# Health Condition and Dendrochronological Study of the Lime Trees in Kaunas City

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The investigation was carried out on 680 lime trees at Laisves alley in the city of Kaunas. Four species of lime trees (*Tilia platyphylla* Scop.; *T. euchlora* K. Koch.; *T. europaea* L.; *T. cordata* Mill.) were studied. Crown defoliation and dechromation, state of treetops, amount of dry branches, fruiting were evaluated. Dendrochronological investigation of different species of the sampled lime trees was carried out. The relationship between crown defoliation degree and the radial increment dynamics of lime-trees was determined. In accordance with the results of the investigation, *Tilia cordata* Mill. has the highest (33.4±2.1%), *Tilia platyphylla* Scop - the lowest (28.0±1.2%) crown defoliation.

The values of the annual radial increment of *Tilia europaea* L. are lowest and these of *Tilia platyphylla* Scop. are highest. According to all monitoring parameters *Tilia platyphylla* Scop. trees are of the best ecological state and *Tilia cordata* Mill. - of the worst ecological state.

**Key words:** health condition, urban lime trees, dendrochronology.

## Introduction

Forests near or in a city are strongly connected with the development of the urban settlement. Urban trees are influenced by a wide range of environmental factors and are in danger of being destroyed by the human impact of air pollution (von Lührte, 1992). Street-trees in areas of local environmental pollution are influenced also by atmospheric pollution. That is why they become soon injured and damaged. Therefore, the dendroecological monitoring of urban forests and forest parks becomes more and more essential.

Deciduous trees are more resistant to pollution impact than conifers; therefore, they are more suitable for planting along streets and are more common in urban areas than conifers. The ecological status of urban deciduous trees is less investigated, because conifers are found to be better indicators for assessment of the state of the environment (Stravinskiene, 1997a, 1997b). Deciduous species, especially from the areas of intensive local pollution, can serve as perfect indicators of changes in the environmental state, although they are less injured by environmental pollution than conifers. Worse state of deciduous trees can be a serious signal of pollution or the effect of negative climatic factors.

Assessment of dendrochronological methods for monitoring of urban trees is very important for estimating the ecological state of trees affected by natural and anthropogenic factors. Dendrochronological analysis provides information on retrospective and actual situation of trees and allows us to compare them. Tree-rings express several different factors affecting the growth. Therefore, it is difficult to prove the effects of climatic or anthropogenic impact. This can be done easier by combining different monitoring methods.

The increasing tree crown defoliation and annual radial increment losses indicate that the state of is deteriorating and that the environment is no more suitable for plants. By assessing the actual health state of street trees it is possible to estimate the environmental state and how it suits for plant growth.

## Materials and methods

As the object for investigation – species of a genus of deciduous trees - *Tilia* growing in the pedestrian zone of the city Kaunas - Laisves alley - were chosen. Four species of limes were examined: *Tilia platyphylla* Scop., *Tilia europaea* L., *Tilia cordata* Mill. and *Tilia euchlora* K. Koch. These lime species are the most

popular among urban deciduous trees in Lithuania. Limes are favorite street trees in urban forests and parks of Lithuania. They are cultivated as single trees or in groups and alleys of natural or shaped trees.

The aim of the investigation was to conduct the ecological monitoring of Kaunas city Laisves alley limes and to estimate their ecological state according to the main forest monitoring parameters.

Monitoring of lime trees has been conducted and the experimental material gathered at the end of July and at the beginning of August 1998 - the most suitable season for monitoring of deciduous trees (Hanish, Kilz.., 1990), - according to the international forest monitoring methodology (Manual on methods..., 1994), adapted to urban environment. It means that bioindicative indices were determined for every sample tree.

Defoliation – the loss of foliage/needles caused not by leave sheding process in autumn – is the most important forest monitoring parameter. It is not only the loss of leaves/needles but also the amount which is possible to form but not formed mass of leaves/needles. That is why in order to estimate the defoliation of a tree visually, we compare the foliage of a tree with the foliage of a reference tree whose defoliation does not exceed 10% (Ozolinčius, 1994). A reference tree usually has the same class of growth and development as the sample tree. It belongs to the same type of branching, grows in the vicinity of the sample tree, or a photo of reference tree corresponding to a sample tree according to special atlases (Muller, Stierlin, 1990). Crown defoliation is observed in the whole crown and in the upper 1/3 of the crown. The sample trees were divided into five classes according to their crown defoliation: class 0 – conditionally healthy trees (defoliation less or equal to 10%); class 1 – slightly defoliated trees (11-25%); class 2 – moderately defoliated trees (26-60%); class 3 – severely defoliated trees (61-99%); class 4 – dead trees (100%).

