INVESTIGATIONS OF THE EFFECT OF DEFOLIATORS ON THE INCREMENT OF FIR FORESTS

von
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Summary

Many Silver Fir(Abies alba Mill) forests in Yugoslavia were subjected to various defoliators. The most dangerous is the Fir needle moth (Argyresthia fundella F.R.).The defoliators destroy the needles of the trees and so they reduce the assimilating apparatus.Therefore I was interested to investigate how does the reduction of assimilating apparatus affect the increment.As the object of my research I choose the management unit "Belevine" in the Gorski Kotar region in Croatia.

In order to be able to give an answer to the query, I put the Silver Fir trees in different groups: 0%,10%,20%,30%,40%, etc where 0% means the trees with full crown; 10% means the trees with the crown reduced by 10%;20% means the trees with the crown reduced by 20% etc.From each Fir tree was taken one increment core-in total 326 cores.After the analysis of cores and after the statistical processing of data we obtained the following result: the reduction of assimilating apparatus by 10% caused a drop of diameter increment by 25%; the reduction of assimilating apparatus by 2o% caused a drop of diameter increment by 3o% etc.

The investigations should be continued in other forets in order to be able to establish a code.

Within the framework of complex investigations on "The epidemic dieback and drying of Silver Fir (Abies alba Mill)" my role was among other things to investigate what repercussions the mentioned dieback had on the increment. As the object of my research I choose the management unit of "Belevine" in the Gorski Kotar region (Croatia), i.e. the same acidophilous Fir forest (Abieto-Blechnetum Horvat) which has been the subject of repeated investigations, and was described in detail in Šumarski list (Forestry Review), Glasnik za šumske pokuse (Annals for Forest Research) etc, So far we have at our disposal very different and valuable data of measurements and observations regarding this faculty demonstration forest. As it was simultaneously subjected to various attacks, beginning with mistletoe (Viscum album f.sp.abiestis Tub.) to the Fir needle moth (Argyresthia fundella F.R.), and other defoliators, I decided to focus my observations and measurements on this forest in order to give an answer to the query under discussion.

The magnitude of increment is influenced by various factors. It is very difficult to isolate but one factor and to investigate its effect only. In the present investigations we have exactly to deal with such a case: it is necessary to find out what repercussion had the dieback of Fir stands on their increment.

Considering that in the last mass attack chiefly defoliators took part, I thought it would be best to establish first how much the assimilating surface of attacked Fir stands was reduced.

I was proceeding in the following manner: in the management unit of "Belevine " were laid out 13.55o km of sample-strips lo m.wide making a total of 13.55 ha.sample-strips, or about 5% of the total area of the management unit (271.15ha.) On these strips were measured the breast height diameters (d.b.h.) of all trees above the minimum measurement limit of lo cm.In addition to this there were observed by means of a field-glass the crowns of each measured tree and was estimated the loss of needles in percents from 0 to 100, were 0 means a healthy Fir tree and 100 a dead one without needles; 10% means that there were destroyed 10% of needles, or that the actual assimilating surface amounts to 0.9 in relation to the full crown; 20% means that 20% of needles were destroyed, etc.

In order to make possible at the same time the determination of increment of individual trees and of the whole forest,there were made borings on all Fir trees which fell into the line of sight (When laying out strips compass). From each Fir Tree was taken one increment core, which was wrapped into a piece of paper on which was recorded the compartment number, diameter b.h. and percentage of reduction of assimilating surface on the bored tree. There were taken in all 695 samples (cores)from as many Fir trees, as follows:

326	cores from	326	Fir trees with full crown ;
23o	cores from	23o	Fir trees with crown reduced by 10%
95	cores from	95	Fir trees with crown reduced by 20%
33	cores from	33	Fir trees with crown reduced by 30%
9	cores from	9	Fir trees with crown reduced by 40%
2	cores from	2	Fir trees with crown reduced by 50%
695	cores in total		

