Trends of European forest resources on the basis of the FAO/ECE Timber Committee resource assessments

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Europe's forest area has increased 5 mill. ha since the late 1960s. The growing stock has increased 43 % and the net annual increment 55 % in exploitable forests since 1950. A part of the increase is caused by sampling inventories, which have been made in greater part of countries. Sampling inventories have corrected earlier underestimates of the growing stock and the increment.

The difference between the annual net increment and fellings has increased since 1950. The net increment, 584 mill. m^3, exceeded fellings, 408 mill. m^3, by 176 mill. m^3, in exploitable forests in 1990. If fellings could be increased to equal the increment, Europe would be an exporter of forest products.

A great increase in the density, in the age and in the mean volume of forests per hectare threaten the biological stability of the growing stock. Degrading of the stock, increasing natural losses and deteriorating environmental qualities of forests can only be prevented by increased fellings and by forest regeneration.

Euroopan metsäpinta-ala on lisääntynyt 5 milj. ha 1960-luvun lopun jälkeen. Puusto on lisääntynyt 43 % ja puuston vuotuinen nettokasvu 55 % puuntuotantometsässä v. 1950 jälkeen. Mittauksiin perustuvat otantainventoinnit ovat osaltaan suurentaneet puuston ja kasvun arvioita poistamalla aikaisempia aliarvioita.

Ero vuotuisen nettokasvun ja hakkuupoistuman välillä on suurentunut v. 1950 jälkeen. Kasvu, 584 milj. m^3, on 176 milj. m^3 suurempi kuin hakkuupoistuma, 408 milj. m^3, puuntuotantometsässä v. 1990. Jos hakkuupoistuma voitaisiin lisätä likimain nettokasvun suuruiseksi, Euroopasta tulisi metsän tuotteiden nettoviejä.

Lisääntyvät tiheys, ikä ja keskitilavuus hehtaaria kohti uhkaavat puuston biologista tasapainoa. Raunioituva puusto, lisääntyvä luonnonpoistuma ja huonevat metsän ympäristölaadut voidaan torjua vain lisäämällä hakkuita ja metsän uudistamista.

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Introduction

European forest resources have been assessed by the FAO/ECE Timber Committee five times, in 1950, 1960, 1970, 1980 and 1990. The results give a detailed picture how forests, their uses and consumption of wood have developed. Timber Trend Studies include also forecasts how resources and uses may develop in the future.

The accuracy of the reported and recorded resources, however, varies much from country to country. Results based on comparable statistical sampling inventories cover the total period from 1950 to 1990 only in Finland and Sweden, and the period from 1970 to 1990 in Austria. Most countries report data compiled from the results of management planning inventories or they are "professional guesses".

The time from field work to the time of reporting may be 10 to 20 years, even longer in some cases. In the time of increasing resources this underestimates the actual resources at the time of recording.

Additionally, underestimates are a traditional excuse to avoid overestimates. Forest administrators have often an implicit desire to have "hidden resources behind their backs". Private forest owners, in their part, have the motive to avoid "unreasonable taxes" by reporting underestimates.

Therefore, the time series of the European forest assessments demonstrate not only how forests have developed but also the discrepancies in forest balances and the gradually improved accuracy of the estimates.

In the earlier Timber Trend Studies the European countries have been grouped on the basis of geographical and political variables. Because of the changed political status in the Eastern Europe, the countries are not grouped in the reports of the results of the Assessment 1990.

In this paper the countries are divided into 9 groups on the basis of the natural vegetation zones determined mostly by the climatic variables (Fig. 1). It turned out that the forestry tradition, current management regimes and the uses of forests are relatively similar within each group.

Fig. 1. Country groups by ecological zones. Compare Table 1.

Forest lands divided into forest land and other wooded land, exploitable and unexploitable forest as the parts of the forest land, growing stock, its increment, and removals and fellings of wood are the variables treated in this paper. Observations of the proportional shares of coniferous and broadleaved tree species are also presented.