Foliage dechromation - one of the main monitoring parameters - shows a part of foliage or needles (%) of the crown whose color has changed due to negative impact of the environment. There were four foliage dechromation classes distinguished: class 0 – without colour changes in the foliage (dechromation 0-10%); class 1 – slight dechromation (11-25% of the foliage has changed colour); class 2 – moderate dechromation (26-60%); class 3 – severe dechromation (61-99%).

Severe crown defoliation and foliage dechromation show negative influence of environmental impact on a tree and indicate damage (Manual on methods..., 1994).

The treetop state, amount of dry branches in the crown was estimated as follows: 0 – healthy treetop, 1- broken, 2- dried, 3- damaged; 0 – 0-10% of dry branches, 1- 11- 30% of dry branches, 2- 31- 50% of dry branches, 3- more than 50% of dry branches.

The degree of tree fruiting was estimated by grades: 0 – no fruiting, 1- slight fruiting, 2- moderate fruiting, 3- rich fruiting.

Tree damages were classified into six groups: game, insects, fungi and diseases, abiotic agents, human activity and others can cause different tree damages.

For dendrochronological research wood samples of all *Tilia* species were taken in different places of Laisves alley: close to crossings with vehicle traffic and from less polluted areas between them. Samples were taken using Presler's increment borer. Sample trees were chosen according to their ecological state (with high and low crown defoliation and foliage dechromation). Tree-ring width was measured and local dendroscales were created. Indexation, correlation and synchronization coefficients were calculated using special equipment LINTAB and TSAP program.

## Results

### *Crown defoliation, foliage dechromation, state of the treetop, amount of dry branches, fruiting*

Using the international monitoring methodology (Manual on methods..., 1994) 680 lime trees from Laisves alley in the city of Kaunas have been investigated. Biometric parameters of sample trees have been measured, the state of tree tops, the amount of dry branches (%), fruiting degree, crown defoliation degree, foliage dechromation degree and tree damages have been estimated.

The investigation has indicated that the limes at Laisves alley in Kaunas usually are moderately defoliated (crown defoliation is 26- 60%). There are about 55% of such trees. Sample trees defoliated slightly comprise 42% and conditionally healthy (crown defoliation less or equal to 10%) only 3%. There are only 3 severely defoliated trees whose crown defoliation is 61- 99%. Table 1 shows the values of different *Tilia* species trees with the average crown defoliation and foliage dechromation. It is seen that *Tilia cordata* Mill. has the highest value of crown defoliation (33.4±2.1%) and foliage dechromation (9.2±1.5%), *Tilia platyphylla* Scop. - the lowest ones (28.0±1.2% and 5.1±0.6%, respectively). *Tilia europaea* L. (crown defoliation is 30.8±1.7%, dechromation - 6.6±0.9%) and *Tilia euchlora* K. Koch.

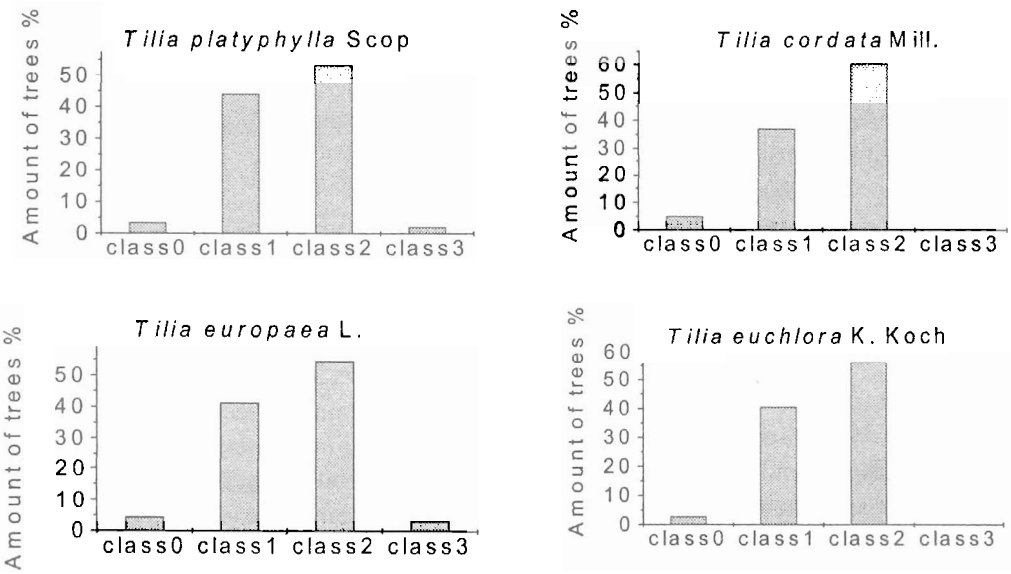
(defoliation is 30.9±3.0%, dechromation - 6.7±1.8%) have very similar values of the average crown defoliation and foliage dechromation.

