Monitoring of the forest status in the Czech Republic. Recent results and prospects

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Abstract
Results of both forest and tree damage based on the defoliation assessment in the Czech Republic are presented as a part of the International Cooperative Programme "Monitoring of Air Pollution Effects on Forests. The worsening trend in health status of the forests is proved during 1986-93. Year to year variances are very much important. Two methods of the statistical evaluation of health status of the whole stand as well as of its development (change) were proposed.

Keywords: *defoliation, forest damage, health status, statistical evaluation*

Introduction

The foundations of the systematic monitoring of the health condition of forests in the Czech Republic were laid towards the end of the fifties when it became evident that the level of damage to forests would spread as a result of rising air pollution. In the first phase the forests in the complex of the Krušné hory mountains were evaluated, later forests in other regions where damage became evident. To a certain extent it is possible to describe the course of the development of damage to forests using this considerable amount of data.

At the end of the seventies it turned out that damage became evident even in localities remote from the primary sources of pollution. Attention began to be paid to the soil changes which could have an influence on the deteriorating condition of forests and to the observation of tree species stands nutrition. Monitoring of air pollution began to be carried out. From 1986 Czechoslovakia joined the system of the all-European monitoring of forest condition within the International Cooperation Programme (ICP-Forest). This programme has been conducted in the Czech Republic up to now (Landmann, 1993). In the first year, about 80 plots were formed. In 1987 this number was extended to 105 plots located within the network with basic dimension 16 x 16 km. In

1989 this network was decided to be thickened to dimension 8 x 8 km. At the same time the methodology of the establishing and evaluating of permanent plots was specified and completed. These plots were established and firstly evaluated in 1990. The total number of plots in the territory of the Czech Republic is about 450 at present (Matějka, 1993). To secure the network with dimension 16 x 16 km with the given area of the republic (78 862 km^2) and percentage of forest land (33.3 %) the basic requirement for the number of plots is about 120. In the selected regions (Šumava, Krkonoše, Brdy; Černý, 1991) further networks of study plots were formed with the basic dimension being 1 x 1 km and they are used for developing regional studies. But this concerns special studies which are performed by various stations.

The existing system of monitoring and of study plots should be completed in order to meet the following conditions. There must be represented proportionally all:

- natural forest regions,
- forest type groups or the own forest types or other plant coenological classification units,
- tree species in relation to their composition in forests of the Czech Republic,

or some other as follows:

- soil classification units and
- groups of parent rock.

The task of this paper is to evaluate the development of forest damage on the basis of the repeated observation of the study plots.

Methods

Several factors were examined within the study plots. The basis for the judgement of the level of damage to tree species is the annual assessment of defoliation of all the trees within the study plot. For more details concerning the methodology see Matějka (1993).

During the data processing, it has turned out that each tree species should be evaluated separately. The tree damage of a certain species on the plot is judged on the basis of the arithmetical average of defoliation of all trees of the selected species (D). Standard deviation (s) of this defoliation is computed parallelly.

Due to self-thinning, natural elimination of certain trees in the stand and inequalities in the distribution of tree frequencies according to the defoliation classes, it is clear that the simple arithmetical average of defoliation is not the most suitable parameter which should indicate a stand potential for its further development. It is important to know the average defoliation of the trees with the highest vitality. The quantity of $D-\alpha s$ seems to correspond to it; α is a positive real constant (the used value was 0.5).

Results

The development of defoliation by Norway spruce and Scots pine is gathered in Table 1. On the basis of the defoliation assessment conducted in 1992 it should be stated that 8.7 % of trees only is without any signs of damage or decrease in vitality. 56.4 % of trees is significantly damaged. This situation is even more considerable in conifers. As by broadleaves, 21.8 % of trees is without any signs of damage and 31.8 % of trees was significantly damaged.

