

## Reduction of timber value from damaged spruce stands after their dieback

R. PETRÁŠ

*Forest Research Institute, Zvolen, Slovak Republic*

**ABSTRACT:** The paper presents a method for the derivation of total timber production and of increments in value units, particularly in net financial yield for spruce stands damaged by crown defoliation after their dieback. The value production was derived by means of value growth models of undamaged stands and models for the adjustment of volume and qualitative production of damaged and died stands. Changes in timber quality after tree drying and changes in the production of damaged stands compared with undamaged ones are illustrated in tables and graphs. The changes are expressed by means of the indexes of total mean increment and total current increment. They depend mainly on the degree of stand damage expressed by crown defoliation, age and yield class of stand, the age of stand when the damage started and duration of damage. The value of damaged stands after their dieback is lower minimally by 50% than before their dieback. It is caused mainly by deteriorated quality of timber from dead trees in stand.

**Keywords:** spruce; total value production of timber; increments

During the investigation of forest stands damage mostly increment reduction and production reduction in relation to partial tree or stand characteristics in current area units are studied. Particularly, for a tree it can be diameter, height or volume increment and for a stand mean diameter increment, height increment or increment of mean stem volume, but mostly it is the increment of standing volume. When tree production is examined, it is particularly total current increment and mean total increment. These increments are very important in forest production as they integrate the increment of main stand as well as secondary crop not only at a certain time but also for a longer time period from its establishment. Their direct measurements and determination in forest stands are very difficult and complicated as to methodology as well as field measurements. This is particularly important especially for damaged stands. In this case the difficulties occur not only due to availability of empirical material but mostly due to a longer time necessary for its collection.

Due to these reasons we searched for alternative methods to derive increment and production reduction for damaged stands. One of them is simulation of reduction by means of growth and production models of undamaged stands and reduction of volume increment, or of the quality of damaged trees. This procedure was already used for spruce and pine stands by PRIESOL (1989), PETRÁŠ and HALAJ (1993), PETRÁŠ et al. (1999), PETRÁŠ and MECKO (2001). The reduction of value production of spruce stands due to lower diameter and volume increments was published by PETRÁŠ (2002). According to his algorithm

the value production was determined from a financial expression of volume and timber quality, from which costs of timber felling were deducted. Lower timber quality is thus characterized only by a smaller diameter of logs due to lower diameter increments of damaged stands. As the reduction of production for living trees was investigated in this case, other changes in timber quality that follow tree drying were not considered.

The aim of this work is to describe the methodology of the derivation of models and based on them the quantification of a reduction in value production of spruce stands from the time when the damage started until their dieback, which is accompanied particularly by marked deterioration of timber quality.

### METHODS AND PROCEDURES

The value of timber from damaged spruce stands after their dieback was derived from models of value production of damaged stands before their dieback and models for adjustment of the structure of assortments from dead trees as given by PETRÁŠ et al. (1995). PETRÁŠ (2002) reasoned out the models of value production of damaged stands whilst he based his reasoning on partial models as follows:

- Total volume production (PETRÁŠ, MECKO 2001),
- Development of mean diameters (PETRÁŠ et al. 1993),
- Development of mean stem volume (PETRÁŠ et al. 1993),
- Stand assortment tables (PETRÁŠ, NOCIAR 1991),
- Mean prices of timber assortments (PETRÁŠOVÁ et al. 2001),

– Own costs of logging (PETRÁŠOVÁ et al. 2001).

He derived the value production of damaged stands from these partial models by converting the volume production into the production of assortments by means of assortment models and the latter into gross financial yield by means of timber prices. He deducted from that model own costs of logging and obtained net financial yield. As damaged stands have lower volume production and smaller tree diameters, consequently they have lower value production than undamaged stands.

A main factor influencing the value production, in addition to the volume, is the quality of timber that was assessed according to the structure of timber assortments. According to the models of assortment tables (PETRÁŠ 1992) the proportion of assortments in spruce stands depends on their mean diameter, external quality and mechanical damage of stems. It can be expressed as follows:

$$V_{\text{sort}} \% = f(d_v, k_v, p) \quad (1)$$

where:  $V_{\text{sort}} \%$  – percentage of the assortments in standing volume,

$d_v$  – mean diameter of stand,

$k_v$  – external quality of stems,

$p$  – proportion of mechanically damaged stems.

This basic relation is valid for damaged or living trees until their dieback. After dieback the situation changes

significantly. Wood of trees starts to decay, which results in quality deterioration. Thus the assortment structure of such trees and stands undergoes changes as well. PETRÁŠ et al. (1995) investigated this issue on a relatively vast empirical material of sample trees. He found that in comparison with living trees dead trees, so called snags, have zero proportions of the highest quality classes of logs, namely quality class I and II and markedly lower proportions of high quality classes of saw logs, namely quality class III A. On the other hand, they have significantly higher proportions of lower quality saw logs of III B quality class, of pulpwood, quality class V, fuelwood – quality class VI and waste wood. He classified dead trees into three classes according to the intensity of damage to sapwood by decay and discolouration. These classes are as follows:

Class 1 – fresh snag. The tree shortly after its dieback, mostly with bark without larger surface cracks. It has only very slight damage to sapwood by discolouration, maximally to 1/10 of the butt end diameter. The stem is without any sapwood damage.