**Table 1.** The values of the average crown defoliation and foliage dechromation of different *Tilia* species trees

| *Tilia* species | Crown defoliation % | Foliage dechromation % |
|---|---|---|
| *Tilia europaea* L. | 30.8±1.7 | 6.6±0.9 |
| *Tilia platyphylla* Scop. | 28.0±1.2 | 5.1±0.6 |
| *Tilia cordata* Mill. | 33.4±2.1 | 9.2±1.5 |
| *Tilia euchlora* K. Koch. | 30.9±3.0 | 6.7±1.8 |

Figure 1 illustrates the distribution of different *Tilia* species trees (%) by the defoliation classes. The greatest part (60%) of the trees of *Tilia cordata* Mill. has been moderately defoliated (defoliation is 26- 60%). Slightly defoliated trees (defoliation 11- 25%) constitute 37%, conditionally healthy trees (defoliation less than 10%) only 4% and severely defoliated trees whose crown defoliation reaches 61- 99% make up a very little part of the examined *Tilia cordata* Mill. trees. The greatest part (55%) of the specimens of *Tilia europaea* L. has been moderately defoliated, slightly defoliated trees constitute 40%, conditionally healthy trees - only 5% and severely defoliated ones make up a very little part of the examined *Tilia europaea* L. trees. Even 58% of *Tilia euchlora* K.Koch. trees are moderately defoliated, slightly defoliated trees make up 39%, conditionally healthy ones - only 3% of *Tilia euchlora* K.Koch. sample trees. Severely defoliated trees comprise a very little part of the examined *Tilia euchlora* K.Koch trees.

**Figure 1.** Distribution of lime trees (%) by defoliation classes.




Even 53% of *Tilia platyphylla* Scop. trees has been moderately defoliated, slightly defoliated trees comprise 43%, conditionally healthy trees - only 3% and severely defoliated ones - a very little part of the examined trees. Severely defoliated trees of all *Tilia* species are located at close distances from the busy street crossings. Dead trees are removed from the streets due to worse aesthetic value.

The investigations have indicated that foliage dechromation is not a widespread phenomenon among the limes of Laisves alley. The greatest part of the sample trees has only the symptoms of dechromation. Class 0 (dechromation up to 10%) predominates, trees of this class form the greatest part (86%) of the sample trees (Table 2). Sample trees with slight dechromation are found to be 14% and only 1 tree has been estimated as moderately dechromated (dechromation is 26 - 60%).

**Table 2.** Distribution of sample trees according to crown defoliation and foliage dechromation classes.

| State parameters according to crown defoliation | | | |
|---|---|---|---|
| Defoliation class | % | Number of sample trees | % |
| 0 | 0–10 | 20 | 3.1±0.6 |
| 1 | 11–25 | 286 | 42.3±1.2 |
| 2 | 26-60 | 371 | 54.5±1.4 |
| 3 | 61–99 | 3 | 0.5±0.1 |
| 4 | 100 | 0 | 0 |
| State parameters according to filiage dechromation | | | |
| Dechromation class | % | Number of sample trees | % |
| 0 | 0–10 | 582 | 85.9±2.6 |
| 1 | 11–25 | 97 | 14.0±1.2 |
| 2 | 26-60 | 1 | 0.1±0.1 |
| 3 | 61–99 | 0 | 0 |

The amount of dry branches of lime trees at Laisves alley is not large, because those trees are being trimmed and tended for their aesthetic value. Trees of bad ecological state are being removed and replaced by new ones. Therefore, it is complicated to estimate the real amount of dry branches in the street tree crowns. Table 3 illustrates the average amount of dry branches of the trees of different *Tilia* species. It is shown that *Tilia europaea* L. and *Tilia cordata* Mill. have the highest (7.6±1.1% and 6.7±1.9%, respectively), *Tilia platyphylla* Scop. - the lowest (4.3±0.7%) mean amount of dry branches. Dry branches of *Tilia euchlora* K. Koch. make up 4.8±0.2% of its crown.