Table 1. Forest land, other wooded land and their sum recorded at 1960/70, 1980 and 1990. European totals, broken down to the estimates of the Mediterranean and other Europe.

Land class	1960/70	1980	1990
		mill. ha	
Totals			
Forest land	145.0	145.5	149.3
Other wooded land	31.1	35.3	45.5
Total	176.1	180.8	194.8
Mediterranean			
Forest land	41.8	41	42.3
Other wooded land	23.3	24.5	36.2
Total	65.1	65.5	78.5
Other Europe			
Forest land	103.2	104.5	107
Other wooded land	7.8	10.8	9.3
Total	111	115.3	116.3

Forest lands

Forest lands are divided into forest land and other wooded land. In principal, forest land is of site quality capable to grow closed forest. The poorest quality of forest land is defined to have a minimum potential annual yield of stem wood, over bark, 1 m^3/ha in Northern Europe. Other wooded land grows stunted scattered trees and woody scrub vegetation.

The boundary between forest land and other wooded land and between the latter and treeless waste land varies especially in the Mediterranean and causes changes in the areas recorded at different times.

Recorded forest land, 195 mill. ha in 1990, has increased by 4.3 mill. ha, other wooded land by 14.4 mill. ha and their sum by 18.7 mill. ha since 1960/70 (Table 1). Oscillating recordings in the Mediterranean, however, disturb the actual development. In the other parts of Europe forest land has increased by 3.8 mill. ha since 1950.

Increase of forest land is caused by afforestation of marginal fields and pastures and by wetland drainage. Built-up land has decreased forest land. The net increase since 1960/70 is approximately 5 mill. ha.

Exploitable and unexploitable forest

Forest land divided into exploitable and unexploitable forest is presented in Table 2.

Exploitable forest is mainly used for wood production. Unexploitable forest comprises na-

Table 2. Forest, exploitable and unexploitable forest, forest percent of land area and forest land per capita by European country groups in 1990.

Country groups	Forest	Exploitable		Unexploitable		Forest	
	mill. ha	mill. ha	%	mill. ha	%	%	ha/cap.
Northern	53.2	48.2	91	5.0	9	52	2.99
Central	24.1	23.3	96	0.8	4	29	0.17
Atlantic	2.6	2.6	100	0.0	0	8	0.04
Sub-Atlantic	14.2	13.5	95	0.7	5	23	0.17
Alpic	5.0	4.4	88	0.6	12	40	0.35
Pannonic	7.9	6.8	86	1.1	14	25	0.23
Mediterranean West	11.1	8.8	79	2.3	21	19	0.23
Mediterranean Middle	16.2	13.1	81	3.1	19	28	0.13
Mediterranean East	15.0	12.3	82	2.7	18	14	0.18
Europe	149.3	133.0	89	16.3	11	27	0.26

Table 3. Development of recorded growing stock of exploitable forest by country groups in 1950–1990.

Country group	Unit	1950	1960	1970	1980	1990
Northern	mill.m³				4298	4721
	proportional	89	93	99	100	110
Central	mill.m³				3671	5099
	proportional	77	77	88	100	139
Atlantic	mill.m³				235	233
	proportional	51	56	72	100	99
Sub-Atlantic	mill.m³				1644	1904
	proportional	56	57	86	100	116
Alpic	mill.m³				1088	1313
	proportional	78	78	87	100	121
Pannonic	mill.m³				1553	1431
	proportional	87	83	93	100	92
Mediterranean West	mill.m³				642	617
	proportional	88	90	94	100	96
Mediterranean Middle	mill.m³				1719	1872
	proportional	79	76	78	100	109
Mediterranean East	mill.m³				1100	1320
	proportional	106	106	114	100	120
Europe	mill.m³				15950	18510
	proportional	81	82	92	100	116

tional parks, nature reserves and forests in the mountains and other conditions where the production of wood is unprofitable. In most European countries wood is also harvested to minor extent in unexploitable forest except in a relatively small area of strict nature reserves.

