UDC 529

DYNAMICS OF FINLAND WOOD SQUARE

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On site http://metla.fi/ we fast have found statistical data on Finland wood square modification in a period of 1921-2007 years. The Finland wood statistics is rich by table models, for example in the wood program, and also always Q-factor of sampling is visible. However we an-ywhere have not found yet statistical models of dynamics, in particular, statistical models on such major landscape parameter as wood square.

Introduction. On site http://metla.fi/ we fast have found statistical data [1, c. 51] on Fin-land wood square modification in a period of 1921-2007 years. The Finland wood statistics is rich by table models, for example in the wood program [2], and also always Q-factor of sampling is visible. However we anywhere have not found yet statistical models of dynamics, in particular, statistical models on such major landscape parameter as wood square. The biotechnical regularity examples are indicated in our books [3-6], and at that in the book [6] detailed examples on timber trade of Finland among 30 advanced countries are indicated. The mathematical modelling technology is indicated in study guide for the bachelors and magisters [7].

The article purpose – to show the biotechnical regularities of Finland wood square dy-namics in a period of 86 years, revealed by us, and also wave dynamics of oscillatory perturba-tion of the Finnish experts in wood management on an exam-ple [1, c.51]. On a ready model prognostic wood square dynamics is shown provided that in Finland the modern wood policy up to a 2100 will be continued without radical modifications. Earlier on data [8] the portrait of tim-ber this country trade [6] in a period of 1961-2005 years was composed.

Time scale. 1921 year is a begin-ning of coordinates $t = 0$ on an abscissa.

Two statistical numbers − on left t_1 and right t_2 time scale boundaries (table 1) on wood square S_1 and S_2 inclusive of different wood inventory periods were received.

If the wood parameter actualization was annual, with cyclicity of Earth rotation round the Sun one time scale would be natural.

Wood grounds. All wood parameters are subjected identification by the biotechnical law [3-7] uniformly. Let's show two ready models of a structural type $S_1 = f(t_1)$ and $S_2 = f(t_2)$ On two scales two models of 86-year's Finland wood square dynamics (fig. 1) were obtained.
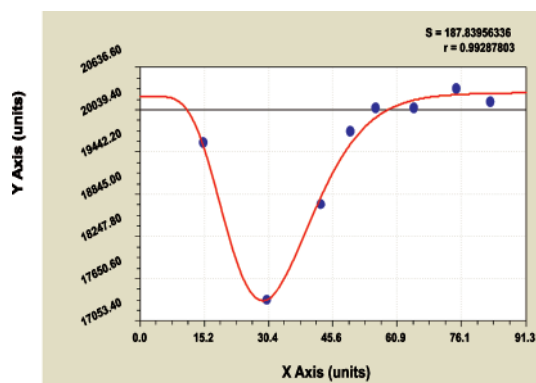
$$S_1 = 20223,37 \exp\left(3,08483 \cdot 10^{-5} t\right) -$$
$$-3,64168 \cdot 10^{-5} t^{7,49898} \exp\left(-0,19715 t^{1,06256}\right); \tag{1}$$

$$S_2 = 20179,95 \exp\left(5,34623 \cdot 10^{-5} t\right) -$$
$$-3,60103 \cdot 10^{-6} t^{7,97308} \exp\left(-0,16816 t^{1,08126}\right). \tag{2}$$

Finland wood square dynamics

The code	Period	Time t, years		Square, 10^3 ha	
		t_1	t_2	S_1	S_2
VMI 10 – NFI 10	2004–07	83	86	20150	20150
VMI 9 – NFI 9	1996–2003	75	82	20338	20338
VMI 8 – NFI 8	1986–94	65	73	20074	20074
VMI 7 – NFI 7	1977–84	56	63	20065	20065
VMI 6 – NFI 6	1971–76	50	55	19738	19738
VMI 5 – NFI 5	1964–70	43	49	18697	18697
VMI 3 – NFI 3	1951–53	30	32	17352	17352
VMI 2 – NFI 2	1936–38	15	17	19580	19580
VMI 1 – NFI 1	1921–24	0	3	20138	20138

The left boundary of a time scale   Right boundary of a time scale

Fig. 1. Dynamics of Finland wood square in a period of 1921-2007 years
(in a right upper angle the sum of squared deviations and formula
correlation coefficient are shown)

The correlation coefficients are accordingly equal 0,9929 and 0,9900. For the further analysis we shall accept the formula (2), substituting tabulated model from data of table 1.

First component is the stable exponential growth law. At that this main trend shows ra-ther small growth on a comparison with the time scale beginning. And second component, with negative sign before itself, shows crisis excitation of na-tional economy with 1925 on 2007 years and further in a period of 110 years.

Together schedules will show (fig. 2) possible scatters of data on a wood parameter.