**Table 3.** The mean amount of dry branches of different *Tilia* species.

| *Tilia* species | Mean amount of dry branches % |
|---|---|
| *Tilia europaea* L. | 7.6±1.1 |
| *Tilia platyphylla* Scop. | 4.3±0.7 |
| *Tilia cordata* Mill. | **6.7±1.9** |
| *Tilia euchlora* K. Koch. | 4.8±2.1 |

The fruiting of lime trees at Laisves alley is rich or moderate (Table 4). Rich fruiting has been estimated for the greatest part (48%), moderate – for 44% of the sample trees. Slight fruiting has been estimated only for 8% of the sampled limes. Figure 2 illustrates the distribution of all examined trees (%) according to fruiting degree. In comparison to other *Tilia* species, *Tilia platyphylla* Scop. has the highest fruiting rate – even 56% of these species trees has rich fruiting, 39% -moderate fruiting and only 5% of trees fruits slightly. *Tilia europaea* L. has the second position according to rich fruiting - 42% of specimens of this species have rich fruiting, 46% - moderate fruiting and 12% of the sample trees have slight fruiting. The fruiting of *Tilia cordata* Mill. is similar: 40% of the lime tree have rich fruiting, 49% - moderate fruiting and 11% of sample trees have slight fruiting. In comparison to other *Tilia* species, *Tilia euchlora* K.Koch. has the most insignificant amount of limes with rich fruiting - 38% of sample trees.

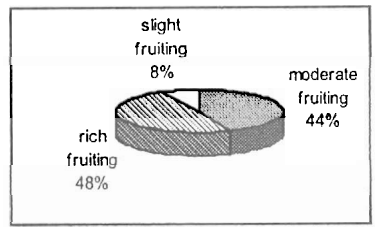
**Table 4.** Distribution of all sample lime trees (A) and different *Tilia* species trees (B) by fruiting degree.

| Fruiting parameters | | | |
|---|---|---|---|
| A | | | |
| Fruiting | | Sample lime trees | |
| Fruiting degree | Fruiting indication | Number | % |
| 0 | No fruiting | 1 | 0.1 |
| 1 | Slight fruiting | 53 | 7.9 |
| 2 | Moderate fruiting | 300 | 44 |
| 3 | Rich fruiting | 326 | 48 |

B

| *Tilia* species | 0 degree | | 1 degree | | 2 degree | | 3 degree | |
|---|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | Number | % |
| *Tilia europaea* L. | 0 | 0 | 24 | 12 | 94 | 46 | 86 | 42 |
| *Tilia platyphylla* Scop. | 0 | 0 | 16 | 5 | 133 | 39 | 185 | 56 |
| *Tilia cordata* Mill. | 0 | 0 | 8 | 11 | 36 | 49 | 29 | 40 |
| *Tilia euchlora* K. Koch. | 1 | 1 | 5 | 7 | 37 | 54 | 26 | 38 |

**Figure 2.** Distribution of all sample lime trees (%) by fruiting degree.




The database analysis has indicated that *Tilia platyphylla* Scop. is of the best health condition. *Tilia europaea* L. is of the worst health condition caused by anthropogenic pollution, strong recreation pressure and negative abiotic factors. It can be noticed that tree crown defoliation is dependent on its development level. Well-developed trees have the lowest crown defoliation. It increases with the deterioration of the biosocial state of the tree. But this statement may not always be correct because of the dynamics of crown defoliation, age of trees and changing impact of negative environmental factors.

*Dendrochronological investigations of urban lime trees*

During the growing process tree rings accumulate information about the phenomena taking place in the environment (Eckstein, 1989; Fritts, 1987) and serve as natural monitors (Schweingruber, 1989). Tree rings can serve as indicators of the state – they show the present condition of a tree and all changes in the environment during growing period: climatic, anthropogenic or even economical changes. The method of dendrochronological indication - one of the suitable methods, not very expensive, able to analyse a large amount of data and to use information from the past, as tree rings indicate, and to come to conclusions about the state of natural ecosystems. It is very important to estimate the dynamics of the climatic background while using these methods. It has been established that the impact of technogenical pollution becomes very strong after climatic extremes (Juknys, 1994).

The results of the dendrochronological research lead to conclusions about the ecological state of different *Tilia* species, depending on environmental pollution and climatic factors. The data show that the ecological state of limes growing near the crossroads is worse than those growing in between the crossroads.

