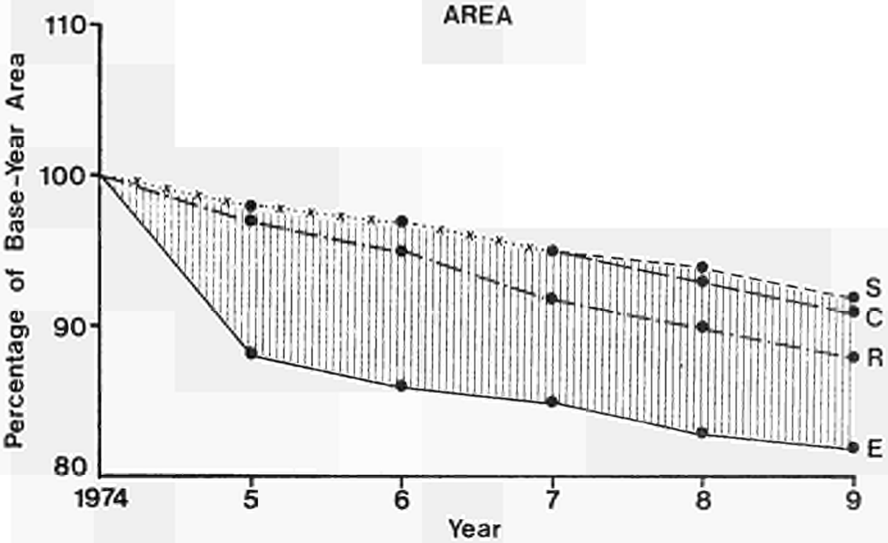
Year	S	R	C	E
1974	100	100	100	100
1975	102	102	102	98
1976	103	103	104	99
1977	106	104	106	100
1978	108	106	107	101
1979	110	107	108	102

Figure 5.1 Sensitivity to within-age group area distributions: Golden Delicious – Density 1 (Alto Adige)



Percentage of Base-Year Production

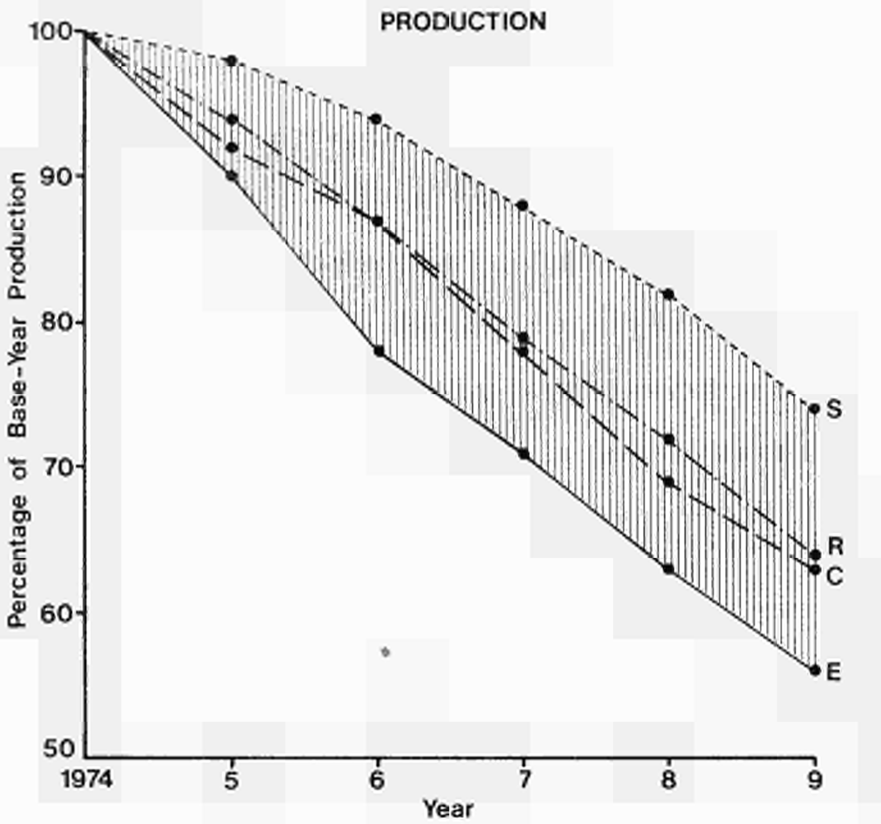
Year	R	S	E	C
1974	100	100	100	100
1975	105	108	96	107
1976	109	114	98	112
1977	111	119	100	113
1978	111	121	100	112
1979	110	120	101	112



Percentage of Base-Year Area

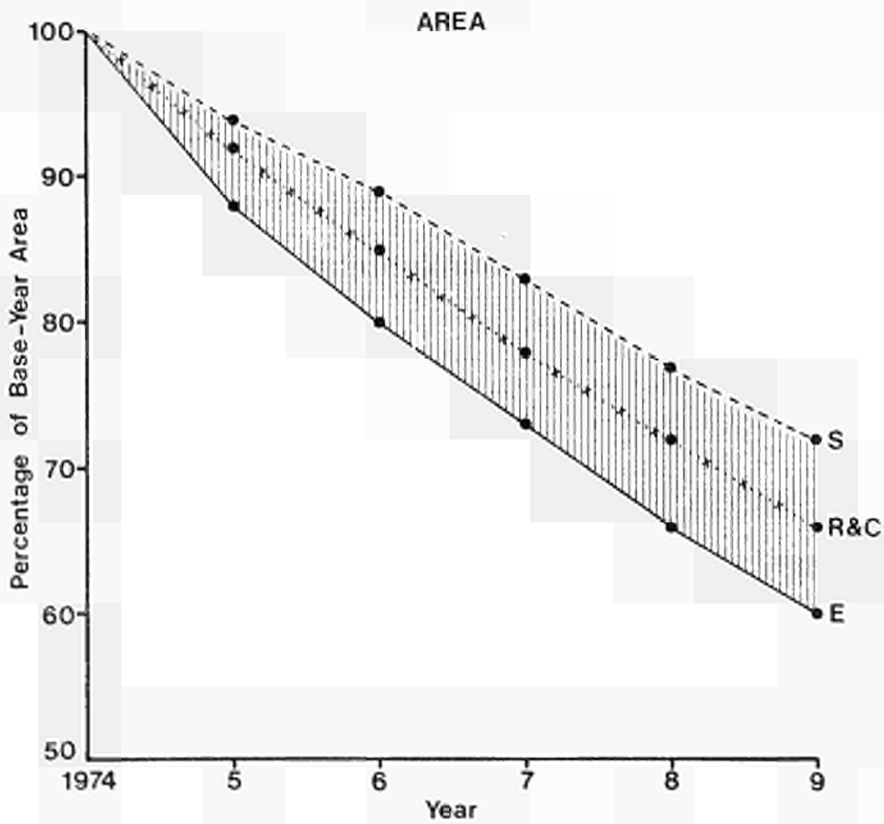
Year	R	S	E	C
1974	100	100	100	100
1975	97	98	88	98
1976	95	97	86	97
1977	92	95	85	95
1978	90	94	83	93
1979	88	92	82	91