Class 2 – older snag, the stem mostly without bark with large surface desiccation cracks. If with bark it shows a significant incipient fungal attack of timber. In a cross-section of the stem sapwood discolouration larger than 1/10 of the butt end, but surface decay of sapwood is maximally on 1/10 of the butt end diameter.

Table 1. Assortment yield tables of spruce snag stands for the main stand of yield class 30

Age	Percentage of log quality classes for respective classes of snags												Age	
	1					2				3				
	III. A	III. B	V	VI	Waste	III. B	V	VI	Waste	III. B	V	VI	Waste	
40	8.4	9.8	80.3	1.5	0.0	16.6	80.2	3.2	0.0	4.4	66.3	28.1	1.3	40
45	12.2	19.2	67.0	1.6	0.0	27.9	68.7	3.3	0.0	7.1	64.1	27.6	1.3	45
50	15.9	27.2	55.2	1.7	0.0	37.8	58.7	3.5	0.0	9.2	62.4	27.1	1.3	50
55	19.1	33.4	45.6	1.8	0.0	45.7	50.6	3.6	0.0	10.8	61.3	26.6	1.3	55
60	21.9	37.9	38.2	1.9	0.1	51.8	44.4	3.7	0.1	11.9	60.7	26.1	1.3	60
65	24.2	41.2	32.6	2.0	0.1	56.5	39.6	3.7	0.1	12.6	60.5	25.7	1.3	65
70	26.1	43.6	28.2	2.0	0.1	60.2	35.9	3.8	0.1	13.0	60.5	25.2	1.3	70
75	27.5	45.5	24.9	2.0	0.1	63.0	33.1	3.8	0.1	13.3	60.7	24.7	1.3	75
80	28.7	46.9	22.3	2.0	0.1	65.2	30.8	3.9	0.1	13.4	61.1	24.3	1.3	80
85	29.5	48.1	20.2	2.0	0.1	67.0	29.0	3.9	0.1	13.4	61.5	23.8	1.3	85
90	30.2	49.1	18.6	2.0	0.1	68.5	27.5	3.9	0.1	13.3	62.0	23.4	1.2	90
95	30.6	50.0	17.3	2.0	0.1	69.6	26.4	3.9	0.1	13.2	62.6	23.0	1.2	95
100	30.9	50.7	16.2	2.0	0.1	70.6	25.4	3.9	0.1	13.1	63.1	22.6	1.2	100
105	31.1	51.4	15.4	2.0	0.1	71.4	24.6	3.9	0.1	12.9	63.7	22.2	1.2	105
110	31.2	52.0	14.7	2.0	0.1	72.1	23.9	3.9	0.1	12.7	64.3	21.8	1.2	110
115	31.2	52.6	14.1	2.0	0.1	72.6	23.3	3.9	0.1	12.5	64.9	21.4	1.2	115
120	31.1	53.2	13.6	2.0	0.1	73.1	22.8	3.9	0.1	12.3	65.5	21.0	1.2	120
125	31.0	53.7	13.2	2.0	0.1	73.5	22.4	3.9	0.1	12.1	66.1	20.6	1.2	125
130	30.9	54.2	12.9	2.0	0.1	73.9	22.1	3.9	0.1	11.9	66.7	20.3	1.2	130
135	30.7	54.7	12.6	1.9	0.1	74.2	21.8	3.9	0.1	11.6	67.2	19.9	1.2	135
140	30.5	55.1	12.4	1.9	0.1	74.4	21.5	3.9	0.1	11.4	67.8	19.6	1.2	140
145	30.2	55.6	12.2	1.9	0.1	74.6	21.3	3.9	0.1	11.2	68.4	19.3	1.2	145
150	30.0	56.0	12.0	1.9	0.2	74.8	21.1	3.9	0.2	11.0	68.9	18.9	1.2	150
155	29.7	56.4	11.8	1.9	0.2	75.0	20.9	3.9	0.2	10.7	69.5	18.6	1.2	155
160	29.4	56.8	11.7	1.9	0.2	75.2	20.7	3.9	0.2	10.5	70.0	18.3	1.2	160

Table 2. Assortment yield tables of spruce snag stands for the secondary crop of yield class 30

