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BIOMASS PRODUCTION AS AN ENERGY SOURCE IN COPPICES OF THE PROVINCE OF FLORENCE, ITALY: CONSIDERING THE ECONOMIC AND EMPLOYMENT ASPECTS

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CONSIDERING THE ECONOMIC AND EMPLOYMENT ASPECTS

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1. INTRODUCTION

Coppice management of forests in Tuscany, and particularly in the province of Florence, has had a chequered history, which has set the stage for the present problems of forestry policy.

The period between 1955 and 1975 saw a marked reduction in use of firewood in the home and its virtual elimination from the industrial context, leading to progressive abandonment of coppice management. This resulted in disruption of the silvicultural practices and forest management techniques that had previously ensured efficient production forests (albeit with some limitations) that were also environmentally sustainable. Beech coppices in mountainous areas formerly managed by thin-out underwent disorderly aging, while the original coppice layout of turkey oak, italian oak and heliophilous broad-leaved trees characteristic of hilly areas was gradually destroyed.

Since 1975, wood-cutting has once again become an increasingly frequent practice, mainly in beech and deciduous oak forests, to the point that this phenomenon has been defined as a veritable revival of coppice management. This change is due partly to a rise in firewood prices but also to the greater yield obtainable from processing activities, although the observed increase is to be attributed not so much to technological progress (only a few enterprises have adequate equipment), as to the mass accumulated during the period of non-harvesting.

The new conditions have given rise to environmentally hazardous phenomena. Whenever cuttings have been resumed, there has been little concern to restore the previous silvicultural organization and very little awareness of the delicate ecological conditions of old forests. On the contrary, cutting has been resumed by starting from the forest areas closest to roads, seeking to clear large areas at a time by felling adjacent plots.

The only forestry policy instrument aimed at regulating coppice management that has recently been implemented and applied is the Europe contribution to the improvement of forests, which, as regards coppice, mainly consists in starting high-forest systems. But although such a measure is well-founded both from the point of view of environmental protection and economic development of the wood sector, the limitations of its field of application have already emerged, as its benefits are mainly restricted to farsighted forest-owners who are willing to run economic and legislative risks in long-cycle forest production.

Despite this, even today coppice can still represent a flexible type of forest management, capable of yielding products that will be appreciated on the market, thus providing considerable opportunity for economic development in general, and particularly in the most disadvantaged mountainous and hilly areas. But to boost coppice management and related business activities, a new forestry policy must be devise, aimed at enhancing the production potential of forests while guaranteeing their environmental sustainability.

2. UTILIZATION OF COPPICES FOR ENERGY-PRODUCTION: CURRENT PROSPECTS.

Firewood is an important form of renewable energy, given that - like any other biomass - it is constantly regenerated by solar energy and carbon dioxide. Using wood for fuel means using the natural processes of the forest ecosystem. The energy potential of Italian forests is far from being utilized: against an energy coverage by forest biomasses that

theoretically equals 5% (data provided by ENEA), wood currently covers 1.5% of final consumption (despite being the second energy source of Italy).
An increase in production and consumption of firewood as an energy source may lead to several advantages:

- increase in the Gross Domestic Product, since use of an internal source means that all the added value would be kept within the country;
- increase in employment, above all in the less advantaged mountain areas where the potential for development of the traditional sectors of industry and services is poor;
- use of wood which is not otherwise commercially exploitable;
- better management of forests (which would otherwise be abandoned) and protection of the land, above all from forest fires;
- partial replacement of non-renewable energy sources with renewable sources;
- diversification of energy supply;
- increasing self-sufficiency in energy supply;
- decentralization of energy production, making it possible to reach more remote areas with lower transport costs.

The effects of such a forestry policy would not only be environmentally sustainable, but would in fact improve the environment, as consumption of firewood does not generate sulfur dioxide or any other highly carcinogenic volatile organic compounds. Extensive research on dust and nitrogen oxide abatement has already yielded important results, and the most modern industrial installations now comply with the strictest European regulations. Wood processing is far less polluting than the processing of the other traditional fuels, and combustion residues (ashes) are not harmful for the environment. When extraction of forest materials is carried out by management methods that are correct from the ecological-forestry point of view, production is sustainable over time and is by far preferable to mere abandonment or sporadic utilization affecting large adjacent areas of forest unified into a single felling operation.
Within this context, the aim of this project is to assess the economic, occupational and environmental potential of coppice management in the province of Florence for biomass production as an energy source.

3 THE FIREWOOD MARKET IN THE PROVINCE OF FLORENCE

3.1 RESOURCES

In the province of Florence, areas managed by simple, sapling or standard coppice amount to about 104,000 ha, according to the Tuscan Forest Inventory (not including clear-cut, degraded and protection coppices). The most widely represented species are beech (27%), followed by italian oak (17%), hornbeam (13%) and turkey oak (15%). All these species except beech provide wood which can be used only as firewood (see fig. 3.1).

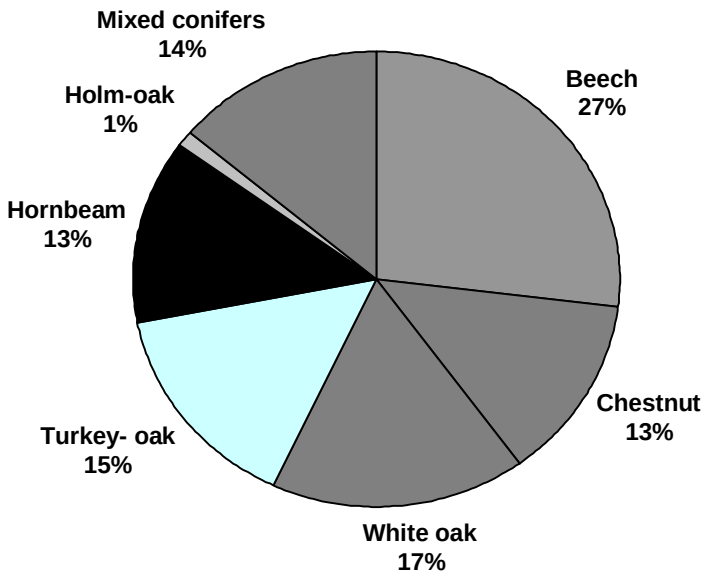

Figure 3.1 Forest resource in the province of Florence.

As regards to geographical localization, the municipalities with the greatest number of coppices are those located in the northern area, on the slopes of the Appennine (see fig. 3.2 and fig. 3.3).

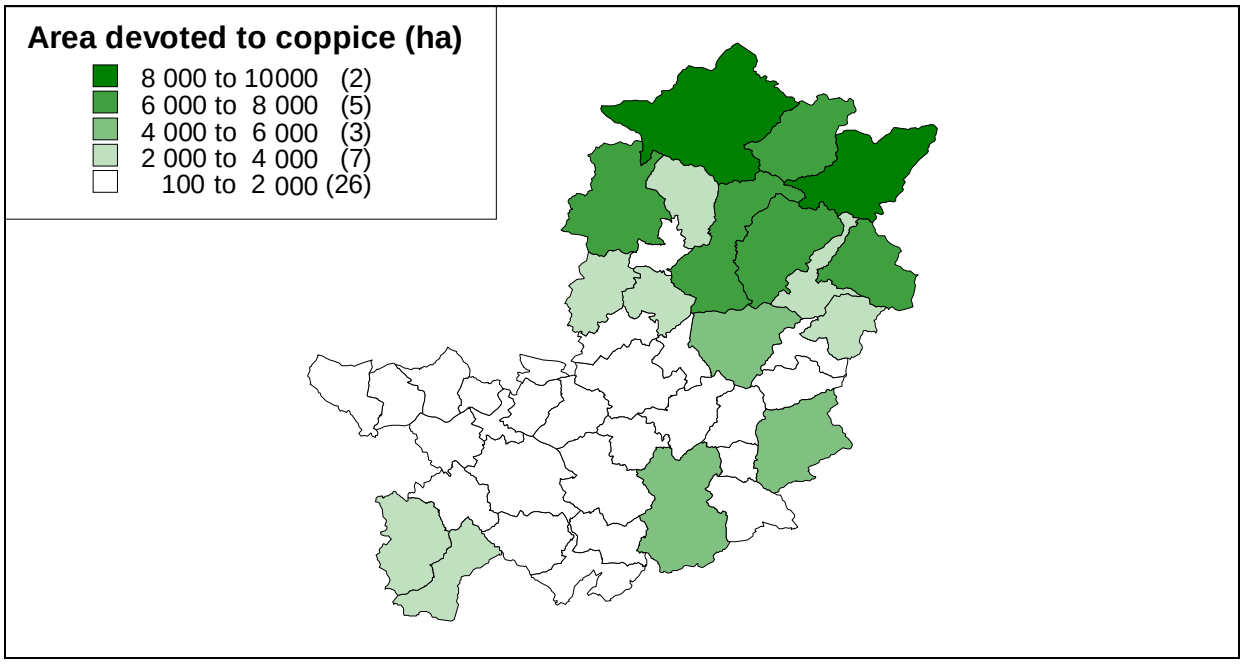

Figure 3.2 Distribution of coppice surfaces in the province of Florence.