The comparison of the schedules shows, that, since 2000 both scales begin to coincide. Therefore it is possible to make a conclusion that the national wood inventory have improved as the years go by. At that country has overcome territorial wood crisis.
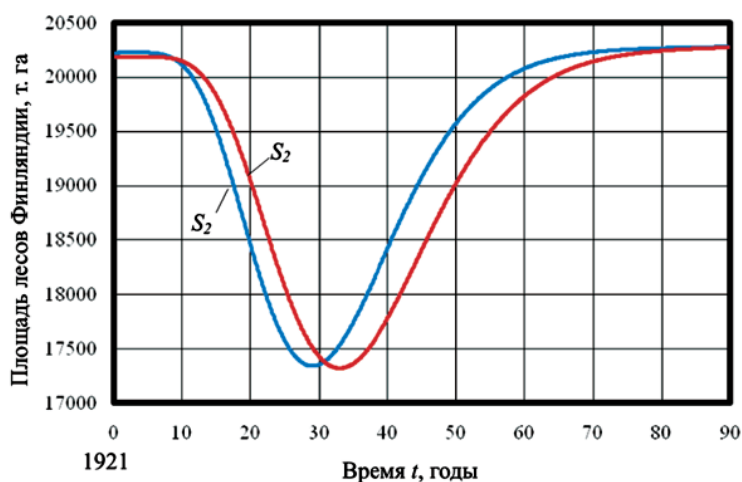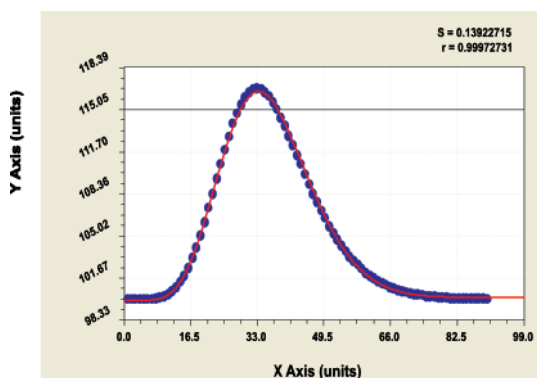
Fig. 2. Dynamics of wood square on taxation periods

From a fig. 1 it is visible, that there are points near schedules, that specifies on realized adaptability of the experts and population to wood square dynamics. Russia sharply differs in timber trade [6] from a fig. 2.
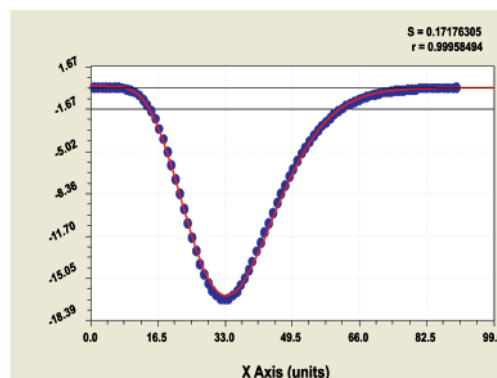
Crisis significance. The deal each component of a general trend (2) shows a significance of rather settlement wood square significances. The expressions $\alpha_2 = 100 S_2 / S$ and $\alpha_1 = 100 S_1 / S$ give from data of table 1 significance parameter dynamics (fig. 3):

$$\alpha_1 = 99,8883 \exp\left(2,79112 \cdot 10^{-5} t\right) + \\ +1,80118 \cdot 10^{-7} t^{6,57849} \exp\left(-0,035133 t^{1,39840}\right);$$

(33)

$$\alpha_2 = 0,16186 \exp\left(-0,038453 t\right) - \\ -2,47049 \cdot 10^{-7} t^{6,47619} \exp\left(-0,035997 t^{1,38907}\right).$$
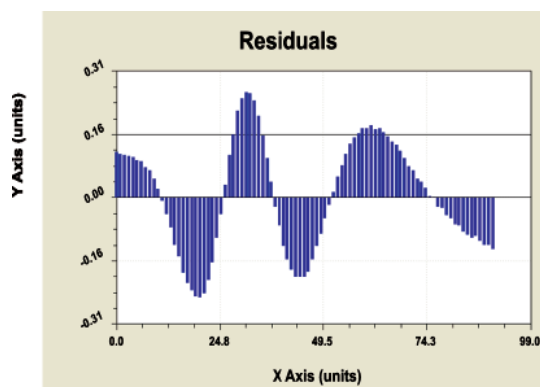
(4)

First component (2)   Crisis component of model (2)

Fig. 3. Dynamics of significance coefficient of Finland wood square
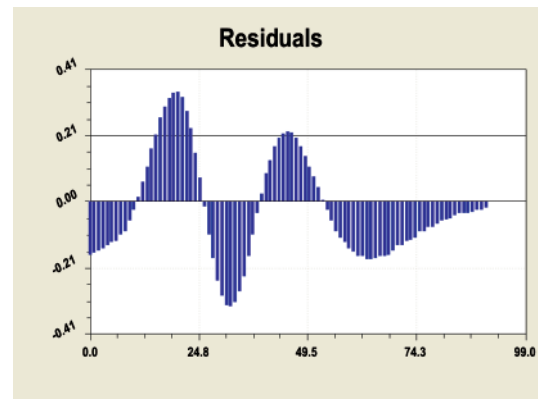   model (2) components