Recorded exploitable forest has only increased by 0.6 % since 1950. Atlantic Europe is one of those regions where afforestation is continued up to the present. Most of the increase of forest land has been moved to unexploitable forest. Therefore, the trends of European resources can be demonstrated most accurately by the estimates of growing stock, its increment and fellings of exploitable forest.

Growing stock of exploitable forest

Development of growing stock is presented in Table 3.

Recorded growing stock in Europe has increased by 43 % since 1950 and by 16 % from 1980 to 1990. Because of the corrected earlier underestimates, the increase is partly ostensible. The first sampling inventories have increased the estimates of growing stock much more than the actual increase could have been. An extreme example of this is the former Federal Germany where the growing stock in the Assessment 1990, after the first sampling inventory, is twice as great as the in the Assessment 1980.

In Atlantic, Pannonic and Mediterranean West Europe, the growing stock recorded in 1990 is smaller than the stock recorded in 1980. Reasons for these unexpected estimates are not known.

Net annual increment of growing stock in exploitable forest

Net increment is the gross increment minus natural losses. Natural losses are composed of trees killed by selfthinning and other natural causes and trees left to decay in forest. Recorded total annual gross and net increments and natural losses in Europe are as follows.

Gross annual increment	647 mill. m³,	over bark
Annual natural losses	35	"
Net annual increment	612	"

Natural losses are not reported by all countries.

Development of recorded net annual increment of exploitable forest is presented in Table 4.

Table 4. Development of recorded net annual increment of exploitable forest by country groups in 1950–1990.

Country group	Unit	1950	1960	1970	1980	1990
Northern	mill.m³				145.9	178.3
	proportional	89	92	92	100	122
Central	mill.m³				97.7	132.5
	proportional	81	89	102	100	136
Atlantic	mill.m³				13.7	14.4
	proportional	27	33	55	100	105
Sub-Atlantic	mill.m³				60.0	73.4
	proportional	66	69	76	100	122
Alpic	mill.m³				24.5	27.8
	proportional	65	70	92	100	114
Pannonic	mill.m³				37	39.8
	proportional	73	78	91	100	108
Mediterranean West	mill.m³				38.8	39
	proportional	52	61	99	100	101
Mediterranean Middle	mill.m³				41.3	46.1
	proportional	83	83	93	100	112
Mediterranean East	mill.m³				30.0	32.6
	proportional	89	101	108	100	109
Europe	mill.m³				488.9	583.9
	proportional	77	82	93	100	119

Net annual increment in the European exploitable forest is 584 mill. m³ in 1990. It has increased by 55 % since 1950 and by 19 % in 1980 to 1990. Recorded net annual increment is now 207 mill. m³ greater than in 1950.

There are two parts in this increase similar to the increase of growing stock. One part is caused by the corrections of the earlier underestimates and another part is actual.

There are only three countries in Europe, Finland, Sweden and Austria where the increment has been measured by comparable sampling inventories. Development in these countries is demonstrated most unbiasedly by the estimates of gross annual increment per hectar of exploitable forest (Table 5).

In Finland, Sweden and Austria the recorded increment per hectare has increased respectively by 21, 43 and 97% since 1950 and by 12, 30 and 9 % since in 1980 to 1990. Although measured by sampling inventory, the recorded increments of Finland were small underestimates in 1950 and 1960. In Sweden the recorded increments were underestimates, markedly greater than in Finland, in 1950, 1960, 1970 and 1980. In Austria, the first sampling inventory was made before 1970.

On the basis of professional judgment, from the recorded increases of increment per hectare in 1950, in Finland 0.64 m³, in Sweden 1.30 m³ and in Austria 3.25 m³, respectively 5, 15 and 40 % were caused by methodological inaccuracies.