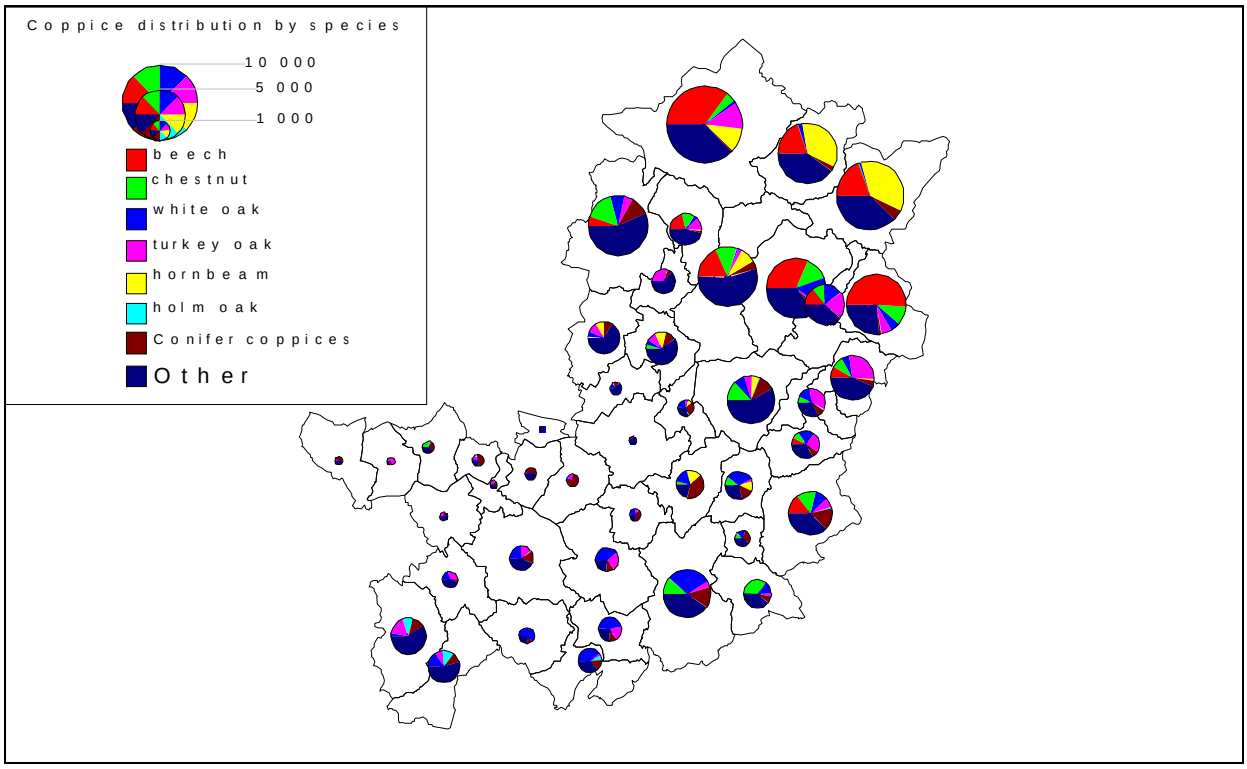

Figure 3.3 Specific distribution of forest resource in the province of Florence

3.2 THE HARVESTING

On the basis of the most recent available statistics, harvesting for purposes of firewood in the province of Florence takes up 1,700 ha, with firewood production amounting to roughly 90,000 cubic meter, corresponding to roughly 730,000 quintals. Mean productivity per hectare can be estimated at 53 cubic meter/ha, equal to roughly 430 quintals, consistent with the alsometric data regarding medium fertility coppices that have reached maturity.
On the other hand, harvesting measured over the total area is considerably lower, equaling **0.8 cubic meters per hectare and per year**. Moreover, charcoal, a product with a higher added value and very much appreciated by the market, seems to have negligible production, ranging between 200-500 cubic meter per year. *Even though no official data or the findings from specific research are available, it is well-known that Tuscany and Italy are importers of charcoal, of which they probably import large amounts.*

3.3 ESTIMATE OF PRODUCTION POTENTIAL

The definition of the production potential of coppices in the province of Florence is based on the findings of the TFI (Tuscan Forest Inventory) on a 400x400 meters grid. Coppice forests considered to be potentially exploitable were highlighted by a map elaboration technique on a purpose-designed Territorial Information System. The following selection criteria were used:

- less than 70% slope
- proximity to roads
- fairly even ground

- limited or absent erosion
- medium or full cover
- softwood (hornbeam, chestnut, mixed coppice of hilly and mountain land, riverbank formations) or hardwood species (turkey oak, beech, italian oak , holm-oak).

The location of the forests selected is shown in the following map (see fig. 3.4).

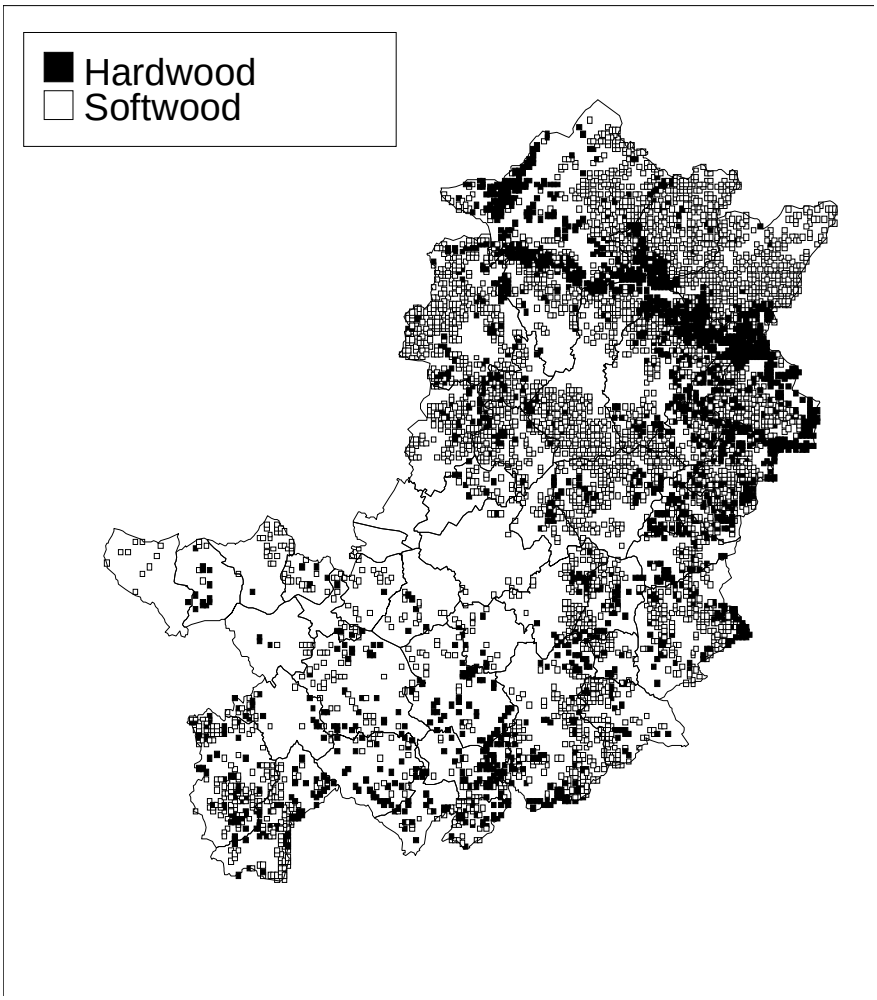

Figure 3.4 Forest distribution in the province of Florence.

Based on the potentially available resources, the potentially utilizable area can be assessed by one area regulation yield, assuming a medium rotation and harvesting planned sustainable from the coppice.

Such elaboration have led to the cautious assessment of a potential production of about 713,000 quintals of (fresh) hardwood and 1,400,000 quintals of (fresh) softwood, amounting to about three times the present harvesting.

It is worth noticing that softwood and hardwood forests have rather different economic characteristics. The former are less attractive to the existing forest utilization businesses due to their lower commercial value. Therefore, softwood forests as a whole are likely to witness a reduction in their harvesting, thus remaining an underutilized resource, unless market conditions change or unless new alternative ways are found to use this kind of production. The tables 3.1 and 3.2 report the previously discussed analytical situation concerning each municipality.

Municipality	Species (ha)					Hyphotesis for harvest plan				
	Beech	White oak	Turkey oak	Holm oak	Total	Yeld	m^3	Quintals	Branchwood quintals	Total quintals
Bagno a Ripoli	0	144	16	0	160	8	480	4,560	1,140	5,700
Barberino di Mugello	272	464	288	0	1,024	51	3,072	29,184	7,296	36,480
Barberino Val d'Elsa	0	400	48	80	528	26	1,584	15,048	3,762	18,810
Borgo San Lorenzo	864	48	80	0	992	50	2,976	28,272	7,068	35,340
Calenzano	0	112	160	0	272	14	816	7,752	1,938	9,690
Capraia e Limite	0	16	32	16	64	3	192	1,824	456	2,280
Castelfiorentino	0	80	112	0	192	10	576	5,472	1,368	6,840
Cerreto Guidi	0	0	192	0	192	10	576	5,472	1,368	6,840
Certaldo	0	288	0	0	288	14	864	8,208	2,052	10,260
Dicomano	272	368	592	0	1,232	62	3,696	35,112	8,778	43,890
Empoli	0	0	48	0	48	2	144	1,368	342	1,710
Fiesole	0	160	32	0	192	10	576	5,472	1,368	6,840
Figline Valdarno	0	128	16	0	144	7	432	4,104	1,026	5,130
Firenze	0	16	0	0	16	1	48	456	114	570
Firenzuola	2,352	48	928	0	3,328	166	9,984	94,848	23,712	118,560
Fucecchio	0	0	16	0	16	1	48	456	114	570
Gambassi Terme	0	304	192	176	672	34	2,016	19,152	4,788	23,940
Greve in Chianti	0	1,040	112	0	1,152	58	3,456	32,832	8,208	41,040
Impruneta	0	48	32	0	80	4	240	2,280	570	2,850
Incisa in Val d'Arno	0	80	0	0	80	4	240	2,280	570	2,850
Lastra a Signa	0	16	0	0	16	1	48	456	114	570
Londa	176	112	816	0	1,104	55	3,312	31,464	7,866	39,330
Marradi	1,024	0	0	0	1,024	51	3,072	29,184	7,296	36,480
Montaione	0	64	368	256	688	34	2,064	19,608	4,902	24,510
Montelupo Fiorentino	0	0	48	0	48	2	144	1,368	342	1,710
Montespertoli	0	208	144	16	368	18	1,104	10,488	2,622	13,110
Palazzuolo sul Senio	768	96	0	0	864	43	2,592	24,624	6,156	30,780
Pelago	32	224	272	0	528	26	1,584	15,048	3,762	18,810
Pontassieve	0	192	112	32	336	17	1,008	9,576	2,394	11,970
Reggello	288	208	240	16	752	38	2,256	21,432	5,358	26,790
Rignano sull'Arno	0	336	0	0	336	17	1,008	9,576	2,394	11,970
Rufina	0	224	608	16	848	42	2,544	24,168	6,042	30,210
San Casciano in Val di Pesa	0	384	224	0	608	30	1,824	17,328	4,332	21,660
San Godenzo	1,840	240	352	0	2,432	122	7,296	69,312	17,328	86,640
San Piero a Sieve	0	0	416	0	416	21	1,248	11,856	2,964	14,820
Scandicci	0	16	64	0	80	4	240	2,280	570	2,850
Scarperia	384	80	288	0	752	38	2,256	21,432	5,358	26,790
Sesto Fiorentino	0	48	16	0	64	3	192	1,824	456	2,280
Tavarnelle Val di Pesa	0	432	176	0	608	30	1,824	17,328	4,332	21,660
Vaglia	0	96	160	0	256	13	768	7,296	1,824	9,120
Vicchio	1,616	496	112	0	2,224	111	6,672	63,384	15,846	79,230
Vinci	0	0	16	0	16	1	48	456	114	570
Total Province	**9,888**	**7,216**	**7,328**	**608**	**25,040**	**1,252**	**75,120**	**713,640**	**178,410**	**892,050**

Table 3.1 Analytic situation concerning the hardwood in each municipality, and their harvest hypothesis.