Table 1. Development of defoliation of both spruce and pine during 1986-93 in the Czech Republic.

	defoliation class [%]	year 1986	1987	1988	1990	1992	1993
		(frequency in per-cent)					
Picea abies	0-9	25.1	21.9	9.0	7.6	1.9	6.5
	10-19	24.1	37.1	23.8	19.0	14.8	19.4
	20-29	26.4	21.0	26.8	23.2	25.5	24.2
	60-100	4.2	2.2	4.2	14.6	7.3	6.7
Pinus sylvestris	0-9	31.6	16.0	10.4	2.5	2.1	0.3
	10-19	8.0	29.6	23.3	18.3	11.8	3.9
	20-29	20.7	27.2	30.5	37.4	26.4	24.3
	60-100	15.1	3.7	5.8	9.0	9.3	9.2

In spruce and pine, the highest frequency of trees was registered within the defoliation class 30 to 40 %, in oak - within the class 20 to 30 % ad in beech - within the class 10 to 20 %.

The main judgement of the development of damage was performed for Norway spruce (*Picea abies*) since it is the most frequently occurred tree species within the system of study plots. The development of its defoliation in the years 1988 to 1993 in the territory of the Czech Republic is shown in Figs. 1a-d. It is clear that the arrangement of regions with different level of damage to spruce has been gradually changed. In the first period the highest damage was recorded in the north-west and north border area of Bohemia. Higher defoliation also occurred in several areas in the southern Bohemia which could be given in connection to probable problems of spruce nutrition in several localities of this region. The lowest defoliation was displayed by the stands in the region of the Bohemian-Moravian border area. Two years later (in 1990), the most significant increase in defoliation was recorded in this region. A high level of damage was found out in the stands of a broader Sudeten region. In 1992, no geographical regularity for the distribution of variously defoliated stands were found out within the Czech Republic. In the following year the situation turned over and areas with a higher level of defoliation were cumulated in the southern (south-west) half of the republic.

Table 2. Frequencies of the 10%-defoliation classes in 1993 in the Czech Republic by the most important species.

species	N	defoliation class									
		0--9	10--19	20--29	30--39	40--49	50--59	60--69	70--79	80--89	90--100
Picea abies	9737	6.5	19.4	24.2	24.5	13.8	4.8	2.5	1.4	.7	2.1
Abies alba	108	1.9	14.8	20.4	30.6	13.0	5.6	2.8	1.9	.9	8.3
Pinus sylvestris	1409	.3	3.9	24.3	35.3	19.8	7.2	2.5	2.2	1.8	2.7
Larix decidua	282	.4	8.2	36.2	37.9	12.8	1.4	1.1	.4	.7	1.1
Quercus sp.	451	.2	5.8	14.0	17.1	16.9	15.1	13.1	8.0	3.8	6.2
- Q. petraea	(227)	.0	4.8	5.3	8.8	18.5	23.3	21.6	10.1	4.4	3.1
- Q. robur	(83)	1.2	8.4	13.3	8.4	9.6	7.2	8.4	15.7	7.2	20.5
Fagus sylvatica	350	3.1	26.0	34.0	20.3	8.6	3.1	2.6	.0	.3	2.0
Carpinus betulus	108	1.9	38.9	25.9	14.8	8.3	7.4	.0	.0	.0	2.8
Alnus glutinosa	97	2.1	27.8	35.1	20.6	11.3	1.0	.0	.0	.0	2.1

In as early as 1988 the geographical distribution of values D-0.5s (Fig. 2) indicated potential danger of the deterioration of the state in spruce stands for example in the southern Bohemia. Actually (only four or five years later) this deterioration became evident. It follows from the study performed in 1993 that dangerous development could be awaited in the western and southern Bohemia and in the Bohemian-Moravian Uplands.

This change is also documented by the distribution of plots with a different change in defoliation expressed by help of C index which is defined by the relation

$$C_{i;j} = (D_j - D_i)/\sqrt{(s_i.s_j)}$$

where D_i is the average defoliation in the first year and D_j is average defoliation in the second compared year, analogously s_i and s_j are standard deviations. Negative index value means decrease in defoliation while, on the contrary, the positive one means an increase. With regard to the change in the character of damage within the years 1990 and 1992 attention was paid particularly to $C_{90;92}$ index. Description of the situation in spruce was completed with that in the Scots pine.