Age	Percentage of logs quality classes for respective snag classes												Age	
	1		2				3							
	III. A	III. B	V	VI	Waste	III. B	V	VI	Waste	III. B	V	VI	Waste	
40	0.9	0.4	97.2	1.5	0.0	1.5	95.3	3.1	0.0	0.5	68.7	29.5	1.3	40
45	2.2	1.6	94.8	1.5	0.0	3.8	93.0	3.2	0.0	1.1	68.5	29.0	1.3	45
50	4.0	3.7	90.7	1.5	0.0	7.4	89.4	3.2	0.0	2.0	68.0	28.7	1.3	50
55	6.2	7.9	84.2	1.7	0.0	13.0	83.6	3.4	0.0	3.5	66.9	28.3	1.3	55
60	8.6	14.2	75.4	1.8	0.0	20.5	76.0	3.5	0.0	5.3	65.4	28.0	1.3	60
65	11.0	20.3	66.7	1.9	0.0	27.8	68.5	3.7	0.0	7.0	64.0	27.7	1.3	65
70	13.4	25.8	58.8	2.0	0.1	34.4	61.8	3.8	0.1	8.5	62.9	27.4	1.3	70
75	15.5	30.4	51.9	2.1	0.1	40.1	56.0	3.9	0.1	9.6	62.0	27.1	1.3	75
80	17.5	34.1	46.1	2.2	0.1	44.9	51.1	4.0	0.1	10.5	61.4	26.7	1.3	80
85	19.2	37.2	41.2	2.3	0.1	48.9	46.9	4.1	0.1	11.2	61.0	26.4	1.3	85
90	20.7	39.7	37.1	2.3	0.1	52.3	43.5	4.1	0.1	11.8	60.8	26.1	1.3	90
95	21.9	41.8	33.8	2.4	0.1	55.1	40.6	4.2	0.1	12.1	60.8	25.8	1.3	95
100	23.0	43.5	30.9	2.4	0.1	57.4	38.2	4.2	0.1	12.4	60.8	25.5	1.3	100
105	23.9	45.0	28.6	2.5	0.1	59.4	36.2	4.3	0.1	12.6	60.9	25.2	1.3	105
110	24.6	46.3	26.6	2.5	0.1	61.1	34.5	4.3	0.1	12.7	61.1	24.9	1.3	110
115	25.2	47.3	24.9	2.5	0.1	62.6	33.0	4.3	0.1	12.8	61.4	24.6	1.3	115
120	25.6	48.3	23.5	2.5	0.1	63.8	31.8	4.3	0.1	12.8	61.7	24.3	1.3	120
125	26.0	49.2	22.3	2.5	0.1	64.8	30.7	4.4	0.1	12.8	62.0	24.0	1.3	125
130	26.2	49.9	21.2	2.5	0.1	65.8	29.7	4.4	0.1	12.7	62.3	23.7	1.3	130
135	26.4	50.6	20.3	2.5	0.1	66.6	28.9	4.4	0.1	12.7	62.7	23.4	1.3	135
140	26.5	51.3	19.6	2.5	0.1	67.2	28.2	4.4	0.1	12.6	63.1	23.1	1.3	140
145	26.6	51.9	18.9	2.5	0.1	67.9	27.6	4.4	0.1	12.5	63.4	22.8	1.3	145
150	26.6	52.4	18.3	2.5	0.1	68.4	27.1	4.4	0.1	12.4	63.8	22.6	1.2	150
155	26.6	53.0	17.8	2.5	0.1	68.9	26.6	4.4	0.1	12.2	64.2	22.3	1.2	155
160	26.5	53.5	17.4	2.5	0.1	69.3	26.1	4.4	0.1	12.1	64.6	22.0	1.2	160

Class 3 – old snag with surface decay of the stem on more than 1/10 of the butt end diameter. For fresh snags classified into class 1 the greatest shift of quality classes of logs was recorded from class I–III A into class III B, for older snags classified into class 2 from quality class I–III A into quality class III B as well as almost equally into quality class V and VI. For older snags classified into class 3 the shift occurs in whole classes I–III A and partially of quality class III B into quality class V and VI. Based on these facts PETRÁŠ et al. (1995) derived the models for the adjustment of assortment structure from dead trees.

By means of the models for timber value production in damaged stands before their dieback PETRÁŠ (2002) and the models for the adjustment of assortment structure from dead trees PETRÁŠ et al. (1995) assortment yield tables for snag spruce stands were derived. These tables represent only a theoretical possibility that all trees in the stand would dry simultaneously at a particular age. They are classified according to classes of snags 1, 2 and 3, age of stands 40–160 years and yield class of the stand 14–42. Assortment yield tables of snag stands give the percentage of quality classes III A–VI. The proportions of quality classes I–II equal zero for all yield classes. A summary from these tables for yield class 30 is presented in Table 1 for the main stand and in Table 2 for a secondary crop.

Based on assortment yield tables for snag stands of class 2 we derived value yield tables for snag stands that give the value of net financial yield of damaged stands immediately after their dieback. These yield tables also contain the data on total mean increment and total current increment in net financial yield. Increment indexes were calculated as the quotient of total mean increment of damaged stand after dieback and total mean increment of undamaged stand. The index for total mean increment is as follows:

$$I_{CPP} = \frac{CPP_{ps}}{CPP_n} \quad (2)$$

where:  $I_{CPP}$  – increment index of total mean increment,  
 $CPP_{ps}$ ,  $CPP_n$  – total mean increment of damaged stand after dieback ( $ps$ ) and of undamaged stand ( $n$ ).