Municipality	Species (ha)							Hyphotesis for harvest plan				
	Chestnut	Hornbeam	Mixed conifers	Others	Mix	Riverians	Total	Yeld	m^3	Quintals	Branchwood quintals	Total quintals
Bagno a Ripoli	16	224	304	208	0	0	752	38	2,256	21,432	5,358	26,790
Barberino di Mugello	800	0	512	3,136	0	0	4,448	222	13,344	126,768	31,692	158,460
Barberino Val d'Elsa	0	0	160	304	16	0	480	24	1,440	13,680	3,420	17,100
Borgo San Lorenzo	720	448	224	2,976	0	0	4,368	218	13,104	124,488	31,122	155,610
Calenzano	0	160	224	1,520	0	0	1,904	95	5,712	54,264	13,566	67,830
Capraia e Limite	0	0	128	80	0	0	208	10	624	5,928	1,482	7,410
Castelfiorentino	0	0	0	192	16	0	208	10	624	5,928	1,482	7,410
Cerreto Guidi	0	0	32	16	16	0	64	3	192	1,824	456	2,280
Certaldo	0	0	80	128	16	0	224	11	672	6,384	1,596	7,980
Dicomano	320	0	32	1,072	0	0	1,424	71	4,272	40,584	10,146	50,730
Empoli	0	0	16	48	0	0	64	3	192	1,824	456	2,280
Fiesole	0	32	128	96	0	0	256	13	768	7,296	1,824	9,120
Figline Valdarno	560	0	112	576	0	0	1,248	62	3,744	35,568	8,892	44,460
Firenze	0	0	32	48	16	0	96	5	288	2,736	684	3,420
Firenzuola	400	560	64	2,080	64	0	3,168	158	9,504	90,288	22,572	112,860
Fucecchio	0	0	80	80	0	0	160	8	480	4,560	1,140	5,700
Gambassi Terme	0	0	176	1,120	32	0	1,328	66	3,984	37,848	9,462	47,310
Greve in Chianti	384	32	464	1,184	48	0	2,112	106	6,336	60,192	15,048	75,240
Impruneta	0	0	64	16	0	0	80	4	240	2,280	570	2,850
Incisa in Val d'Arno	64	0	128	192	0	0	384	19	1,152	10,944	2,736	13,680
Lastra a Signa	0	0	128	80	0	0	208	10	624	5,928	1,482	7,410
Londa	240	32	112	1,296	16	0	1,696	85	5,088	48,336	12,084	60,420
Marradi	32	1,984	304	1,744	0	0	4,064	203	12,192	115,824	28,956	144,780
Montaione	0	0	272	1,520	0	0	1,792	90	5,376	51,072	12,768	63,840
Montelupo Fiorentino	0	0	32	64	0	0	96	5	288	2,736	684	3,420
Montespertoli	0	0	112	368	0	0	480	24	1,440	13,680	3,420	17,100
Palazzuolo sul Senio	16	1,344	64	1,600	0	0	3,024	151	9,072	86,184	21,546	107,730
Pelago	80	0	80	288	0	0	448	22	1,344	12,768	3,192	15,960
Pontassieve	512	192	288	1,984	16	0	2,992	150	8,976	85,272	21,318	106,590
Reggello	496	0	576	1,136	64	0	2,272	114	6,816	64,752	16,188	80,940
Rignano sull'Arno	128	144	160	224	32	0	688	34	2,064	19,608	4,902	24,510
Rufina	128	0	160	336	48	0	672	34	2,016	19,152	4,788	23,940
San Casciano in Val di Pesa	0	0	112	240	0	16	368	18	1,104	10,488	2,622	13,110
San Godenzo	624	0	80	1,152	0	0	1,856	93	5,568	52,896	13,224	66,120
San Piero a Sieve	0	16	96	896	0	0	1,008	50	3,024	28,728	7,182	35,910
Scandicci	0	0	208	0	0	0	208	10	624	5,928	1,482	7,410
Scarperia	208	16	32	944	0	0	1,200	60	3,600	34,200	8,550	42,750
Sesto Fiorentino	0	16	80	272	0	0	368	18	1,104	10,488	2,622	13,110
Signa	0	0	32	48	0	0	80	4	240	2,280	570	2,850
Tavarnelle Val di Pesa	0	0	96	256	16	0	368	18	1,104	10,488	2,622	13,110
Vaglia	80	256	128	1,040	0	0	1,504	75	4,512	42,864	10,716	53,580
Vicchio	800	32	96	1,568	32	0	2,528	126	7,584	72,048	18,012	90,060
Vinci	112	0	128	96	0	0	336	17	1,008	9,576	2,394	11,970
Total Province	**6,720**	**5,488**	**6,336**	**32,224**	**448**	**16**	**51,232**	**2,562**	**153,696**	**1,460,112**	**365,028**	**1,825,140**

Table 3.2 Analytic situation concerning the softwood in each municipality, and their harvest hypothesis.

3.4 PRODUCTION ENTERPRISES

According to the 1991 business census, 53 enterprises operate in the province of Florence, mainly in the Mugello area (see figure 3.5). Based on research carried out in Tuscany (Marinelli et al., 1993), the productivity of these enterprises is rather low, less than 2-3 cubic meters per worker. From a structural point of view, they have a rather low number of employees, with most enterprises consisting of units with only 1 or 2 employees, who often work part-time, utilizing, on average, only 60% of their working capacity. Their locked up capital is extremely reduced, about 70-100 million Liras on average. Furthermore, over 30% of the installed inventory is more than 10 years old and only 27% of employees are less than 40 years old. Finally, over 30% of the enterprises are envisaging a conveyance or a change in their activity in the near future.

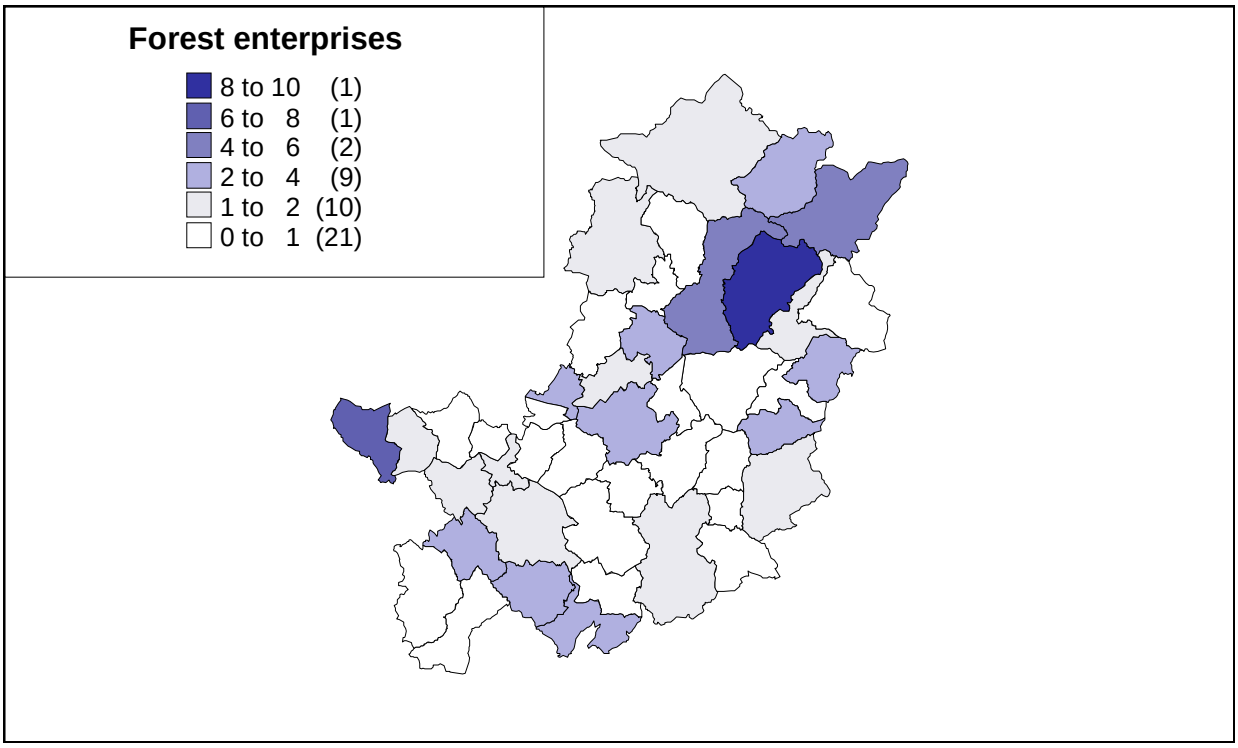

Figure 3.5 Distribution of forest enterprise in the province of Florence

3.5 THE MARKET

The production process connected to firewood production includes the following phases:
- purchase of stands;
- cutting and logging;
- desiccation and marketing.

There are no updated data available concerning the prices obtained in the various phases of the wood cycle, but reference can be made to the amounts reported by Marinelli et al. (op. cit.). The average stumpage price obtained by enterprises for the purchase of forest stands can be estimated at about 2,000 Liras per quintal; the wholesale price of wood is about 12,000-13,000 Liras, while the retail price may reach 20,000-30,000 Liras per quintal. **Interestingly, most of the increases in product prices (and therefore in revenues obtainable) are to be attributed to the retail marketing phase, while most costs are incurred in the cutting and growing phases**.

No regional or provincial statistical data exist concerning consumption of, and therefore demand for, wood used as fuel. However, the following considerations can be made:

- recent studies have shown that in the most developed countries the use of wood for energy production is a superior good, linked to the category "luxury goods" such as a holiday home in the country, catering, barbecues. **Consumption should increase more than proportionally to the increase in individual revenue**;
- the most recent development of heating technologies for dwellings and small environments **have allowed considerable technological improvement in heating systems using wood biomasses**, which are now more economical and easier to use, have lower gas emission levels and offer greater safety. Overall, the use of wood biomasses in the energy sector is competitive with oil and gas fired systems;

- the province of Florence is witnessing the phenomenon of families moving from the urban centers to the surrounding municipalities located about 20-40 kilometers from the provincial capital (such a phenomenon is also confirmed by the increase in property values in the latter municipalities). The characteristics of dwellings in these new areas point to a probable increase in the demand for wood as an energy source;
- the development of tourism in the province of Florence should lead to an increase in the demand for wood as an energy source in the field of catering.

As regards the geographical location of the two most important variables available and usable as demand proxy, the situation is highly diversified. Catering facilities are mainly located in the surroundings of the provincial capital or in the adjoining municipalities, while holiday homes in the country and houses on sale (1991 housing census) are mainly located on the Appennines slopes and in the Mugello area (see fig. 3.6 and 3.7).