If we proceed from the simple comparison of tree frequencies in individual defoliation classes (Table 1) within the all observed plots, we can conclude that the situation has worsened substantially. The shift upwards to the highest defoliation classes representation was noticed in both the species (similarly from the class 20-29 % to that 30-39 %). Above that in spruce we can notice that the defoliation range has been narrowed probably as a result of the silvicultural interventions - thinning of the most damaged trees (it becomes evident in the class with the level of defoliation higher than 50 %).

We must fundamentally change our view choosing for the comparison only those plots which were evaluated within both the years. This concerns 70 plots with spruce (6067 trees evaluated) and 13 plots with pine (906 trees evaluated). By comparing the average defoliation on each plot it was found out that within the whole area of republic the situation in spruce has not actually changed while in pine it means increase of average defoliation. Distribution of the frequencies of plots according to the index of defoliation change is given in Fig. 4. The evaluation of the

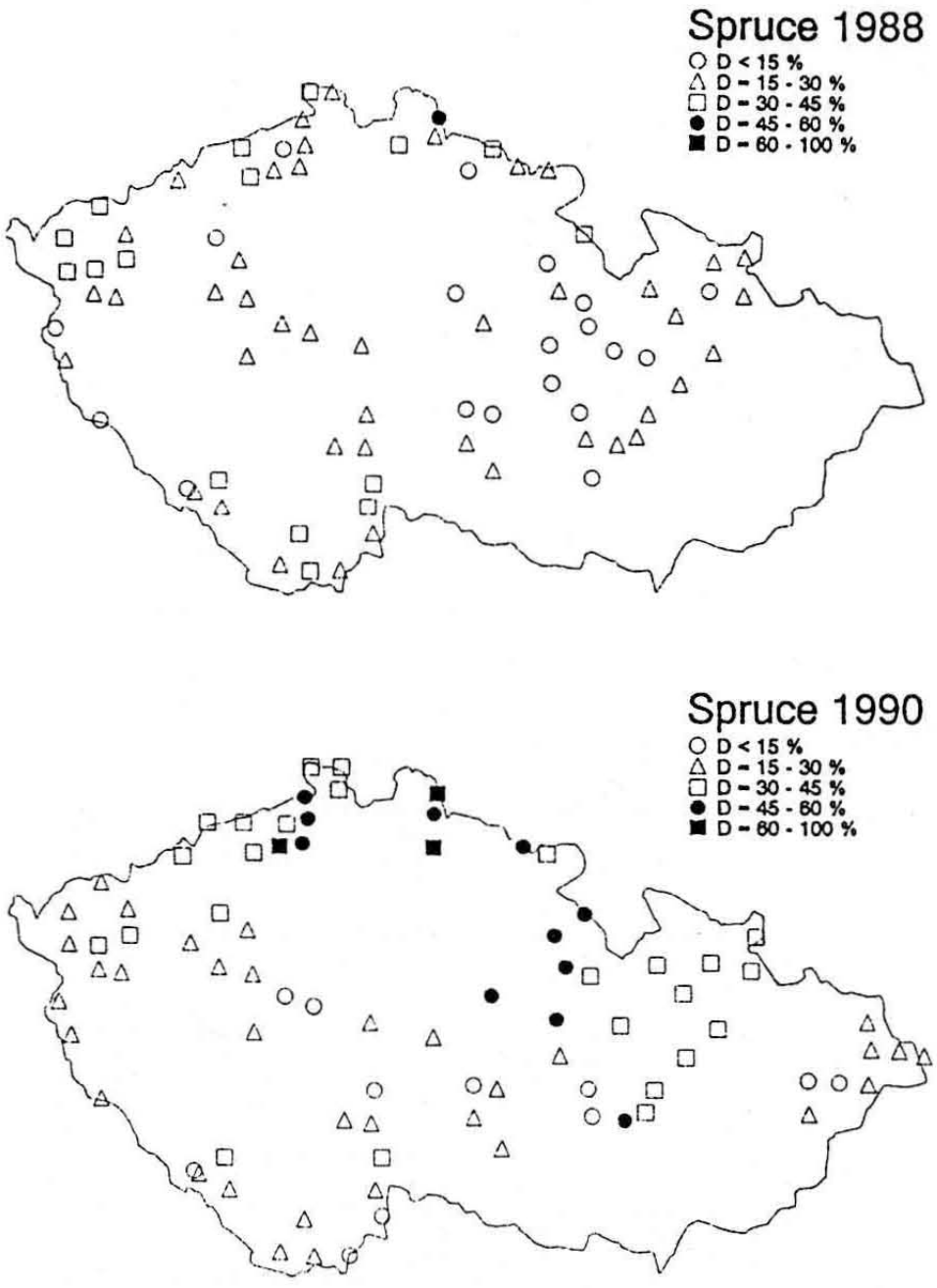


Fig. 1. Development of the spruce average defoliation in the Czech Republic during 1988 - 90

