Outbreaks of Pine Defoliating Insects and Radial Growth

Artūras GEDMINAS
Lithuanian Forest Research Institute, Liepu 1, Girionys, LT-4312 Kaunas reg., LITHUANIA

Abstract. Analysis of radial increments of pines in southern Lithuania suggest that outbreaks of needle-eating pests became more frequent during periods of reduced radial increment of pine trees (every 12-15 years). Reductions in radial increment included: 1.05% of volume increment, (i.e. 3.28 m³/ha) due to damage by *Diprion pini* L., for 3 years; - 3.46% (10.8 m³/ha) due to *Lymantria monacha* L. over 5 years;; - 2.58% (8.05 m³/ha) over 5 years due to *Dendrolimus pini* L.; and - 2.11%, (6.58 m³/ha) due to damage by *Panolis flammea* Schiff..

I. Introduction

It is said, that a severe damage of needles is expressed by a 6-fold loss of mean annual increment, and normal functioning of trees can start again only after 10 years. The studies of other authors in III-IV age class pine stands show, that they can withstand a complete loss of needles caused by pine noctuid only once, while 60% loss of needles fails to worsen the state of pine stands [11]. 100% damage of needles means the loss of six mean annual increments [10].

In 1957, under mass outbreak of *Acantholyda posticalis* Mats. in 60-80-year-old pine stands in the Vitebsk region, the increment of pines decreased 2.5-3.5 times and did not fully recover in ten years [6]. Due to the loss of needles, top branches of trees begin to die, which lead to the reduction in stand height [5].

Until recently, not much attention was paid to stand losses caused by pests and to their economic evaluation. Prof. Vorontsov [4] tried to tackle the problem on a wider scale.
Some authors state that diversity in the assessment of losses is independent of the species of insects [9]. It was found that levels of defoliation of up to 80% caused by *Diprion pini* L., *Lymantria monacha* L., *Dendrolimus pini* L., *Panolis flammea* Schiff. or other needle-eating pests, reduce diameter increment of that year by 12-30%, that of the next year by 40-60%, and that of the subsequent year by 30-60%., i.e. by 80-150% calculating from mean annual increment.

A complete loss of needles only once reduces increment in the current and two subsequent years by 60%, 60-100% and 40-80%, or cumunatively by 160-240%. On average, diameter increment recovers only after 6-8 years, but not in all trees [9].

In general, data in the literature differ even when the influence of only one species of insects is described, and especially in cases of low or average defoliation. Some authors think that 10-30% defoliation has no major impact on the stand, while others state that 10-15% loss of needles requires a recovery period of two years. In most cases this is the consequence of different calculation methods. According to the scientists from Ukraine, pine trees with defoliation levels up to 25% over all years of their weakened condition lose 0.5, 25-50% - 3, 50-75% - 4, 75-100% - 6 mean annual increments [10].

In practice, very often calculations of losses are based on elimination of other factors, comparing the increment of damaged or control stands [8], or comparing the increment of the same stand in the year of damage and in following years [3,7,12].

Estimation of increment losses is necessary to ascertain the usefulness of counteracting measures. According to the data of V.N.Trofimov and O.V.Trofimova, counteracting measures should be applied under greater than 60% loss of needles [11].

This work was aimed to ascertain the peculiarities of changes in pine radial increment over a 30-year period (1972-2002) as well as to estimate the losses of radial increment in pine stands of southern Lithuania, suffering from permanent outbreaks of needle-eating insects.

II. Methods

The work was carried out in 2002 in the pine stands of southern Lithuania (in forest enterprises of Druskininkai, Veisiejai and in Dzūkija National Park). Based on the data collected by the Station of Forest Sanitary Protection [1] on damage in Lithuanian stands over 30 years, we have chosen needle-eating pests which dominated in this period: *Diprion pini* L.; *Lymantria monacha* L.; *Dendrolimus pini* L.; and *Panolis flammea* Schiff.

In various damaged pine stands, 13 plots with differing tree damage characteristics were selected. Pine trees in one plot (plot 1) over the studied period were damaged 4 times, in another (plot 2) – 3 times, in six (plots 3-7 and 15) – twice, and in five remaining plots (8, 12, 17-19), only once. Diverse combinations of damage were chosen: by one of all the mentioned needle-eating pest species; repeated damage by the same species; damage by different species, etc. Control plots (9, 11, 13, 14, 16) were selected in pine stands where over the last 30 years no damage was registered. All chosen pine stands were of similar age (on average 85 years), and site type -Na.

In each plot 20 pine trees were randomly selected and in October 2002, one core sample was taken from them with Presler's borer in a NS direction at 1.3 m height from the ground. All in all, 340 samples were taken. Analysis of the samples was conducted in the laboratory of the Lithuanian Forest Research Institute.