The dynamics of the annual radial increment is determined by complex impact of environmental factors. The increasing or decreasing of the radial increment of the lime trees at Laisves alley is determined by stronger or weaker unfavourable impact of pollution and climatic factors.

In the dynamics of the annual radial increment of examined *Tilia* species we can determine some periods with high increment: 1950- 1960 (annual ring widths 2.5 – 3.5 mm), 1985-1996 (1.5 – 2.0 mm) and with low increment: 1910 – 1940 (0.2– 1.5 mm), 1970- 1980 (0.5 – 1.0 mm). Figure 3 illustrates the similarity of the dynamics of the annual radial increment of different *Tilia* species. The periods of good growth for urban lime trees are determined by favourable climatic conditions of these periods (warm winters, humid summers). They are similar to radial increment cycles of Lithuanian forests determined according to the climatic background. The periods of bad growth are determined by unfavourable climatic conditions (cold winters, dry summers). A decrease in the annual radial increment is observed in the periods: 1900 – 1940, 1961 – 1980; an increase – in the periods: 1941 – 1960, 1981 – 1998. Extreme climatic conditions as summer droughts in 1941, 1963, 1992, and cold winter in 1979 influenced a decrease in the radial increment of urban limes. Low annual radial increment in 1939 was determined by high solar activity of that year. The tendency of an increase in the annual radial increment in 1994 is atributed to the depression of industrial activity and to lowering period of solar activity cycles of 11 – 13 years. The local conditions and reconstruction of Laisves alley influenced on the dynamics of the annual radial increment: after 1930 the horse tramway was no longer used; in 1982 Laisves alley became a pedestrian zone – transport and smoking were prohibited, flower grounds were arranged, soil cover was changed around the trees. It made a positive influence on the annual radial increment of the trees. As annual radial increment data shows (Fig. 3), the ecological state of Laisves alley lime trees is becoming better.

By comparing of annual radial increment rates and dynamics of different *Tilia* species shows that *Tilia platyphylla* Scop. is of the best ecological state. In comparison to other *Tilia* species, *T. platyphylla* has the highest annual radial increment. This proves the pollution-resistance of this species and favourability for urban plantation. The aesthetic value of *Tilia platyphylla* Scop. is significant – even damaged trees look like the healthy ones. The maxima of the annual radial increment of *Tilia platyphylla* Scop. were recorded in 1942, 1950 and the minimum - in 1977. In accordance with the results of our investigation, *Tilia europaea* L. and *Tilia euchlora* K. Koch. are of worse ecological state, they are more injured than other *Tilia* species. The maxima of the radial increment of *Tilia europaea* L. were recorded in 1955 and 1990, the minimum -in 1974. The maximum of the radial increment of *Tilia euchlora* K. Koch. was recorded in 1960, the minimum - in 1932. The ecological state and health conditions of *Tilia cordata* Mill. serves as the mean ecological status of all *Tilia* species. Its annual radial increment serves as the average annual radial increment rate. The maxima of the annual radial increment were recorded in 1880 and 1954, the minima - in 1910 and 1920. *Tilia cordata* Mill. is a pollution-resistant species and is favourable for urban plantation. By the way, the trees of this species are found to be the oldest ones in Laisves alley. The wood samples of the oldest (123 years old) lime tree (*T. cordata)* at Laisves alley were taken and measured. Figure 4 illustrates its radial increment dynamics. The maxima of the annual radial increment of oldest lime were recorded in 1880 (4 mm), 1950 (2.6 mm) and the minima - in 1910 (0.2 mm), 1980 (0.3 mm). With the help of such old trees it is possible to conduct historical tree monitoring – to estimate the state of the annual radial increment of trees since the beginning of their life until the moment when wood samples were taken. Crown defoliation (30%) and foliage