Increment indexes for total current increment  $I_{CBP}$  were also calculated according to formula (2) using the value of total current increment. These increment indexes are a very good measure to express relative increment changes for damaged stands after their dieback in comparison with living and undamaged stands. Their hundredfold value gives these changes in per cent. A complement to 100% gives relative reduction of net financial yield of these stands in comparison with living and healthy stands.

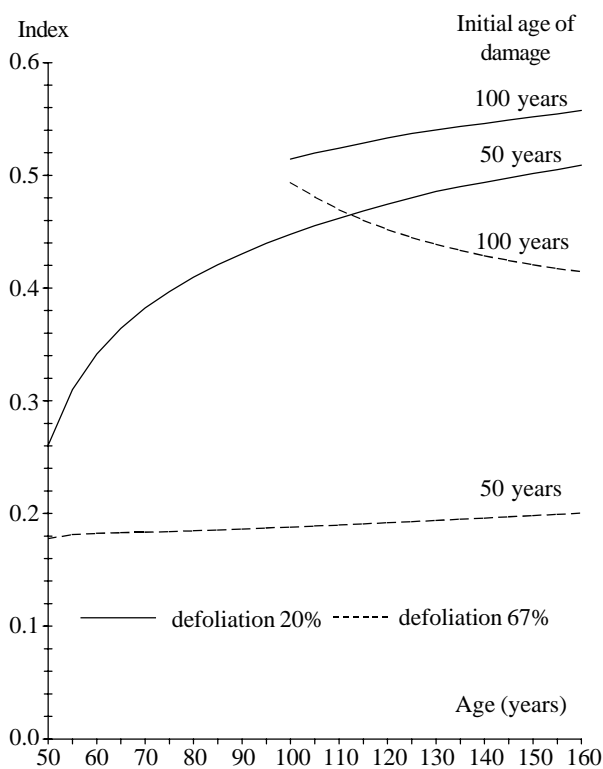


Fig. 1. Development of the indexes of total mean increment from the net yield of snag spruce stands with yield class 40 and 20% and 67% crown defoliation

## RESULTS AND DISCUSSION

To derive and assess required results we calculated increment indexes for damaged spruce stands with mean defoliation 20% and 67%, according to PETRÁŠ and HALAJ (1993) corresponding to the lowest degrees of damage 0 + 1 and the highest degrees of damage 3 + 4. We calculated them according to formula (2). The initial age of stands when damage started was 50 or 100 years. Damage by constant defoliation 20% or 67% lasted until the chosen age, when all trees suddenly died. After the dieback the 3<sup>rd</sup> class of snags is considered.

Graphs that were plotted from calculated indexes illustrate these results. The development of the indexes of total mean increment in dependence on the age for spruce stand of yield class 40, with damage beginning at the age of 50 or 100 years, is illustrated in Fig. 1. For defoliation 20% the index increases with higher age in a non-linear form. With the initial age of damage 50 years in the interval 0.26–0.51 and the initial age of damage 100 years the indexes are higher only by 0.05–0.06. For defoliation 67% the indexes of total mean increment have significantly lower values. With the initial age of damage 50 years they slightly increase with higher age in a liner form in the interval 0.18–0.20. For the initial age of damage 100 years they decrease with higher age in the interval 0.49–0.41.

The development of some indexes of total current increment for yield class 40 in dependence on age is presented in Fig. 2. For defoliation 20% the indexes of total current increment increase with higher age, particularly for the initial age of damage 50 years in the interval 0.45–0.66. For the initial age of damage 100 years the indexes are higher maximally by 0.02. For defoliation 67% the indexes of total current increment have significantly lower values. For the initial age of damage 50 years they slightly increase with higher age within the range 0.18–0.25. For the initial age of damage 100 years the indexes are higher by about only 0.05.

Summarizing the comparison of increment changes expressed by increment indexes from value production of damaged and dead spruce stands we can state that they depend differently on the basic stand characteristics and following factors:

- Degree of stand damage expressed by crown defoliation,
- Age of stand when the damage started and damage duration,
- Yield class of stand.

The importance of these factors changes and largely depends on the respective increment. In general, we can state that both indexes are influenced to the largest extent by crown defoliation, followed by the age of stand when damage started, duration of damage and yield class of the stand. The effect of these factors is more significant for total mean increment than for total current increment.

