ARGUMENTA OECONOMICA
No 2(5) · 1997
PL ISSN 1233-5835

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IDENTIFICATION AND VALUATION OF CONSEQUENCES OF AIR POLLUTION RELATED HAZARDS TO FORESTS A CASE STUDY OF POLAND

The authors of the paper present the identification and valuation of consequences of air pollution related hazards to forests in Poland. Special attention has been paid to the:
– significance of forests in Poland and their exposure to environmental dangers (part 2),
– valuation of forest resources in the light of Polish legal solutions (part 3),
– methods of pricing the air pollution related forest damages used in the Polish forest economy (part 4) and
– proposal of working out a new method of valuation of air pollution related forest damages.
The paper has been mostly based on findings of vast empirical investigations carried out by the authors within their report (Identification and Valuation of Consequences of Air Pollution Related Hazards to Forests. A Case Study of Poland) prepared for the United Nations Environmental Programme and the Harvard Institute for International Development. The authors express their thanks for the permission to use excerpts from the Report.

1. INTRODUCTION

The valuation of natural resources requires to use diversified estimating and calculation methods. The main purpose of the submitted paper is to present a method of forest area valuation with respect to the exposure of forests to hazards being brought about by air pollution. The issue of air pollution related forest damages is of particular significance to Poland. It is linked to the fact that despite a considerable decrease in the current emission of major airborne pollutants during the last 5–7 years, the Polish forests are still exposed to substantial dangers due to air pollution. All the questions related to this issue have been discussed in the second part of the paper submitted.

During the process of the transformation of the economic system which is now underway in Poland, there have been taking place changes in many legal, organizational and institutional arrangements concerning the use and protection of environmental resources. The changes concerned also pertain to forest economy and management. The new Forest Law of 1991 has introduced some

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legal provisions (we refer to them in a detailed way in part 3 of the paper) which confine a possibility to valuate forests in the context of damages suffered by their owners. It can result in insufficient forests protection and different difficulties in vindicating forest damage.

Taking into account the deficiencies and shortcomings of current legal and institutional arrangements, in the next part of our elaboration we undertake an attempt to present and evaluate the solutions that were used before the new Forest Law had been passed and implemented. This evaluation proves that a method which was utilized for valuating forest areas and forest damage under the circumstances of command-and-control economy cannot be effective from the point of view of forest protection in the period of transition towards a market economy.

Therefore, in part 5 of our paper we outline a proposal of new method of forest valuation. Its main goal is a proper pricing of forest uses, and, first of all, extra-productive ones. To illustrate the nature of the method proposed, we present a macroeconomic case within which we try to estimate for Poland the value of forests and air pollution related forest damages.

2. SIGNIFICANCE OF FORESTS IN POLAND AND THEIR EXPOSURE TO ENVIRONMENTAL DANGERS

2.1. Significance of Forests in the Polish Economy

The area of forests in Poland amounts to ca. 87.2 thousand km^2 which is 27.9% of country's territory. The forestation coefficient is lower than the European average. Until the year 2020, an increase in forest area by ca. 7 thousand km^2 is expected. The bulk of Polish forests are coniferous tree stands whose share in the total area of forests amount to ca. 79%. As far as the species structure is concerned, a prevailing species is the pine (69.4% of forest area). The second most popular tree species is spruce (6%), and the third one is fir (2.5%). Coniferous tree species are mostly sensitive to air pollution.

Currently, 82.9% of forests in Poland are publicly owned, of which 78.4% is under the Forest State Administration. Private forests cover an area of ca. 15 thousand km^2. The private ownership of forests is characterized by an immense dispersion. There are approximately 1,4 million natural and legal persons who are owners of forests. The surveillance over private forest is performed by the voivods (heads of regional/voivodship governments) or heads of the so-called district offices (they are subordinated to regional governments as units of country-wide state administration). They commission the units of State Forest Administration to carry out this task against payment. Nevertheless, the management and protection of private forests is not satisfactory. In comparison to state forests, they are characterized by a lower age and decidedly less opulent tree stands and other forest resources. Moreover, due to a more liberal public control over the private forests in the last five years one can observe an accelerated tree felling in privately owned forests. When analysing the issue of forest value in the context of their exposure to air pollution, one encounters a very important institutional problem. Its nature is as follows. Most Polish forests belong to the state. On the other hand, these are just state owned enterprises which are responsible for a prevailing part of air pollution bringing about acute dangers to Polish forests.

The timber stock in Poland is estimated at over 1.5 billion m^3 of gross large timber. The yearly growth of this stock is 1.6%. In the state forests, the per annum increase in timber stock amounts to ca. 3.6 m^3/ha. The overall yearly increase in stand volume is estimated at 32 million m^3. Due to many factors, including the exposure of forests to air pollution, the increase in stand volume is significantly lower then the potential one (45 million m^3).

The cutting plan (i.e. the amount of wood which can be obtained from tree stands without impairing thereby the sustainability of growth of forests and their resources) amounts in Poland to ca. 20.5 million m^3 yearly. Although the timber harvesting amounts to ca. 18.5 m^3 per annum only, one has to do with excessive tree felling in many forests below the felling age and, on the other hand, with not fulfilling the cutting plan in forests of felling maturity.

The per capita yearly wood consumption in Poland reaches the 0.5 m^3 level and is lower than that in Europe amounting to ca. 0.7 m^3. In 1994 and the first half of 1995, a shortage of wood supply took place which resulted in higher wood price growth than the inflation rate.

The role of forestry in Poland's economy is insignificant. Its share in the GDP came to 0.4% in 1993 (with 1990 constant prices, this share would have amounted to 0.8%).

The protected forests (including those of them that are subject to the so-called special protection) constitute forest areas which are protected with respect to functions they perform: soil and water protecting forests, forests of upper forest boundary, health-resort – climatic forests, recreational forests, landscape forests, seminal tree stands and forests of high greenery zone. To protected forests are also numbered the following ones: forests which are considered valuable from the natural point of view, forests which are significant in the context of country's defensive system and forests playing the role of habitats for animals belonging to protected species. Also forests located within administrative borders of town and up to 10 km from administrative borders of towns of above 50 thousand population, as well as located in protected zones of health-resorts and in areas being threatened by industrial influences are regarded as protected ones. The decision on giving a specific forest area the status of protected forest belongs to competencies of the Minister of Environmental Protection, Natural Resources and Forestry.

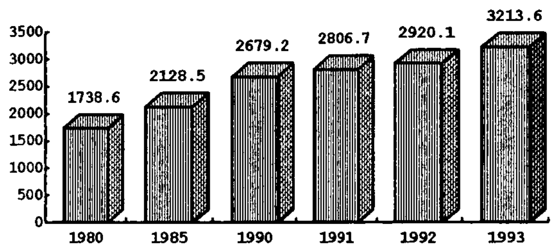

Fig. 1. Area of protected forests (thousands ha)
Source: *Ochrona środowiska 1994*, p. 238.

The area of protected forests was growing relatively quickly, particularly in the nineties (Table 1).

Table 1
Area of protective forests in Poland (thousand km^2)

Year	1980	1985	1990	1991	1992	1993
Area	17386	21285	26792	28067	29201	32136

Source: *Leśnictwo 1994*, p. 148.

It is worth emphasizing that in the period of system transformation, along with increased competencies of local authorities to take their administrative units related decisions, the area of protected forests also grew up quite significantly. It proves the willingness of those authorities to prefer the forests' protection function at the cost of limitation of their economic uses.

Also the number and area of National Parks and forest reserves is steadily growing Table 2).

Table 2
Area of forests in National Parks (thousands km$^{2)}$

Year	1980	1985	1990	1991	1992	1993
Area	829.1	885.7	1187.9	1295.6	1296.2	1503.2
Therein: under the strict protection	309.4	359.6	422.0	425.0	573.4	599.4

Source: *Leśnictwo 1994*, p. 148.

Nature reserves in Poland cover an area of 1 174 km^2, of which 382 km^2 are forests. Based on decisions taken by voivodship governments, 96 landscape parks have been established. Their overall area amounts to 18 605 km^2, there in 10 528 km^2 fall to forests. The areas of protected landscape occupy 52 575 km^2 out of which 23 561 km^2 are forests. Thus the forests constitute the main part of the nature protection system in Poland.