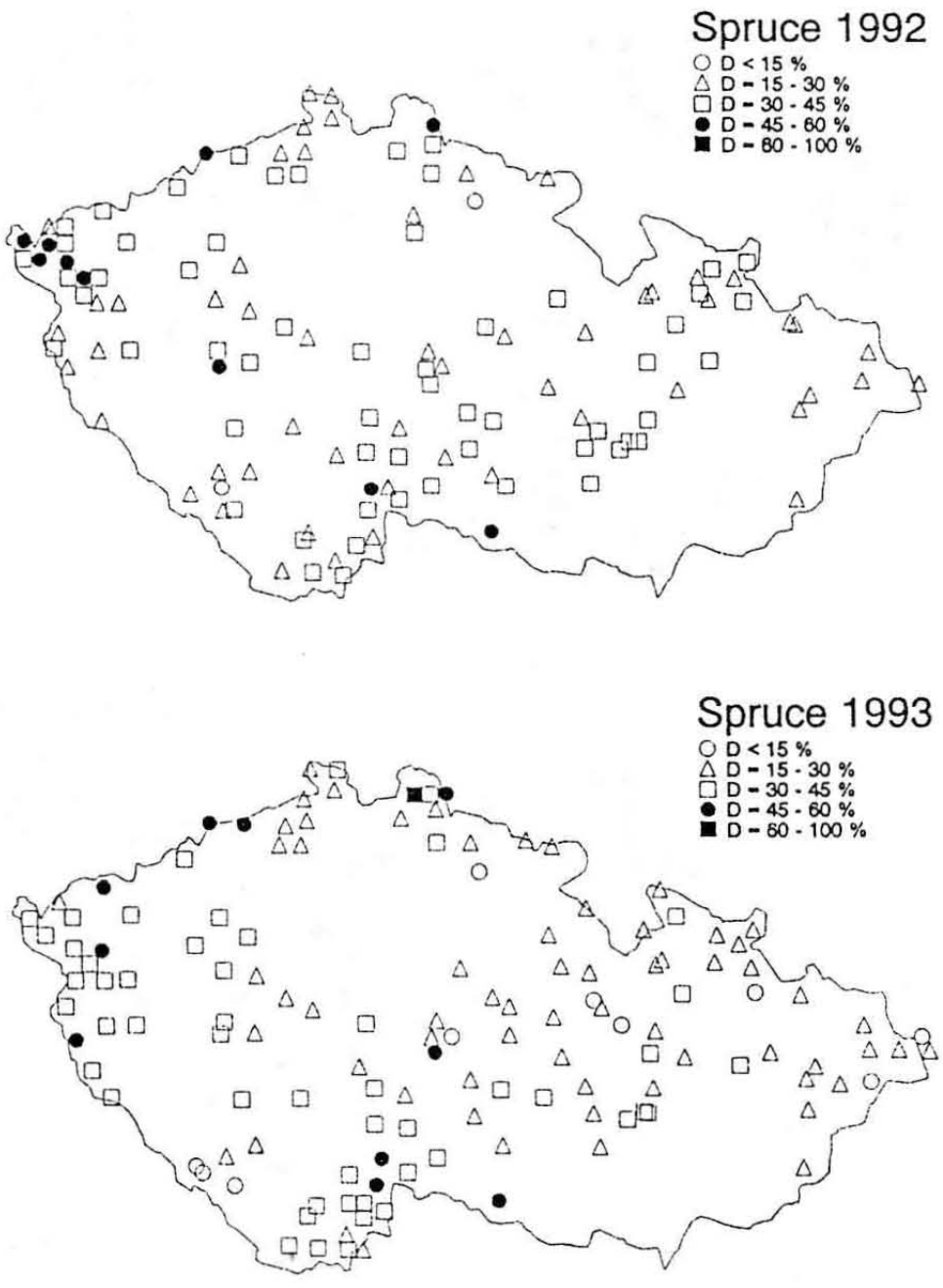


Fig. 1. Development of the spruce average defoliation in the Czech Republic during 1992 - 93