Another variant of presentation would be as follows;

1	x 326	=	326.0
0.9	x 230	=	207.0
0.8	x 95	=	76.0
0.7	x 33	=	23.1
0.6	x 9	=	5.4
0.5	x 2	=	1.0
			638.5

The figure 638,5 means the present state of the assimilating surface.If this state is compared with the state before damage (695) we obtain a difference of 56.5.This difference gives us information about the reduction of the assimilating surface,which in percents amounts to:

$$p = \frac{56.5}{695} \quad 100 = 8\%$$

Which would mean that in the management unit of"Belevine" the assimilating surface is diminished by about 8%.We obtained a similar data on the basis of a more complete calculation taking into consideration all measured trees on strips, where the situation was as follows: 3,368,9 means the state of assimilating surface at the beginning of July,1971; the state before damage was 3.7o2. The difference is 333.9 or 8,9%. Which means that the samples (cores)are good representatives of the condition of the forest,

which is understandable, because the sample-strips were laid out according to the principle of random sampling.By the same proceeding we obtained the same result two years ago.

Accordingly we may say that the state in the management unit of "Belevine" did not worsen, or that the dieback of Fir there did not have a progressive character.Nevertheless, we are dealing with a forest where the assimilating surface of Fir- taken on an average- was reduced by about 8 - 9%.

Having thus determined the state or the area in question and taken a considerable number of representative samples, there exists a possibility for different analyses and considerations.
I restricted myself to the following problems:

1. How do healthy and infested trees put on their increment?
2. When did the diameter increment of Fir begin to fall off?
3. How does the reduction of assimilating apparatus affect the tree increment?

To this purpose the increment cores were analysed in different ways.

First, on each core was measured the individual recruitment time (t) for 5 cm.-diameter sub-classes.
Second, on each core was measured the diameter increment for the past lo years, i.e.from 1961-197o.
Third, on each core was measured the diameter increment for the past 5 years, i.e.from 1966-197o.

Fourth, on each core was measured the diameter increment during the previous past years, i.e. from 1961-1965.

After a fourfold analysis of cores a sorting of cores was carried out and the resulting data smoothed according to the theory of least squares.

Annual diameter increment of healthy Fir trees as compared with the increment of Fir trees whose assimilating surface was reduced

All samples (cores) were divided into two groups or collectives. The first collective included all samples extracted from healthy Fir trees. The second collective contained samples extracted from Fir trees whose assimilating surface was reduced. For the purpose of simplification the first collective will be called "healthy" and the second "infested Fir trees".

The analysis of increment cores was performed in the manner already mentioned.

The annual diameter increment of healthy Fir trees in the management unit of Belevine " may be expressed by equation (1) :

$$Z_r = - 0.001203 \quad D^2 + 0.136334 \quad D + 0.800815 \quad \ldots\ldots(1)$$

The annual diameter increment of infested Fir trees may be expresse by equation (2):

$$Z'_r = - 0.001311 \cdot D^2 + 0.131027 \cdot D + 0.202656 \quad (2)$$

Taking into calculation the number of cores according to diameter sub-classes, we found that the increment of infested Fir trees was by 3o% lower than the increment of healthy Fir trees.

This finding is very important, because it gives us an insight into the economic losses in the forests attacked.But, in addition to such a global determination of increment losses, it would be interesting to establish a functional interdependence between the falling-off of increment and the degree of infestation, or, properly speaking, of the reduction of assimilating surface.Before solving this problem, we shall make an attempt at giving an answer to the query when the falling-off of increment had set in?

Annual diameter increment of Fir at different times

Diameter increment of Fir for the 1966-197o time interval by equation (3), and for the 1961-1966 time interval by equation (4) is presented.

$$Z_{1r} = -0.000461 \cdot D^2 + 0.060856 \cdot D + 2.135759 \quad \ldots.(3)$$

$$Z_{2r} = -0.000402 \cdot D^2 + 0.073009 \cdot D + 1.896828 \quad \ldots.(4)$$

Diameter increment of Fir fell off by over 15% during the 1966-197o time interval.

