MODERN MASTERCHRONOLOGIES OF BLACK ALDER AND BIRCH IN MOIST FOREST SITES OF LITHUANIA

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Abstract

New masterchronologies of black alder in Alnetum carecosum and carecoso-calamagrosticosum forest sites and birch in Betuletum carecosum and carecoso-calamagrosticosum forest sites are presented. These chronologies are established using growing trees radial increment data. Duration of black alder chronologies – since 1870 till 1997 and since 1883 till 1997. Duration of both birch chronologies lasts since1900 till 1997. Lasting master dendrochronologies of high precision reflect past ecoclimatic changes and can also be used as one of methods to estimate degradation of forest ecosystems and the state of natural environment.

Keywords: masterchronologies, annual radial increment, black alder, birch, moist habitats

INTRODUCTION

As far as tree-rings accumulate information about phenomenon taking place in the environment (Eckstein, 1989; Fritts, 1987) and serve as natural monitors (Schweingruber, 1989), information provided by them allows to objectively evaluate all changes taking place in the natural environment and in specific forest ecosystems. So lately dendrochronological studies are more and more broadly applying in the environmental state assessment and forest research for environmental state changes indication, for assessment of efficiency of antropogenic rearrangements in the forest ecosystems, even for reconstruction.of past climatic conditions.

Application of these methods in forest research allows to estimate the efficiency of forest draining, fertilization, felling, to determine retrospectively seed years of the past forests and to foresee them in the future, to forecast mass diseases and invasions of pests in the forests. These methods in the environmental state assessment can serve for the estimation of natural environmental state and climatic background dynamics.

One of dendrochronological methods providing possibilities to estimate and foresee climatic fluctuation, environmental state and forest economic measures is referent dendroscales. Mastercronologies join individual annual radial increment measurement data of many trees and reflect general increment tendencies in uncontaminated territories.

Up till now there were prepared not a few local chronologies of pine forests growing in dry habitats (Bitvinskas, 1966, 1974, 1984; Kairiukstis and Stravinskiene, 1987; Stravinskiene, 1980). Masterchronologies for pine, spruce and black alder in bogged up and boggy forest sites of Lithuania were elaborated earlier (Stravinskiene, 1979, 1980, 1998). There wasn't till now longtime trees annual radial increment data for birch, differentiated according to habitats and forest types, a base of master chronologies prepared on the ground of moist sites.

MATERIAL AND METHODS

Collection of the experimental material

Experimental material (boreholes), meant for the collection of the dendrochronological (historic) monitoring data base, estimation of annual radial increment dynamics and for the indication of forest ecosystem reaction to the natural environment state changes was collected in 1989-1997. As a whole, about 1700 wood samples of growing trees (dendrochronological information of about 130 000 annual tree-rings) of the above mentioned species collected in 35 experimental plots were examined. Boreholes were bored using Pressler's increment bore according to the methodics of collecting experimental material for dendrochronological research.

Measurement of tree ring widths and standardization of measurement data

For the trees' annual radial increment (annual ring width) measurement and measurement results' estimation tree-rings measurement system LINTAB and computer programs set TSAP of the German production were used. Tree-ring width (annual radial increment of early and late wood) was measured with the accuracy of 0.01 mm. Primary tree-rings measurement data were recorded into the floppy disk. It facilitates further information treatment by the mathematical statistics and dendrochronological analysis methods according to the special CATRAS and TSAP programs, allotted for the dating of trees annual rings measurement data, synchronizing of tree rings calculating means and creating local chronologies.

For the tree-rings dating and trees radial increment synchronizing, methodics applied in the world dendrochronological and dendroindicational research practice was used (Eckstein, 1989; Fritts, 1987; Schweingruber, 1989). On the base of the same methodics sets of CATRAS (R.W.Aniol and Fr.G.Schleswig, Germany) and TSAP (Fr. Rinn and S.Jakel, Germany) programs were created. Also the methodics of local dendrochronological research (Bitvinskas, 1974; Stravinskiene, 1997) were used.

As it's known, the width of rings of different age trees varies very much. At the early age they are wide, later - narrow. Seeking to eliminate influence of the trees age to the radial increment size and expose increment dynamics cycles, predetermined by fluctuations of climatic background, and also for convenience in comparing radial increment dendrochronologies (dendroscales) from different sites, data were standardized, i.e., radial increment indexes were calculated. The indexes are relative values, showing the ratio of radial increment concrete in calendar years with these years' increment norm. Increment norm or average periodic increment is calculated according to formula:

$$Zr_{vid.} = \frac{Zr_m + Zr_{m+1} + Zr_{m+2} + Zr_{(T-1)+m}}{T}$$

Where $Zr_{vid.}$ - increment norm or average periodic increment;

Zr_m; Zr_{m+1}; Zr_{m+2} ... $Zr_{(T-1)+m}$ - annual radial increment of certain calendar year;

m - positive number, when T=11, m=T-10;

T - levelling period.