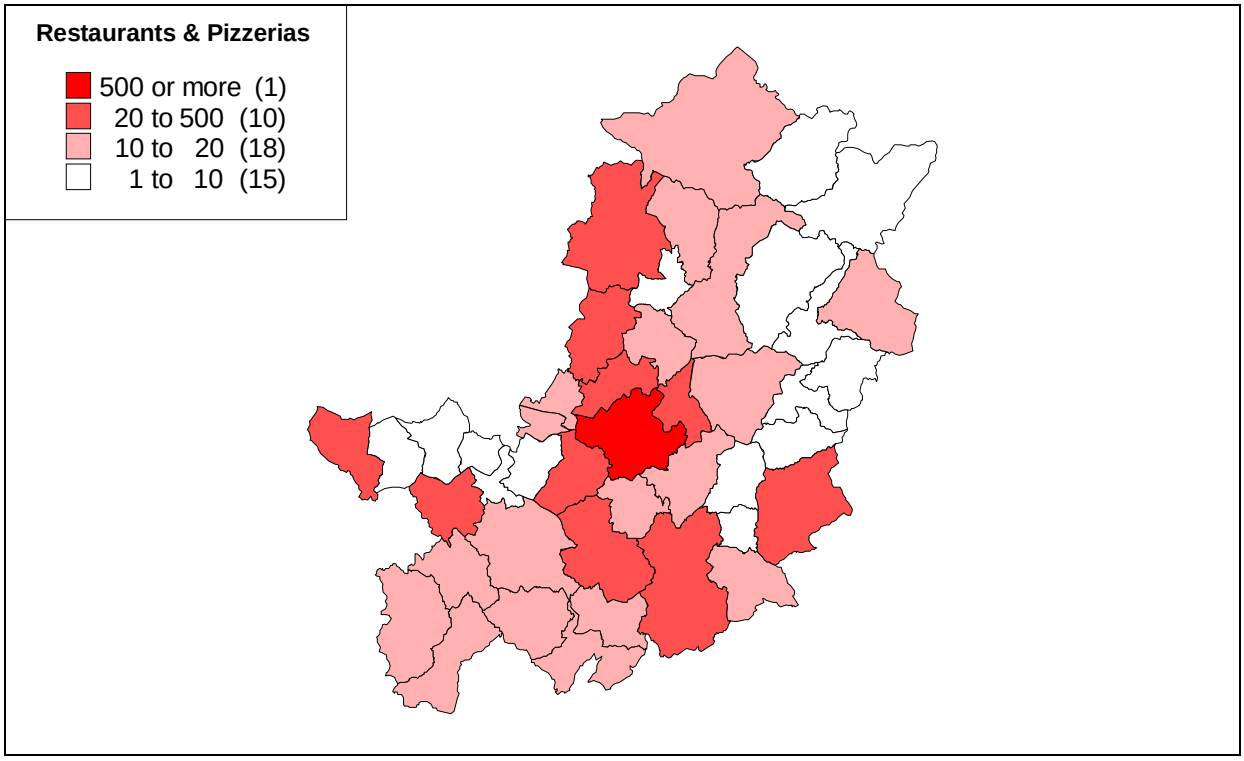

Figure 3.6 Distribution of catering facilities in the province of Florence.

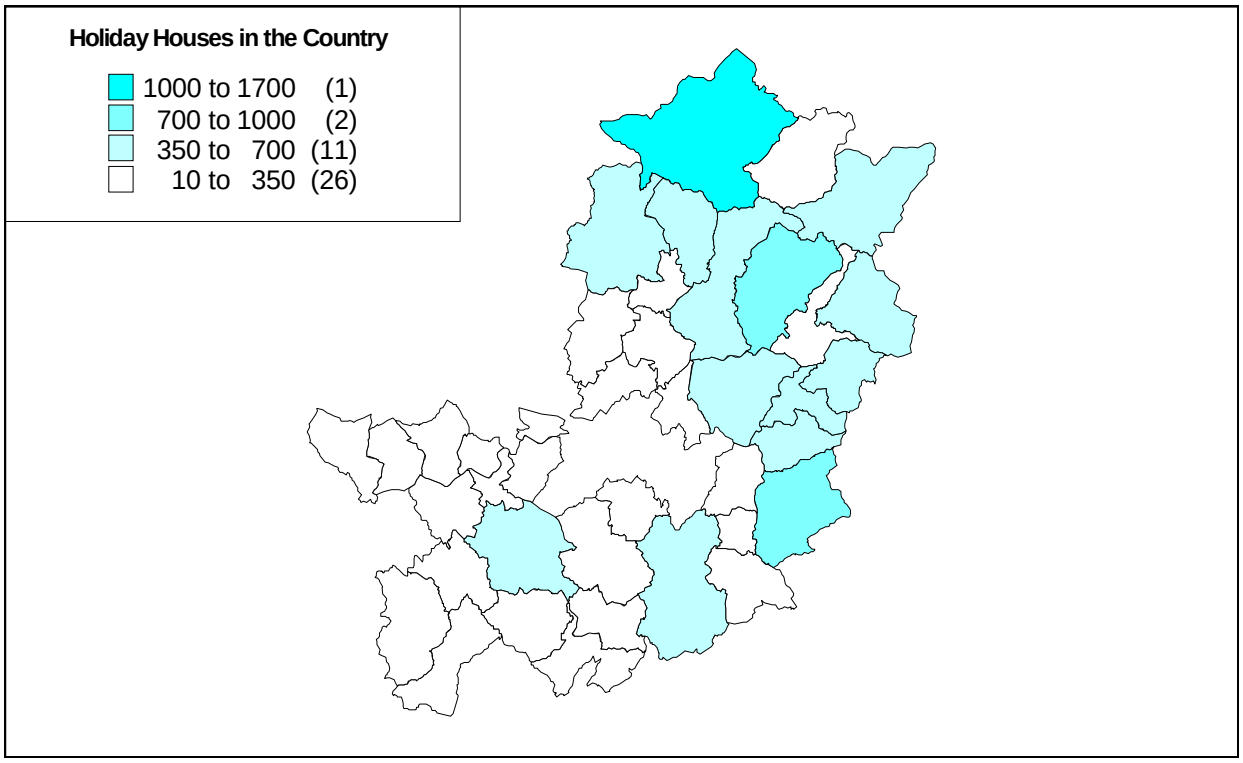

Figure 3.7 Distribution of holiday homes in the province of Florence

In conclusion, it should be pointed out that the situation described refers only to the province of Florence, while firewood stocks, though being a poor product, may aspire to a somewhat wider market than the province alone.

4. THE NEW MARKET PROSPECTS

4.1 THERMAL ENERGY PRODUCTION

Although endogenous local development based on coppice utilization appears feasible both from a technical and economic point of view, penetration of a fairly non-dynamic market such as that of heating systems should ideally be supported by local government policies.

Local government policies should be directed towards:

- the household heating market: a provincial energy plan should be set up to incentive conversion of traditional heating systems to wood-burning systems based on innovative technology (using a type of fuel that represents a renewable energy source, which is therefore in line with the objectives of the national energy policy);
- the public building heating market, favoring progressive replacement of obsolete traditional heating systems by wood-burning systems managed by the enterprises.

The new boilers fueled by wood biomasses constitute a modern heating system which is completely automatic; its functioning is highly similar to that of an oil-fired boiler. In the last few years dramatic improvements have been made in the technology of wood-burning boilers, above all in the field of the new pellet-burning boilers.
The main advantages offered by an automatic pellet-burning boiler are the following:

- wood is a local renewable energy source;
- by using energy derived from wood, an important contribution is made to lasting forest management and maintenance;
- as far as CO_2 emission is concerned, the contribution made by wood is neutral, as the amount of CO_2 released during the combustion process is the same as that released by the natural process of decomposition of wood in the forest.

Heating systems using pellet-burning boilers are suitable above all for use in public buildings. Annual pellet consumption is dependent on a number of different factors, including: pellet quality, external temperature, the construction materials used in the building (insulation), minimal external temperature, boiler performance.
In order to minimize emission of harmful substances during combustion, it is essential that an extremely elevated temperature be reached inside the combustion chamber.
The humidity of the material used as fuel has only a limited effect on energy potential per unit of volume[5]. Wood humidity is generally indicated as a % of absolute dry weight, i.e. as water content out of the total weight of the wood (U.ATRO). On the other hand, the relative humidity of wood indicates the percent water content out of the weight of humid wood (R.H.).
As an example, consider semi-aged pellet fuel of a hardwood species, in other words, of species having a U. ATRO content varying between 35% and 60%, or having a R.H. content varying between 25% and 35%. Its calorific value varies between 1,120 and 1,180 KWh/m^3, corresponding to 92-98 kg. of heating oil. Analogously, semi-aged pellet fuel of mixed species, with the same humidity conditions, has a calorific value varying between 980 and 1,020 KWh/m^3, corresponding to 82-86 Kg of heating oil. Thus in principle, one can apply the general rule of comparing a ton of heating oil to 10 m^3 of mixed broadleaf wood pellets or to 13 m^3 of resinous timber pellets.
Boiler performance represents another important factor that needs to be taken into consideration. It is important to note that in recent years technology has advanced by leaps and bounds in this field, and has successfully overcome many of the problems that were previously responsible for the low efficiency typical of traditional boilers. New techniques such as exploitation of the calorific value of smoke emitted and the downdraft technique (blue flame) have made it possible to obtain performances close to 90% and extremely low CO_2 emission levels.
Basing calculations on these data and considering the equivalence between KWh and Kcal/h[6], it can be stated that one cubic meter of hardwood pellets can fuel a high performance (86%) 30,000 Kcal/h thermal output boiler for roughly 30 hours, corresponding to consumption of roughly 92-98 kg of heating oil.
Therefore in this example one quintal of hardwood pellets produces 141 KWh and can fuel the same type of boiler for about 3.7 hours, corresponding to roughly 27 Kg of pellet per hour.
After considering these performances obtainable with pellet, it is interesting also to explore the performance obtainable from firewood. Firstly, it should be noted that firewood possesses a calorific value ranging between 2.300 and 3.000 Kcal/kg; now if we consider the same kind of boiler as in the previous example (thermal output 30.000 Kcal/h, corresponding to 34,88 KWh and 86% performance), it can be estimated that consumption will range between 13 and 16 Kg of firewood per hour of use of the boiler.
In this case, if the cost of a quintal of firewood transported to a householder's home is 25.000 Liras, the machine-operating cost will range between 85 and 105 Liras per KWh delivered by the wood-fired boiler, as compared to a cost of 117-118 Liras per KWh

[5] In contrast to wood pellets, the humidity of firewood has a marked effect on its calorific value.
[6] In the sector engineering 1 KWh is 860 Kcal/h.

delivered by an oil-fired boiler.
In order to quantify the demand for firewood deriving from use of this type of boiler and heating systems, two different cases were modeled: a biomass-burning boiler for an independent single-household 34.88 KWh central heating system, and a centralized 400 KWh biomass-burning central heating system, suitable for a medium-small condominium building or a small public building (e.g. a primary school). Calculations take into account both daily consumption and the period during which it is generally felt necessary to have the heating on in mountainous areas of the province of Florence, Results show that requirements amount to 153 quintals a year for the independent single-household system and 3072 quintals a year for the condominium system.