The constantly growing significance of extra-productive functions of forests finds its expression in the steadily increasing share of protected forests and forests within the national parks in the total area of forests in Poland. It is to be observed in 1990s, in particular (Table 3).

Table 3
Share of protective and other forests in national parks as a percentage of forest area as a whole (%)

Year	1980	1985	1990	1991	1992	1993
Area	20.5	25.6	32.2	33.7	35.0	38.6

Source: authors' own calculations based on Tables 1 and 2 and: *Leśnictwo 1994*, p. 15.

2.2. Hazards to Polish Forests

Most forests lie on mediocre soils being characterized by a high permeability of rainwater. It also relates to a substantial part of forests that during the last forty years have been planted on mediocre post-agricultural lands not having yet the structure and microbiological conditions which are suitable for the forest growth.

A considerable part of abiotic hazards results from Poland's geographical location and, in particular, climatic anomalies related to it. Due to decreased (as compared to the average yearly level) rainfalls in the last 6–8 years, almost all Polish forests are affected by a water shortage and a constantly falling level of ground water.

Many tree stands are characterized by the inconsistency of their species composition with features of habitats which they grow in. Pine and spruce tree stands having habitats that are too rich to them (in terms of variety and amount of nutrients) are more sensitive to strong winds and air pollution which, in turn, makes them less resistant to different pests.

During the last decades, the amount of insect species that threaten forests with dangerous diseases has increased noticeably. In the eighties mass migrations of pest insects took place.

Tree stands in Poland belong to these components of natural environment that are most sensitive to environmental pollutions. Particularly dangerous to them are the NO_x and SO_2 because their smallest concentrations in atmospheric air can negatively influence the growth of trees. These gases are mostly emitted through the energetic combustion of coal and earth oil based fuels and are transported over big distances. Therefore, they are able to damage tree stands that lie in areas located far away from the emission sources. Although the exposure of forests to hazards being brought about by air pollution takes place everywhere in Poland, the intensity of the threat referred to is different in particular voivodships. According to the so-called damage inventory, some 20% of Polish forests are located in areas being exposured to damage caused by air pollution.

Fortunately, during the last five years the process of diminishing air pollution related contamination of Polish forests can be observed. The process concerned is particularly intensive within areas which still in the decade of eighties belonged to most imperilled over air pollution: Upper Silesia and Cracow District. Nevertheless, the Upper Silesian forests continue to be most contaminated ones in Poland. Also the whole zone of mountain forests in the south of Poland is characterized by intensive air pollution related damage.

A considerable share in the total emission of airborne pollutants have high emission sources (high stacks). It is, simultaneously, very important that the influences of main high stacks (power plants) overlap to a big extent, thus creating the so-called pollution background. Its parameters can be roughly estimated which enables, in turn, to approximate the share of particular high stacks in the background concerned.

Low emission sources (low stacks) can significantly influence the local concentration of airborne pollutants. It is, however, very difficult to separate the influence of particular low stacks on the local air quality.

Of crucial significance for the quality of forests is SO_2 emission. The significance of NO_x emission is much lower. It has to be stressed, however, that there frequently occurs the phenomenon of synergy in harmful influences of these two gases on forests.

The decrease in SO_2 emission started already at the beginning of 1980s, with a remarkable acceleration taking place in the decade of nineties (Table 4). Such a tendency is hardly visible for the NO_x emission (Table 5).

As statistical figures presented in Table 4 and 5 prove, the share of low stacks in total SO_2 and NO_2 emission is growing. In the case of NO_2, this is mostly connected with the increased contribution of mobile (vehicles) emission sources to total emission of this gas.

The significance of particular factors that are harmful to the environment is shown in Table 6.

The above presented figures prove that the ecologically disadvantageous influences of air pollution is one of the most important danger to Polish forests. At the same time, it has to be emphasized that due to some imperfections of the inventory methodology the actual area of forest being threatened with air pollution is probably considerably larger. Findings of the biological monitoring univocally confirm this supposition.

Table 4
Total SO_2 emission (thousand tonnes)

Emission sources	1990	1991	1992	1993
Total	3210	2995	2820	2725
Commercial electricity generation*	1570	1480	1310	1290
Industrial power plants*	500	430	420	400
Industrial processes	270	235	250	235
Other stationary sources**	760	760	750	750
Mobile sources	110	90	90	50

* According to Polish industrial statistics, the commercial power generation relates to the electricity output which is sold to external consumers within the State Electroenergetic Network. In turn, the output of industrial power plants is used exclusively by business entities being owners of these plants (e.g. power plants in big iron and steel works etc.)

** Small district heating systems, individual boilers, handicraft sector, agriculture and others.

Source: "Ochrona Środowiska" 1994, p. 162.

Table 5
Total NO_x emission (thousand tonnes)

Emission sources	1990	1991	1992	1993
Total	1280	1205	1130	1120
Commercial electricity generation	370	395	3 70	380
Industrial power plants	130	140	115	70
Industrial processes	200	175	145	120
Other stationary sources	100	100	100	130
Mobile sources	480	395	400	420

Source: see Table 4.

Table 6
Area of damaged forests* in 1993

Damage caused by:	Area of affected forests (ha)	Share in forest grounds (%)
influence of gases and dusts	1 785 903	26.1
occurrence of insect pests	971 322	14.2
occurrence of infectious (fungoid) diseases	573 080	8.4
mining activities	43 453	0.6
forest fires	4 421	0.06
deer**	1 293 876***	19.0

* Forest under the State Forests Administration (79% of forest grounds in Poland).

** As estimated for June 1990.

*** Of which serious damages comprise the area of 388 968 ha.

Source: authors' own calculations based on: *Leśnictwo* 1994.

If the emission of airborne pollutants, and that of SO_2 in particular, was to grow, achieving in 2000 the level of the mid-eighties, then one could expect forest damages to occur to a very large extent. According to the pessimistic variant of relevant forecast, the area of forests threatened with air pollution related dangers would amount to ca. 69% of the total area of Polish forests. (Graczyk 1991b, pp. 5–11)

One can alternatively assume that the emission of airborne pollutants will keep constant in the decade of the nineties. This assumption may be justified with the fact that the biggest SO_2 emitters, the power plants, have been obliged to substantially reduce their emission only after the year 1998. In this variant of forecast of forest damages, only 40% of the area of Polish forests can be expected to be exposed to air pollution related dangers in the year 2000.

It seems, however, that the most probable forecast is that assuming a considerable reduction of emission from biggest high stacks, due, first of all, to the implementation of the 1990 ordinance of the Minister of EPNR&F imposing a duty of abating the SO_2 emission in flue gases being emitted by power plants and thermoelectric power stations. The reduction of SO_2 emission by the electroenergetic sector has also to be seen against the background of Poland's obligations resulting from the ratification of the Second Sulphur Protocol. Under this scenario, one can expect the significance of distant damages to fall, whereas the importance of local dangers to air quality will grow.

It is very likely that the inflow of airborne pollutants from abroad will decline. It is linked, above all, to a West German ordinance according to which all the power plants in the Eastern Bundesländer will have to meet German emission standards before July 1, 1996 (except the Hagenwerder Power Plant which will be closed down in December 1998 after the depletion of lignite deposits). It should result in a considerable decrease in the air pollution background in south-western Poland. Hitherto, this part of Polish territory was receiving ca. 70% of SO_2 and dust emission from the German part of the so-called "Black Triangle". It is estimated that due to the above-mentioned ordinance the import of emission concerned will decrease by ca. 98%.

3. VALUATION OF FOREST RESOURCES IN THE LIGHT OF POLISH LEGAL SOLUTIONS

3.1. Legal Foundations of Forest Economy in Poland

The main issues related to the use and protection of forest resources are regulated in the Polish legal system by the September 28, 1991 Law on Forests (to be also called the Forest Law). This legal act defines the principle of preservation, protection and enlargement of forest resources, as well as the principles of forest management against the background of other environmental components and the national economy as a whole (Article 1).