III. Results and discussion

Latvian dendrochronologist E. Špalte [13] has ascertained that the greatest influence on pine radial increment (in Latvia) is mean air temperature in April and precipitation in July. We have also compared the dynamics of pine radial increment with the changes in air temperature and precipitation in April-August over 30 years (1972-2002). However, we did not find correlations between these factors and pine radial increment. There was a difference of several years in the period of pine radial increment fluctuation, which in Latvia reiterates every 12 years. Reductions in the radial increment of Lithuanian pines were observed in 1979 and 1994 (15-year period).

Seeking to eliminate the influence of climatic factors, radial increment of damaged pines was compared with the radial increment of pines in control plots.The obtained results revealed the main periods of pest outbreaks, which in most cases corresponded to the periods recorded by the Station of Forest Protection. In the dynamics of 30-year increments, 4 main periods of increment reduction due to needle-eating pests may be singled out: 1972-1976; 1978-1982; 1993-1998; and 2000-2002.

For the sake of convenience, radial annual increments were recalculated as a percentage from the total increment over the last 30 years. In this way we could calculate how much increment was lost by pines over a certain growth period.

Analysing radial increment of pines in the studied plots, a specific growth history of each stand was revealed. Plots best revealing increment losses will be mentioned. One of them is plot 1. It was specially chosen to observe the whole spectrum of pest damage on pine trees, and to find out the duration of the recovery of pine increment after mass losses of needles. The data obtained reliably differed from the data in control plots (Table 1).

Table 1. Comparison of the radial increment (1972-2002) of pine trees damaged and undamaged by needle eating pests.

Insect pest	*First year of the invasion*	*Code of the plot*	*Radial increment of the pine trees*		t*
			in outbreak	*in control*	
			M(%) ±m	M(%) ±m	
Panolis flammea	1980	12	3,58±0,10	3,91±0,13	1,89
		2	3,61±0,06	3,85±0,06	2,82
	2001	1	1,65±0,28	2,24±0,42	1,16
		3	1,35±0,37	2,24±0,42	1,57
Dendrolimus pini	1995	8	2,14±0,20	2,92±0,22	2,52
		1	2,35±0,23	3,23±0,14	3,24
		2	2,74±0,19	3,09±0,17	1,35
		3	2,27±0,13	2,92±0,22	2,45
		7	2,67±0,16	2,99±0,26	1,05
Lymantria monacha	1979	15	2,74±0,49	3,62±0,30	1,50
	1994	17	2,50±0,26	3,11±0,23	1,72
		18	2,83±0,34	2,87±0,29	0,16
		19	2,31±0,25	2,90±0,24	1,66
Diprion pini	1987	1	3,48±0,04	3,98±0,01	10,35
	1992	5	1,84±0,07	2,14±0,19	1,42
	1997	5	2,46±0,04	3,31±0,23	3,61

t* - 1,725 = 0,90

With respect to the influence of different pests on pine radial increment and increment recovery periods, we found, that:

- radial increment recovery of pines damaged by *Panolis flammea* (outbreaks in 1980 and 2000) lasted 6-7 years;
- *Diprion pini* (outbreaks in 1987, 1992, 1997) – 2-3 years;
- *Dendrolimus pini* (outbreak in 1995) – 4-5 years;
- and *Lymantria monacha* (outbreaks in 1979, 1994) – 4-5 years.

Recovery periods of pines is directly dependent on the size of crown damaged and the level of damage. If needle losses comprise 100%, of the foliage, then the increment recovery period is longer. If not only needles, but also shoots and buds are damaged, then the increment regeneration period is prolonged. In contrast, if only old needles are damaged, and the loss of needles in the crown is less than 80%, then this period becomes shorter.

The curves of radial increment dynamics of the studied pines show that pest outbreaks are periodically repeated. The outbreaks of needle-eating pests become more intensive during the periods of radial increment reduction (i.e. every 12-15 years). Each of the studied pest species has its own characteristic period of population increase. Our studies confirm the following:

- *Panolis flammea* outbreaks in our forests reiterate every 18-20 years;
- *Diprion pini* – every 6 years;
- *Dendrolimus pini* invasion in 1995 was the only one, therefore their reiteration period is not clear;
- *Lymantria monacha* – every 8 years.

However, we have noticed, that, if the period of population augmentation fails to coincide with the period of radial increment reduction, then pest invasions are insignificant or absent. For instance, damage by *Lymantria monacha* was not registered in the pine stands of southern Lithuania in 1986-1987.

The period of damage by *Diprion pini* is rather short (2 years) and does not damage generative organs. Therefore increment loss attributable to this insect does not last long. The most significant influence on pine radial increment reduction is attributable todamage by *Dendrolimus pini, Lymantria monacha* and *Panolis flammea*. In the dynamics of increment reduction, a gradual increment reduction in the first 3 years, followed by a 2-4-year long increase in increment up to the previous (predamage) level can be observed.