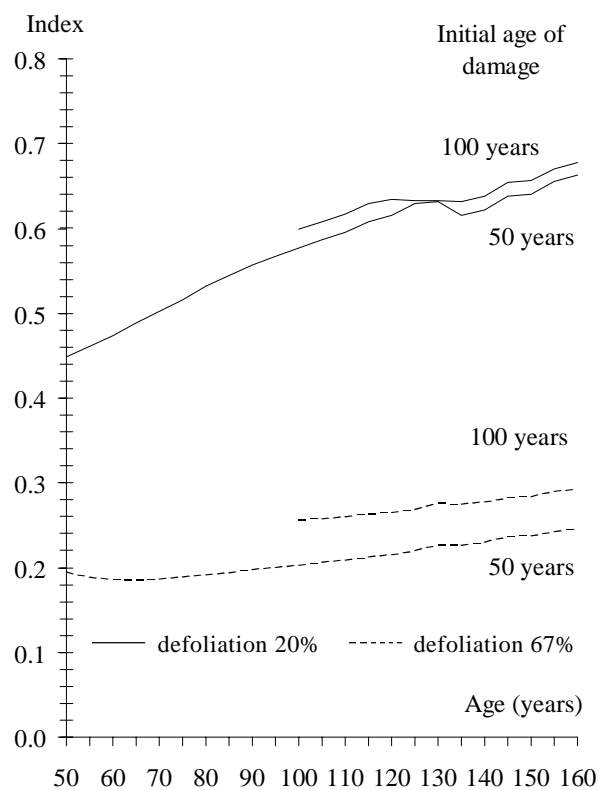


Fig. 2. Development of the indexes of total current increment from the net yield of snag spruce stands with yield class 40 and 20% and 67% crown defoliation

To evaluate the importance of increment reduction assessment from value production of damaged and dead stands in a more complex way we also made a comparison with similar indicators of volume production as presented by PETRÁŠ and MECKO (2001) and value production as presented by PETRÁŠ (2002). Fig. 3 illustrates such a comparison by means of the indexes of total mean increment for yield class 30, which is approximately an average yield class of spruce stands in Slovakia with defoliation 20% and 67% and initial age of damage 50 years. Fig. 3 shows that increment indexes for volume increment have the highest values. For 20% defoliation these values decrease with higher age in the interval 0.97–0.87. The indexes of value increment have almost the same constant value 0.84 in the whole age range, which is less by about 0.03–0.11 than for volume production. Unanimously, the indexes of total mean increment from value production of snag stands have the lowest value. They increase with higher age of stands, within the range 0.0–0.42. Thus only for the highest values it is only a half value of earlier mentioned indexes. For 67% defoliation the increment indexes have the same trend with higher age as for 20% defoliation. The values of these indexes are markedly lower. At the same time there are larger differences between the indexes of total mean increment from volume and value production as well as production of snag stands. Although the largest differences between these indexes were determined for the lowest age, they are relatively

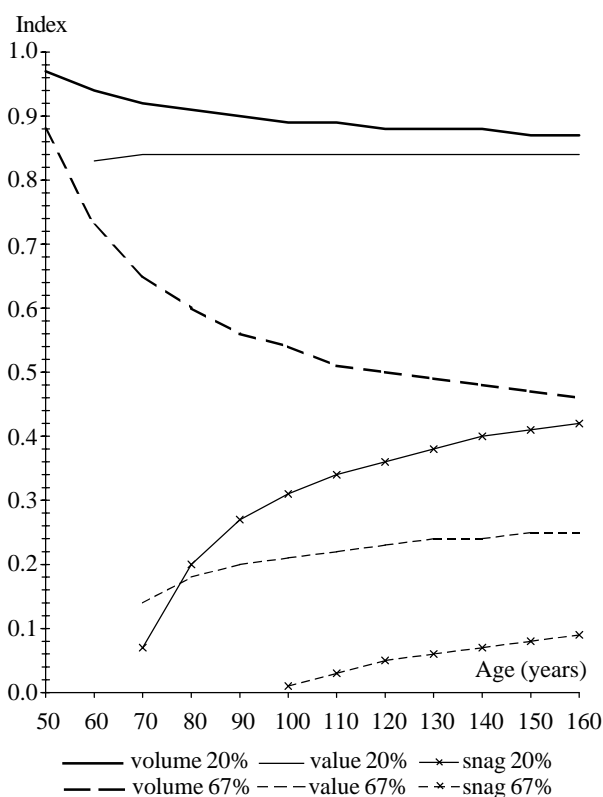


Fig. 3. Comparison of the indexes of total mean increment from volume and value production of damaged and snag stands with yield class 30 and 20%, 67% defoliation respectively

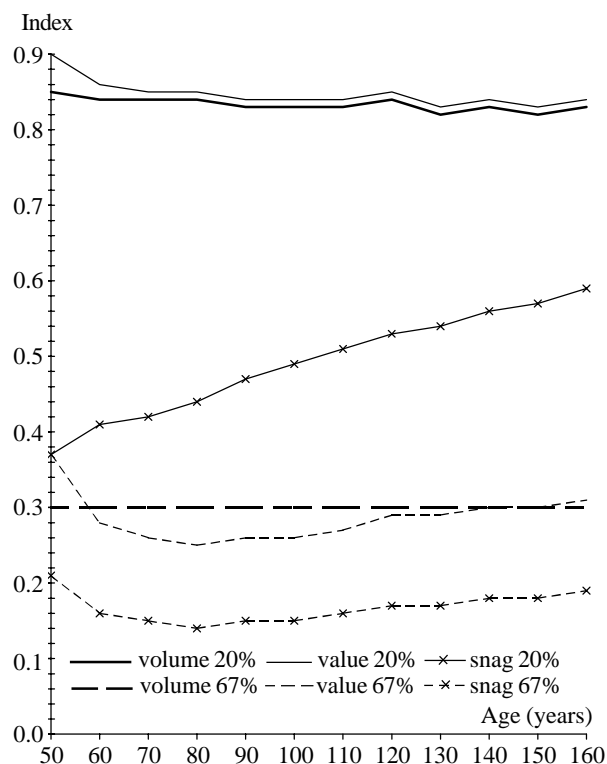


Fig. 4. Comparison of the indexes of total current increment from volume and value production of damaged and snag stands with yield class 30 and 20%, 67% defoliation respectively

high also at the highest age of 160 years. The indexes of total mean increment from volume and value production of damaged and snag stands have the values 0.46, 0.25 and 0.09.