On the basis of increment estimated by the comparable methods in the 1980's, an inevitable conclusion is that the accumulated residue emissions of production, traffic and consumption have not decreased the increment potential so far. On

Table 5. Development of recorded gross annual increment per hectar of exploitable forest in Finland, Sweden and Austria.

Country	1950	1960	1970	1980	1990
Finland					
m³/ha	2.99	2.97	3.04	3.25	3.63
proportional	92	91	94	100	112
Sweden					
m³/ha	3.00	3.25	3.00	3.30	4.30
proportional	91	98	91	100	130
Austria					
m³/ha	3.35	3.70	6.07	6.09	6.60
proportional	55	61	100	100	108

Table 6. Development of recorded annual fellings of exploitable forest by country groups in 1950–1990.

Country group	Unit	1950	1960	1970	1980	1990
Northern	mill.m³				129.8	125.2
	proportional	83	91	106	100	96
Central	mill.m³				98.1	92.4
	proportional	83	78	84	100	94
Atlantic	mill.m³				5.2	9.7
	proportional	85	83	89	100	187
Sub-Atlantic	mill.m³				45.8	53.0
	proportional	93	105	93	100	116
Alpic	mill.m³				20.0	22.6
	proportional	77	96	99	100	113
Pannonic	mill.m³				28.2	22.0
	proportional	77	90	116	100	78
Mediterranean West	mill.m³				24.1	25.9
	proportional	81	99	101	100	107
Mediterranean Middle	mill.m³				31.3	31.6
	proportional	166	147	124	100	101
Mediterranean East	mill.m³				28.6	25.9
	proportional	64	77	106	100	91
Europe	mill.m³				411.1	408.3
	proportional	88	93	101	100	99

the contrary, increased deposition of nitrogen and content of carbondioxice in the air have most probably increased the increment potential. This conclusion does not eliminate the possibility that continued residue depositions in the soil may decrease the potential in the future.

Removals and fellings

Recorded annual total removals of wood assortments, under bark, have developed in Europe as follows.

	1950	1960	1970	1980	1990
Mill. m³				354	369
Proportional	83	86	98	100	104

Removals have increased by 25 % since 1950 and by 4 % in 1980 to 1990.

Fellings of exploitable forest, removals under bark plus bark plus logging residues, in the period of 1950 to 1990 are presented in Table 6.

Increasing fellings has levelled in 1970 to 1990. In the fellings reported by some countries, however, bark and logging residues are missing. If this is corrected, the fellings of exploitable forest in 1990 are about 420 mill. m³, or 2 % greater than fellings in 1980.

Forest balance

In forest balance net annual increment is compared with annual fellings. The European balance of exploitable forest is as follows (*corrected estimate).

	1950	1960	1970	1980	1990	1990*
Net annual increment, mill. m³	377	402	453	489	584	
Annual fellings, "	363	384	413	411	408	420
Balance,"	14	18	40	78	176	164

In the balance of 1990, net annual increment is about 164 mill. m³ greater than annual fellings. This is about 134 mill. m³ in removals, under bark. If annual removals could be increased to equal net annual increment, Europe would be an exporter of forest products.

Table 7. Recorded annual increment, m³/ha, in 1950–1990 in respect to climatic potential by country groups.

Country group	1950	1960	1970	1980	1990	Potential
Northern	2.88	3.03	2.87	3.22	3.83	4.25
Central	4.20	4.34	4.81	4.75	6.38	5.97
Atlantic	2.29	2.51	4.18	5.96	5.57	8.90
Sub-Atlantic	3.51	3.64	3.56	4.52	5.69	6.80
Alpic	3.77	4.00	5.93	6.01	6.33	6.47
Pannonic	4.60	4.36	4.94	5.32	6.11	5.04
Mediterranean West	1.33	1.68	3.27	4.57	4.68	4.83
Mediterranean Middle	2.23	2.21	2.98	3.23	3.76	6.84
Mediterranean East	1.81	1.99	2.47	2.66	2.92	5.87
Europe	2.98	3.09	3.50	3.91	4.67	5.44

Recorded increment and climatic potential

The estimates of climatic potential increment for European countries have been available since 1950 when a Swedish geographer S.S. Paterson published the CVP-Index and the estimates of climatic potentials. Recorded and potential increments by country groups are presented in Table 7.