4.2 ELECTRIC POWER PRODUCTION

Production of wood biomass need not be destined exclusively to the household and public building heating markets. Another potential use lies in the electric power market, as the energy produced by the transformation of wood biomass could be used cost-effectively in times of peak power consumption in the area studied.
At present, peaks in demand for power are covered by relatively small power plants which involve very high costs for limited and sporadic usage. In order to reduce these peaks, there is a world-wide trend for more and more power production plants to offer incentives to their customers for electric power self-production during peak periods.
Italy also offers incentives for electric power supply produced by biomass-fueled plants. Self-produced electric power in excess can be sold to ENEL at the prices and conditions established by the articles 20 and 22 of Act 9/91, by the CIP provision n. 6/92, by the D.M.I.C.A. dated September 25th 1992 and by the D.M.I.C.A. dated August 4th 1994. Such regulations establish the standard type of agreement, prices and conditions for sale, compatibility with the generating stock (the sum total of electric power generation plants), with the national grid and with the development programs (for further details, see the analysis of opportunities for access to incentives).
Biomass-fueled electric power production seems to be the most rational solution to satisfy demand during peak periods. Furthermore, the best solution is probably not represented by large high-capacity power plants located in a limited number of areas distant from biomass production sites, but rather by a series of small plants set up near the areas of raw material production, so that the limited demand arising in critical periods can be satisfied and production costs reduced. In addition, small plants have the undeniable advantage of being simple to use, functioning automatically, and allowing easy maintenance. It is particularly important to note that the characteristic of easy servicing is crucial to ensure the plant's full effectiveness in peak periods.
In the area examined, namely the mountains of the province of Florence, peak demand for electric power mainly occurs during the summer, due to tourist flows and the use of holiday homes. In such circumstances, the most suitable plants for electric power production by wood biomass utilization are gasification plants functioning together with generators. Through chemical processes these power plants transform the vegetal biomass into a mixture of combustible gases (methane, hydrogen and other inert gases) that can be used to fuel internal combustion engines, usually diesel engines adapted and transformed for the purpose into an Eight cycle (commanded combustion) in order to obtain the required amount of power, and connected to a generator.
The use of such generators makes it possible to orient production exclusively towards high

output[7] (33 %) electric power, preferably with low production of thermal energy since in the case examined the latter would not be easily marketable because it would be produced during the summer.
Taking into consideration the thermal output used (100-1000 KWh), fuel consumption and an average price of 15,000 Liras per quintal of firewood, it was calculated that the electric power would cost about 108 Liras/KWh, independently of the size of the plant, as performances are constant for plants whose size ranges from 100 to 1000 KWh.
If classical cogeneration plants were use, producing both electric power and thermal power, the thermal power generated in that period of the year could possibly be used for heating sawmill desiccation chambers. Another alternative that can be envisaged is that sawmill enterprises may produce both thermal and electric energy, exploiting the total amount of thermal energy for their desiccation chambers and then selling the excess electric power they have self-produced according to the prices and conditions laid down by Art. 20 and 22 of Act of Law 9/91, by the CIP provision n. 6/92, by the D.M.I.C.A. dated 25/9/92 and by the D.M.I.C.A. dated 4/8/94.
The basic proposal for production of electric power by gasifiers connected to electric-generators is based on the assumption that the period during which peak demand occurs lasts about 90 days, with the gasifying and electrogenerator installations being in use for about 8 hours a day. Three types of power plants were considered, differing in thermal output deliverable (100, 500 and 1000 KWh), and sized according to the demand for power (see tab. 4.1).

Generator power (KWh)	Hours of utilization per year	Hours of utilization per day	Biomass Requirements (T/day)	Biomass Requirements (T/year)
100	720	8	0.58	52
500	720	8	2.88	259
1000	720	8	5.76	518

Table 4.1 Biomass requirements for three types of electric plants.

If calculations are based on the hypothesis outlined above, also taking into account the mean performance of biomass-fueled electric power plants, then the annual pellet requirements for the area studied would amount to 520 quintals for the 100 KWh power plant, 2,590 quintals for the 500 KWh power plant and 5,180 quintals for the 1000 KWh power plant.
These results show that there would be substantial requirements, and these requirements would suffice to take up a considerable portion of the biomass production in the study area. It should however be noted that within the framework of our analysis the peak period energy requirements could probably be met efficiently by medium-small power plants, each of which would have fairly limited requirements.

5 ADVANCED ENTERPRISE ORGANIZATION IN THE SECTOR OF FOREST BIOMASSES FOR ENERGY PRODUCTION

Conditions for structural expansion of production enterprises are now favored by the positive trend observable on the market for biomasses as an energy source, although further successful development will be conditional on overcoming some evident limitations

[7] We rimind you, that, the performance for electric-cogenerator plants with stream turbine and with the same output as the electric-generator in object, are about 15-20 %.

intrinsic to the sector.
Firstly, it is necessary to plan forest harvesting so as to guarantee continuity in supply and ensure that biomass production is accompanied by rational use of forest resources and safeguards for a sustainable environment. The main limitations involved in pursuing these goals are the following:

- fragmentation of forest properties;
- environmental risk connected to the methods used for exploitation;
- difficulties and bureaucratic uncertainties concerning cutting authorizations;
- lack of an adequate road network and infrastructures;

Furthermore, it is imperative for the industry of this sector to achieve appropriate technical, economic and marketing efficiency by means of:

- use of modern equipment and machinery, suitable for the type of forest considered;
- professional training;
- acquisition of knowledge of market characteristics and trends by operators in the sector.

Finally, it is necessary to diversify production even in the energy-production wood sector by encouraging modern, flexible and efficient activities, so that the entire added value of the wood cycle can be absorbed by the industry. In particular:

- production of fuels different from firewood, such as charcoal, pellets, etc.;
- greater marketing effectiveness both in the retail and wholesale phases (e.g. packaging of charcoal for supermarket distribution, etc.);
- diversification of production activity, so that utilization and marketing activities can be accompanied by the installation of new energy production and heating plants, processing of sawmill and joiners' shop residues, silvicultural operations and protection against forest fires. It is desirable that all such activities should give rise to by-products in the sector of forest energy production.

Efficiency in the sector of forest biomasses used for energy production should be based fundamentally on two closely connected entities: consortiums of forest owners and specialized enterprises.

5.1 OWNER CONSORTIUMS

Owner consortiums represent a form of entrepreneurial association that can lead to appreciable benefits both in terms of economic returns and enhancement of agro-forest resources; they also have beneficial effects on corporate management and organization and offer substantial advantages in gaining access to European, national and regional financial support. In addition, a consortium provides an optimal solution to problems linked to property fragmentation. For large forest utilization businesses, investment in planning is economically advantageous, whereas for small and medium-sized businesses the cost of the business plan is not amortizable except in the framework of unifying adjacent properties: and this is precisely what is achieved by creating a consortium of forest owners. It follows that the creation of a consortium can play a crucial role in promoting planned forest management.
The minimum size required for such a consortium can be estimated to be roughly 2000 - 3000 hectares of productive forest area, preferably adjacent or as close to one another as possible. The fundamental planning tool to be used by this kind of economic entity is the **management plan.** The management plan should be drawn up mainly with a view towards production goals but should also incorporate binding safeguards for sustainable forest production. This tool makes it possible to guarantee that the consortium will enjoy regularity of production and revenue, allocated proportionately to the value of the landed

capital invested; it also avoids the problems and uncertainties linked to cutting authorizations. The costs involved, apart from those of the schedule itself, are limited to the consultancy fees of a forestry operator for application of the cutting plan and the expenses involved in business relations with the “forest biomass production as an energy source” enterprise linked to the consortium.

5.2 THE SPECIALIZED “FOREST BIOMASS PRODUCTION AS AN ENERGY SOURCE” ENTERPRISE

This firm, which is **highly specialized** in this sector, has close contractually specified links to the consortium, and must be capable of supplying all the products and services required by the sector under study. In particular:

- forest utilization in terms of clear-cutting, silvicultural practices and environmental protection;
- processing of products such as charcoal, wood-shavings and chippings, briquettes, utilization of wood-working wastes, customized bucking, possibly also product packaging;
- retailing or distribution of the finished product through supermarket chains;
- installation and maintenance work on heating systems fueled by wood or its derivatives.

The equipment required in the individual production sectors can be listed as follows:

- **Forest utilization sector**: agricultural tractors suitable for forest use, mini-articulated tractors, tractors equipped with forward and rear cradles, trailer-mounted cranes with lightweight overhead cables, portable pelleting and chipping machines, skidding channels, chain saws, and lumberjack gear (helmets, overalls and other accessories)
- **Product processing sector**: automatic choppers for firewood, briquetting machinery, equipment for charcoal production and charcoal packaging, plazas or holding areas for the wood curing and aging process;
- **Marketing sector**: trucks and haulage vehicles;
- **Heating system installation and maintenance sector**: trucks, specific equipment.

Each sector should have at least one specialized operative who is responsible for ensuring that procedures are carried out correctly and has taken a specific professional training course.

The figure 5.1 shows how the hypothetical enterprise in question should be organized. At the present state of research, analysis of the economic parameters of the structure of this enterprise has so far been restricted to activities dealing with forest harvesting and the early stages of wood processing (processing wood in the green stage); this limitation has been adopted because these stages are not only the most critical but also those which impose the greatest burden in terms both of labor and capital requirements.