Fig. 4 illustrates the indexes of total current increment for the same input parameters as for total mean increment. The value index of total current increment has the highest value that slightly decreases with higher age within the range of 0.90–0.84. The volume index has the values lower by 0.01 only in comparison with the value index. The trend and the value of the index of total current increment for snag stands are totally different. Its values increase with higher age in a linear form. At the beginning of damage the value is 0.37 and at the age 160 years 0.59. The indexes of total current increment for the stands with 67% defoliation have obviously substantially lower values. For volume production it is a constant value 0.30 and for value production it is almost the same value. The indexes of total current increment for snag stands are almost parallel to the indexes of total current increment from value production. They are lower by about 0.10. By comparing the trend of the indexes of total current increments and total mean increments we can state that the indexes of total current increments from volume production and value production have very similar values for 20% defoliation and 67% defoliation. The indexes of total current increments for snag stands have much more lower values.

Based on this analysis we drew some conclusions that are very important for practice. They are as follows:

- In the quantification and evaluation of direct increment reduction of timber production for damaged stands it is necessary to investigate also its value production in financial units in addition to timber volume.
- In dependence on the degree of damage the value production of damaged stand is lower by about 5–50% and by 1–5% only than volume production for total mean increment and total current increment, respectively.
- The value production of damaged and dead trees, so called snags, is even lower. The value of stand production after dieback is lower at least by a half than before dieback.
- From the methodological as well as practical point of view the application of production and increment reduction requires to recognize principal differences between total mean increment and total current increment.

### CONCLUSION

A method for the derivation of value production of damaged spruce stands after their dieback is described. Their value production is expressed by net financial yield from timber production by means of total mean increment and total current increment. To evaluate increment changes in more general terms we calculated their increment indexes from the investigated increments as the quotient of the increments of damaged and undamaged stands. A complement to the value 1.0 represents a relative financial loss of net yield from produced timber in such stand. Based on the presented analysis we can state that the value production of damaged stands and dead stands depends mainly on the degree of stand damage given by crown defoliation, age of stand, yield class of stand as

well as the age of stand, when damage started including the duration of damage. The value of damaged stands after their dieback is lower minimally by a half than before the dieback. It is caused only by the impaired quality of timber after the dieback of trees in the stand.

### References

- PETRÁŠ R., NOCIAR V., 1991. Sortimentáčn  tabuľky hlavn ch drev n. Bratislava, Veda: 304.
- PETRÁŠ R., 1992. Mathematisches Modell der Sortiments-tafeln f r Hauptbaumarten. Lesn.  as., 38: 323–332.
- PETRÁŠ R., HALAJ J., 1993. Pr rastky imisne poškoden ch smrekov ch porastov. Lesn.  as. – Forestry Journal, 39: 553–558.
- PETRÁŠ R., NOCIAR V., PAJT K J., 1993. Changes in increment of spruce damaged by air pollution. Lesnictv , 39: 116–122.
- PETRÁŠ R., MECKO J., NOCIAR V., 1995. Reduk n  koeficienty pre sortiment ciu smrekov ch such rov. Lesn.  as. – Forestry Journal, 41: 219–229.
- PETRÁŠ R., MECKO J., NOCIAR V., 1999. Pr rastky z sob drev  poškoden ch borovicov ch porastov. Lesn.  as. – Forestry Journal, 45: 205–216.
- PETRÁŠ R., MECKO J., 2001. Model of volume production of damaged spruce stands. J. For. Sci., 47: 158–163.
- PETRÁŠ R., 2002. Value production of damaged spruce stands. Ekol gia (Bratislava) (submitted).
- PETR SOV  V., MECKO J., PETR Š R., 2001. Prices of spruce timber and costs of spruce timber logging. J. For. Sci., 47: 322–330.
- PRIESOL A., 1989. Produkcia smrekov ch porastov poškodenov ch imisiami. Lesnictv , 35: 899–910.