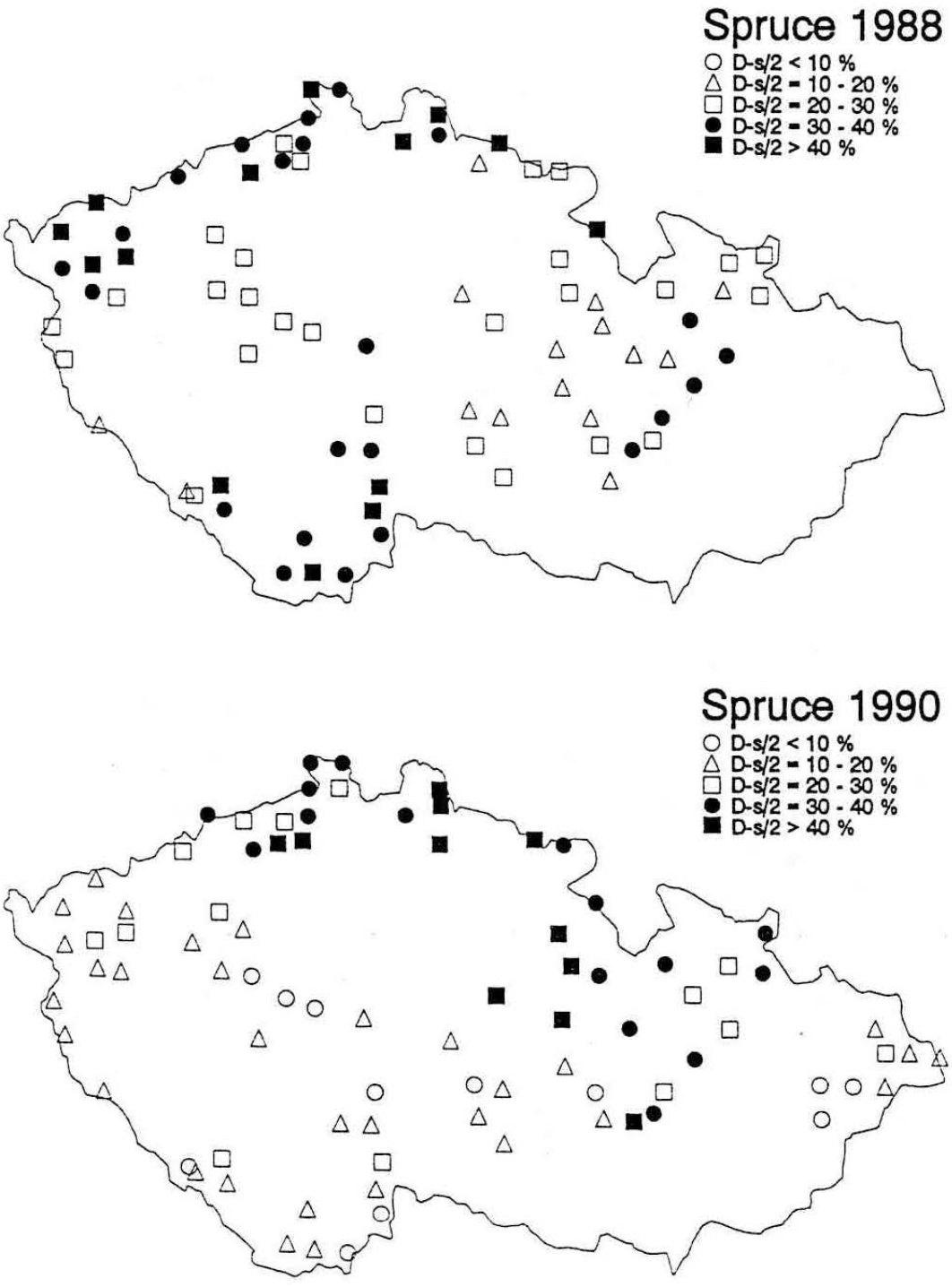