Figure 5.2 Sensitivity to within-age group area distributions: Passe Crassane — Density 3 (Loire)



Percentage of Base-Year Production

Year	R	S	C	E
1974	100	100	100	100
1975	94	98	90	93
1976	87	94	78	87
1977	79	88	71	78
1978	72	82	63	69
1979	64	74	56	63



Percentage of Base-Year Area

Year	R	S	C	E
1974	100	100	100	100
1975	92	94	88	92
1976	85	89	80	85
1977	78	83	73	78
1978	72	77	66	72
1979	66	72	60	66

Figure 5.3 Sensitivity to within-age group area distributions: Morettini – Density 1 (Val Padana)

given the shape of the yield curve which ascends fairly rapidly and then flattens. In both the production and area forecasts, the results of experiment E show a slight depression over base year for the 1975 forecast. This is easily explained when one examines the area vector showing that 360 ha were assigned to element 36 and in the first forecast year this is lost from the vector. This loss thus represents a clearing of old trees which is unavoidable in the finite element forecasting model we have used. The slight dip in the results soon picks up, however, because the data at the younger end becomes associated with higher parts of the yield curve as the forecast progresses.

A further factor which must be borne in mind is the effect of the weighted planting mechanism which in some cases can add more area to the younger end of the area vector than is being lost through clearings and by element truncation at the older end of the vector. In the case of Alto Adige large plantings of Golden Delicious in the few years prior to 1974 are influencing the planting mechanism to such an extent that this is more than compensating for area losses during the forecast period.

5.3.1b Pears

The results shown in Figure 5.2 show a very similar pattern to that of apples. Experiment E produced a forecast lower than the base year and a clue to the explanation of this result is immediately seen in the very low area forecast curve. This curve drops immediately because more data is lost from the end of the area vector during the first forecast year than is gained by the planting process, there having been only small amounts of planting during the four years immediately preceding 1974.

5.3.1c Peaches

Figure 5.3 shows that all four experiments produced declining production and area forecasts. However, like apples and pears, the highest forecasts were obtained in experiment S and the lowest in experiment E. The Morettini Density 1 yield curve, provided by the national expert, rises very steeply from age 3 and is at a maximum by age 9 after which is descends more gently. Certain types of area distribution superimposed on such a curve will produce a declining area and production forecast. We can examine the forecasts in more detail by looking at the demographic changes that take place during the forecast period.

AREA DISTRIBUTION (%) MORETTINI – DENSITY 1						
	Age Groups					
Year	0–4	5–9	10–14	15–25	25+	
1974	16	26	32	22	3	
1979)	13	21	28	32	6	Experiment R
)	13	21	28	37	1	Experiment C
)	11	19	28	40	1	Experiment S
)	14	23	27	25	11	Experiment E

Because the yield curve for the above example peaks at about age 9, we can see from the above table that a high proportion of the area data lies on the descending part of the yield curve. This fact, together with the relative severity of EUROSTAT peach clearings, explains why both area and production trends act in the manner they do.

5.3.2 Sensitivity within the 5-9 age group

A further opportunity to study the sensitivity of the forecasts to area data distribution is provided by the fact that the French data used in the above example (Pears – Passe Crassane, Loire) were collected with slightly finer detail in that information was available for the areas corresponding to individual years within the age group 5-9. Let us suppose, however, that the French data were typically aggregate for this age class. What difference in the forecasts would be produced by this loss of information? To answer this question, a set of experiments was performed using the designs described above and aggregate area data for age group 5-9. The results are as follows:

1979 PRODUCTION FORECASTS (as % of base year)					
Experiments	R	S	E	C	
1	117%	146%	96%	120%	age 5-9 aggregated
2	110%	120%	101%	112%	data not aggregated

It is clear that the sensitivity of the forecast results is reduced in experiment 2 above by retaining data details in the group 5-9 years. Although this implies that the sensitivity of the forecasts might be reduced by collecting data corresponding to individual years or finer age groups, this is not always practical under survey conditions. However, EUROSTAT has decided to subdivide two of the age groups for peaches and oranges in future surveys.

Experiments S and E are improbable events for well-established varieties and thus represent the theoretical limits to the sensitivities. However, experiment S will occur in a newly introduced variety and we illustrate this using data for Granny Smith – Density 4 from

S.W. France.

	Ages											
	0	1	2	3	4	5	6	7	8	9	10-14	15+
1974 area (ha)	52	69	32	5	1	2	0	0	0	0	23	0
1977 area (ha)	?	?	?	52	69	32	5	1	2	0	?	?

(assuming no clearing)

Situation S actually occurred in 1974 in the 5-9 age group and although a trivial amount is involved this does illustrate our basic point. In 1977, if no clearings have taken place, we know that 32 ha out of 40 ha in the 5-9 group will occur at age 5. To redistribute this data rectangularly will lead to an upward bias in the forecast as this part of the yield curve rises steeply.

5.4 Sensitivity of Forecasts to a change in the 1976/7 Clearing Rates

The reader will recall that in Chapter 1 it was suggested that there was a structural surplus of approximately 165 000 tonnes of apples per annum and 200 000 tonnes of French and Italian pears. In order to simulate the possible effects of the 1976/7 grubbing grant in reducing these structural surpluses, three experiments were performed. One had a 1976/7 standard clearing rate, i.e. similar to previous years with no additional incentive to clear. The other two had, for 1976/7, additions of 10% and 20% respectively to the standard rates for each eligible age group.

5.4.1 Results

The results of the standard[(1)] forecasts are shown in Tables 6.5 – 6.8 for the four varieties concerned. In general, the additional 10 and 20% clearing for 1976/7 reduces the overall forecasts by approximately 10 and 20% respectively.

When the area and production trends are compared interesting aspects of the demographic structure are revealed. A decreasing trend in area can be accompanied by a quite dramatic increase in production. This is particularly noticeable in the case of Golden Delicious in Italy and the Netherlands (Figure 5.4) and of Passe Crassane pears in France (Table 6.8).