Annual radial increment indexes (I_{zr}) are calculated according to formula:

$$IZr = \frac{Zr\left(\frac{T-1}{2} + m\right)}{Zr_{vid.}} \cdot 100\%,$$

where $Zr\left(\frac{T-1}{2} + m\right)$ - radial increment of current calendar year in the middle of the period T.

Longtime experience of dendrochronological researchers showed, that it's most optimum to apply the period of 11 levelling years for increment calculation. It helps to expose the influence of Solar activity cycles of 11 and 22 years upon trees radial increment more objectively.

Formation and supplement of masterchronologies

Simple methods, supported by large experimental database, have to be used for dating of trees annual radial increment and identification of distinct increment extremes. Only in this case it's possible to summarize and estimate dendrochronological information, collected from a larger region (Schweingruber, 1989)

The first stage of dendrochronologies formation is wood samples dating and synchronizing of annual radial increment data. Visual synchronizing of two trees rings series is carried out, paying attention to especially narrow annual rings, if only annual ring area was measured, or to a part of late annual ring in the annual ring when parts of early and late annual rings were measured separately. Thus, comparing among themselves, is carried out the synchronizing of all available tree series. Visual synchronizing sometimes wasn't enough precise because of the "untruthful" or "missing" tree-rings. To detect the mentioned rings, crossdating according to "pointer years" (distinctly notable years) was used. Prof. F.H. Schweingruber (1989) uses this term to value the quality and quantity of rings. "Positive" years he calls such years, when in the annual ring with normal width forms a wide part of late wood, and "negative" years - when the part of late wood is very narrow. When estimation is carried out only according to the annual ring width, "negative" are years of narrow rings, and "positive" - years of wide rings. This is very important when local chronologies are dating and synchronizing, because rings of distinctly notable years differ very much from the rings which are above and under them with their width, ratio of early and late wood in the annual ring. Local chronologies of different objects are synchronizing among themselves in accordance with “negative” years. They are compared with the existing master chronology. Having no masterchronology, they can be compared with the increment of master forest stand. It's desirable, that chronologies compared among themselves would recover at not less than 10-15 years intervals.

When the identity of distinctly notable years is determined visually, coefficients of similarity were calculated. Here are used very similar formulas to those of Huber (cit. according to Bitvinskas, 1974). Huber compares the number of varying (asynchronous) rings with the total ring number in searching chronology rings:

$$G = \frac{n^{-} \cdot 100}{n-1}$$

T Bitvinskas (1974) has modified this formula, comparing the number of varying (synchronous) rings with the total number of compared rings:

$$C_x = \frac{n^{+} \cdot 100}{n-1},$$

where: G and C_x - coefficients of similarity and synchronicity;

n- - number of varying direction rings;

n+ - number of coinciding direction rings;

n - total number of compared tree-rings.

Applying this formula, we compared coinciding and varying indexes of trees annual radial increment.

According to our calculation, about 10-15% of trees in the each research area have asynchronous dynamics of increment. In further investigation they weren't used. Also in the further master dendrocronologies formation process we didn't use local chronologies with synchronicity coefficient C_x less than 50%.

Radial increment synchronicity coefficients Cx of dendroscales dated and synchronized in the earlier years according to habitats and forest types, reach 75-80% within the forest enterprise area limits, 65-70% - within the republic limits (Stravinskiene, 1980). Within the mentioned limits radial increment synchronisity coefficients C_x fluctuate within the newlyt filled up and made more exact dendrochronologies.

RESULTS

Masterchronologies of black alder and birch

Synchronous fluctuations of cyclic trees radial increment, which were determined by dendroecological and dendrochronological researches and expressed in masterchronologies (standard series of annual radial increment), enlarge the possibilities of this field in ecology science. Dendrochronological information, especially cyclic fluctuations notable in the master dendrochronologies, can be used as the control (norm or standard) to evaluate and forecast the changes of natural environment, productivity of forest and agrarian ecosystems. Masterchronologies of black alder in Alnetum carecosum and Alnetum carecoso-calamagrosticosum indicates the radial increment state in moist habitats. The lenght of black alder masterchronologies – 127 and 114 years (Fig.1, 2). Annual radial increment indices of black alder in Alnetum carecosum and Alnetum carecoso-calamagrosticosum forest sites are presented in tables 1 and 2.