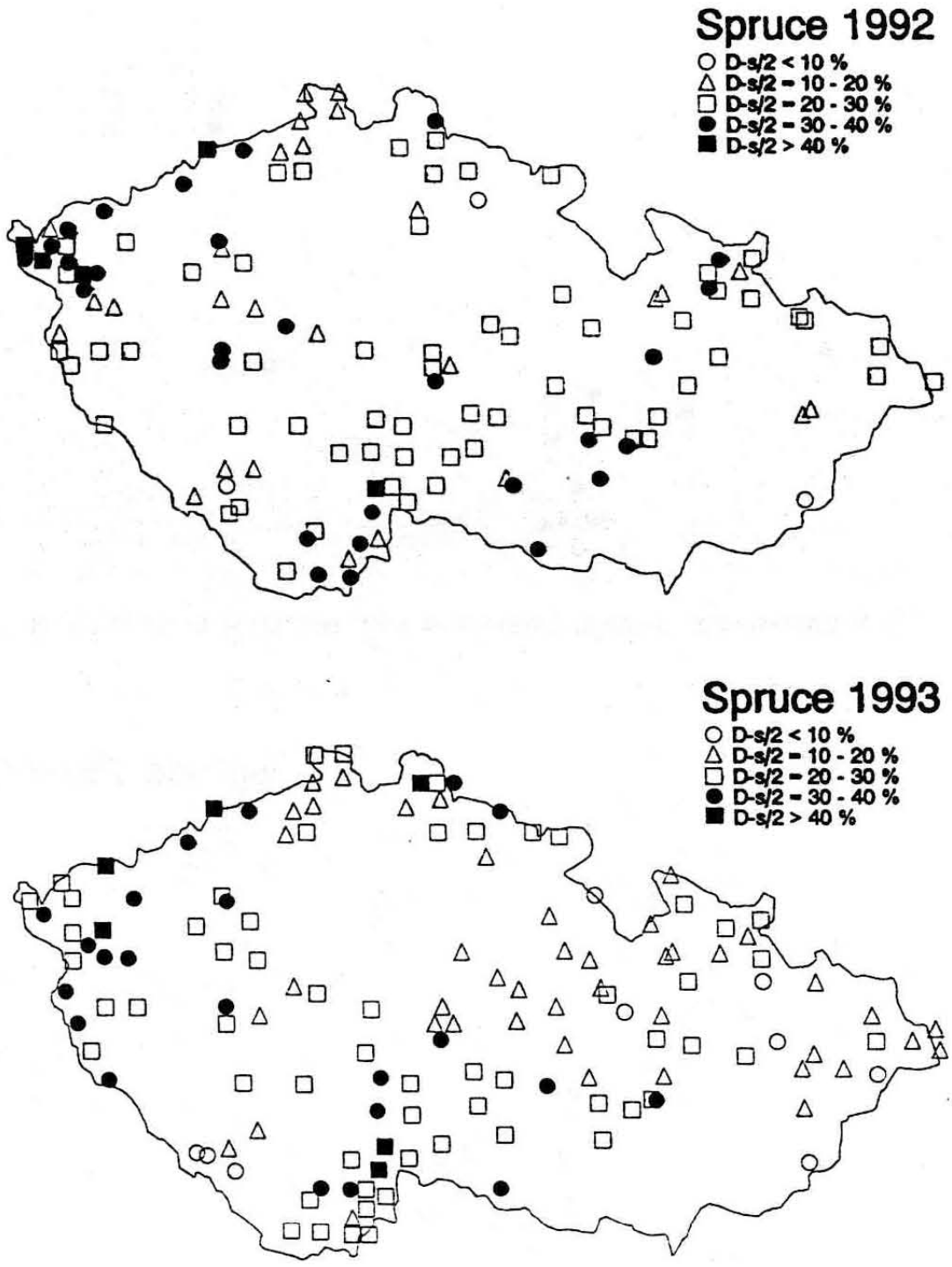