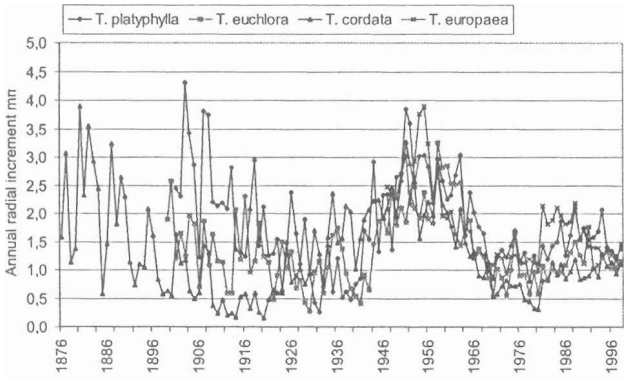



**Figure 3.** Similarity of annual radial increment dynamics of different *Tilia* species trees.

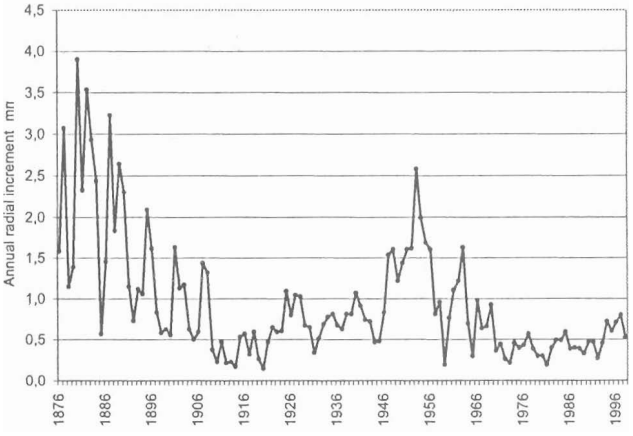



**Figure 4.** Annual radial increment dynamics of the oldest lime tree (*Tilia cordata* Mill.) at Laisves alley in Kaunas.

dechromation (20%) of the oldest lime-tree show its growing condition. In comparison to others, the health condition of this tree is quite good, although its crown and stem are damaged by insects.

With increasing tree age, the crown defoliation rate and its influence on the annual radial increment become more severe (Stravinskiene, 1997b). After comparing annual radial increment dynamics of different *Tilia* species trees to the dynamics of corresponding reference trees it was established that differences between the radial increment of reference tree and sample trees of the same species are stronger when the ecological state of sample limes is worse (when crown defoliation is more severe).

Figure 5 shows the dynamics of the annual radial increment of *Tilia europae* L. and *Tilia euchlora* K. Koch. by different degree of crown defoliation. It is shown that with low size of crown defoliation trees are healthy (defoliation under 10%) or slightly damaged (defoliation 11–25%), the annual radial increment is good, similar to the annual radial increment of reference tree – a tree with low crown defoliation rate and good annual radial increment. When tree is defoliated moderately (defoliation 26–60%) or severely (defoliation more than 60%), the annual radial increment is smaller

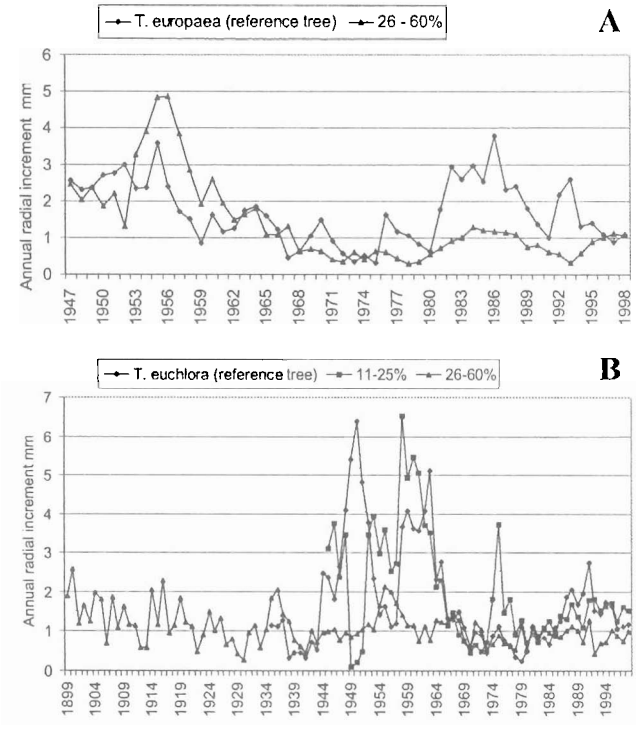



**Figure 5.** The dynamics of the annual radial increment of *Tilia europaea* L. (A) and *Tilia euchlora* K. Koch. (B) by different crown defoliation degree.

and the ecological state of this trees is worse, their dendroscales are very different from the dendroscales of the reference trees. In accordance with this, the ecological state of *Tilia platyphylla* Scop. appears to be the best and *Tilia europaea* L. appears to be of the worst ecological state.