We may use these results to estimate the percentage rate of clearing necessary to eliminate the expected surplus of the crops in question. We outline this procedure below:

(1) 'Standard' conditions are described in 6.1

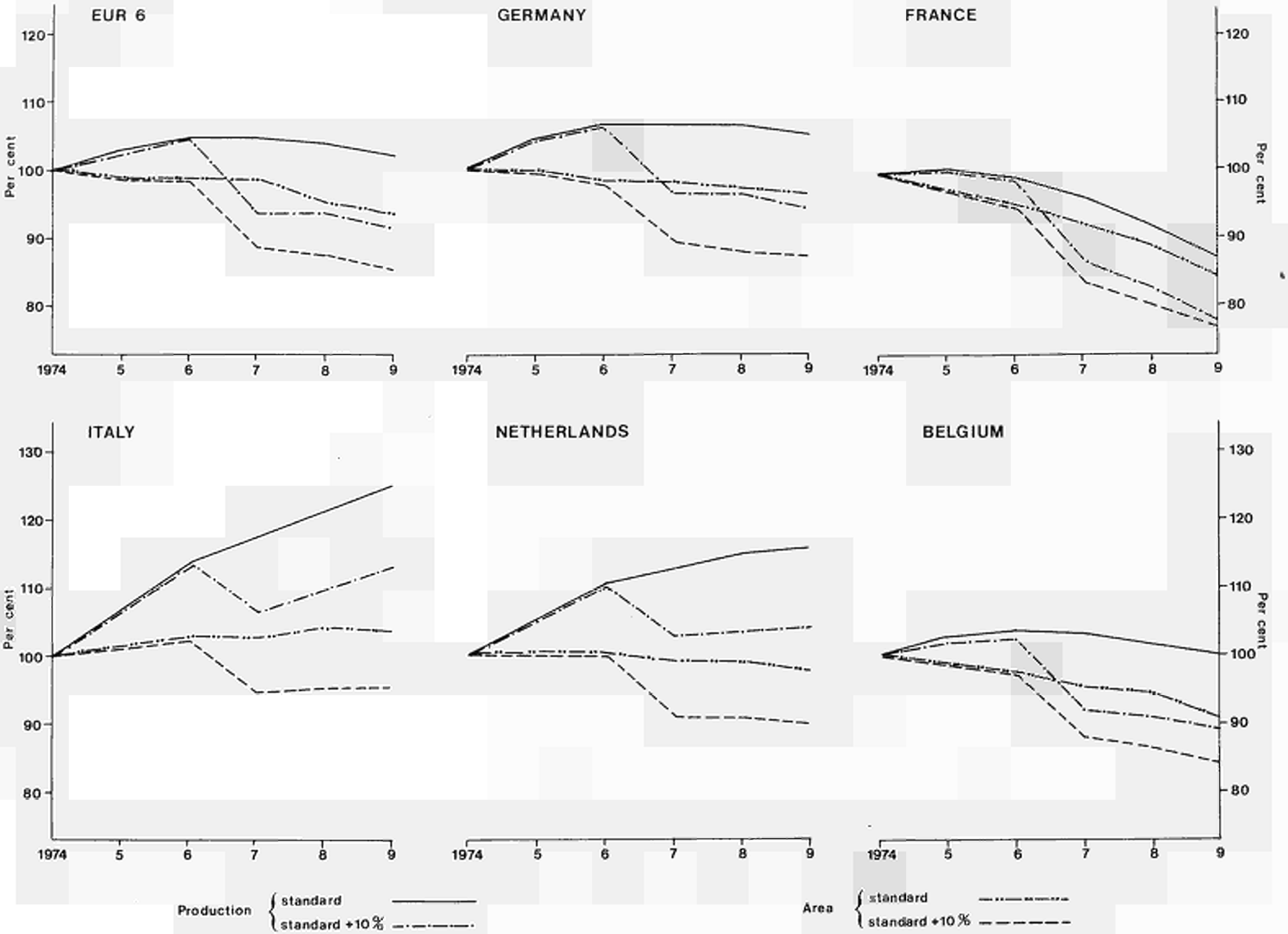


Figure 5.4 Trends in the forecast of area and production of Golden Delicious — with standard and 10% additional clearing rates

PASSE CRASSANE – (ESTIMATED PRODUCTION IN THOUSANDS OF TONNES)

1974	1979	
529	511	standard clearing
	460	standard + 10% (1976/7)
	408	standard + 20% (")
	357	standard + 30% (")

Therefore an additional 35% grubbing in 1976/7 will reduce the estimated production potential by about 200th. tonnes. Similarly, comparing the standard expected production for 1979 with that for 1974, under the different grubbing rate responses, we estimate that the policy objective will be achieved with an additional rate of clearing under grant of 3% for apples and of 30-35% for pears. In terms of area this represents 10 000 to 12 000 hectares that will have to be grubbed in 1976/7 to achieve the above results (about half being Passe Crassane pears). Thus pears would seem to present proportionately a much greater problem than apples in a policy which is limited to one year. In any case, the shifting demographic structure does not mean that the desired production potential would be maintained, but the restrictions imposed on new plantings by grant recipients should help to keep the situation in check.

CHAPTER 6

SUMMARY OF FORECAST RESULTS

6.1 Introduction

In this chapter we shall present a selection of results from several hundred separate forecasts made using the parameters and forecasting model outlined in earlier chapters of this study. These results, which are presented as summary tables, have been obtained by aggregating results from individual forecasts, all of which have been made under 'standard' conditions. By standard conditions we mean the following:

(i) The yield curves used were those of the 'experts' rather than our own statistical curves. Although it would have been appropriate to use curves determined in the manner outlined in Chapter 3, it would not have been possible to apply such curves throughout. This is because individual orchard yield data were not available for many production zones. For the sake of homogeneity, therefore, we chose to use the curves supplied by the experts.

(ii) The clearing and planting rates are those described in Chapter 2.

6.2 Production Trends by Fruit Species

The tables of forecasts need little explanation and so we merely describe the more important features.

6.2.1 Apples

Table 6.1 indicates that, nationally, only the Netherlands is likely to increase production potential over the forecast period. EUR–6 is likely to experience a small drop in production in 1979 to approximately 96% of the 1974 estimates.

6.2.2 Pears

Table 6.2 indicates that the EUR–6 pear production is also likely to fall by 1979. Perhaps the most striking result is that of Val Padana whose estimated production, in absolute terms, is over half that of EUR–6. In this case a 7% reduction over the period 1974 to 1979 is quite substantial.

6.2.3 Peaches

Table 6.3 shows the production potential for both yellow and white flesh peaches. With the one exception of Italy-Centrale, all regions in EUR–6 show a clear decline by 1979.

TABLE 6.1

FORECAST PRODUCTION POTENTIAL FOR APPLES IN EUR–6

Country/Zone		Forecast Prod. Potential (t) 1974	1979	1979 as % of 1974
Germany	North	172 624	173 475	100.5
	Middle	98 023	94 393	96.3
	South	252 953	239 407	94.6
		523 600	507 275	96.9
France	SE	694 033	633 772	91.3
	SW	449 732	411 612	91.5
	Loire	417 629	361 719	86.6
	Rest	111 919	97 560	87.2
		1 673 313	1 504 663	89.9
Italy	Alto Adige	727 898	767 534	105.4
	Val Padana	806 241	730 501	90.6
	Piemonte	195 183	209 383	107.3
	Centrale	20 396	20 517	100.6
	Meridionale	135 822	106 565	78.5
		1 885 540	1 834 500	97.3
Netherlands		456 700	504 269	110.4
Belgium		212 264	207 084	97.6
Total apples – EUR–6		4 751 417	4 557 791	95.9