Recorded increments have approached step by step the potentials. If the CVP-index had been used for checking the possible inaccuracies in the recorded increments, the underestimates could have been corrected earlier than what has happened.

On the basis of the climatic potentials, increment is obviously still underestimated in some countries.

Critical stages of growing stock

Increasing volume of growing stock decreases the marginal rate of return to a critical point where the rate of return, calculated by the real value of money, is zero. Beyond this point the marginal rate of return is negative. If growing stock and the length of rotation (time in years from stand establishment to the age of final cutting) increase further, growing stock starts to degrade and the natural losses caused by storms, insects and fungal diseases increase. Continued increase of age and volume causes great losses of wood crop. Forest deteriorates also as environment.

The idea of the critical stages of growing stock as the function of increasing rotation age is demonstrated by an example of forest dominated by spruce in a region of southern Finland.

	Rotation years	Marginal rate rate of return	Growing stock m³/ha	Natural losses
Fully regulated forest	80	H 3–4%	132	
Greatest income per hectare	100	0	170	
Current forest	110	negative	185	start
Biologically critical stage	120	"	200	increasing
Degrading stock	over 130	"	under 200	great

It can be concluded on the basis of this example that the mean growing stock in Switzerland, 329 m³/ha, and the stock of the former Federal Germany, 298 m³/ha, are near to the biologically critical stage. The great storm damages in Central Europe can be considered as a symptom of this.

In many European countries the growing stocks have passed the stage where marginal rate of return of growing is zero. Increasing age and volume of growing stocks is the greatest threat to the stability of forests in Europe.

The tree-species composition of forests

Recorded percentage of coniferous trees have been about 63 of growing stock and it has increased from 63 to 65 percent of net increment in exploitable forests of Europe. Percentage is greater than average in Northern, Atlantic, Central and Alpic Europe. Tree-species composition is more or less similar as it has been in the natural conditions in Northern Europe. In the other country groups mentioned above, conifers dominate in the low lands where broadleaved trees have been the natural climatic-climax trees.

The coniferous forests which grow outside their natural vegetation zones are genetically unstable. They are more sensitive to wind blows, insects and fungal diseases than forests composed of broadleaved trees.

Because of their higher value as industrial wood, conifers have been favoured more than broadleaved trees in the re- and afforestation plantations. Fast growing eucalyptuses and poplars are exceptions of this rule.

The recent aims to increase the proportion of broadleaved trees may change slowly the tree-species composition in the future. The idea is to improve the stability of forests against the harmful effects of residue emissions and to increase their value as landscape and recreation forests.

Findings

Growing stock and its increment have been and are still underestimated to such extent in same European countries that it is very difficult to describe quantitatively the actual development of forests.

Effective re- and afforestations and fellings smaller than net increment have increased markedly the volume and the increment of growing stock.

It can be concluded on the basis of increment measured by sampling inventories that the deposited residue emissions of production, traffic and consumption have not decreased the increment potential so far. On the contrary, deposited nitrogen and increasing carbondioxide in the air have obviously increased the potential.

Coniferous tree species have been favoured in the re- and afforestations because of their value as industrial wood. There are signs of the aim to increase the proportion of broadleaved trees in order to improve the stability of forests against residue emissions and the quality of landscape and recreation forests.

Direct fume effects of residue emissions, genetic instability of stands established by exotic trees and unsuitable provenances, and growing stocks approaching the biologically critical stage are the most important factors threatening the stability of forests. The most dangerous factor seems to be the increasing density, age and volume of growing stock which can only be prevented by increased cutting and regeneration measures.

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