Unfortunately, in the scientific literature there is no common opinion about the tendencies of annual radial increment dynamics related to an increase in tree crown defoliation rate. It depends on a variety of environmental factors. It is proved that the losses of the radial increment from older stands are bigger than these from younger stands with the same crown defoliation degree (Rohle, 1986). The relationship between the crown defoliation and annual radial increment is closer when crown defoliation is more severe (Pretzisch, Utschig, 1989). Slight and moderate crown defoliation (not more than 30%) is still being discussed. It is established that the size of the annual radial increment is inversely proportional to the degree of defoliation: severely defoliated trees (defoliation 60 – 80%) have the lowest annual radial increment, conditionally healthy (defoliation not more than 10%) and slightly defoliated trees (defoliation 10 – 20%) have the highest annual radial increment size (Stravinskiene, 1997b). Our investigations on limes show the same.

The reaction of different urban *Tilia* species tree to meteorological factors like air temperature and precipitation during the vegetation period is quite different. It is proved according to the reliability of calculated correlation coefficients between the annual radial increment and meteorological factors (air temperature and precipitation).

The radial increment of *Tilia europaea* L. positively correlates with the temperature of October (correlation coeficient equal 0.22) and the precipitation of August (0.24), negatively – with the temperature of February (-0.28), April (-0.36) and the precipitation of November (-0.33). The radial increment of *Tilia cordata* Mill. posityvely correlates with the precipitation of June (correlation coeficient equal 0.23), *Tilia euchlora* K. Koch. - positively correlates with temperature (0.24) and precipitations (0.27) of January, negatively – with precipitations of November (-0.20). When the correlation coefficients are negative, high temperature negatively influences the growth, low temperature causes good increment and precipitation makes a negative influence. When correlation coefficients are positive – high temperature and precipitation are favourable.

In accordance with our calculations, the radial increment of urban lime trees have reliable correlation with

the quantity of precipitation, but not with temperature during the vegetation period.

In accordance with calculations of radial increment synchronety coefficients, *Tilia platyphylla* Scop. and *Tilia cordata* Mill. are sinchronous ($C_x$=67%), *Tilia platyphylla* Scop. and *Tilia euchlora* K. Koch. ($C_x$=63%), *Tilia europaea* L. and *Tilia euchlora* K. Koch. ($C_x$=60%) have synchronous dynamics of the radial increment. The radial increment dynamics of *Tilia europaea* L. and *Tilia* platyphylla Scop. ($C_x$=48%), *Tilia europaea* L. and *Tilia cordata* Mill. ($C_x$=48%) are asynchronous. *Tilia cordata* Mill. and *Tilia euchlora* K. Koch. have the same synchronety of radial increment dynamics ($C_x$=53%).

The mean annual radial increments of different *Tilia* species have been calculated: the tree rings of *Tilia platyphylla* Scop. appear to be widest (1.81 mm), the tree-rings of *Tilia euchlora* K. Koch. (1.35 mm) and *Tilia cordata* Mill. (1.31 mm) are rather narrow.

Dendrochronological and dendroindicational monitors – the annual radial increment of trees and crown defoliation degree – serve as natural monitors to objectively evaluate the impact of all changes occurring in natural environment, especially the impact of pollution.

## Conclusions

1. Deciduous trees are less sensitive to environmental pollution impact than conifers, but they are suitable to be used for indication of the state of natural environment. The bad health condition of deciduous trees indicates the existing of complex environmental factors, especially unfavourable for plants.

2. It is established that the average crown defoliation of lime trees growing in Kaunas city Laisves alley is 30.8±2.0%, foliage dechromation is not widespread (the mean foliage dechromation is 6.9±1.2%). It is established that 1/3 crown top part of sample trees is less defoliated comparing to full crown.

3. The investigations have indicated that in comparison to other *Tilia* species, *Tilia platyphylla* Scop. (crown defoliation is 28.0±1.2.%), comparing to other *Tilia* species, is of the best ecological state. *Tilia cordata* Mill. with mean crown defoliation 33.4±2.1% is of worst ecological state. The mean crown defoliation of *Tilia europaea* L. makes up 30.8±1.7% and that of *Tilia euchlora* K. Koch. - 30.9±3.0%.

4. It is estimated that conditionally healthy trees (crown defoliation up to 10%) have the highest average radial increment width, moderately damaged trees (defoliation 26-60%) - lower radial increment.

5. It is established that the main factors limiting the growing process and causing the deterioration of the ecological state of limes in Kaunas city are environmental pollution, negative human activities and unfavourable climatic and soil conditions.

## References

**Eckstein D.** 1989. Qualitative assessment of past environmental changes: Methods of dendrochronology. Applications in the environmental sciences. Dordrecht, pp. 220-223.