TABLE 6.2

FORECAST PRODUCTION POTENTIAL FOR PEARS IN EUR–6

Country/Zone		Forecast Prod. Potential (t) 1974	1979	1979 as % of 1974
Germany	North	11 873	11 770	99.1
	Middle	11 607	12 807	110.3
	South	16 389	15 582	95.1
		39 869	40 159	100.7
France	SE	282 875	263 590	93.2
	SW	93 737	115 638	123.4
	Loire	119 781	116 895	97.6
	Rest	24 852	26 513	106.7
		521 245	522 636	100.3
Italy	Alto Adige	44 093	33 609	76.2
	Val Padana	1 091 255	1 017 633	93.3
	Piemonte	45 533	43 461	95.4
	Centrale	34 327	33 389	97.3
	Meridionale	148 310	150 712	101.6
		1 363 518	1 278 804	93.8
Netherlands		111 679	115 663	103.6
Belgium		55 866	54 608	97.7
Total Pears – EUR–6		2 092 177	2 011 870	96.2

TABLE 6.3

FORECAST PRODUCTION POTENTIAL FOR PEACHES IN EUR–6

Country/Zone		Forecast Prod. Potential (t) 1974	1979	1979 as % of 1974
White Flesh				
France	SE	89 079	75 020	84.2
	SW	15 217	12 993	85.4
	Loire) Rest)	1 956	1 282	65.5
		106 252	89 295	84.0
Italy	Alto Adige) Val Padana)	52 112	41 108	78.9
	Piemonte	31 638	25 683	81.2
	Centrale	14 287	13 614	95.3
	Meridionale	44 828	40 451	90.2
		142 865	120 856	84.6
Peaches – White flesh		249 117	210 151	84.4
Yellow Flesh				
France	SE	280 848	224 612	80.0
	SW	73 338	47 510	64.8
	Loire) Rest)	7 122	5 437	76.3
		361 308	277 559	76.8
Italy	Alto Adige) Val Padana)	324 928	298 422	91.8
	Piemont	66 415	58 290	87.8
	Centrale	67 504	73 150	108.4
	Meridionale	249 696	217 526	87.1
		708 543	647 388	91.4
Peaches – Yellow flesh		1 069 851	924 947	86.5
Total Peaches – EUR–6		1 318 968	1 135 098	86.1

TABLE 6.4

FORECAST PRODUCTION POTENTIAL FOR ORANGES IN ITALY

Variety/Zone	Forecast Prod. Potential (t) 1974	1979	1979 as % of 1974
ALL VARIETIES			
Basilicata & Puglia	55 345	66 878	120.8
Calabria	379 123	371 542	98.0
Sicilia	808 553	877 724	108.6
Rest	185 415	189 522	102.2
TOTAL – Italy	1 428 441	1 505 666	105.4
TAROCCO			
Basilicata & Puglia	19 826	26 595	134.1
Calabria	108 693	116 381	107.1
Sicilia	270 075	349 699	129.5
Rest	54 121	60 776	112.3
TOTAL	452 715	553 451	122.3
MORO			
Basilicata & Puglia	3 739	4 512	120.7
Calabria	80 583	82 969	103.0
Sicilia	147 276	161 074	109.4
Rest	21 290	20 029	94.1
TOTAL	252 888	268 584	106.2
NAVEL & VALENTIA			
Basilicata & Puglia	12 015	15 852	131.9
Calabria	3 345	5 910	176.7
Sicilia	22 613	28 972	128.1
Rest	4 672	10 006	214.2
TOTAL	42 645	60 740	142.4

6.2.4 Oranges

EUR–6 production of oranges is mostly confined to Italy and in fact our results relate only to this country. Table 6.4 shows that with the exception of Calabria all zones are estimated to increase their production by 1979.

6.3 Trends in Area and Production of Some Important Varieties

In the short space of this study it is not possible to give details of the vast number of varieties/ zones studied. However, in Tables 6.5 – 6.8 we have presented some details of those varieties subject to the 1976 EEC clearing scheme.

Table 6.5 suggests that Golden Delicious is likely to show a small increase in production in the medium term. In spite of substantial clearings, particularly in France, the level of production is maintained by an estimated increase in Italy, Germany and the Netherlands. It can also be seen that although the area in EUR–6 is estimated to fall in 1979 to around 94% of the base year, production is expected to increase by about 2%. This is obviously a demographic effect with young orchards coming more and more into full production.

In the case of Red Delicious and Morgenduft (Tables 6.6 and 6.7) both area and production are expected to fall throughout the Community.

The area and production forecasts for Passe Crassane pears (Table 6.8) show a decline for EUR–6. However in France, an estimated fall in area of 4% is accompanied by 11½% increase in production potential over the same period. This is because approximately 36% of the orchards are younger than nine years, thus during the forecast period these young orchards will increase production quite rapidly and more than compensate for loss of production through clearings.

We must emphasise that the forecasts obtained are highly sensitive to the chosen clearing rates. All the results given in this chapter are based on the assumptions of the 'standard' run and have not taken into consideration the 1976 clearing scheme.

TABLE 6.5

GOLDEN DELICIOUS – FORECAST RESULTS

Production (t)

Country	1974	1979	1979 as % of 1974
FRANCE	1 228 777	1 078 612	87.8
ITALY	683 761	846 851	123.8
GERMANY	157 384	167 259	106.3
NETHERLANDS	187 610	215 428	114.8
BELGIUM/ LUXEMBOURG	116 121	115 656	99.6
EUR–6	2 373 653	2 423 806	102.1

TRENDS IN AREA AND PRODUCTION (%) FOR FRANCE AND ITALY

Country	1974	1975	1976	1977	1978	1979
FRANCE						
area	100	98	96	93	90	86
production	100	101	100	97	93	88
ITALY						
area	100	101	102	102	103	103
production	100	106	112	116	120	124
EUR–6						
area	100	99	98	97	96	94
production	100	103	105	105	104	102

TABLE 6.6

RED DELICIOUS – FORECAST RESULTS

Production Potential (t)

Country	1974	1979	1974 as % of 1974
FRANCE	138 547	131 499	94.9
ITALY	337 499	310 403	92.0
* EUR–6	479 368	445 144	92.9

** includes a small amount grown in the Netherlands*

TRENDS IN AREA AND PRODUCTION (%)

Country	1974	1975	1976	1977	1978	1978
FRANCE						
area	100	99	98	97	95	93
production	100	101	101	99	97	95
ITALY						
area	100	97	94	91	89	86
production	100	99	97	96	94	92
EUR–6						
area	100	98	95	93	90	88
production	100	99	98	97	95	94

TABLE 6.8

PASSE CRASSANE – FORECAST RESULTS

Country	Production Potential (t) 1974	1979	1979 as % of 1974
ITALY	416 620	385 463	92.5
FRANCE	112 793	125 730	111.5
EUR–6	529 413	511 193	96.5

TRENDS IN AREA AND PRODUCTION (%)

Country	1974	1975	1976	1977	1978	1979
ITALY						
area	100	98	96	93	90	87
production	100	101	100	98	96	93
FRANCE						
area	100	100	99	98	97	96
production	100	104	107	110	111	112
EUR–6						
area	100	98	97	94	92	89
production	100	101	101	101	99	97

TABLE 6.7

MORGENDUFT – FORECAST RESULTS

Country	Production Potential (t) 1974	1979	1979 as % of 1974
ITALY	372 659	286 845	77.0
EUR–6	372 659	286 845	77.0

TRENDS IN AREA AND PRODUCTION (%)

Country	1974	1975	1976	1977	1978	1979
ITALY						
area	100	95	89	84	79	74
production	100	96	90	86	82	77

CHAPTER 7

CONCLUSIONS

7.1 Introduction

The value of this study lies perhaps more in the development of methodology than the specific forecasts that have resulted. There will certainly need to be further studies of this kind, and these will undoubtedly be made easier by the experience gained in this present study and the information it has provided.