The forest economy is based on three essential principles (Article 8):

– common protection of forests,

– sustainability of forests and their uses,

– augmentation of forest resources.

Sometimes, a fourth principle is added:

– principle of making forests available to society.

The last of the above mentioned principles enables to bring into prominence the recreational and amenity uses of forests which is very important in the context of scope and methods of valuation of forest areas.

According to the Forest Law (Article 7) the forest economy should contribute to meeting the following objectives:

– preservation of forests and their advantageous influence on climate, air, water, soils, human health and life and natural balance;

– protection of forests and, above all, those belonging to the native nature and particularly valuable with respect to the preservation of forest genetic pool and scientific value/needs;

– protection of soils and other areas being particularly exposured to pollution or destruction, as well as areas of special social significance;

– highly efficient production of wood and other forest raw materials and goods.

The first three of the above enumerated objectives relate explicitly to the ecological aspects of forest economy, whereas the last of these objectives emphasises the economic uses of forests.

In forests belonging to nature reserves and national parks, the forest economy should also take into consideration the principles of nature protection. In turn, the forest economy in areas entered in the register of historical monuments has to be performed in consultation with the Voivodship Conservator of Historical Monuments.

3.2. Forest Law and the Valuation of Forest Resources

According to the Forest Law, there are two practical possibilities of valuation of forest resources. They may be based either on the forest tax or on the pricing of environmental damages to forests.

Article 60 of the Forest Law defines the scope of forest tax. Subject to this tax are all forests except three special cases and four statutory exemptions. The three exceptions are as follows:

– forests not connected with the forest economy,

– forests occupied by recreational centres, building and recreational plots,

– forests that are excluded from the forest economy on the grounds of administrative decisions.

According to para. 1, Article 62 of the Forest Law, the following forests are the subject to forest tax exemption:

– forests with tree stands whose age is below 40 years,

– forests belonging to the nature reserves and national parks,

– forests entered in the Register of Historical Monuments.

The forest tax duty encompasses natural and legal persons and organizational units not having legal status but possessing the forests on January 1 of a given tax year. As far as the forests under the control of Forest State Administration are concerned, the forest tax duty pertains to forest inspectorates.

The taxation base is the quantity of "conversion hectares". It is estimated (according to the state on January 1 of the tax year) on the grounds of area occupied by the main tree species in a given tree stand and the tree stand quality classes for those species.

Article 64 (para. 2) of the Forest Law determines the following conversion coefficients:

Table 7

Coefficients for re-counting the forest area for taxation purposes

Main tree species in tree stand	Quality classes of tree stand for main tree species					
	Ia	I	II	III	IV	V
Fir, spruce, Douglas spruce	-	2.30	1.80	1.30	0.90	0.60
Oak, ash, elm, maple	-	2.00	1.60	1.30	0.80	-
European beech	-	1.80	1.50	1.10	0.70	0.40
Pine, common larch	1.40	1.20	1.00	0.80	0.60	0.30
Hornbeam	-	1.10	0.80	0.50	0.30	0.20
Birch	-	0.60	0.40	0.30	0.20	0.20
Aspen	-	0.60	0.40	0.20	0.20	0.20
Alder	-	0.50	0.30	0.30	0.30	0.30
Poplar	-	0.50	0.30	0.30	0.30	0.30

Source: Prawo o lasach ..., 1991, Art.6, para.2.

The forest tax for one conversion hectare is collected every half year. It amounts to the equivalence of 0.125 m^3 of coniferous sawmill wood calculated according to its average selling price in the previous half year within a given forest inspectorate. The taxation base is diversified depending on whether the forest development plan for a given forest has been prepared. For a forest having such a plan, the taxation base is the quality of conversion hectares (as above explained). If there is no forest development plan, the forest area is calculated in real hectares.

A question can be raised, how to treat the forest tax? Is it a kind of local tax or environmental charge (fee)? The Law on Local Taxes and Charges of January 12, 1991 does not mention of forest tax (Dziennik Ustaw 1991). Also, no legal regulation considers this tax a kind of environmental charge. Taking into account its features, natural and legal persons being released from it, as well as institutions collecting the tax concerned, it seems to be reasonable to regard the forest tax as a quite separate one. In Polish tax law, it is treated as a direct property tax (Kosikowski, Ruśkowski 1994, p. 182).

According to article 11 of Forest Law, organizational units, natural or legal persons whose activities brought about forest damage are obliged to compensate them on the grounds of the general principles of *Civil Code*. It has changed thoroughly the former legal situation. Prior to this new provision resulting from Article 11, the issue of air and dust emission related forest damages was subject to individual negotiations between the forest inspectors and industrial plants emitting the airborne pollutants.

Once forest damage due to air pollution has occurred, the *Civil Code* assumes two principles:

– proven fault principle,

– risk principle.

According to the Article 415 of the *Civil Code*, the former is interpreted as a direct liability of perpetrator (polluter) consisting in the duty of repairing relevant damage. The latter is understood in the following way: legal or natural persons conducting on their own account enterprises or plants that are steam-, gas-, electricity or liquid fuels-driven bear liability for damage to human health (life) or property that have been brought about by those enterprises' or plants' operation unless damages referred to have occurred as a result of circumstances outside their control or due to the guilt of affected persons or other parties.

The second of the above mentioned principles is very close to the notion of strict liability in the ecological legislation of many Western countries (e.g. Germany, USA or France). From the forest owners' point of view, the risk principle is undoubtedly more advantageous because it relieves affected persons from the necessity to prove the occurrence of damage, the fault of the perpetrator and the existence of a casual relationship between damage and fault. All this is, in turn, a duty of sufferers in the case of fault principle.

Other articles of the *Civil Code* determine the scope and detailed forms of liability for damages, including the forest ones. On the one hand, the perpetrator's liability is confined to "normal" outcomes of his/her damage related activity (or its abandonment, Article 361, para. 1 of the *Civil Code*). On the other hand, this liability covers not only actual losses of affected persons but also the benefits they might have achieved if no damages would occur (Article 361, para. 2 of the *Civil Code*). As far as the manner of repairing the harms is concerned, the *Civil Code* speaks of the right of sufferers to choose from two alternatives: restoration to the original state or the payment of respective money compensation. At the same time, the *Civil Code* makes a reservation that if the restoration to the previous state was impossible or implied excessive costs and difficulties to the perpetrator, then the claim for damages is confined to money compensation (Article 363, para. 1 of the *Civil Code*).

The most important element of forest damage pricing as a method of forest areas valuation is the rate of monetary benefits to be received by sufferer. The *Civil Code* determines it in the following way: if the repair of harm is to take the shape of monetary compensation, then the rate of compensation should be fixed accordingly to prices at the date of damage occurrence, unless the specific circumstances make it necessary to apply prices of another point of time (Article 363, para. 2 of *Civil Code*).

Introducing all the aforementioned principles, the *Civil Code* assumes the liability for the overall damage, as comprising the actual loss and lost benefits. In the case of forest damage, the latter include:

– reduced revenues from current activities of a given forest inspectorate (wood production and other forest uses),

– increased costs of forest inspectorates (forests renovation, more frequent cultivation measures or measures to protect forests against the pests),

– future economic losses (lowered increase in stand volume and reduced tree stand quality, necessity of premature tree lumbering and changing the stand volume composition for a less profitable one, etc.).

It is worth noticing here, that the legislator emphasises the economic outcomes of forest damages whereas the issue of extra-economic uses (amenity uses, first of all) of forests was not given sufficient significance.

The problem of air pollution is strictly linked to the question: what is the influence of observance or not complying with administratively determined emission and ambient air standards on the civil liability for air pollution related environmental damages? As far as the ambient standards are concerned, the legal interpretation of the Supreme Court does not preclude the risk principle based liability even when the allowable concentration of specific airborne pollutants is not exceeded. Also, in the case of emission standards, the issue under consideration is approached in a very univocal manner. According to Article 30, para. 1 and 2 of the Law on Protecting and Shaping the Natural Environment, the voivods issue air pollution permits for organizational units and natural persons conducting the economic activity. Those permits determine allowable kinds and quantities of airborne pollutants a given enterprise/plant can yearly emit. The compliance with the above-mentioned administrative decisions of voivods does not confine the liability of business entities and natural persons for damages being brought about by air pollution.