Fig. 2. Development of statistics D-0.5*s by Norway spruce in the Czech Republic during 1988 -90



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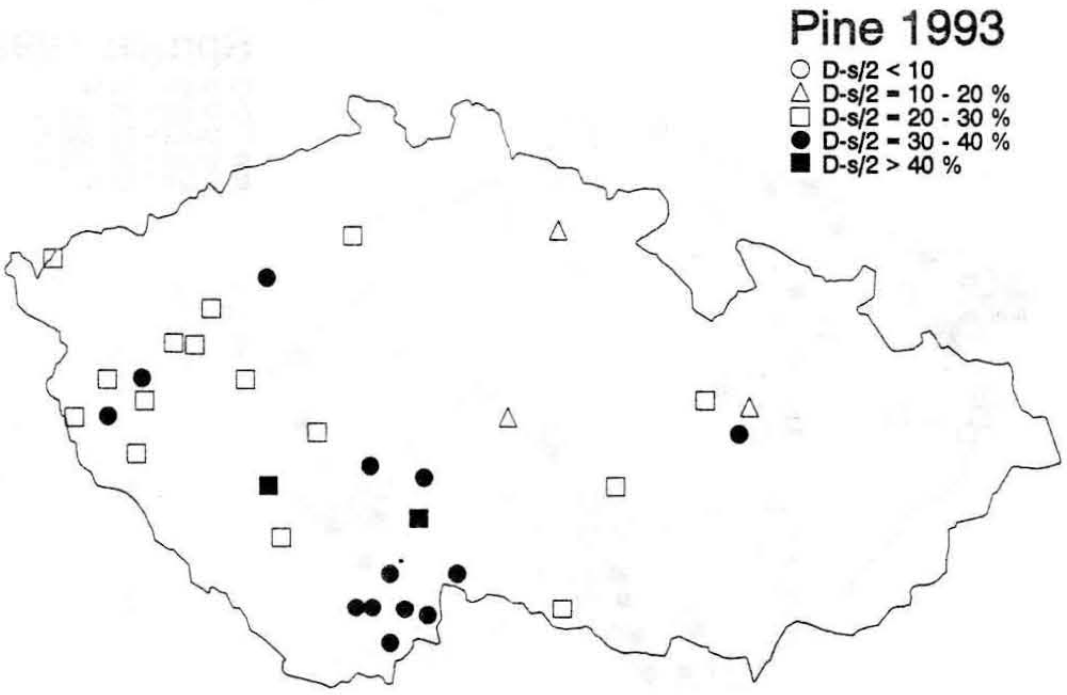