7.2 General Reservations on Forecast Accuracy

Various limitations must be borne in mind when assessing the results of the forecasting exercise. The most important arise from the simplifying assumptions we have had to make, particularly with regard to the clearing rates. It is useful, therefore, to review briefly some of the more important factors that confront the researcher when trying to forecast production trends.

(i) **Climate** – This is probably the most important single factor in determining the variability of orchard yields. However, it is neither possible to determine the exact relationship between yields and climate, nor, indeed to forecast climate. EUROSTAT has called production, given average climatic conditions, 'normal' production and the forecast 'normal production potential'. To a large extent the variation in climate between production zones is incorporated in the yield curve for the zones and varieties concerned.

(ii) **Clearings** – Clearings have an immediate effect on production levels and the estimation of clearing rates during the forecast period remains a highly speculative procedure. Until the results of the 1977 Community Orchard Fruit Survey are received, so that comparisons can be made with earlier surveys, the rates suggested by EUROSTAT are tentative. Furthermore, we have assumed the same rate of grubbing for each year, variety and region. This we know to be untrue, but we must assume that the rates used are close to the average situation.

(iii) **Yields** – The shapes and levels of the yield curves will obviously influence forecasts of production potential but they are difficult to determine precisely and need adequate data over the whole range of orchard age for true definition. For example, it is difficult to predict the yield curves for newly introduced varieties.

(iv) **New Technologies** – Technological improvements may influence production levels even in the short term, through for example, application of new pesticides and herbicides. In the longer term, use of improved rootstocks and virus free material can be expected to produce higher crop levels.

7.3 The Pragmatic Approach to Curve Fitting

In view of our experience outlined in Chapter 3 we believe that the fitting of mathematical curves to orchard yield/age data should follow the dictum of Ockham's Razor.

> "non sunt multiplicanda entia praeter necessitatum"
>
> William of Ockham c 1285-1349

Where many curves are to be fitted to many species, varieties and density classes, the time and costs involved could be inhibitive and unwarranted. We hope that this study can be viewed as the starting point for any would be 'curve-fitter'. The results of the forecast sensitivity to the different curves (Chapter 5) give further support to our belief that sophistication is unwarranted. The non-linear routines are often difficult to use and dependent on the size of computer available, the availability of double precision arithmetic and the type of routines. There is much to be said for the simple approach of combining a linear least squares curve, such as the Hoerl's, with a subjective freehand curve provided by an 'expert' – or, allowing an expert's subjective modification of a Hoerl's curve. In many instances the available data does not allow a sensible mathematical curve to be fitted and subjective curves are the only alternative.

We believe that curve fitting, by whatever means, should be reviewed frequently as those produced at one point in time may soon become obsolete as technological change may shift the level and growth part of the curve quite dramatically.

7.4 The Forecasting Model

The model and program outlined in Chapter 4 provide a satisfactory vehicle for forecasting given the quality and quantity of data at Community level. This is but one method of forecasting fruit production; another method has been outlined in this series by Winter (1969). Perhaps the major advantages of the method that we have used and described in this study is its simplicity and flexibility.

7.5 Sensitivity Analyses

In Chapter 5 we performed a number of sensitivity analyses and in particular to, (a) different yield curves, (b) the method of data distribution within the AREA vector and (c) a simulation involving changes in the vector CLEAR, to accommodate the 1976 grubbing inducement.

(i) **Curve Type** – Because we chose a restrictive set of curves which were very similar in shape, there was no great range in the subsequent forecasts, in terms of percentage change; although in absolute terms the differences could be quite substantial. We found no significant difference between the 'linear' and 'non-linear' curves. Also we found no pattern of discrimination between forecasts based on the expert's curves and those we derived mathematically. This adds further support to our belief that simplicity has much to commend it.

(ii) **Area Distribution within Age Groups** – We performed several experiments involving assumptions of data distribution within age classes and found that the forecasts are very sensitive to the method of distribution within those groups which correspond to non-horizontal segments of the yield curve.

(iii) **Clearing Vector** – We demonstrated how modifications could be made to the program in order to change the clearing rates for any single year during the forecast period. This experiment, which increased the rates for 1976, was intended to give some indication of the order of magnitude of the problem of over-production of apples and pears in EUR–6. In the short term our results suggest that the grubbing grant may significantly reduce the large surpluses of the named varieties of apples but the excess production of Passe Crassane pears is likely to remain a problem in spite of clearing inducements.

Considering the sensitivity to clearings in general, it is quite obvious that the forecasts will be highly sensitive to the rates chosen. The reader should remember that we automatically impose a 100% clearing after the age at which we closed the open ended class (25 years and over).

(iv) **Plantings** – Forecasts are, in the whole, rather insensitive to plantings in the medium and short term. This is because there is an initial non-yielding period of about three or four years. However, an exception would be the case of a newly introduced variety or planting density where the age distribution is heavily skewed towards the very young orchards. In this case the forecasts, in terms of percentage change, will be sensitive to planting assumptions.

We may summarize our findings by stating that a five-yearly orchard fruit survey is an obvious requirement, together with regular information on clearings, if any attempt is to be made to monitor production trends necessary for policy formulation in the Community.