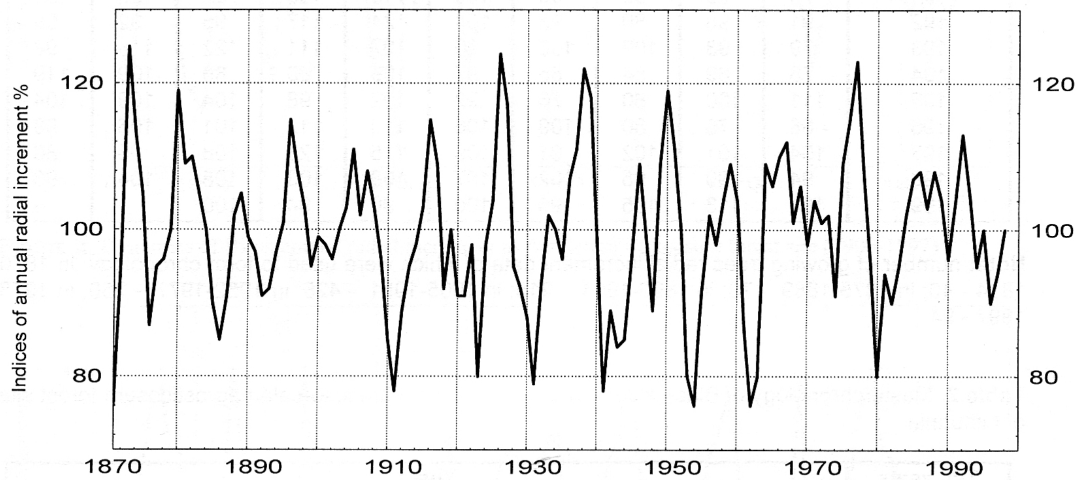

Figure 1. Dynamics of Black alder radial increment in Alnetum carecosum forest site (1870-1997)

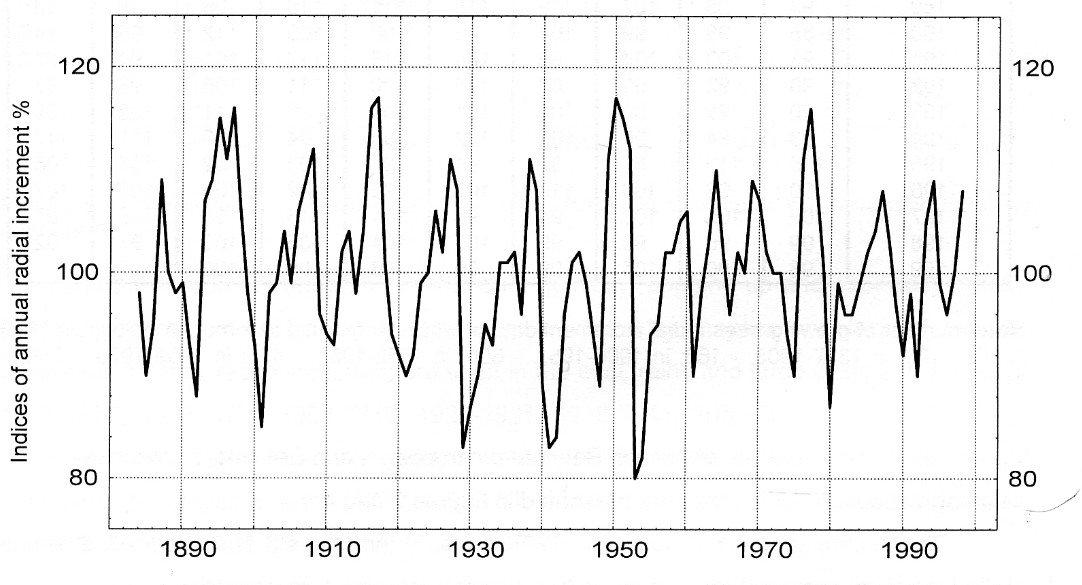

Figure 2. Dynamics of Black alder radial increment in Alnetum carecoso-calamagrosticosum forest site (1883-1997)

Table 1. Masterchronology of Black alder forests (in Alnetum carecosum forest site) of Lithuania

Ten years periods	Years									
	0	1	2	3	4	5	6	7	8	9
	Indices of annual radial increment (%)									
187	76	98	125	113	105	87	95	96	100	119
188	109	110	105	100	90	85	91	102	105	99
189	97	91	92	97	101	115	108	103	95	99
190	98	96	100	103	111	102	108	103	96	85
191	78	89	95	98	103	115	109	92	100	91
192	91	98	80	98	104	124	117	95	92	88
193	79	93	102	100	96	107	111	122	118	98
194	78	89	84	85	97	109	99	89	109	119
195	111	100	80	76	92	102	98	104	109	104
196	88	76	80	109	106	110	112	101	106	98
197	104	101	102	91	109	115	123	108	95	80
198	94	90	95	102	107	108	103	108	104	96
199	104	113	105	95	100	90	94	100	-	-

Note: number of growing trees radial increment data of which were used to form chronology: in 1870-1874 - 40; in 1875-1889 - 70; in 1890-1904 - 215; in 1905-1951 - 425; in 1952-1977 - 250; in 1978-1997 - 94.