Carrying out increment studies in the places of pest outbreaks it was observed that rather frequently increment

Table 2. Losing of the pine trees radial increment an wood damaged by different pests*

No.	*Pest*	*The period of the decline and set up increment, years*	*Average losing*	
			% *increment*	m^3/ha *wood*
1	*Diprion pini*	3	1.05	3.28
2	*Panolis falmmea*	6	2.11	6.58
3	*Dendrolimus pini*	5	2.58	8.05
4	*Lymantria monacha*	5	3.46	10.8

** - pine stand: habitat – Na; average age – 85 y.; high (H) – 18 m; average diameter ($D_{1.3}$ – 24 cm; class of high – IV; site index – III; stand stoching – 0.7; growin stock - 312 m^3/ha.*

reduction in the course of several years is followed by increment augmentation, sometimes even exceeding the increment of control pines. On average damaged stands experienced 1.16% more radial increment than trees in control stands following each type of insect damage.

Due to needle damage the greatest increment losses were found in plot 1, where total increment loss was 5.13%. In this plot pines were damaged by needle-eating pests on four different occasions. Pines in plot 2 suffered from invasions of three different pests, and lost 3.67% of radial increment compared to controls. Two invasions were recorded in plots 3 and 15.

It was ascertained that different needle-eating pests have characteristic ways and types of damage. All this influences radial increment of pines. Table 2 shows, that the greatest increment losses are in pines damaged by *Lymantria monacha* – 3.46% over 5 years of increment loss.

Radial increment reduction of pines damaged by *Diprion pini* outbreaks are short (3 years), and therefore reductions in radial increment resulting from defoliation by this pest is less than that by other pests. However, outbreaks by this pest reoccur every 6 years. Over the 30-year period of this study 4 outbreaks of this pest were registered.

It might seem that increment reductions and therefore timber losses per ha are quite small, however, the losses calculated on 10 or 20 thousands of hectares of stands would comprise millions of litas. Besides, these losses do not include trees that died due to severe defoliation, as well as many other factors.

Summary

The analysis of the radial increment of pines in south Lithuania ascertained that the invasions of needle eating insects made frequently in the period of radial increment decrease (over the 12-15 years). The spans 3 year to detriment of *Diprion pini* while pines lose on average 1.05% of volume increment i.e. 3.28 m^3/ha; in the case of the detriment of *Lymantria monacha* within 5 years 3.46%, 10.8 m^3/ha; in case of *Dendrolimus pini* within 5 years 2.58%, 8.05 m^3/ha; *Panolis flammea* 2.11%, 6.58 m^3/ha respectively.

References

[1] *Miško apsaugos stoties metinė ataskaita*. Kaunas-Girionys, 1972-2002.
[2] *Miško taksuotojo žinynas*. Vilnius, p. 168, 1983.
[3] В.М. Березина. *Влияние на рост сосны химического метода борьбы с жуками майского хруща*. – Лесной журнал, №, 1960
[4] А.И. Воронцов. *Патология леса*. М., С. 266, 1978.
[5] Н.Г. Коломиец. *Звездчатый пилильщик – ткач*. Новосибирск, С.134, 1967.
[6] Л.П. Малый. *Биологические и экологические особенности звездчатого пилильщика – ткача (Acantholyda stellata Christ.), в Белорусии и меры борьбы с ним*. Гомель, С. 21, 1972.
[7] Е.Г. Мозолевская, И.П. Тудор. *Влияние дубовой хохлатки на состояние и прирост насаждений*. Вопросы защиты леса, вып. 15, 1967.
[8] И.Т. Покозий. *Влияние повреждений кравчика на рост дуба*. Ученые записки Харьковского сельскохозяйственного института, т. 13, 1957.
[9] Ф.Н. Семевский. *Прогноз в защите леса*. М.: Лесн. Пром-сть, т. 69, 1971.
[10] *Справочник по защите леса от вредителей и болезней*. (Т.А. Тимченко, И.Д. Авраменко, Н.М. Завада и др.) – К.: Урожай, С. 244, 1988.
[11] В.Н. Трофимов, О.В. Трофимова. *Влияние степени обьедания на прирост насаждений, поврежденных сосновой совкой*. "Экология и защита леса". Межвузовский сборник научных трудов. Л. с. 70-74, 1987.
[12] И.Я. Турчинская. *Влияние обьедания листьев непарным шелкопрядом и другими листогрызущими вредителями на рост дуба*. –Зоологический журнал, т. 42, 1963.
[13] Э. П. Шпалте. *Влияние метеорологических факторов на радиальный прирост сосны в Латвийской ССР*. Лесоведение. №3. М., с.11-18, 1978.