In Article 12 of Forest Law, a case is analysed when the perpetrator of forest damage caused by air pollution cannot be identified. It relates to long-distance influences of gas and dust emissions and ecological disasters caused by biotic and abiotic factors. In such cases, the costs of forest renovation, as well as expenses connected with the stand reconstruction, are covered through subsidies granted by the State Budget.

Using both the forest tax and forest damages pricing as a foundation for the valuation of forest areas cannot be considered a proper approach to this valuation. This is so because of numerous deficiencies and shortcomings of these two methods:

1. The forest tax is subject to regulations included in the Law on Tax Obligations of December 19, 1980 (Dziennik Ustaw 1980) and, therefore, its rate may be easily brought in question. It essentially reduces the significance of forest tax as a base for forest area valuation.

2. An important shortcoming of forest tax as a base for forest area valuation is the frequent practice of statutory exemptions and allowances. As a consequence of them, the forest tax can not be applied in the valuation of such valuable forest areas like those which are entered in the Register of Historical Monuments or forests belonging to nature reserves, national parks and protected forests. It should be recalled that also all the tree stands at the age of below 40 years (they make ca. 45% of total forest area in Poland) are not subject to the forest tax.

3. The forest tax does not take into account extra-economic uses of forests (amenity uses) which are very significant for the forest area valuation. The worth of specific forest areas varies also depending on their site and importance for the native environment of a given region. Furthermore, the age structure and health state of forests belong to major factors underlying the forest area valuation.

4. A possibility to apply the forest damage pricing for valuation the forest areas is considerably confined due to the very narrow extent to which it takes into account the numerous unmeasurable or hardly measurable processes and phenomena influencing significantly forest growth. These are: species and genetic biodiversity, aesthetical and recreational uses of forests, resistance to pests and anthropogenic impacts of human habitats.

4. METHODS OF PRICING THE AIR POLLUTION RELATED FOREST DAMAGES USED IN THE POLISH FOREST ECONOMY

4.1. Objectives of the Pricing

In accordance with the *Instruction Manual on How to Make Forest Inventories and Determine and Introduce Zones of Forests Threatened with Damages, as Well as Estimate Damages and Costs of Stand Reconstruction in Forest Areas Affected by Disadvantageous Influences of Industrial Gas and Dust Emissions*, the estimates referred to in this *Instruction* serve to achieve the following objectives:

– defining the scope of losses and the rate of monetary compensations for damages in forests and forest grounds,

– estimating costs of stand reconstruction and costs of restoration of forest grounds to the previous state in forest areas affected by industrial air pollutions (Załączniki ... 1970).

4.2. Determining the Zones of Forests being Damaged by Air Pollution

The extent to which tree stands are threatened with air pollution is determined on the grounds of examining the air pollution related morphological changes in trees. The assessment of changes under consideration is of a statistical character and is carried out for a selected sample of forest areas. Such investigations, commonly known as the damage inventory, belong to the daily business of forest state administrations since the beginning of 1970s. (Dziennik Ustaw 1980) They consist of the identification of damage and include particular sites in specific hazard zones. The identification is based on symptoms of damage to the assimilative mechanism, and changes in growth and life resulting in dry-out of boughs and leaves and tree-crown thinning. Based on these investigations, the forest areas can be numbered among the following zones:

– zone I – minor damage, where the injury of assimilative mechanism is in the introductory stage (minor damage zone),

– zone II – medium damage, where advanced injuries of assimilative mechanism of trees are to be observed (medium damage zone),

– zone III – major damage, where strong injuries of assimilative mechanism takes place which, subsequently, leads to the die off of trees (major damage zone).

The initial inventory study was done in 1967. Since 1970, it has been carried out according to unified methodology. The results of successive studies prove that the area of endangered forests is constantly growing (Table 8). The data included in Table 8 do not reflect the actual hazard increase, since the forest inspectorates make the damage inventory only every 10 years and in the interval they make available statistical figures of the previous one. Thus one can reasonably presume that the actual increase in area of endangered forests would be faster if the country-wide damage inventory was made every year. Nevertheless, the data presented in Table 8 do show the pace at which the growth of area of forest threatened with air pollution is proceeding.

Table 8
Area of tree stand exposured to harmful influences of gases and dusts*
(thousand ha)

Year	Total	Zone I	Zone II	Zone III
1967	180	.	.	.
1971	239	114	79	46
1978	366	235	110	21
1980	382	247	109	26
1985	588	389	166	33
1990	1089	825	233	31
1991	1308	995	287	26
1992	1464	1125	312	27
1993	1786	1339	422	25

* Forests under the State Forests Administration.
Source: Bosiak 1985, p. 224.

4.3. Scope of Estimated Outcomes of Forest Damage

Estimates of damages the forest economy is suffering are focused on forest productivity falling due to the influences of gases and dust. The very notion of forest productivity is understood as the total increase in stand volume of large timber during the whole period of tree stand cultivation; since its planting up to the time of achieving lumbering age.

Additionally, in the case of protected forests, some outcomes resulting from the limitation of forests' extra-productive uses are also taken into account. In the already mentioned *Instruction Manual ...*, the following categories protected forests are enumerated: climatic health-resort recreational (strictly speaking, serving for the so-called mass recreation of the population), high greenery zones and landscape forests. In the subsequent year, the amount of categories of protected forests has been increased. In practice, it means the decreased ability of forests to contribute to climatic, recreational and landscape-aesthetical conditions in a given local natural environment.

The estimates referred to encompass the following kinds of losses being brought about by the emission of airborne pollutants:

– losses due to lowering the productivity of tree stands. Respective estimates were mostly conducted for forest areas with dominating shares of pine, spruce and fir. The point of reference for estimating such losses are coniferous timber stands located in the hazard zones whose normal growth can be preserved through changes in their species composition so as to increase the percentage of trees which are less vulnerable to air pollution,

– losses consisting in the overall destruction of productive functions of forest grounds. It relates to all the tree stands and grounds where the forest economy can not be continued with respect to the scale of ground deterioration.

– losses due to premature tree stand lumbering,

– costs of stand reconstruction. They are estimated for all these tree stands located in the hazard zones which are expected to be reconstructed within the 10 year period since the inventory date.

– losses linked to the limitation of extra-productive uses of forests. They are estimated for protected forests merely.

4.4. Manners to Estimate Specific Losses (based on the Ordinance of Minister of Forestry and Wood Resources dated September 19, 1970)

In this category of losses, two separate items are recognized with respect to different methods of loss estimates:

1. Estimate of losses due to reduced productivity of such tree stands for which the increase in volume stand of large timber has been determined.

2. Estimate of losses due to reduced productivity of forest crops, greenwoods and those stands for which the increase in volume stand of large timber has not been determined.

Ad 1. The size of losses as expressed in natural units is estimated according to the following formula:

$$dp = Pz - p_1 z_1 p. \qquad (1)$$

where:

dp – total loss of current large timber (net large timber in m^3) in the time period of carrying out the estimate in a given hazard zone; the volume of current increase in large timber is determined on the grounds of so-called taxating components. These are: size and prevailing tree species of a given tree stand, age and tree stand quality class;

P – current large timber increase for a given tree stand quality class and age in the first year of carrying out the estimate;

z – tree-coverage ratio in the first year of carrying out the estimate;

Pz – total current large timber increase in the first year of time period during which the estimate is carried out (in m^3);

p_1, z_1 – P and z for the last year of carrying out the estimate;

p_1z_1 total current large timber increase (net large timber in m^3) in the last year of time period during which the estimate is carried out,

p – the reduction coefficient for current increase in large timber for particular forest hazard zones. It amounts, respectively, to: zone I – 0.75 (the reduction of current increase by 25%), zone II – 0.50 (analogical reduction by 50%), zone III – 0.25 (analogical reduction by 75%).

The volume of losses in monetary units is estimated according to the following formula:

$$SA_1 = dpy, \tag{2}$$

where:

SA_1 – total value of losses caused by the reduced productivity of tree stands in a given hazard zone (estimated with taking into account tree species prevailing in particular tree stands);

y – average price of 1 m^3 of standing large timber from forests of both felling and pre-felling age (separately for prevailing tree species) for the time period [0, t = n].