Table 2. Masterchronology of Black alder forests (in Alnetum carecoso-**c**alamagrosticosum forest site) of Lithuania

Ten years periods	Years									
	0	1	2	3	4	5	6	7	8	9
	Indices of annual radial increment (%)									
188	-	-	-	98	90	95	109	100	98	99
189	93	88	107	109	115	111	116	106	98	93
190	85	98	99	104	99	106	109	112	96	94
191	93	102	104	98	104	116	117	101	94	92
192	90	92	99	100	106	120	111	108	93	87
193	90	95	93	101	101	102	96	111	108	89
194	83	84	96	101	102	99	94	89	111	117
195	115	112	80	82	94	95	102	102	105	106
196	90	98	103	110	102	96	102	100	109	107
197	102	100	100	94	90	111	116	108	100	87
198	99	96	96	99	102	104	108	103	97	92
199	98	90	105	109	99	96	100	108	-	-

Note: number of growing trees radial increment data of which were used to form chronology: in 1883-1896 - 120; in 1897-1905 - 162; in 1906-1951 - 600; in 1952-1958 - 425; in 1959-1978 - 206; in 1979-1997 - 75.

Masterchronologies of birch in Betuletum carecosum and Betuletum carecoso-calamagrosticosum forest sites are presented in figures 3 and 4.

These chronologies include 1900-1997 years. In the tables 3 and 4 indices of annual radial increment summarized in these masterchronologies are represented.

Showed master dendrochronologies are different in absolute sizes, but they, especially ones representing habitats of resembling humidity, are synchronous in the increment extremes, i.e. in the characteristics of minimums and maximums.

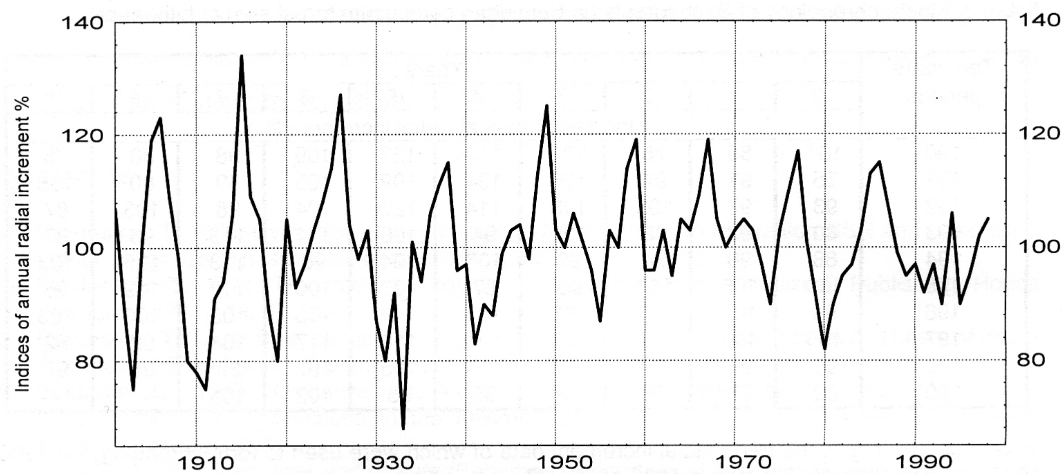

Figure 3. Dynamics of Birch annual radial increment in Betuletum carecosum forest site (1900-1997)