Having established that in the past 5 years a marked falling-off of increment had set in, we are now interested to know what year it was most marked.

An analysis of the cores showed that the growth rings were narrowest in 1968 and 1969. In fact, at that time the studied forest had a "diseased" and alarming appearance.

Let us state by the way that to - day the condition of the forest has improved, and that in the summer of 1971 an unheard - of cone crop was recorded.

The first query to which we should lend an ear is: Did the climatic factors not cause perhaps the reduction of the diameter increment? " In order to answer this question we had to resort to those climatic data which we have at our disposal from the weather stations Zalesina and Delnice. From the weather station we computed that in the course of 5 years.i.e.from 1965 to 197o, the amount of rainfall was 1o,66o mm or annually 2,132 mm; for the same time period the rainfall in the course of the growing season was 5,15o mm or annually 1.o3o mm. During the 1961-1965 period the amounth of rainfall totalled 1o,88o mm or annually, 2,16o mm , while for the same time in the course of the growing season it was 5.o33 mm or annually 1.o66 mm. It is evident that the time intervals of 1961-1965 and 1966-197o did not differ as regards rainfall. If we study separately the years 1968 and 1969, we see that they did not deviate from the average.

Consequently, we cannot ascribe to the rainfall the reduction of diameter increment in the last 5 years. Neither are the differences in temperatures such as to cause the mentioned reduction of increment.

With regard to the management measures (fellings) it ought to be stressed here that in the management unit of Belevine " the annual cut is ca.2.500 cu.m.,which is approximately as much as the annual increment.The cutting is performed under the scientific guidance of specialists from the Faculty of Forestry, and thus the management interventions could not be accounted for the reduction of increment of fir either, but,what is more, we should expect it to increase.

Accordingly, it may be said rather reliably that certain defoliators caused the reduction of increment which we had established.

And now let us try to give an answer to the third query:" how does the reduction of assimilating apparatus affect the tree increment.

How does the reduction of assimilating apparatus affect the increment ?

In order to be able to give an answer to this query, I sorted the samples according to the groups 0%, 10%,20%,30%,40% etc.where 0 means the samples from fir trees of the normal assimilating surface, 10% means the trees in which the assimilating surface was reduced by 10%, 20% means the trees in which the assimilating surface was reduced by 20% etc. On the cores we measured the annual diameter increment during the five-year period of 1966-197o. After the statistical processing of data, we obtained the following results:

Loss of needles	0 %	10 %	20 %	30%	40%	50 %
b	326	23o	95	33	9	2
d_s	5o.1	45.8	41.3	45.1	3o.8	15.o cm
Z_s	3.82	2.86	2.76	2.36	2.37	1.3o mm
Index	1.oo	o.75	o.72	o.62	o.62	o.34

(b) = number of samples; (d_s) = mean diameter b.h. of Fir trees

(Z_s)= average annual diameter increment in the course of the 1966 - 197o time interval.

If we look at the results obtained, we see that the diameter increment decreases with the reduction of the assimilating surface of the Fir tree. In healthy Fir trees with their crowns intact the average annual diameter increment amounted to 3.82 mm, while it dropped to 2.86 mm in trees whose assimilating surface was reduced by 10%, and to 2,76 mm in trees whose assimilating surface was reduced by 2o%, etc.It catches our eye immediately that the falling off diameter increment is not linear, because the reduction of needles by 1o% caused a drop of increment by 25%. Regrettably in groups of 3o%, 4o% and 5o% we have not a large number of samples, because in the investigated forest they were not at our disposal in sufficient amounts. This forest is intensively managed,and thus the trees that lost more than 2o% of their needles are rather rapidly removed.Therefore these investigations will be continued in those forests where the dying away of trees spread heavily.

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