"vis consili expers mole ruit sua" Horace 65-8 BC

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APPENDIX 1

LIST OF NATIONAL EXPERTS
(official and private)

GERMANY (FR)	:	Prof. Dr Lohden, Prof. Dr Reinken, Prof. Dr Winter
FRANCE	:	MM. Brossier, Defrance, Hevin, Hugard, Thiault, Monet
ITALY	:	Prof. Bargioni, Prof. Dr Branzanti, Dr Casadio, Dr Giberti, Prof. Lalatta, Dr Lezuo, Prof. Spina, Dr Vetromile
BELGIUM	:	Dr Liard
UNITED KINGDOM	:	Dr Luckwill
DENMARK	:	Prof. Dalbro
NETHERLANDS	:	Mr Van Welie (official expert)

APPENDIX 2 LISTING OF THE PROGRAM — FORECAST


```
      PROGRAM HOPE(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C
C
C
C
C
C                P R O G R A M   F O R E C A S T
C
C                *************   ***************
C
C
C           WRITTEN BY DR P VINCENT AND MISS J M HAWORTH
C
C
C
C
C                ************************************
C           *****I N S T R U C T I O N S   F O R   U S E*****
C                ************************************
C
C
C
C
C           CARD 1.    PUNCH BASEYEAR AND LENGTH OF FORECAST
C                      USING FORMAT 1
C
C
C           CARD 2.    PUNCH THE TOTAL NUMBER OF FORECASTS
C                      USING FORMAT 2
C
C
C           CARD 3     PUNCH THE DENSITY CLASS USING FORMAT 3
C
C
C           CARD 4.    PUNCH A TITLE TO IDENTIFY THE FORECAST
C                      ALL 80 COLUMNS MAY BE USED IF NECESSARY
C
C
C           CARDS 5,6,7. PUNCH THE AREA DATA AS 36 NUMBERS
C                         ACCORDING TO FORMAT 5.ELEMENT I OF THE VECTOR
C                         CORRESPONDS TO AGE ZERO AND SO ON
C
C
C           CARDS 8,9,10. PUNCH THE YIELD DATA AS 36 NUMBERS
C                         ACCORDING TO FORMAT 5. ELEMENT I OF THE VECTOR
C                         CORRESPONDS TO THE YIELD AT AGE ZERO AND SO ON
C
C
C           REPEAT CARDS 3 THROUGH10 NU TIMES WHERE NU IS THE NUMBER ON
C                           CARD 2.
C
C
C           TO TERMINATE THE PROGRAM  PUNCH NU AS 99
```

```
C
      DIMENSION TITLA(20),AGE(36),AREA(36),VV(5),VVV(5),
     1YIELD(36),CLEAR(10,36),APLAN(10),A(36,10),IIY(15),
     1APRODN(36,10),IY(10),TP(10),TPP(10),XX(5),B(10,5),
     1BP(10,5),V(5),BPROD(36),AREAB(36),ATP(10),ATPP(10),XXA(5),
     1BA(10,5),BAP(10,5),XB(10),XV(5),D(10),DD(10),BRES(10),ARES(10),
     1PARES(10),PBRES(10)
C..   READ IN THE BASE YEAR AND FORECAST LENGTH
       READ(5,1)IYEAR,JT
C.....READ IN THE TOTAL NUMBER OF FORECASTS REQUIRED
9999   READ(5,2)NU
      IF(NU.EQ.99)GOTO 600
      DO 11 IK=1,JT
      ARES(IK)=0.
11    BRES(IK)=0.
      RES1=0.0
      RES2=0.0
      DO 12 JN=1,NU
C....READ IN THE DENSITY CLASS
      READ(5,3)ID
C.... READ IN A TITLE UP TO 80 COLUMNS IN LENGTH
      READ(5,4)(TITLA(I),I=1,20)
C..  .FILL THE AGE VECTOR
       AGE(1)=0.
       AK=0.
      DO 13 I=2,36
       AK=AK+1.
13    AGE(I)=AK
C.... FILL THE AREA VECTOR
      READ(5,5)(AREA(I),I=1,36)
C....FILL THE YIELD VECTOR
       READ(5,5)(YIELD(I),I=1,36)
C..   CALCULATE THE BASE YEAR PRODUCT
      DO 14 I=1,36
14     BPROD(I)=YIELD(I)*AREA(I)
C.... CALCULATE THE TOTAL PRODUCTION FOR THE BASE YEAR
       SUM1=0.
       BSUM=0.
      SUM99=0.0
      BSUMA=0.
      DO 15 I=1,36
       SUM1=BPROD(I)+BSUM
       BSUM=SUM1
       SUM99=AREA(I)+BSUMA
15     BSUMA=SUM99
C..   THE FOLLOWING SECTION CALCULATES WEIGHTED PLANTINGS
      DO 16 K=1,4
16    D(K)=AREA(K)
      DO 17 KK=1,JT
      DO 18 KL=1,4
18    DD(KL)=D(KL)
      ABC=(((DD(1)*4.0)+(DD(2)*3.0)+(DD(3)*2.0)+DD(4))/10.0)
      APLAN(KK)=ABC
      DO 19 KM=1,3
       KKM=KM+1
19     D(KKM)=DD(KM)
```

```
17     D(1)=ABC
C...   TRANSFER TO PICK UP CORRECT CLEARING RATES FOR DENSITY CLASS
C...   THE EQUIVALENCIES SHOULD BE CHANGED TO ALTER CLEARING RATES
       GOTO(20,21,22,23),ID
20     AAA=1.0
        BBB=1.0
        CCC=1.0
       DDD=4.0
        EEE=10.0
       GO TO 24
21     AAA=1.0
        BBB=1.0
        CCC=1.0
        DDD=8.0
        EEE=15.0
       GO TO 24
22     AA=1.0
        BBB=1.0
        CCC=1.0
       DDD=3.0
       EEE=10.0
       GO TO 24
23     AA=1.0
        BBB=1.0
        CCC=1.0
        DDD=15.0
        EEE=25.0
24     CONTINUE
C...    THE INDEX 'K' CONTROLS THE AGE CLASS GROUPINGS
C...   IT MAY BE CHANGED TO ALTER THE AGE CLASS IF REQUIRED
       DO 25 K=1,5
25      CLEAR(1,K)=AAA
       DO 26 K=6,10
26      CLEAR(1,K)=BBB
       DO 27 K=11,15
27      CLEAR(1,K)=CCC
       DO 28 K=16,25
28      CLEAR(1,K)=DDD
       DO 29 K=26,36
29      CLEAR(1,K)=EEE
       DO 30 K=2,10
       DO 31 J=1,36
31      CLEAR(K,J)=CLEAR(1,J)
30     CONTINUE
C.     THE MATRIX A IS FILLED WITH FORECAST AREA VECTORS
       DO 32 I=1,36
       DO 32 J=1,JT
        AREAB(I)=AREA(I)*(1.0-CLEAR(1,I)/100.0)
32      A(I,J)=0.
C    FIND THE FORECASTS FOR EACH STEP
       DO 33 I=1,JT
        IJ=0
       DO 34 J=2,36
        JJ=IJ+1
        IJ=JJ
34      A(J,I)=AREAB(IJ)
```

```
      IJ=0
C.... PLANTINGS ARE ADDED TO THE FORECAST AREA MATRIX
       A(1,I)=APLAN(I)
       II=I+1
      IF(II.GT.JT)GO TO 33
      DO 35 L=1,36
35     AREAB(L)=0.
C.... IN DO LOOP IS THE VECTOR AREAB CONTAINS THE RESULT OF A CLEARING
C.....THIS RESULT IS READ BACK INTO THE AREA MATRIX
      DO 36 K=1,36
36     AREAB(K)=A(K,I)*(1.0-CLEAR(II,K)/100.0)
33    CONTINUE
      DO 37 II=1,JT