Received 31 December 2001

## Straty na hodnote dreva poškodzovan ch smrekov ch porastov po ich odumret 

R. PETR Š

*Lesn cky v skumn   stav, Zvolen, Slovensk  republika*

**ABSTRAKT:** Pr ca prezentuje postup odvodenia celkovej produkcie dreva a jej pr rastkov v hodnotov ch jednotk ch, tj.  istom finan nom v nose pre smrekov  porasty poškoden  defoli ciou kor n po ich odumret . Hodnotov  produkcia sa odvodila pomocou hodnotov ch rastov ch modelov nepoškoden ch porastov a modelov na korekciu objemovej a kvalitat vnej produkcie poškoden ch a odumret ch porastov. V tabuľk ch a na obr zkoch s  prezentovan  zmeny v kvalite dreva po uschnut  stromov a produk n  zmeny poškoden ch porastov vo i nepoškoden m. Zmeny s  vyjadren  prostredn ctvom indexov celkov ho priemern ho pr rastku a celkov ho be n ho pr rastku. Tie z visia hlavne od stupňa poškodenia porastu vyjadren ho defoli ciou kor n, veku a bonity porastu, v ktorom poškodenie za alo, a od doby jeho trvania. Hodnota poškodzovan ch porastov je po ich odumret  minim lne o polovicu menšia ako pred odumret m. Je to sp soben  hlavne zhoršenou kvalitou dreva po odumret  stromov v poraste.

**Kl  ov  slov :** smrek; celkov  hodnotov  produkcia; pr rastky

Cieľom práce je popísať metodiku odvodenia modelov a podľa nich aj kvantifikovať straty na hodnotovej produkcii dreva smrekových porastov od začiatku ich poškodzovania až po ich odumretie, pri ktorom dochádza najmä k výraznému zhoršeniu kvality dreva.

Hodnota dreva poškodzovaných smrekových porastov po ich odumretí sa odvodila z modelov hodnotovej produkcie poškodzovaných porastov pred ich odumretím a modelov na korekciu štruktúry sortimentov z odumretých stromov, ako ich uvádza PETRÁŠ et al. (1995). Modely hodnotovej produkcie poškodzovaných porastov pred ich odumretím podrobne zdôvodnil PETRÁŠ (2002) a vychádzal pritom z parciálnych modelov:

- celkovej objemovej produkcie (PETRÁŠ, MECKO 2001),
- vývoja stredných hrúbok (PETRÁŠ et al. 1993),
- vývoja objemu stredného kmeňa (PETRÁŠ et al. 1993),
- porastových sortimentačných tabuliek (PETRÁŠ, NOCIAR 1991),
- priemerných cien sortimentov dreva (PETRÁŠOVÁ et al. 2001),
- vlastných nákladov ťažbovej činnosti (PETRÁŠOVÁ et al. 2001).

Hodnotovú produkciu poškodených porastov odvodil z týchto parciálnych modelov tak, že objemovú produkciu prepočítal prostredníctvom sortimentačných modelov na produkciu sortimentov a túto prostredníctvom cien dreva na hrubý finančný výnos. Od tohto odpočítal modelové vlastné náklady na ťažbu dreva a dostal čistý finančný výnos. Vzhľadom na to, že poškodené porasty majú nižšiu objemovú produkciu a menšie hrúbky stromov, majú potom aj menšiu hodnotovú produkciu ako nepoškodené porasty.

Hlavným faktorom, ktorý hodnotovú produkciu ovplyvňuje, je popri objeme najmä kvalita produkovaného dreva, ktorá sa hodnotila podľa štruktúry sortimentov. Podľa modelov sortimentačných tabuliek (PETRÁŠ et al. 1992) podiel sortimentov v smrekových porastoch závisí od ich strednej hrúbky, vonkajšej kvality a mechanického poškodenia kmeňov.

Tento základný vzťah platí pre poškodené, ale žijúce stromy až do okamihu ich odumretia. Po odumretí stromov sa ich situácia výrazne mení. Ich drevo postupne nahníva, čím významne mení svoju kvalitu. Z tohto dôvodu sa mení aj skladba sortimentov z takýchto stromov a porastov. Túto otázku na relatívne veľkom empirickom materiáli stromových vzorníkov podrobne preskúmali PETRÁŠ et al. (1995) a zistili, že odumreté stromy – tzv. sucháre – majú oproti živým stromom nulové podiely najcennejších akostných tried výrezov I a II a výrazne nižšie podiely kvalitnejších piliarskych výrezov triedy III A. Naproti tomu majú výrazne vyššie podiely menej kvalitných piliarskych výrezov triedy III B, vlákninového dreva triedy V, palivového dreva triedy VI a odpadu. Podľa intenzity poškodenia beľovej časti dreva jej sfarbením a hnilobou zatriedovali odumreté stromy do troch tried s touto charakteristikou:

Trieda 1 – čerstvý suchár, strom v krátkom čase po odumretí prevažne ešte v kôre, bez väčších povrchových

trhlín. Má len veľmi slabé poškodenie beľi, a to len jej sfarbením najviac do 1/10 hrúbky čela. Kmeň ešte nemá žiadnu hnilobu beľi.

Trieda 2 – starší suchár, kmeň je prevažne už bez kôry, s veľkými povrchovými výsušnými trhlinami. Keď je v kôre, tak má výrazné zaparenie dreva. Na priečnom reze kmeňa má sfarbenie beľi väčšie ako 1/10 čela, ale povrchová hniloba beľi siaha najviac do 1/10 hrúbky čela.