Ad 2. The volume of losses of this category is estimated in monetary units in the following way:

$$SA_2 = (W_i/i - W_{il}/i)n, \tag{3}$$

where:

SA_2 – volume of losses caused by reduced productivity of 1 ha of forest crops and greenwoods, estimated separately for prevailing tree species;

W_i – value of 1 ha of tree stand as calculated on the grounds of volume of inputs which were indispensable for cultivating a given tree stand in the time period [0, t = 1]; when estimating the value of W_i the weighted means of "taxating components", are taken into account;

W_{il} – the modification of W_i consisting in taking into consideration the weighted means of "taxating components" at the end of the time period during which the estimate of losses is carried out;

i – the age, calculated as a half of age class among which given forest crops and greenwoods have been numbered;

n – number of years of time period during which the estimate of losses is carried out.

The value of SA_2 multiplied by the area of forest crops and greenwoods, as well as tree stands for which the increase in large timber has not been recorded, is regarded as the total value of losses suffered by the forest economy as a consequence of lowered productivity of forest crops and greenwoods.

The volume of losses in monetary units per 1 ha is estimated as follows:

$$SB = (W_{30} - c)/30, \tag{4}$$

where:

SB – loss volume per 1 ha of forest ground, calculated separately for prevailing tree species;

c – direct and indirect cost of preparing 1 ha of forest crops for cultivation purposes, $t = 30$ has the same significance as in formula (3).

The value of SB multiplied by the area of forest grounds that lost their productive functions is regarded as the total value of losses suffered by the forest economy with respect to the loss of forest grounds' productive functions.

The monetary volume of losses per 1 ha of forest crops, greenwoods and tree stands in a given hazard area according to prevailing tree species is estimated according to the following formula:

$$SC = W_i - W_{sp}, \tag{5}$$

where:

SC – value of losses;

W_i – value of 1 ha of a given tree stand as calculated on the grounds of volume of inputs which were indispensable for cultivating it in the time period $[0, i]$; when estimating the value of W_i the weighted means of "taxating components" of forest crops, greenwoods and tree stands according to the state at the "beginning" of the time period during which the estimate is carried out are taken into account;

i - the age, corresponding to a half of age class of given forest crops, greenwoods and tree stands;

W_{sp} – is the selling price of standing tree stand. It corresponds to the selling price of obtained large timber. For forest crops, greenwoods and tree stands where no large timber has been harvested, the factor concerned equals zero.

The value of SC multiplied by the area of forest crops, greenwoods and tree stands gives the total value of losses suffered by the forest economy due to premature tree felling.

A base for estimating costs of stand, greenwood and forest crop reconstruction, including costs of restoration of productive functions of forest grounds, is the data on the reconstruction requiring area in the hazard zones. Moreover, in order to approximate the losses in monetary units, the average cost of creating 1 ha of forest crop jointly with its cultivation and protection costs is taken into consideration.

The volume of such losses is assessed on the grounds of estimates of losses resulting from (already mentioned) decreased or lost productivity of tree stands and forest grounds.

The rates of losses ensuing from reduced extra-productive functions of forests are assumed on the *a priori* basis, according to the following enumeration:

– minor damage zone (I) – 25% of average losses due to lowered productivity of tree stands, forest crops and greenwoods,

– medium damage zone (II) – 50% of the above mentioned average losses,

– major damage zone (III) – 75% of the above mentioned average losses,

– for forest grounds with completely deteriorated productive functions – 100% of value of losses resulting from the lost productive functions.

4.5. Defining Prices and Costs in the Procedures of Estimating Forest Damages Caused by Air Pollution

The price of 1 m^3 of standing net large timber is understood as the average price of 1 m^3 of large timber reduced by direct and indirect costs of its harvesting and transportation. The average selling price of a given tree species is defined on the base of share of major wood sorts (sawmill wood, mine timber, pulpwood, poles, fuel wood). The average selling price is a mean of prices of those sorts weighted with their percentage shares.

The costs by which the average selling price is reduced comprise the following elements:

– average cost of harvesting 1 m^3 of large timber,

– average cost of taking away from the forest 1 m^3 of large timber (transportation cost),

– average cost of maintenance and repair of forest roads per 1 m^3 of large timber,

– administration overheads per 1 m^3 of large timber,

– 5% surcharge of the overall accumulation related costs.

The value of standing tree stands is calculated according to inputs which were indispensable for their production. The calculation concerned is based on the value of tree stand of felling maturity for a prevailing tree species of a given tree stand quality class.

The value of standing tree stand of felling maturity is calculated as the product of multiplying the standard (Partyka and Trampler 1985) volume stand of net large timber at a given lumbering age by the average price of 1 m^3 of net standing large timber for particular kinds of felling tree stands.

The volume of tree stand at the pre-lumbering age is calculated on the grounds of felling tree stand which in turn results from the following formula:

$$W_i = W_U kz, \tag{6}$$

where:

W_i – the value of 1 ha of tree stand at the age of i (for a prevailing tree species and a given tree stand quality class), calculated according to inputs that were necessary for its production;

W_U – the value of standing tree stand at the age of i (for the same tree species and tree stand quality class) being characterized by the full (as specified by the tree stand volume tables) tree-coverage;

i – the age of tree stand at the pre-lumbering age, calculated as a half of age interval for a given age sub-class;

k – the reduction coefficient for major tree species according to their age and quality class. The coefficient under consideration reflects the ratio (in %) of inputs for cultivation of tree stand at a given age to cost borne since the beginning of cultivation up to the felling maturity age;

z – the tree-coverage of a given area.

A base to calculate the selling value of standing tree stands that have been lumbered before achieving the felling maturity age is the selling value of specific wood sorts calculated through multiplying their volume stands by unit selling prices.

A base to calculate the tree stand greenwood and forest crop reconstruction costs are:

– area of reconstruction,

– direct and indirect costs of creating 1 ha of forest crop and its protection and cultivation during the first year after a given forest crop has been created.

4.6. Assessment of Method of Forest Damages Pricing

The above presented method of pricing forest damages caused by air pollution is characterized by some deficiencies. They came to light in its practical application. The deficiencies concerned are as follows:

1. High labour-intensity of on-site and calculating works.

2. Principles of estimating the productivity at the beginning and, respectively, at the end of time period during which the estimates were carried out were not uniform. The hazard zones were determined exclusively at the end of this period, whereas for obtaining proper estimate findings the determination of hazard zones at the beginning of period concerned is also necessary. For this way defined hazard zone, an adequate conversion coefficient concerning the large timber increase should, in turn, be adopted. Then a loss would be the value of difference between this increase at the beginning and at the end of examined period and not, as the method referred to implies, of the difference between this increase reduced and, respectively, not reduced by the conversion coefficient.

3. Losses due to the productivity functions of forest grounds are reflected in the decreased productivity of tree stands. In turn, a part of grounds reclamation

costs is included in the tree stand reconstruction costs. Therefore, it is not justified to list separately these kinds of losses, particularly with respect to the fact that cases where after deforestating the forest grounds no trials of renewed forestation took place were extremely rare.

4. Estimates of losses in greenwoods and forest crops were usually too high which resulted from improper classification of them into particular quality classes. When carrying out those estimates, an assumption was taken that losses in the productivity of tree stands are equal, irrespective of their age. At the same time, some components negatively influencing the development of young tree stands (e.g. the lack of cultivation and forest ground melioration, planting inproper tree species, insufficient protection against losses caused by game) were not taken into account.

5. A necessity of premature forest tree felling did not exclusively result from air pollution related damage. It was also caused by some other factors (e.g. damage brought about by insects, windblows). In particular, among this category the losses due to decreased area of forest crops and greenwoods should not be numbered.

6. Interpretations concerning the manner of calculating tree stand reconstruction costs are lacking the transparency. In particular, they allow for optional estimates of the reconstruction area.

7. Losses are not taken into account brought about by the decreased possibilities of harvesting non-wood forest uses (fruits, mushrooms, resin and game).