Fig. 3. Contemporary average defoliation of Scots pine in the Czech Republic

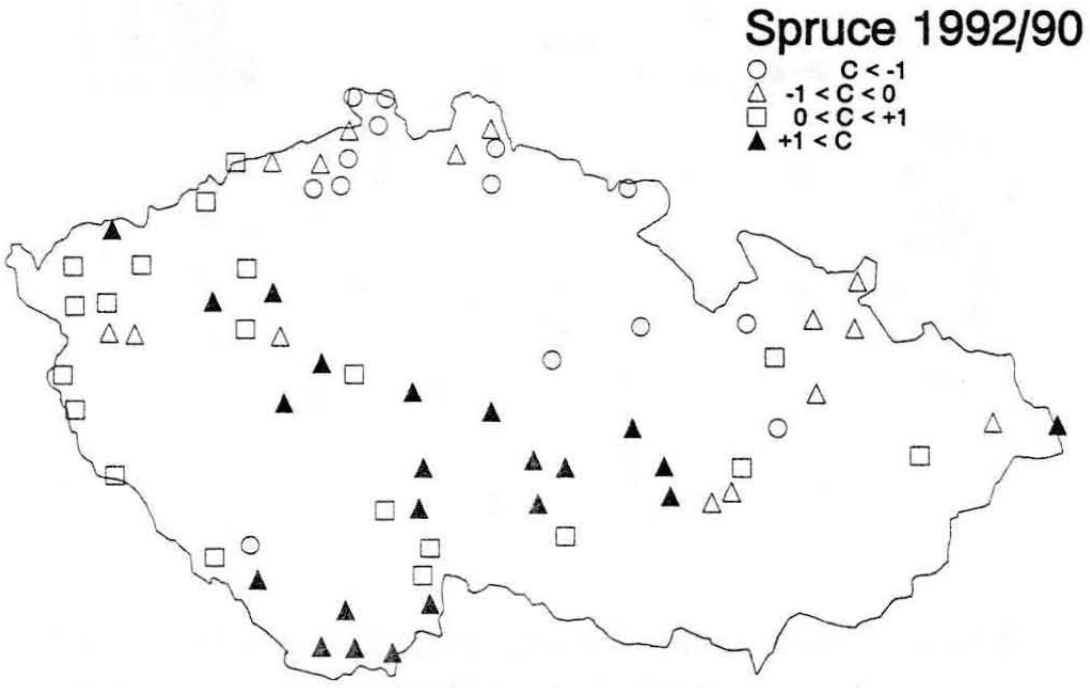

Fig. 4. Index C of the defoliation change by Norway spruce between years 1990 and 1992

regional distribution of plots with different character of defoliation change is substantial. The improvement of the tree status occurred particularly in the area of the north (north-east) Bohemia and in the part of the north Moravia, i.e. in heavily damaged regions. On the contrary, worsening of the tree status was observed in a large part of the west, middle and south Bohemia and especially in the Bohemian-Moravian Uplands.

Conclusion

It was evident that within the years 1990 and 1992 the distribution of regions with a different intensity of damage (defoliation) of forest trees changed in the Czech Republic, particularly in spruce and pine. This change can probably cause on the change in the environmental conditions (decrease in pollutant load in certain regions, climate change during last years, particularly the significant rain deficit during several last years, probably poor management in the forests of certain regions). The results of the monitoring of forest status indicate the inappropriate high representation of coniferous trees in the territory of the Czech Republic. Particularly spruce should be gradually replaced by broadleaved species. By using beech the situation could improve in perspective as well as the stability of forest ecosystems, particularly in certain regions (typical would be the region of the Bohemian-Moravian Uplands where this situation continues aggravating).

In future it will be necessary to pay an increased attention especially to the ecosystems with oak (*Quercus petrea*, but also *Q. robur*) the situation of which is critical.

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Karel Matějka: Monitoring stavu lesů České republiky. Současné výsledky a perspektivy.

Jednoznačně se ukázalo, že mezi lety 1990 a 1992 došlo ke změně rozmístění regionů s různou intensitou poškození (defoliace) lesních dřevin, zvláště smrku a borovice, na území České republiky. Tuto změnu lze pravděpodobně dávat do souvislosti se změnou podmínek prostředí (snížení imisní zátěže v některých exponovaných regionech, změna klimatických poměrů v posledních letech [zvláště výrazný srážkový deficit v několika po sobě následujících letech], pravděpodobně i nedokonalé hospodaření v lesích některých regionů). I výsledky monitoringu stavu lesních porostů poukazují na nevhodně vysoké zastoupení jehličnatých dřevin na území České republiky. Zvláště smrk by měl být postupně nahražován listnatými dřevinami. Náhradou bukem by bylo možno perspektivně zlepšit stav a stabilitu lesních ekosystémů zvláště v některých oblastech (typickou by byl region Českomoravské vrchoviny, jehož stav se neustále zhoršuje).

V budoucnu bude nutné věnovat zvýšenou pozornost zvláště ekosystémům s dubem (*Quercus petraea*, ale i *Q. robur*), jejichž stav je kritický.