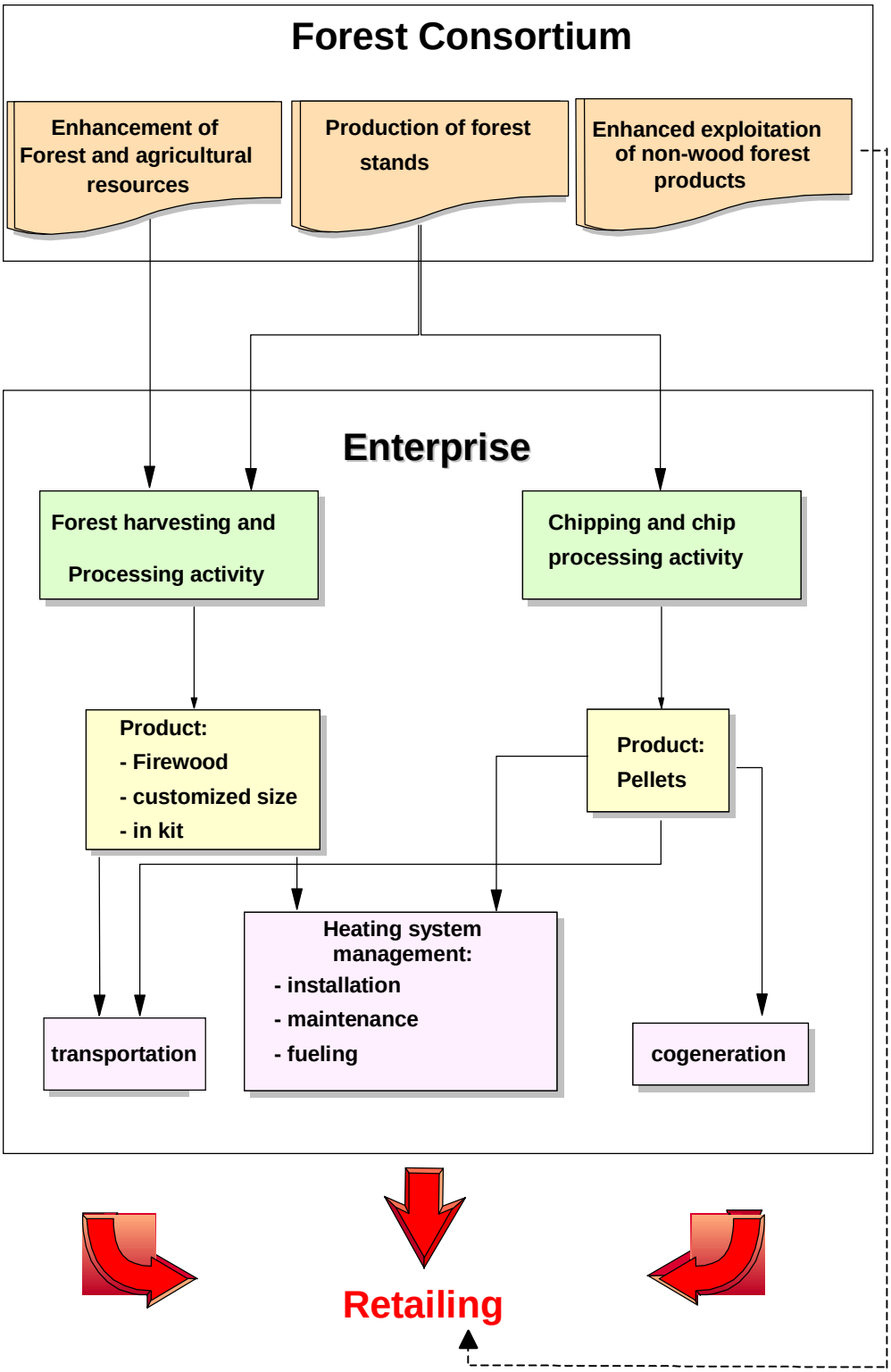

Figure 5.1 The organization of hypothetical enterprise.

5.3 EMPLOYMENT PROSPECTS FOR FORESTRY ENTERPRISES

Let us assume that enterprises are set up in the administrative area termed the Mugello-Upper Valley of the Sieve Mountain Community, which represents the area richest in potentially exploitable forests. Such enterprises would have available roughly 17,000

hectares of hardwood forests and over 34,000 hectares of softwood forest. On the basis of the tables shown earlier, they could count on annual production of 400,000 quintals of high commercial value firewood and over 1.300,000 quintals of biomass under-appreciated by the market. The analytical recapitulation of these resources is shown in the table 5.1:

Recapitulation	Cubic meters	Quintals - fresh	Quintals - aged
Hardwood species	52080	494760	247380
Branchwood		123690	61845
Softwood species	103200	980400	490200
Branchwood		245100	122550
Total firewood	52080		
Total chippings		1349190	674595

Table 5.1 Available resources.

Under the hypothesis that the enterprise would deal predominantly with types of wood less appreciated by the market, and, for the sake of caution, basing the model on use of only a fraction of the available resources, one would have the following situation (see tab. 5.2).

Hypothesis			
Resources used as % of total		Hectares harvested	Resources in hectares
Hardwood species	10 %	86.8	1736
Softwood species	10 %	172	3440
Total		258.8	5176
Recapitulation	Cubic meters	Quintals -fresh	quintals - aged
Hardwood species	5,208	49,476	24,738
Branchwood		12,369	6,185
Softwood species	10,320	98,040	49,020
Branchwood		24,510	12,255
Total firewood	5,208	49,476	24,738
Total chippings		134,919	67,460

Table 5.2 Available resources division.

This result would allow a roughly 13% increase compared to current production in the province.
As regards the production phase consisting in harvesting and pelleting of materials, the following yields can be obtained (see tab. 5.3); note that yields differ according to the degree of difficulty involved in the various operations depending on location of the forest resources (slopes, rough ground, road access, etc.):

Softwood utilization for pelleting		
Difficult conditions	quint/d	operative
Felling and lumbing operations	104	2
Logging	144	3
Pelleting	176	2
days/1000 q/operative	51	
Easy conditions	quint/d	operative
Felling and lumbing operations	368	2
Logging	760	1
Pelleting	648	1
days/1000 q/operative	8	

Table 5.3 Harvesting performance for different working conditions.

Maintaining the same hypotheses concerning available resources as described above and hypothesizing equal probability of operating in difficult or easy conditions, one has the situation in table 5.4.

Mean conditions, days/1000 q/operative	30
Easy	50%
Difficult	50%
Days	4029
Number of operatives	20

Table 5.4 Number of work units under the hypothesis that there is the same probability to find both easy and difficult condition.

Overall, can be estimated, on the basis of existing resources, that with only the activities of forest harvesting, there is the employment opportunity to roughly twenty operatives unit. As regards equipment requirements, our simulation showed that depending on the volume of harvests, the amount of labor needed and the geographical conditions of the forests utilized, the following equipment will be required for harvesting, chipping and transporting materials:

Equipment for harvesting and preparatory activities	Liras	15 000 000
Equipment for logging	Liras	917 000 000
Transport equipment	Liras	724 000 000
Other equipment	Liras	292 000 000
Total investments	Liras	1 948 000 000

The investment required thus amounts to roughly 2 billion Italian Liras, corresponding to roughly 80 million per working unit used; this cost is relatively low if compared to the investment required for small-sized manufacturing or industrial businesses.
Production cost forecasts are based on data obtained from existing worksites that are already operating in Tuscany with state-of-the-art technology. Data refer to wood and pellet production or to production of wood only or pellet only; in addition, various levels of difficulty linked to the geographical location and presence of infrastructures are also taken into consideration. The data used are reproduced in the table 5.5:

Production costs	Liras/ton	Liras/ qu.fresh
Pellets, loaded on trucks and ready for transportation:		
From coppices with species appreciated by the market, branchwood only	65,000	6,500
From coppices with species not appreciated by the market	45,900	4,590
Cleaning out river beds	38,400	3,840
Inadequate infrastructures	98,800	9,880
Firewood, adjacent to roads		
Adequate infrastructures	22,300	2,230
Inadequate infrastructures	64,800	6,480
Transportation	18,000	1,800
Purchase of stands	20,000	2,000

Table 5.5 Production costs for different harvesting conditions.

By comparing results with reference data, it's possible to identify the gap between the minimum and maximum cost for each timber assortment, whether referring to units of fresh weight or aged product. Calculation of the mean unit cost per quintal of product was

performed in proportion to the estimated timber assortment mix, under the hypothesis of working in forests under favorable conditions in 50% of cases and difficult conditions in the remaining 50% of cases.

Calculation of mean production costs		max	min	mean
Pellets, per fresh quintal	Liras/quintal	10,300	8,300	
Pellets, per dry quintal	Liras/quintal	17,167	13,833	15,500
Firewood per fresh quintal	Liras/quintal	10,280	6,030	
Firewood per dry quintal	Liras/quintal	20,560	12,060	16,310
Pellet product, cubic meters		49,476		
Firewood product, cubic meters		16,600		
Mean unit cost,	Liras/quintal	15,703		

Table 5.6 Mean unit cost under the hypothesis that there is the same probability to find both easy and difficult conditions

The mean unit cost of yield mass transported to customer, for the sake of caution, is estimated at about 15.000 Liras for quintal.
Under the hypothesis that the enterprise would deal predominantly with types of wood less appreciated by the market, and, for the sake of caution, basing the model on use of only a fraction of the available resources, one would have the following situation (see tab. 5.2).

5.4 ENTERPRISE EFFICIENCY INDEXES

Using the above-estimated parameters, one can calculate several rough indexes for estimation of the economic efficiency of the proposed production set-up.
The table 5.7 shows the main index calculated.

Analysis of economic results *Recapitulated data*	
Fixed annual costs	335,817,000
Mean price	25,000
Mean variable unit costs	15,703
Estimated quantity in quintals	67,460
Business indicators	
Operational results	291,320,718
Total added value	1,097,077,505
% added value	65%
Break even point of quantity sold	36,123
Safety margin of quantity sold	46%
Break even point price	20,682
Safety margin price	17%

Table 5.7 Main index.

As can be seen from analysis of the table, and considering only the activity of the sale of wood and pellets for consumption, the proposed enterprise should achieve a turnover of roughly 1.6 billion Liras per year, with an added value of roughly 1 billion Liras, corresponding to 65% of the production achieved. The elevated added value clearly shows the high labor intensity of the enterprise and therefore its importance from the point of view of job creation.

In order to analyze the risk factors for such an enterprise, we calculated the break-even point and the safety margins in relation to variation in the amount sold and price fetched.
The break-even point of the amount sold represents the minimum quantity of wood that needs to be sold in order to ensure coverage of fixed costs, variable costs and the minimum retribution levels to be paid for labor, the latter being set in the case examined at a wage of 200,000 Liras gross per day. The analysis shows that the smallest quantity necessary corresponds to roughly 36 000 quintals of aged product, with an admissible reduction of about 46% as compared to the planned quantity.
The simulation was repeated maintaining the planned quantity constant but introducing price variation. In this case the break-even point was reached at a sale price of roughly Liras 20,600 a quintal with an admissible reduction of 17%.
Both parameters were found satisfactory.