8. It is not justified to confine the loss estimates concerning the extra-productive uses of forests to the protected forests. Furthermore, by the assumption that the reduction in large timber increase proves the decline in forests' abilities to perform the extra-productive functions, the application of conversion coefficient amounting to less than 100% will additionally result in underestimating the category of losses referred to. Expecting the productivity of tree stands in zone I to decrease by 25%, an assumption should also be taken that to the same extent a given forest's ability to perform the extra-productive functions will fall. Meanwhile, the losses discussed are estimated at the level of 25% of those due to the productivity decrease. This would mean that tree stands whose productivity would have declined by 25% loose only 6.25% of their ability to perform the extra-productive functions (analogical estimates can be made for the remaining hazard zones).

9. Estimates of extra-productive functions of forests can best achieve 100% of productive value of a given tree stand (strictly speaking, the value of yearly increase in volume stand of standing large timber). In turn, many groups of forests' users are in agreement that the real value of such functions exceeds by

many times the wood increase value. Also a tendency to widen the scope and area of forests being regarded as protected ones (to which we refer to in the second part of this paper), seems to prove the validity of such a view. This tendency can also be considered an attempt at protecting the extra-productive functions of forests, since the forest economy in such forests (including the overall tree felling) is subject to many constraints.

Practical experiences connected with the hitherto used method of estimating the air pollution related forest damages allow for formulating some other critical remarks:

– the method concerned was available for the administrators of state owned forests only. The private owners usually give up to claim compensations for losses they suffered;

– the enforcement of compensation claims was weak due to a frequent practice of appeal of damage perpetrators against respective judicial decisions. Besides this, there frequently occurred disputes concerning the compensation rate. Finally, many perpetrators of forest damages did not comply with payment deadlines etc.;

– the influence of forest value assessment on localization decisions concerning the construction of "dirty" industrial plants was quite insignificant.

Ultimately, the presented method of estimating forest damages caused by air pollution has lost its practical validity under generally new economic conditions connected with the transition towards a market economy, and as a consequence of passing the new Forest Law of 1991.

Many emittents perceived those new economic conditions as the release from the administrative duty to calculate the forest damages and respective compensations or even as an opportunity to evade the payment of them. Both a bad financial standing of most state owned enterprises and the inefficiency of jurisdiction meant that under conditions of high inflation rate the vindication of payments for forest damages was (and, in fact, still is) very costly. It frequently happened that the judicial decisions on compensations for those damages did not mean to affected parties the real return of monetary equivalent of them.

Basing the vindication of compensation for air pollution related forest damages on the *Civil Code*, resulted in depriving most forest owners of possibilities to counteract such damages. Administrative permits for the allowable emission of specific air pollutants are issued on the grounds of findings of pollution dispersion models which are submitted to the voivodship authorities by the emitters themselves. They are given such permit conditions that their activities do not result in exceeding the permissible concentration of air pollutants. Unfortunately, for most coniferous forests, the ambient air standards that are currently in force are too liberal which means that compliance with them does not prevent the forests from the deterioration being brought about by air pollution.

5. PROPOSAL OF WORKING OUT A NEW METHOD OF VALUATION OF AIR POLLUTION RELATED FOREST DAMAGES

5.1. Prerequisites of Introducing a New Method

As most important reasons underlying the necessity of introducing a new method of forest damage valuation one can consider the previously discussed deficiencies and shortcomings of the old method. Moreover, such a necessity should be viewed against the background of changing economic conditions during the process of transition from a centrally planned to a market economy.

The significance of forests as a source of supplying the country's economy with wood products is constantly falling which is reflected, among other things, in a declining share of forestry in the GDP. On the other hand, the area of protected forests is steadily growing. So is the area of "economic forests" which belong to territories being protected due to their natural values (e.g. landscape parks). The previously underestimated extra-economic uses (functions) of forests are becoming a source of measurable benefits to inhabitants and self-governments of numerous municipalities.

Many municipalities and forest inspectorates with forests that are rich in amenity uses (landscape value, recreational opportunities etc.) and are located in the vicinity of major urban agglomerations took advantage of these natural factors in terms of accelerating economic development and welfare growth. The possession of forests is becoming to many municipal budgets a source of considerable revenues due to real estate taxes from recreational, touristic and other immovable property (mostly buildings), as well as from economic activities aimed at the attendance of visitors. Many owners of forests with a location which is particularly attractive from the touristic point of view receive remarkable returns due to leasing them, as well as the arrangement of forest campings, sale of building and fuel timber, organization of hunting etc.

Thus a thesis can be put forward on the growing interest of municipalities and their authorities in such forest uses that go beyond the timber harvesting which was, undoubtedly, the most important economic function of forests under the former (up to the end of the 1980s) economic conditions. There are many reasons underlying this change.

These are, among other things:

1. Under the circumstances of economic growth, including its local and regional dimension, the steadily increasing welfare of rapidly expanding middle class, and the high development rate of private motoring the inhabitants of forest areas and local self-government bodies can expect considerable revenues due to both economic and amenity uses of forests.

2. Growing responsibility of local governments for protecting the natural environment on the area of their performance, along with the delegation of relevant decision powers results in increased awareness of these governments of the positive influence of forests on water conditions, local climate and preventing soil erosion.

In the context of the aforementioned arguments, it seems a view justified that:

– local authorities are becoming interested in a proper forest area valuation,

– they are willing to make available data on benefits related to the forest ownership, as well as on costs potentially to be bom with respect to overall or partial loss of forests' economic functions and their ability to influence the welfare of inhabitants of a given municipality,

– they are capable of indicating and valuating the economic consequences resulting to local communities and their business activities from constraints that are necessary for forest protection.

5.2. Objectives of a New Method

The method proposed should enable the forest owners (irrespective of ownership forms) to:

– valuate forests,

– vindicate the compensations for losses caused by air pollution.

In turn, with respect to a growing significance of extra-economic uses of forests, a new method should enable local self-governments (as main beneficiaries of forests' amenity uses) to:

– take into account the value of forests in decisions on shaping the spatial order,

– find optimal solutions concerning the choice between allowable pollution of forest areas and their protection.

Having in view this duality of objective of forest valuation, one can recognize two components of the proposed valuation method:

– a component to reflect direct economic consequences of forest endangerment; it mostly relates to timber harvesting and other economic uses of forests;

– a component connected to the valuation of extra-economic uses of forests.

5.3. Methodological Foundations

There are two main approaches towards the methodology of valuation. When the subject of valuation is the reduction in timber increase or the loss of potential benefits to be achieved from other economic uses of forests, then of essential significance is the benefit estimating technique of the dose-response type.

When, in turn, the valuation pertains the extra-economic uses of forests, two approaches to valuation methodology are conceivable. The first one is based on hedonic wages. The second is known as the contingent valuation. With regard to the valuation of recreational functions of forests, it is also possible to adopt the travel cost method. For aesthetical (landscape) functions of forest, one can apply the hedonic property method (instead the contingent valuation one) (*Environmental...*, 1989, pp. 64-65)

From the forest valuation's point of view, of crucial significance is the contingent valuation method (CVM). An important element of CVM is the frequency of question concerning the Willingness to Attend (WTA) or Willingness to Pay (WTP). The interviewer has to determine the "starting point" of price, whereas interviewed people have to have data on their hypothetical budget.

Of particular significance is information on the consequences of dangers to which the forests are exposed to. The dose-response method can be applied only when the concentration of specific pollutants exceeds the tree stand sensitivity threshold. For instance, the yearly weighted mean of this threshold for spruce tree stands in mountain areas amounts to 20 $\mu g/m^3$. Then it can be assumed that a reduced life of tree stands has been caused just by air pollution.

Alternatively, there is a possibility of using the hazard zones as coefficient of ecologically harmful influence of air pollution on tree stands. The application of hazard zones as a relevant information base can be justified with the fact that there exists a verified method of designating them and that they are still commonly used in the Polish forest economy in the procedure of choosing the planting and cultivation manners.