      DO 37 I=1,36
37     APRODN(I,II)=A(I,II)*YIELD(I)
C.... FILL A VECTOR WITH YEARS
      DO 38 J=1,JT
38    IY(J)=IYEAR+J
C.... FILL TOTAL PRODUCTION VECTOR FROM BASE YEAR PLUS 1
      DO 39 K=1,JT
      ASUM1=0.
      ASUM2=0.
       SUM1=0.
       BSUM2=0.
      DO 40 J=1,36
       SUM1=APRODN(J,K)+BSUM2
       BSUM2=SUM1
      ASUM1=A(J,K)+ASUM2
      ASUM2=ASUM1
40    ATP(K)=ASUM2
39     TP(K)=BSUM2
C.... DEFINE TOTAL PRODUCTION AS % OF BASE YEAR
      DO 41 J=1,JT
       TPP(J)=(TP(J)/BSUM)*100.0
41    ATPP(J)=(ATP(J)/BSUMA)*100.0
C...  FOR THE BASE YEAR AND FOR THE FORECASTS FIND THE % IN EACH AGE CLASS.
C..   PUT BASEYEAR RESULT INTO A VECTOR AND THE FORECASTS INTO A MATRIX
      DO 42 II=1,5
      XX(II)=0.
42    XXA(II)=0.
      DO 43 I=1,JT
      DO 44 J=1,36
      GOTO(47,47,47,47,47,48,48,48,48,48,49,49,49,49,49,
     150,50,50,50,50,50,50,50,50,50,51,51,51,51,51,51,51,51,51,51,51),J
47    XX(1)=APRODN(J,I)+XX(1)
      XXA(1)=A(J,I)+XXA(1)
      GOTO 45
48    XX(2)=APRODN(J,I)+XX(2)
      XXA(2)=A(J,I)+XXA(2)
      GOTO 45
49       XX(3)=APRODN(J,I)+XX(3)
      XXA(3)=A(J,I)+XXA(3)
      GOTO 45
50      XX(4)=APRODN(J,I)+XX(4)
      XXA(4)=A(J,I)+XXA(4)
      GOTO 45
```

```
51     XX(5)=APRODN(J,I)+XX(5)
       XXA(5)=A(J,I)+XXA(5)
45     CONTINUE
       DO 46 K=1,5
       B(I,K)=XX(K)
46     BA(I,K)=XXA(K)
44     CONTINUE
       DO 52 II=1,5
       XX(II)=0.0
52     XXA(II)=0.0
43      CONTINUE
C.     CONVERT THE ABSOLUTE VALUES IN B TO %
       DO 53 I=1,JT
        DO 53 J=1,5
       BP(I,J)=(B(I,J)/TP(I))*100.0
53     BAP(I,J)=(BA(I,J)/ATP(I))*100.0
       DO 54 II=1,5
       XU(II)=0.
54     U(II)=0.0
       DO 55 J=1,36
       GOTO(56,56,56,56,56,57,57,57,57,57,58,58,58,58,58,
      159,59,59,59,59,59,59,59,59,59,60,60,60,60,60,60,60,60,60,60,60),J
56     U(1)=BPROD(J)+U(1)
       XU(1)=AREA(J)+XU(1)
       GOTO 55
57     U(2)=BPROD(J)+U(2)
       XU(2)=AREA(J)+XU(2)
       GOTO 55
58     U(3)=BPROD(J)+U(3)
       XU(3)=AREA(J)+XU(3)
       GOTO 55
59     U(4)=BPROD(J)+U(4)
       XU(4)=AREA(J)+XU(4)
       GOTO 55
60     U(5)=BPROD(J)+U(5)
       XU(5)=AREA(J)+XU(5)
55      CONTINUE
       DO 61 IK=1,5
       UU(IK)=(U(IK)/BSUM)*100.0
61     UUU(IK)=(XU(IK)/BSUMA)*100.0
        JTJ=IYEAR+JT
       WRITE(6,500)(TITLA(I),I=1,20)
       WRITE(6,501)IYEAR,JTJ
       WRITE(6,502)
       IR=0
       DO 62 I=1,36
62     WRITE(6,503)AGE(I),YIELD(I),AREA(I),BPROD(I),A(I,JT),
      1APRODN(I,JT)
       ASUM=0.0
       AASUM=0.0
       DO 63 IA=1,36
       ASUM=AREA(IA)+ASUM
63     AASUM=A(IA,JT)+AASUM
       WRITE(6,504)ASUM,BSUM,AASUM,TP(JT)
       WRITE(6,505)
       DO 64 I=1,JT
```

```
      II=I+1
64    IIY(II)=IY(I)
       IIY(I)=IYEAR
      DO 65 IM=1,JT
65     WRITE(6,506)IIY(IM),(CLEAR(IM,IJ),IJ=1,36)
      WRITE(6,507)
      WRITE(6,508)IYEAR
      WRITE(6,509)IYEAR,BSUM,(U(I),I=1,5)
      WRITE(6,510)(UU(I),I=1,5)
      DO 66 I=1,JT
      WRITE(6,511)IY(I),APLAN(I),TP(I),TPP(I),(B(I,J),J=1,5)
66    WRITE(6,510)(BP(I,J),J=1,5)
      WRITE(6,512)
      WRITE(6,513)IYEAR
      WRITE(6,609)IYEAR,BSUMA,(XU(I),I=1,5)
      WRITE(6,510)(UUU(I),I=1,5)
      DO 67 I=1,JT
      WRITE(6,611)IY(I),APLAN(I),ATP(I),ATPP(I),(BA(I,J),J=1,5)
67    WRITE(6,510)(BAP(I,J),J=1,5)
      RES1=BSUM+RES1
      RES2=BSUMA+RES2
      DO 68 JP=1,JT
      ARES(JP)=TP(JP)+ARES(JP)
68    BRES(JP)=ATP(JP)+BRES(JP)
12    CONTINUE
C   COLLECT PERCENTAGES
      DO 69 KP=1,JT
      PBRES(KP)=(BRES(KP)/RES2)*100.
69    PARES(KP)=(ARES(KP)/RES1)*100.
      WRITE(6,514)
      WRITE(6,515)IYEAR,(IY(J),J=1,JT)
      WRITE(6,516)RES1,(ARES(J),J=1,JT)
      WRITE(6,517)(PARES(J),J=1,JT)
      WRITE(6,518)RES2,(BRES(J),J=1,JT)
      WRITE(6,517)(PBRES(J),J=1,JT)
      GOTO 9999
1     FORMAT(I4,I2)
2     FORMAT(I2)
3     FORMAT(I1)
4     FORMAT(20A4)
5     FORMAT(13F6.0)
6     FORMAT(2I3)
500   FORMAT(1H1/////////9X,20A4)
501   FORMAT(/25X,'BASE YEAR  ',I4,7X,'**',10X,'EXTRAPOLATION FOR',I4)
502   FORMAT('         AGE        YIELD(T/HA)    AREA(HA)    PRODUCT
     1AREA(HA)          PRODUCT(T)')
503   FORMAT(9X,F3.0,2X,F6.1,3X,'   **   ',F6.1,4X,F8.1,'   **   ',4X,F7.2,
     112X,F8.1)
504   FORMAT(/7X,'TOTALS',13X,F8.1,3X,F10.1,6X,F10.1,10X,F10.1//)
505   FORMAT('                    CLEARING VECTORS ARE AS FOLLOWS'/)
506    FORMAT(2X,I4,2X,36(F3.0))
507   FORMAT(1H1////92X,'PRODUCTION BY AGE GROUP'//)
508   FORMAT(10X,'WEIGHTED PLANTING   PRODUCTION',5X,'AS PER CENT OF'
     1,I4,16X,'0-4      5-9       10-14      15-24      25+'/)
509    FORMAT(4X,'YEAR',2X,I4,15X,F11.2,10X,'100.0',20X,5(F8.0,'T'))
510   FORMAT(78X,5('(',F4.0,')',3X)/)
```

```
511   FORMAT(10X,I4,4X,F6.2,5X,F11.2,10X,F5.1,20X,5(F8.0,'T'))
512   FORMAT(//52X,'AREA DISTRIBUTION BY AGE GROUP')
513   FORMAT(//10X,'WEIGHTED PLANTING            AREA',6X,
     1'AS PER CENT OF',I4,17X,'0-4       5-9        10-14      15-24       25+'
     2/)
514   FORMAT(1H1/1X,'RESULTS SUMMED OVER THE DENSITY CLASSES'//)
515   FORMAT(1X,'YEAR',4X,I4,10I10//)
516     FORMAT(1X,'PROD',F8.0,10F10.0)
517     FORMAT(5X,'     100.0',10F10.0//)
518     FORMAT(1X,'AREA',F8.0,10F10.0//)
609    FORMAT(4X,'YEAR',2X,I4,15X,F11.2,10X,'100.0',20X,5(F8.0,'H'))
611   FORMAT(10X,I4,4X,F6.2,5X,F11.2,10X,F5.1,20X,5(F8.0,'H'))
600    STOP
       END
      FINISH
```