Trieda 3 – starý suchár s povrchovou hnilobou kmeňa na viac ako 1/10 hrúbky čela.

Pomocou modelov hodnotovej produkcie dreva poškodzovaných porastov pred ich odumretím (PETRÁŠ 2002) a modelov na korekciu štruktúry sortimentov z odumretých stromov (PETRÁŠ et al. 1995) sa odvodili sortimentačné rastové tabuľky suchárových smrekových porastov. Tieto tabuľky predstavujú len teoretickú možnosť, že všetky stromy v poraste by v konkrétnom veku naraz uschli. Sú členené podľa tried suchárov 1, 2 a 3, veku porastov 40–160 rokov a bonity porastu 14–42. Sortimentačné rastové tabuľky suchárových porastov obsahujú percentuálne podiely akostných tried výrezov III A–VI. Podiely akostných tried výrezov I–II sú pri všetkých bonitách nulové.

Zo sortimentačných rastových tabuliek suchárových porastov s triedou suchárov 2 sa odvodili hodnotové rastové tabuľky suchárových porastov, ktoré udávajú hodnotu čistého finančného výnosu poškodených porastov ihneď po ich odumretí. Tieto rastové tabuľky obsahujú aj údaje celkového priemerného prírastku (CPP) a celkového bežného prírastku (CBP) v čistom finančnom výnose. Ich podielom s hodnotami živých a nepoškodených porastov sa vypočítali prírastkové indexy.

Pre odvodenie a zhodnotenie požadovaných výsledkov sa vypočítali podľa vzorca (2) prírastkové indexy pre poškodené smrekové porasty s priemernou defoliáciou 20 % a 67 %, ktoré odpovedajú podľa PETRÁŠA a HALAJA (1993) najslabším stupňom poškodenia stromov 0 + 1 a najsilnejším stupňom poškodenia stromov 3 + 4. Počiatkový vek poškodenia porastov je od 50 alebo 100 rokov. Poškodenie konštantnou defoliáciou 20 % alebo 67 % trvá až po zvolený vek, v ktorom všetky stromy náhle odumrú. Po odumretí sa uvažuje s 3. triedou suchárov.

Vývoj indexov celkového priemerného prírastku ( $I_{CPP}$ ) v závislosti od veku pre smrekový porast bonity 40, ktorý je poškodzovaný od 50 alebo 100 rokov, je znázornený na obr. 1. Na obr. 2 je vidieť vývoj vybraných indexov celkového bežného prírastku ( $I_{CBP}$ ) pre bonitu porastu 40 v závislosti od jeho veku. Po súhrnnom porovnaní prírastkových zmien vyjadrených prostredníctvom prírastkových indexov z hodnotovej produkcie poškodených a odumretých smrekových porastov môžeme konštatovať, že tieto rôznou mierou závisia od hlavných porastových veličín a faktorov, ako sú:

- stupeň poškodenia porastu vyjadrený defoliáciou korún stromov,
- vek porastu, v ktorom poškodenie začalo, a doba jeho trvania,
- bonita porastu.

Významnosť týchto faktorov sa mení a veľmi závisí aj od toho, na ktorý prírastok sa vzťahuje. Po väčšom zovšeobecnení môžeme konštatovať, že obidva indexy najviac ovplyvňuje defoliácia korún stromov, potom nasleduje vek porastu, pri ktorom poškodenie začalo, a doba jeho poškodzovania a nakoniec je to bonita porastu. Pri celkovom priemernom prírastku je vplyv týchto faktorov významnejší ako pri celkovom bežnom prírastku.

Z predchádzajúceho rozboru sa odvodili niektoré dôležité poznatky, ktoré majú aj značný praktický význam. Sú nasledujúce:

- Pri kvantifikácii a ohodnocovaní priamych prírastkových strát na produkcii dreva poškodzovaných porastov je potrebné popri objeme dreva skúmať najmä jeho hodnotovú produkciu vo finančných jednotkách.

- Hodnotová produkcia poškodeného porastu je aj v závislosti od jeho stupňa poškodenia pri celkovom priemernom prírastku približne o 5–50 % a pri celkovom bežnom prírastku len o 1–5 % nižšia ako objemová produkcia.
- Ešte podstatne nižšia je hodnotová produkcia poškodených a odumretých (tzv. suchárových) porastov. Hodnota produkcie porastu po odumretí je minimálne o polovicu menšia ako pred odumretím.
- Pri aplikácii produkčných a prírastkových strát je potrebné z metodologického, ale aj praktického hľadiska uznávať principiálne rozdiely medzi celkovým priemerným a celkovým bežným prírastkom.

---

*Corresponding author:*

Doc. Ing. RUDOLF PETRÁŠ, CSc., Lesnícky výskumný ústav, T. G. Masaryka 22, 960 92 Zvolen, Slovenská republika  
tel.: + 421 45 531 41 25, fax: + 421 45 531 41 92, e-mail: petras@fris.sk

---