5.4. Scope and Mode of Operation of Proposed Method

The proposed approach towards forest and forest damage valuation can be applied at different management levels. It should turn out to be most useful at municipal level. However, a country-wide valuation of forest resources can also be based on the method proposed, particularly in decisions on locating ecologically dangerous plants and on the choice of measures to prevent forests from excessive emission of airborne pollutants. With respect to data availability, when presenting the method proposed we confine ourselves to an example which relates to the whole country's territory. Since the elaboration we are submitting is to be a country case study, such an approach seems to be the most proper one.

The negative consequence of forests' exposure to environmental dangers are mostly considered from the perspective of limiting the benefits a given society (community) can derive from forests. When expressed in natural units, those consequences are regarded as damages. In turn, monetarily expressed damage is commonly considered losses.

The benefits that could be derived from forests are of an ongoing character. In other words, forests are expected to be continuously able to yield such benefits. It makes justified an assumption on taking the yearly functions (to be named uses, also) of forests as a base to estimate forest damage and losses. According to this approach, the forests uses mean the one year related respective utilities. The quantification of forest functions creates the foundations for damage estimates. Thus a given forest damage is a quantitatively expressed measure of not attaining a given forest function. A respective loss is, in turn, a monetary magnitude serving to valuate the extent to which a given economic or extra-economic function of forests is not achieved given the constant level of inputs. Forest losses can also be considered the value of inputs that would turn out to be necessary to achieve a given economic or extra-economic function of forests under conditions changed through the appearance of ecologically harmful influences.

Thus estimating the air pollution related forest damages requires to define the functions of forests which are not exposed to air pollution and, subsequently, to quantify and valuate those functions. On this basis, methods of estimating forest damages and losses can be developed.

Economic functions of forests relate directly to the forest economy. Their very nature consists in securing wood production which in turn depends on the yearly increase in tree stands and creating possibilities of harvesting of other forest crops. The forest plays important extra-economic functions too, which are not directly related to the forest economy. However, they can indirectly influence the results of activities in many other economic sectors or branches, thus contributing (or not) to the economic and social welfare. As human civilization develops, the significance of forests' extra-economic uses is constantly increasing. On the one hand, it ensues from the increase in demand on such functions. On the other, it is determined by a growing significance of forests in the process of keeping the natural balance.

Given no exposure of forests to air pollution the potential benefits the forest economy can derive from forests' economic functions can be classified as follows:

– current increase in tree stands,
– current harvesting of other forest crops.

The productive capacities of state owned forests under the State Forest Administration are diversified, depending on the tree-coverage ratio and tree stand quality classes. They range from 3.02 to 3.94 m^3 of yearly increase in gross timber stand per 1 ha. (*Leśnictwo 1993*, p. 53) Forests belonging to other owners are characterized by smaller yearly increases. There is lacking, however, data that could allow for credible estimates of them. Since the state owned forests occupy ca. 78% of total forest area in Poland, taking an assumption that all the Polish forests are expected to yield the above mentioned yearly increases in large timber will not result in considerable overestimating these increases.

The scope of other economic uses of forests can be confined to those which are most important from the point of view of derived benefits (incomes). A relevant assessment is based on statistical figures concerning their harvesting at the turn of the 1970s. The data on subsequent time periods is characterized by a high dispersion and instability which is related both to the decentralization of purchasing network of forest crops and a very high inflation rate. We have applied in our analysis the harvesting coefficients of forest crops which are close to the lower frontier of intervals within which the level of this harvesting was fluctuating. (Graczyk 1988, pp. 14–16) And so, the potential yearly harvesting of forest fruits, forest mushrooms, venison and resin amounts, respectively, to 2.5 kg/ha, 0.6 kg/ha, 0.35 kg/ha and 1.1 kg/ha.

With respect to a substantial diversification, lacking homogenity and, sometimes, unmeasurability, a similar quantification of extra-economic functions seems to be not necessary. Therefore, we may confine ourselves to the statement, that the forest has the ability to perform such functions. This ability can be expressed as a certain percentage ratio. And so, it means e.g. that a forest that is not exposed to air pollution is capable of performing the extra-economic functions in 100%.

The valuation of economic benefits that are achieved by the forest economy consists in quantifying potential benefits derived from forest uses with the help of constant 1992 prices, given a situation that no dangers to forests' productivity and quality would have occurred. When defining the value of increase in standing tree stand, the average 1992 selling prices of wood in state owned forests have been adopted, reduced by harvesting and selling costs (amounting to ca. 28% of selling prices). (*Leśnictwo 1993*, p. 72) For pricing the benefits to be derived from forest fruits and mushrooms harvesting, their average export prices, reduced by harvesting, purchasing, storage and transportation costs (coming up to ca. 80% of export prices), have been, in turn, adopted. To valuate the venison and resin related benefits, the average inland purchasing prices have been used.

Most disputable is the valuation of extra-economic functions of forests. Since our case study pertains to the whole country's territory, it seemed reasonable to apply coefficients based on the findings of the valuation of these functions in the eighties. The yearly value of benefits to be derived from them has been estimated through multiplying the yearly potential increase in large timber in particular voivodships by relevant coefficients of multiplicity of extra-economic functions. A base to calculate the coefficients concerned was the data on the area of reserve, protected and economic forests in particular voivodships and respective coefficients for specific forest kinds. The following coefficients have been adopted:

– reserve forests – 9.0,

– forest in National Parks – 9.0,

– soil protecting forests – 8.0,

– water reserves protecting forests – 8.0,

– tree-line forests – 8.0,

– forests in health-resorts and of climatic significance – 7.0,

– forests of high greenery zone – 6.0,

– forests in areas of mass recreation – 5.0,

– landscape forests – 4.0,

– forests of the highest cultivation quality and constituting natural habitats to the fauna – 4.0,

– economic forests and those in areas of industrial influences – 1.0. (Bosiak 1983–1984).

They coefficients served as weights in the procedure of determining the coefficient of muliticiplicity of forests extra-economic functions for a given voivodship (in relation to the large timber increase).

The country's benefits related to the extra-economic uses of forests have been estimated as 2.4-times higher than those which could be attribute to the large timber increase. Respective numbers range from 1.28 to 6.06 in particular voivodships (Fig. 2). The extra-economic functions of forests are particularly important in forests in southern voivodships which is linked to a high share of mountain forests in the total area. And so, for instance, the number under consideration exceeds the value of 4 in the following voivodships: Wałbrzych, Bielsko-Biała, Nowy Sącz and Krosno.

The total value of potential benefits the Polish forest could have yielded in 1992 (on the above mentioned condition of non-occurrence of air pollution) has been estimated at ca. 2.47 billion Zl yearly (slightly over 1 billion USD according to current official exchange rate and over 2 billion USD according to purchasing power parity), (Table 9). The value of potential benefits to be derived from Polish forests is mostly determined by the value of extra-economic uses. Admittedly, this value is currently considerably higher than that related to the wood and other forest crops harvesting. (Graczyk 1987, pp. 88–90).

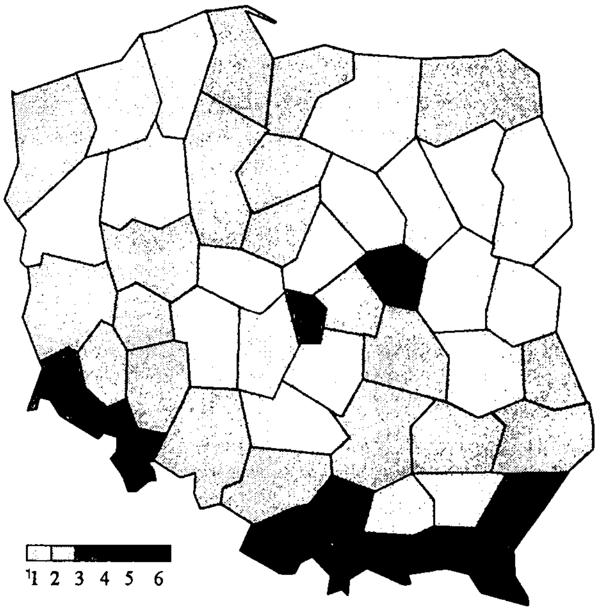

Fig. 2. Multiplicity coefficients of the value of extra-economic uses of forests in relation
Source: authors' own elaboration.