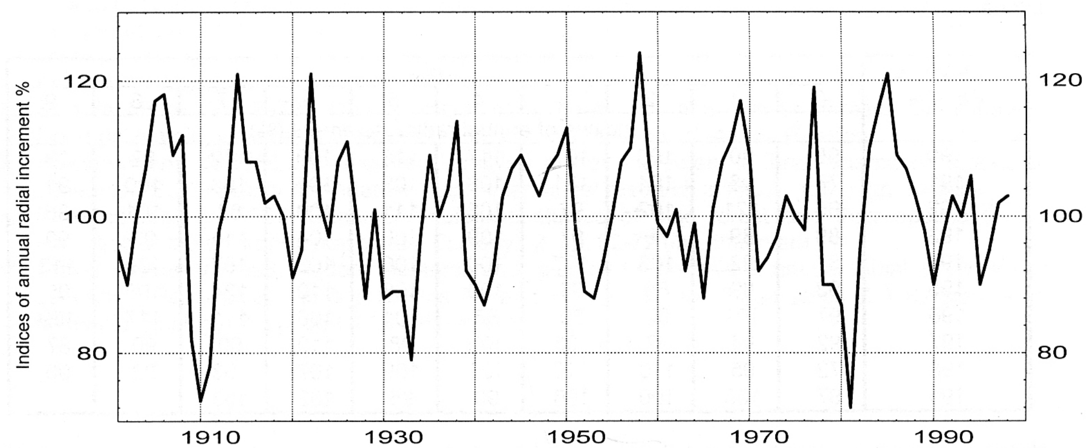

Figure 4. Dynamics of Birch annual radial increment in Betuletum carecoso-calamagrosticosum forest site (1900-1997)

In the habitats of temporarily redundant humidity, bogging up and especially marshy habitats, where factors limiting the growing are humidity surplus and lack of warmth, minimums of trees radial increment are seen in the cool, rainy and large Solar activity years: 1871-1873, 1888-1891, 1908-1910, 1929-1931, 1939-1941, 1953-1954, 1964-1965, 1979-1981 and 1990-1992. Years of good increment in wet habitats and favourable climatic conditions for growing are: 1873-1875, 1885-1887, 1894-1896, 1903-1904, 1914-1916, 1924-1926, 1936-1937, 1949-1951, 1959, 1967-1968, 1985-1986.

Large amplitudes of increment fluctuation characteristic for growing in forests in the habitats of temporarily redundant humidity, bogging up and marshy habitats are estimated.

Table 3. Masterchronology of Birch forests (in Betuletum carecosum forest site) of Lithuania

Ten years periods	Years									
	0	1	2	3	4	5	6	7	8	9
	Indices of annual radial increment (%)									
190	107	89	75	101	119	123	109	98	80	78
191	75	91	94	106	134	109	105	89	80	105
192	93	97	103	108	114	127	104	98	103	87
193	80	92	68	101	94	106	111	115	96	97
194	88	90	88	99	103	104	98	113	125	103
195	100	106	101	96	87	103	100	114	119	96
196	96	103	95	105	103	109	109	105	100	103
197	105	103	97	90	103	110	117	101	92	82
198	90	95	97	103	113	115	107	99	95	97
199	92	97	90	106	90	95	102	105	-	-

Note: number of growing trees radial increment data of which were used to form chronology: in 1900-1927 - 102; in 1928-1978 – 192; in 1979-1997 - 87.

Table 4. Masterchronology of Birch forests (in Betuletum carecoso-**c**alamagrosticosum forest site) of Lithuania

Ten years Periods	Years									
	0	1	2	3	4	5	6	7	8	9
	Indices of annual radial increment (%)									
190	95	90	100	107	117	118	109	112	82	73
191	78	98	104	121	108	108	102	103	100	91
192	95	121	102	97	108	111	100	88	101	88
193	89	89	79	97	109	100	104	114	92	90
194	87	92	103	107	100	106	103	107	109	113
195	98	89	88	93	100	108	110	124	108	99
196	97	101	92	99	88	101	108	111	117	109
197	92	94	97	103	100	98	119	90	90	87
198	72	95	110	116	121	109	107	103	98	90
199	97	103	100	106	90	95	102	103	-	-

Note: number of growing trees radial increment data of which were used to form chronology: in 1900-1936 – 408; in 1937-1990 – 210; in 1991-1997 – 76.

The tendency of radial increment decrease since 1989 is observed. It was determined, of course, by a complex of unfavorable environmental factors (unfavorable climatic conditions, growing background contamination of environment etc.) and related with the dynamics of Solar activity. In 1988 began the growth of ordinary Solar activity, which reached maximum in 1990-1991. Its activity then reached above 150W. Now the maximum of Solar activity in the 22 years cycle is ending and ordinary minimum will begin. In 1994 Solar activity was rather high (above 50W), but a complex of climatic conditions determined by it normalizes. In all research objects in 1995-1997 were noticed tendencies of increment stabilizing, but there wasn't fixed any considerable growing of increment (as compared with the increment norm of many years) neither in dryer, nor in wet habitats.

Presented masterchronologies of high precision reflect past ecoclimatic changes and can also be used as one of methods to estimate the degradation of forest ecosystems and the state of environmental conditions .

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