6 INCENTIVES FAVORING CONVERSION OF LIQUID FUEL HEATING SYSTEMS INTO SOLID FUEL SYSTEMS

In Italy the incentive technique was already used successfully in the 1997 car demolition campaign. This was a campaign that made it possible to take off the roads many vehicles that were obsolete from point of view technique, economic and environmental.
In the case under study, the hypothesis of a state intervention (incentives) to favor the installation of heating systems fueled by wood biomass should be directed exclusively towards private citizens. Installation of low environmental impact heating systems in public buildings should be undertaken by the competent local authorities themselves.
In order to assess the need to implement a policy of the above type, we evaluated both the financial and practical advantages and disadvantages of solid fuel (wood-burning) boilers as compared to oil or gas-fired boilers.
In the table 6.1 we present a comparison between the characteristics of boilers burning wood biomass, liquid propane gas (LPG) and heating oil. This comparison is of relevance as gas and oil-fired boilers are widespread in the dwellings located in the geographical area under study.
This table 6.1 highlights the **advantages** of boilers fueled by wood biomass:

- extremely elevated thermal performance;
- very low maintenance costs;
- prolonged average lifespan of the installations;
- use of renewable resources
- low environmental impact of polluting emissions (see table 6.2);

The following **disadvantages** can also be discerned:

- need for a suitable place in which to install the boiler (fireplace or boiler room);
- requirement of available covered areas in which to store biomass reserves;
- need for manual feeding of the boiler (twice a day)[8]
- need for manual start-up

Type of Fuel	Type of boiler	Location	Output in Kcal	Perfor-mance	Loading	Duration of load	Main-tenance	Servicing available locally	Main-tenance costs (Liras x 1000)	Average lifespan of system (years)	Price (Liras x 1000)
gas, methane	thermo-convector	external walls	20000	0.75	automatic	unlimited	yearly	yes	100-200	12	3.000
gas, methane	hot air generator	any-where	30000	0.75	automatic	months	yearly	yes	100-200	12	3.000
gas, methane, heating oil	pressure. downdraft	boiler room	30000	0.9	automatic	months	yearly	not necess.	50-100	15	3.000
logs	forced ventilation	fireplace	20000	0.65	manual	3-4 h	weekly	not necess.	50	18	3.100-4.200
logs	downdraft	boiler room	17000	0.9	manual	6-7 h	weekly	not necess.	50	15	3.500-5.300
logs+ heating oil	combined: solid-liquid	boiler room	25000	0.8	manual-automatic	6-7 h, months	weekly	not necess.	50-100	15	6.000
wood pellets & residues processed products	automatic hopper	boiler room	25000	0.85	automatic	week	weekly	not necess	50-100	15	4.500-5.000

Table 6.1 Technical characteristics concerning the solid fuel boilers, gas and liquid fuel boilers

Comparison of polluting emissions deriving from combustion of wood and oil (see table 6.2) shows that the fundamental advantages of wood-burning boilers are linked to the low levels of CO_2 (natural cycle), SO_2, hydrocarbons and heavy metals.

Fuel	CO_2	CO	NOx	HC	SO_2	Particle	Heavy metals µg/MJ		
	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	Pb	Zn	Cd
Firewood	1	80	140	3	22	84	18	27	0.5
Heating oil	87	4	30	11	111	7	164	164	21

Table 6.2 Comparison of polluting emissions from combustion of wood and oil.

In general, private dwellings will be able to take up products with thermal output varying between 34 KWh and 400 KWh (for independent single-household systems and centralized small condominium systems respectively), while larger systems (up to 1000 KWh) can be used for industries or public buildings. On the basis of these considerations it can be concluded that the market will mainly absorb small sized boilers with thermal output of roughly 34 Kwh.

For boilers with this thermal output, our study therefore attempted to define the differences in installation, operating and maintenance costs between traditional systems (oil-fired, LPG, etc.) and new generation systems (solid fuel boilers).

To this end, we determined the present value of the difference in installation, operating and maintenance costs between oil-fired boilers and solid fuel (wood-burning) boilers, considering a discount rate of 5%. To define the monthly cost, we hypothesized the use of a 34.88 KWh (30 000 Kcal) boiler suitable for heating and providing hot water for an apartment or small house measuring roughly 120 m^2; the boiler is assumed to be kept running for 6 hours a day for 125 days a year (the maximum duration allowed by heating legislation), and the economic duration of the investment is 12 years.

[8]Except boilers running on pellets, which can have an automatic feeder by means of a purpose-designed hopper.

It emerges that

$$PV = \sum_{i=1}^{n} \frac{C_i \ oil.fired - C_i \ \ firewood}{\left(1 + r\frac{i}{12}\right)^{\frac{i}{12}}}$$

where:

PV = Present value of difference costs;
C_i = Costs incurred in the i-th month;
r = Interest rate applied;
i = duration of the investment (in month);

To assess yearly maintenance costs and boiler sales prices, reference was made to data supplied by several manufacturers, while operating costs were derived from the technical characteristics of the boilers, the calorific value of the various types of fuel and the market prices of such fuel types.
Extreme variability in boiler sales prices and maintenance costs was observed on the market; therefore it was decided for purposes of the study not to identify a point value but rather a PV range.
The table 6.3 shows the present values pertaining to differences in operating costs between oil-fired boilers and, respectively:

a) forced ventilation boilers set in the fireplace;
b) log-burning boilers with downdraft;
c) downdraft boilers fueled by pellets and wood processing wastes;

PV Costs difference	max PV	min PV	mean PV
PV_1 heating oil - fireplace	4.037.199	758.341	2.397.770
PV_2 heating oil - firewood	3.637.337	- 549.516	1.543.911
PV_3 heating oil - pellets	2.637.684	- 957.686	839.999

Table 6.3 Present value of difference in operating costs.

It was found that although boilers set in the fireplace have a very low thermal output (65%), they are the most advantageous economically, because in the worst-case scenario they have a positive PV of about Liras 758,000, while under the best hypothesis they allow a net saving of Liras 4,037,000 over a period of 12 years. This is due to the low installation costs of the system, comparable to the cost of installing traditional boilers, and the low operating and maintenance costs.
Recoupment Time[9] (RT) is only 1 month in the best-case hypothesis, and 36 months in the worst (on average, it takes 11 months) (see fig. 6.1).

[9] Period of time after which the present value of the difference in installation, operating and maintenance costs between oil-fired and solid fuel (wood-burning) boilers assumes positive values. It corresponds to the minimum duration of the investment (purchase of solid fuel boiler) required to compensate the greater initial burden by means of savings resulting from low operating and maintenance costs of the investment.

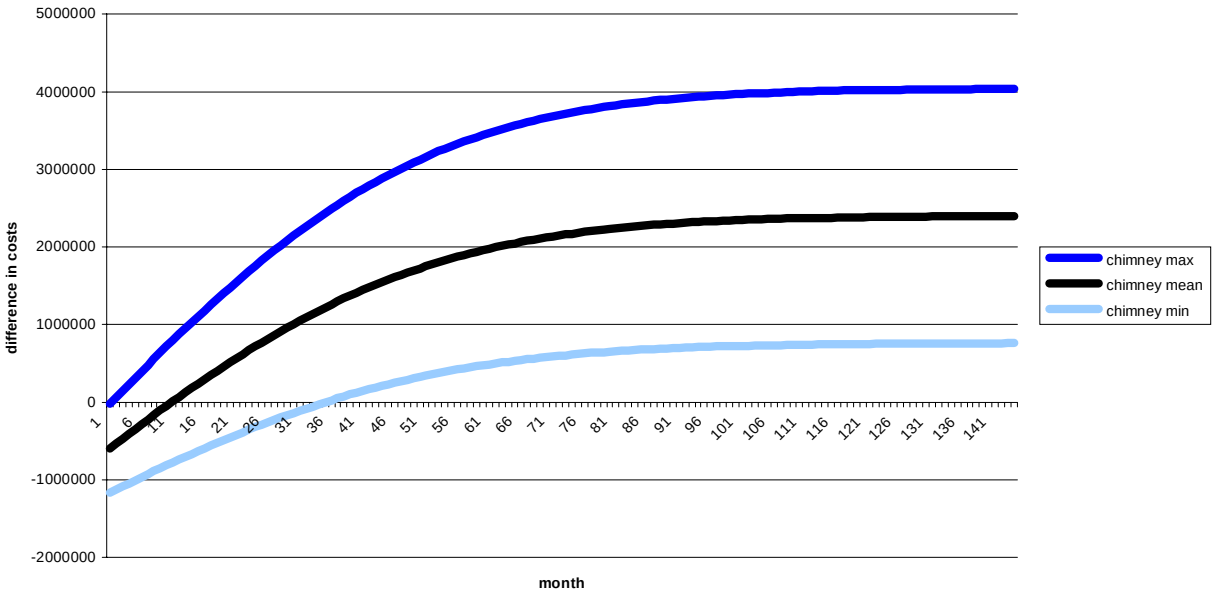

Figure 6.1 Difference in costs between oil-fired boilers and fireplace boilers

In the case of log-burning downdraft boilers, which have an average performance of 90%, the worst-case PV is roughly Liras 549,000, while in the best-case hypothesis it is roughly Liras 3,637,000 , with an average PV of Liras 1,544,000.
In this case Recoupment Time is meaningful only in the best-case hypothesis, and corresponds to 6 months (on average, it corresponds to 25 months). In the worst-case scenario the investment is not compensated by low annual operating costs resulting from use of a log-burning boiler (see fig. 6.2).

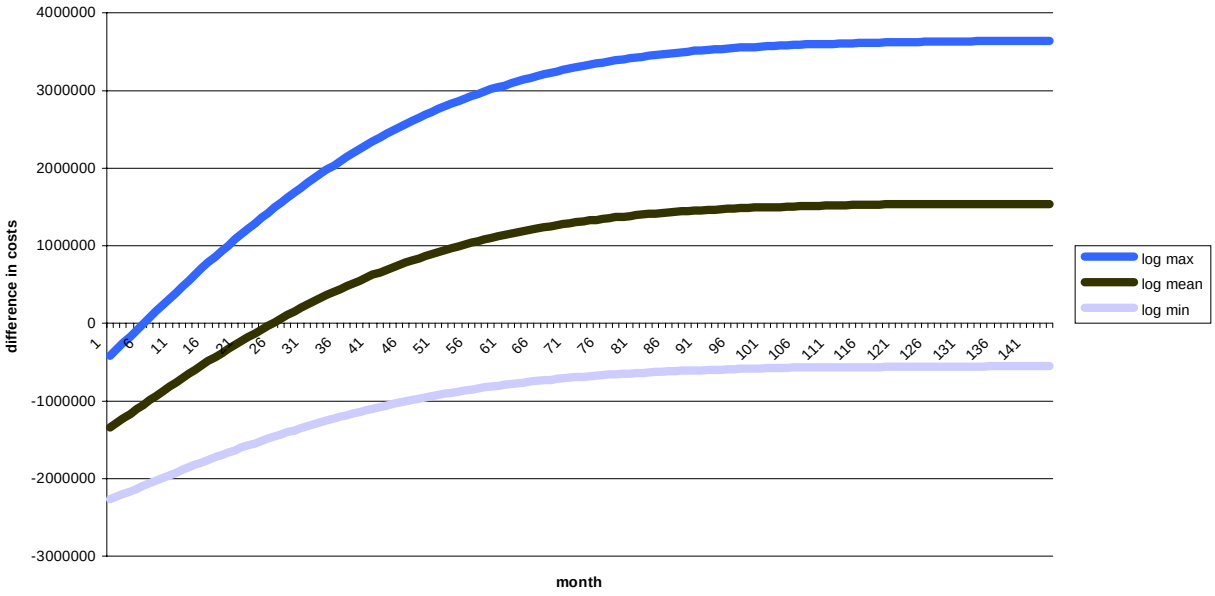

Figure 6.2 Difference in costs between oil-fired and wood-burning boilers

Finally, solid fuel heating systems running on pellets or processing residues (seed cake and pulp, almond hulls, etc.), it can be found that the PV is even lower than in the previous case: in the best-case hypothesis the PV corresponds to roughly Liras 2,638,000 while in the worst-case hypothesis (higher price of the boiler) the capitalized costs of newly

installed systems are always higher than those of traditional systems, so that the difference in costs assumes a negative value and corresponds to Liras -958,000 (see tab. 6.3).