Agrarstatistische Studien — Agricultural Statistical Studies — Études de statistique agricole

1	Influence des différents caractères de la carcasse de bovins sur la détermination de son prix — B.L. DUMONT, J. ARNOUX	1968	FR
2	Statistische Methoden zur Feststellung der Produktionskapazität der Obstanlagen — G. NEURAY, S. MASSANTE, M. PETRY Méthodes statistiques en vue de déterminer le potentiel de production des vergers — G. NEURAY, S. MASSANTE, M. PETRY	1968	DE,FR
3	Die methodischen Probleme bei einer Erhebung der Struktur der Betriebe mit erwerbsmäßigem Anbau von Gartengewächsen — H. STORCK Méthodologie d'une enquête sur la structure des exploitations horticoles professionnelles — H. STORCK	1968	DE, FR
4	Untersuchung über die Schlachtkörperqualitäten von Rindern in Frankreich — B.L. DUMONT Étude sur les qualités des carcasses de bovins en France — B.L. DUMONT Studie over de verschillende kwaliteiten geslachte rinderen in Frankrijk — B.L. DUMONT	1969	DE, FR[1]), NL
5	Die „Behangdichten-Methode", ein Modell zur Analyse und Prognose von Kernobsterträgen — F. WINTER Méthodes des densités de charge, modèle d'analyse et de prévision de la production de fruits à pépins — F. WINTER	1969	DE, FR
6	Die Statistik der Eierpreise in den Mitgliedsländern der EWG — O. STRECKER, H. GOCHT La statistique des prix des œufs dans les États membres de la CEE — O. STRECKER, H. GOCHT	1969	DE, FR
7	Untersuchung über die Schlachtkörperqualitäten von Rindern in Italien — P.B. BUIATTI Études sur les qualités des carcasses de bovins en Italie — P.G. BUIATTI Studio sulle qualità di carcasse dei bovini in Italia —P.G. BUIATTI	1970	DE, FR, IT
8	Modell und Methoden zur Vorausrechnung von Rinderprozessen — H. DIEHL	1970	DE, EN[2])
9	Ein System der Agrarpreisstatistik für die EG — S. GUCKES Un système de statistiques des prix agricoles pour la CE — S. GUCKES	1970	DE, FR
10	Klassifizierung landwirtschaftlicher Betriebe mit Hilfe multivariabler statistischer Verfahren — K.A. SCHÄFFER	1972	DE
11	Methoden zur Aufstellung von Futterbilanzen in den Mitgliedstaaten der Europäischen Gemeinschaften — H. LANGEN Méthodes d'établissement des bilans fourragers dans les Pays membres des Communautés européennes — H. LANGEN	1972	DE, FR
12	Vorschläge „I" zur Harmonisierung der Rinderstatistiken der Mitgliedstaaten der Gemeinschaften — A. CANGUILHEM Étude «I» de l'harmonisation des statistiques bovines des États membres de la Communauté — A. CANGUILHEM	1973	DE, FR
13	Vorschläge „II" zur Harmonisierung der Rinderstatistiken der Mitgliedstaaten der Gemeinschaften — F. UHLMANN Étude «II» de l'harmonisation des statistiques bovines des États membres de la Communauté — F. UHLMANN	1973	DE, FR
14	Statistiken auf dem Gebiet der Schweineerzeugung in den Mitgliedstaaten der Europäischen Gemeinschaften 1968-1971 — Bericht des SAEG Statistiques dans le domaine de la production de porcs dans les États membres des Communautés européennes — Rapport de OSCE	1973	DE, FR
15	Ansätze zur Harmonisierung der Mengenstatistik für Eier und Geflügelfleisch in der EWG Essai d'harmonisation des statistiques quantitatives des œufs et de la viande de volaille dans la CE	1973	DE, FR
16	Zielsetzung, Aussagemöglichkeiten und Aussagegrenzen von mengen- und wertmäßigen Gesamtrechnungen — M. BESCH, E. WÖHLKEN Objectif, évidences et limites de l'agrégation de quantités et de valeurs — M. BESCH, E. WÖHLKEN	1974	DE, FR
17	Untersuchung über die Bodenpreise — Drs. H. JACOBS Études sur les prix des terres — Drs. H. JACOBS	1974	DE, FR
18	Einführung in die Diskussion über die Klassifizierung landwirtschaftlicher Betriebe — W. FRANK	1975	DE
19	Medium-term forecasting of orchard fruit production in the EEC: Methods and analysis — Miss J. HAWORTH, Dr. P. VINCENT	1977	EN

[1]) The French version is published in the series 'Statistical Information' under the number 4-1967.

[2]) An English version is available on special order.

DE EUROPÆISKE FÆLLESSKABERS STATISTISKE KONTOR

STATISTISCHES AMT DER EUROPÄISCHEN GEMEINSCHAFTEN

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