Table 9

Valuation of benefits that the Poland forest would have brought in 1992 if they were not affected by air pollution

Benefits	billion Zl	%
TOTAL	24 73.88	100.0
therein, related to extra-economic uses	17 25.33	69.8
therein, related to economic uses of which:	7 48.55	30.2
– current yield of tree stand	7 12.94	28.8
– other uses	35.61	1.4

Source: authors' own estimates based on a modified method proposed in section 5.

Therefore, the spatial diversification of the total value of potential benefits being derived from forests is consistent with the spatial distribution of coefficients serving to value the forests' extra-economic uses (compare Fig. 2 and 3). With the national average amounting to 284 Zl/ha in 1992, the benefits to be potentially derived from 1 ha of forest area amount in particular voivodships to:

– Wałbrzych	– 6.77,	– Kraków	– 4.21,
– Krosno	– 5.36,	– Przemyśl	– 4.14,
– Nowy Sącz	– 4.82,	– Jelenia Góra	– 4.06,

(all of these voivodships are located in southern territories and are characterized by high shares of mountain areas).

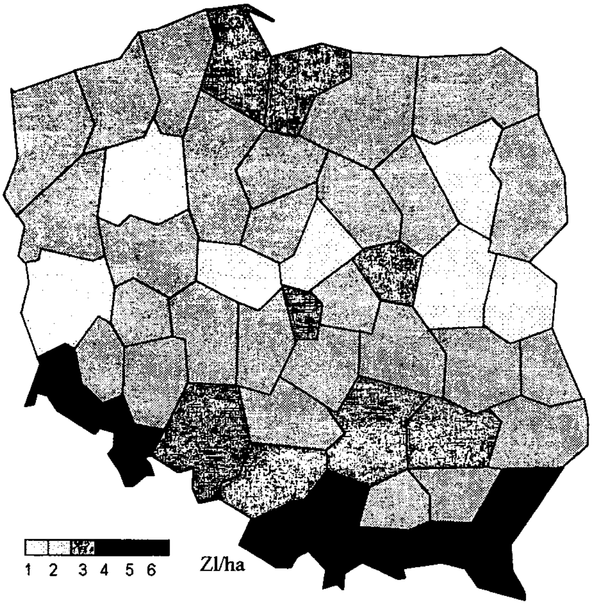

Fig. 3. Valuation of benefits that the Polish forests would have brought in 1992 if they were not affected by air pollution (Zl/ha)
Source: authors'own elaboration.

The influence of atmospheric air pollution on forests results in the reduced longevity of tree stand. As a consequence of this, the forests' ability to perform other functions is also declining. The increase in tree stands is falling and a respective damage is just reflected in a reduced amount of standing large timber (as compared to the "no-pollution situation"). The disturbance of wood production may also be caused by a necessity of premature tree felling. Then the damage is equal to the difference between the amount of wood at the tree stand felling maturity age and that achieved at the time of premature felling. Air pollution results also in reduced wood quality, in comparison to areas not affected by them. In this case, the damage is interpreted as the difference in volume of most valuable large timber sorts between the polluted and unpolluted forest areas.

Also other (then wood) forest crops are negatively affected by air pollution. Again, respective damages are equal to differences in those crops' harvesting between the polluted and unpolluted forest areas.

The forests' ability to perform the extra-economic functions depends on the longevity of tree stands. This ability related damages are reflected in the extent to which the longevity of tree stands (as measured by their current increment) is reduced and the area of forests affected by this phenomenon.

Besides the aforementioned damages whose nature mostly consists in the abatement of benefits to be derived from forest uses, all the activities implied by the disturbance of forest cultivation cycle have also to be numbered among forest damage. The continuation of wood production in areas being exposed to high concentrations of airborne pollutants requires to reconstruct partially the tree stands each year. If the air pollution negatively influences the greenwoods and other forest crops, then it is necessary to reproduce them. It may happen that in order to make possible the continuation of wood production the overall reconstruction of tree stands becomes indispensable. Most often it consists in replacing a tree stand which is particularly vulnerable to a given air pollutant with a new one, more resistant to this pollutant. The damage under consideration is reflected in the area of tree stand requiring such a reconstruction.

With respect to the diversified functions of forests, such a method of estimating damages and losses should be applied which could enable the inclusion of all of them. Therefore, when estimating the damage we apply many kinds of conversion coefficients. They have been based on investigations about the interdependencies between pollution concentrations, hazard zones and the scale of abatement of forest uses (Graczyk 1987). For the purpose of this elaboration the coefficients concerned have been simplified. They are presented in a unified form in Table 10.

Only one kind of damage, the area of tree stands being subject to the reconstruction within a given year, can be defined on the grounds of state forest statistics. To estimate other damage, it is necessary to calculate the sum of products of the area of a given hazard zone by the reduction coefficients related to them (Table 10). In this way the area of totally (in the conventional meaning) destroyed forest crops and greenwoods, as well as the area totally (once again, in the conventional meaning) deprived of its ability to perform the extra-economic uses will be estimated. For other kinds of damage, the above mentioned sum of products has to be multiplied by a given damage kind related coefficient of large timber increase or the coefficient of harvesting other forest crops.

Table 10
Coefficients for re-counting damages in particular zones
of harmful bearing of gases and dusts upon forests

Kind of damage	Zone I	Zone II	Zone III
Decrease in current yield of large timber volume	0.250	0.500	0.750
Not a chieving the large timber yield due to premature felling	0.012	0.025	0.033
Decrease in the large timber yield due to wood quality deterioration	0.000	0.040	0.031
Destruction of forest crops and greenwoods	0.00024	0,001	0.0176
Reduced forest fruit crops	0.250	0.500	1.000
Reduced mushroom crops	0.300	0.500	1.000
Reduced amount of game	0.000	0.300	0.500
Reduced resin harvesting	0.250	0.500	0.750
Decrease in forests' ability to perform extra-economic uses	0.250	0.500	0.750

Source: authors' own elaboration based on Graczyk 1987.

Losses due to reduced large timber increase, premature tree felling and reduced quality of wood and other crops are estimated as the product of damages estimated and respective prices (the same that have been adopted in the procedure of valuation of forest uses). In turn, losses related to the abatement of extra-economic uses of forests require to calculate the product of area deprived (in the conventional meaning) of its ability to perform the extra-economic functions in a given voivodship by this voivodship related coefficient of multiplicity of the value of such functions (in relation to the value of current large timber increase). To estimate losses resulting from the destruction of forest crops and greenwoods, it is necessary to multiply the area of destroyed (in the conventional meaning) forest crops and greenwoods by the unit (per 1 ha) cost of planting them. The losses resulting from a necessity to reconstruct the tree stands are equal to the product of the reconstructed area (in a given year) by the unit reconstruction cost.

Expectations concerning the future consequences of current dangers to which the Polish forests are exposed to have to take into account the changes in area of endangered forests. This area will depend, apparently, on changes in the emission of airborne pollutants, as well as on findings of inventory works aimed at the identification of new endangered forests which have not yet been subject to such works. In spite of the fact that during the last few years air pollution was constantly decreasing, the area of forests exposed to this emission related hazard has increased. This is mostly connected with the very methodology of inventory works. It makes possible to reveal the consequences of forests exposure to air pollution with a certain delay. It is determined by the frequency with which the inventory works are conducted. Moreover, the reaction of tree stands to air pollution is characterized by a specific inertia which makes the consequences of air pollution visible only after a certain time period has passed.

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Zarządzenie Ministra Leśnictwa i Przemysłu Drzewnego z 19 września 1970 w sprawie wprowadzenia stref zagrożenia lasów, gospodarki w tych strefach, a także szacowania rozmiaru szkód i kosztów przebudowy drzewostanów w lasach znajdujżcych się pod ujemnym wpływem szkodliwych pyłów i gazów wydzielanych przez zakłady przemysłowe [September 19, 1970 Ordinance of the Minister of Forestry and Wood Industry on Introducing the Forest Hazard Zones and Estimating Damages and Tree Stand Reconstruction Costs in Forests Affected by Harmful Influences of Gases and Dusts Emitted by Industrial Plants] (1979), Dziennik Urzędowy Ministra Leśnictwa i Przemysłu Drzewnego, no. 16–20, pos. 111.