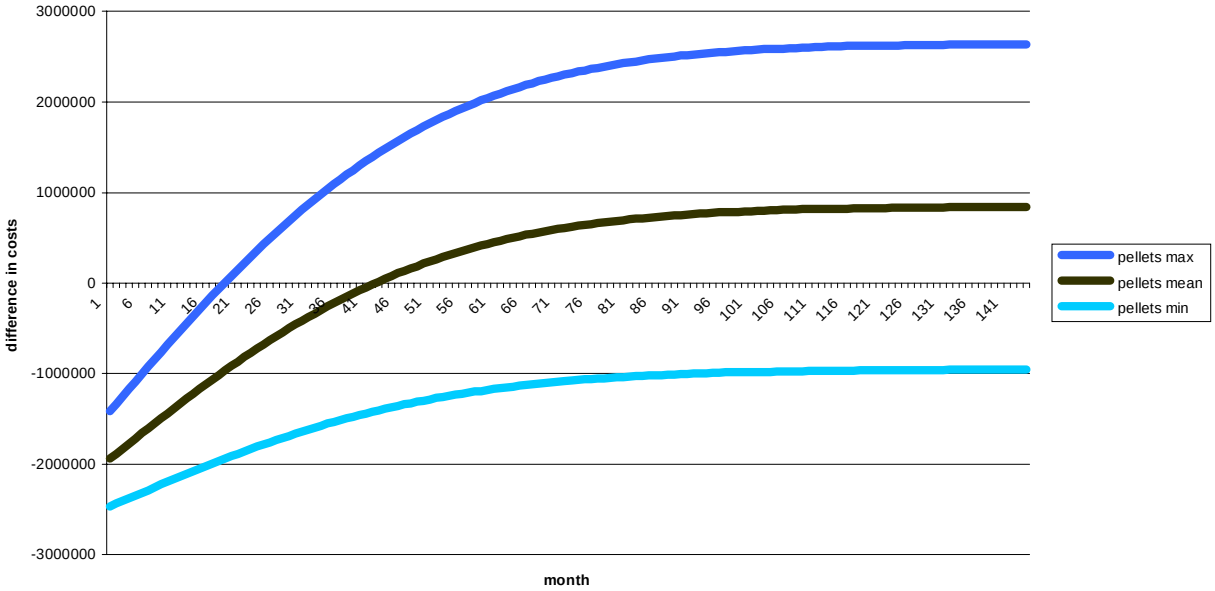

Figure 6.3 2 Difference in costs between oil-fired and pellet-burning boilers.

In this case too, in the worst hypothesis the lower running costs don't permit to cover the initial costs.
Recoupment Time (RT) is meaningful only in the best-case hypothesis (19 months). On average, RT for this type of investment is 43 months (see fig. 6.3).
Given these scenarios, who would be the most appropriate beneficiary of this kind of incentive? And how can the amount of a putative incentive be defined?
Let us start out from the observation that a state intervention policy of this type would be designed to favour the introduction of more advanced technology in the sector of heating systems for private homes (low environmental impact, low consumption of resources, etc.). Therefore, the incentive could be directed towards all those who purchase a new generation (high performance > 85%) solid fuel boiler, regardless of whether this purchase entails the scrapping of traditional systems. This proposal would also provide an incentive to change even for householders who consider their traditional heating system as still valid, either because it has only recently been installed (< 5-7 years ago) and is therefore endowed with elevated residual value, or because it is more practical to use and has a greater number of automatic functions. Such potential buyers could be stimulated by the state intervention measure to purchase solid fuel boilers thanks to the possibility of installing them in parallel with pre-existing boilers.
Turning now to fireplace boilers with forced ventilation, which have a low thermal performance, it seems rational to rule out the possibility of incentivating the purchase of these boilers, firstly because the system is cheaper than the traditional oil-fired system, and secondly because, as stated above, These boilers have a low thermal performance.
Downdraft boilers fueled by logs or pellets may prove not to be any more economical to run than oil-fired boilers: their lower running costs don't cover the initial costs. On this case the incentive could be quantified as the amount corresponding to the compensatory value that would have to be granted at the time of purchase to cancel out the PV of the

difference total costs between oil-fired and solid fuel boilers[10] (see tab. 6.3).
In the case analyzed here, which considers 34 KWh thermal output boilers, our calculations showed that an incentive of roughly 1,000,000 Liras would likely be required to favor purchase of downdraft boilers fed with pellets or processing residues, and roughly Liras 600,000 for downdraft boilers fed with logs.

7 CONCLUSIONS

The coppices, after the various events which happened during the last decades, seems to receive new interest also thanks to the possibility to obtain the productions of wood biomass to direct towards new markets. But, in the forest sector, frequently there are dangerous phenomenons, because the harvesting areas are those with more elevated stumpage price: these areas are found nearer the roads and have cuttings of considerable bulk.
The present work is originates from this consideration, and tries to analyze the potentialities offered by the new commercial opening, to which the productions of the coppices could be aimed, consistent with the sustainable use of this forest typology in the province of Florence.
Following such objectives, we have verified that the production of biomass for energetic use, has undoubtable advantages from the environmental point of view, and also presents different advantages from the economic and occupational point of view.
The research starting from *status quo* represented by the actual distribution of the coppices in the examination area, where two complemental analysis have been carrying out.
The first based on the study of the biomass supply for energetic usage, that is possible harvesting without ecological impact and with economic efficiency, from the coppices of the province of Florence. In this ambit we have analyzed the necessary actions needed for the private sector, and those of the public sector for the sustainable development of the biomass supply.
The second concerns the analysis of the demand and the possibility of commercial openings to employ this product for energy production. To this end we have individuated the market that could represent the fly-wheel to assert and enlarge the market demand.
The research has been carry out in the province of Florence, where the richer areas of forest resources are found in the Mugello and the Sieve Valley areas, their annual production potentiality could be about 400.000 quintals (fresh) of high commercial value firewood and over 1.300.000 quintals of biomass for chipping, correspondent to roughly 17.000 hectares of surface with hardwood and over 34.000 hectares with softwood.
At the moment this kind of product is not fully appreciated by the market, they could find commercial openings using biomass for energetic production.
Under the hypothesis that business activities would focus mainly on the wood products currently under-appreciated by the market, and, for reasons of caution, utilizing at first only a fraction of the available resources, it was determined that production of biomass as an energy source would undergo an approximate 13% increase compared to current production in the province.
This productions would have the household and public building heating systems as a market *target*, together with electric power production achieved by means of gasification

[10] We remember you that in the case of boilers fed with logs the difference in costs assumes a value of 550,000 Liras, and with wood pellet-fed boilers the value 958,000 Liras.

plants (which make use of *pellets* only) connected to electrogenerators, or by cogeneration plants for simultaneous production of electric power and thermal energy.
In particular, we must underline that the conditions needed to develop the supply of biomass for energetic use will be represented by the development of an efficient sector for forest biomass production as an energy source. This sector is identified with two closely interlinked bodies: the consortiums of forest owners and the specialized enterprises.
Owner consortiums represent an optimal solution to problems linked to property fragmentation. For large forest utilization businesses, investment in planning is economically advantageous, whereas for small and medium-sized businesses the cost of the *business plan* is not amortizable except in the framework of unifying adjacent properties: so by creating a consortium of forest we can obtain a wood production environmentally sustainable.
The hypothesis considered here starts out from the assumption that the specialized enterprises will engage in harvesting and processing activities during the spring and summer period, and will complement these operations with business activities involving heating systems (installation, maintenance and fueling) to be carried out during the fall and winter. This arrangement would have the beneficial effect of continuity of employment for those working in this sector.
Based on the hypothetical market and available resources, the results of the simulation of coppice management as an energy source in the northern part of the province of Florence also demonstrated that the overall complex of activities involved in utilization and processing of material extracted (bucking/lumbing, briquetting etc.) and product marketing would lead to employment opportunities consisting of 2-3 enterprises each having 30-40 employees.
For these reason, some incentives to promote a market with a permanent demand of renewable resources able to consume the production are necessary. This market is represented by using wood biomass as an energy source.
This phase gives rise to the greatest number of problems, on account of inertial resistance to replacement of traditional oil or LPG fired systems by new generation systems running on biomass. The main reason for such resistance is mainly to be found in the elevated investment cost for new technology plants.
The financial analysis of this type of investment, had showed the necessity of economic incentives to promote the purchase of new generation solid fuel boiler (high performance > 85%), to favoring the substitution of traditional plants.
The incentives ought to be between 600.000 Liras and 1 billion Liras depending on the type of plants.
The obtained results have stressed that through the public and private intervention project is possible on one hand, to re-qualify and improve the management of the coppice forests in the examination area and, on the other, to create new stable employment in a forest area, characterized by the strong rurality and marginality.
From the private point of view, the constitution of forest consortiums and enterprises able to work not only in the forest harvesting sector is necessary, but also in the biomass supplying sector for energetic use and the maintenance service for the new generation plants.
The result will depend mainly on the availability and on the abilities of the local human resources and the future demand in this sector.
In the examination area, the action of the public sector in the starting phase of development of the biomass production sector for energetic use is necessary. The action should be directed on two fronts: on wood supply, as further information and support activity of the forest consortium and the specialized enterprises; on the other front for the demand of wood, as incentives directed to encourage the installation of new solid fuel

plants, that ought to constitute the fly-wheel for the creation of demand capable to absorb the estimated increase in forest biomass production.

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