**Fritts H. C.** 1987. Tree rings and climate. Warsaw. V. 2, 567 p.

**Hanish B., Kilz. E.** 1990. Monitoring of forest damage. Stuttgart: Ulmer; London: Helm, 317 p.

**Juknys R.** 1994. Dendrochronological data applications at forest monitoring system. Climate and Atmospheric Deposition Studies in Forests, Conference Papers 19:245-254, IGSO PAS, Warszawa, pp. 245-254.

**von Lührte A.** 1992. Dendroecological studies on pine and oak in the forests of Berlin (West): Lundqua reports, pp. 212 - 216.

Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forest. 1994. 3rd edition. Edited by the Programme Coordinating Centres Hamburg and Prague. 177 p.

**Muller E., Stierlin R.** 1990. Tree crown photos (with percentages of foliage loss). Swiss Federal Institute for Forest, Snow and Landscape Research. 2nd Revised and extended edition. 229 p.

**Pretzisch H., Utschig H.** 1989. Das "Zuwachstrend-Verfahren" für die Abschatzung krankheitsbedingter Zuwachsverluste auf den Fichten-und Kiefern-Weiserflachen in den bayerischen Schadgebieten. Forstarchiv, 60. 5: 188-193.

**Ozolinčius R.** 1994. Diagnostiniai testai miškų monitoringe [Diagnostic tests in forest monitoring]. Lietuvos miškų institutas. 40 p. (in Lithuanian).

**Rohle H.** 1986. Waldschaden und Zuwachsreaktion dargestellt am Beispiel geschadigter Fichtenbestande im Nationalpark Bayericher Wald. Forstwiss. Zentralbl. 105: 115-122.

**Schweingruber F. H.** 1989. Dendroecological information in pointer years and abrupt growth changes: Methods of dendrochronology. Applications in the environmental sciences. Dordrecht, p. 277-283.

**Stravinskienė V.** 1997a. Pušynų dendroekologiniai tyrimai ir jų taikymas gamtinės aplinkos būklės pokyčių indikacijai [Dendrochronological studies of pine forest and their application for indication of the environmental status]. Ekologija, 2: 62 – 72 (in Lithuanian).

**Stravinskienė V.** 1997b. Urbanizuotos gamtinės aplinkos vertinimas pagal medžių lajų defoliacija ir radialinį priaugį pušynų ekosistemose [Assessment of urban environment status according to crown defoliation and radial increment of pine forest ecosystems]. Ekologija, 3: 68 – 72 (in Lithuanian).

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# СОСТОЯНИЕ ЗДОРОВЬЯ И ДЕНДРОХРОНОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ ЛИП ГОРОДА КАУНАСА

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*Резюме*

Приводятся результаты экологического мониторинга и дендрохронологических исследований 680 деревьев 4-рех наиболее часто в городском озеленении встречаемых видов липы (*Tilia platyphylla* Scop.; *Tilia euchlora* K. Koch.; *Tilia europaea* L. и *Tilia cordata* Mill.).

Руководствуясь методикой экологического мониторинга (Manual on methods., 1994), модифицированной для урбанизированных территорий, определена дефолиация, дехромация крон учетных деревьев, состояние их вершин, % сухих ветвей в кроне, уровень плодоношения, установлены повреждения крон и стволов. Основными индикаторами состояния деревьев и их среды послужили дефолиация и дехромация крон, также динамика годичного радиального прироста.

Исследования показали, что *Tilia platyphylla* Scop. отличается наилучшим состоянием по сравнении с другими видами лип Лайсвес алеи города Каунаса. Ей характерны наименьшие показатели дефолиации (28.0 ± 1.2%) и дехромации крон (5.1±0.6.%), наибольший среднепериодический радиальный прирост. *Tilia platyphylla* Scop. наиболее устойчива к отрицательным влиянием городской среды и наиболее пригодна в городском озеленении. По основным показателям мониторинга, в наихудшем состоянии находится *Tilia cordata* Mill. со средней дефолиацией (33.4±2.1%) и дехромацией крон (9.2±1.5%) учетных деревьев, наименьшим среднепериодическим радиальным приростом.

Проанализирована динамика радиального прироста лип и ее зависимость от метеорологических показателей, изучены тенденции связей величин радиального прироста городских лип и дефолиации их крон. Анализируются причины и факторы окружающей среды, способствующие ухудшению состояния городских лип.

**Ключевые слова:** мониторинг, городские липы, экологическое состояние, дендрохронология.