On a construction the models (3) and (4) are similar to a trend (2). Here both formulas were identified on settlement significances obtained on (2) in the software environments Excel. The residuals after (3) and (4) are indicated in a fig. 4, from which it is visible, that wave func-tion exists in addition to (2). Or else, not only crisis, realized by the Finns, but also natural oscil-latory wood square per-turbation exist. Therefore, third compo-nent as a perturbation wave can be refered, apparently, to a wood behaviour.

Obviously, that the sum of sig-nificance coefficients of two components trend model (2) is equal 100%, that is $\alpha_1 + \alpha_2 = 100$.

Residuals after the formula (3)   Residuals after the formula (4)

Fig. 4. Dynamics of residuals from models of significance coefficient of model (2) components

Staff adaptability. The realized professional activity of Finland wood line is known all over the world. For revealing regularities of staff behaviour, in the given example of the Finnish society, it is neces-sary in the beginning to accept, that first component of the formulas (2) charac-terizes natural process or main tendency, and second and consequent components in main depend on activity of th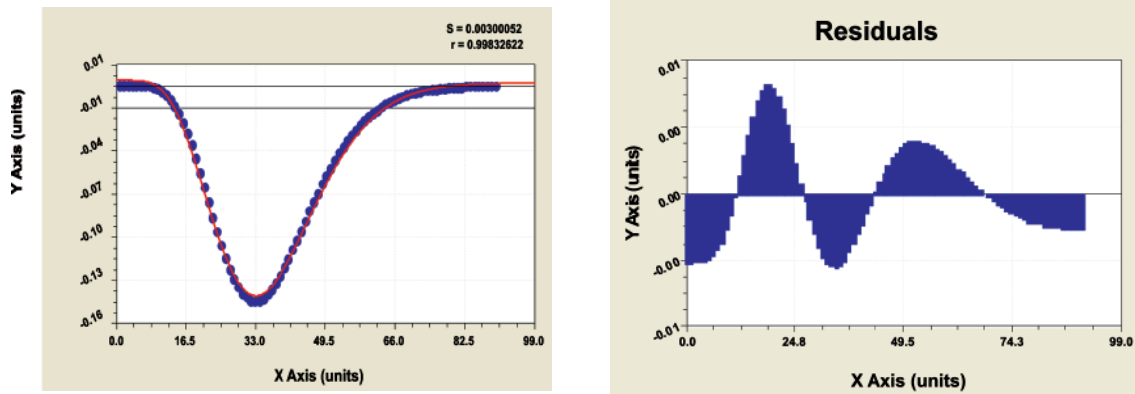e people. Thus, in the polynomial formula second and consequent not wave or wave compo-nents of general model characterize man impact. The second effect kind is precisely cha-racteristic for Finland wood economy. In substance it also is actual manifestation of a people and wood tree symbiosis.

Significance coefficient k, for the formula (2) calculated as the relation k_2 / k_1, ambassa-dor structural – para-metrical identifications [7] has received (fig. 5) formula

$$k = 0,0040897 \exp(-0,0065310t) -$$
$$-1,52343 \cdot 10^{-8} t^{6,00609} \exp(-0,069697 t^{1,21925}).$$

(5)

The more significance k in absolute magnitude, the activity of the given people popula-tion on use national natural riches becomes more intense. The negative sign shows crisis process. It will be stopped in Finland by a 2035 year.

The schedule of significance coefficient (5)

Dynamics of residuals after a model (5)

Fig. 5. Dynamics of adaptability of the population and Finland wood economy to wood territory

The wave perturbation small and it coincides by time. The wood square in dynamics could be shown with high adequacy only on a trend (2). Though the oscillatory perturbation sig-nificance is small, however from a methodical view point wave perturbation has scientific and common sense. The oscillation can affect the future.

Wave perturbation. For the analysis of wave dynamics we shall accept a trend (2) $S = S_2$ and on its residuals shall obtain the asymmetric wavelet-function [5, 6] (fig. 6a). And after joint parametrical identification we have received trinomial dynamics model:

$$S = S_1 - S_2 - S_3; \tag{6}$$

$$S_1 = 20198,054; \qquad S_2 = 1,90352 \cdot 10^{-6} t^{8,19420} \exp\left(-0,15924 t^{1,10266}\right);$$

$$S_3 = A\cos\left(\frac{\pi t}{p} - 1,38781\right);$$

$$A = 8,65852 \cdot 10^{-13} t^{10,77139} \exp\left(-0,13253 t^{1,06568}\right);$$

$$p = 11,56241 - 0,21116 t^{0,32671},$$

where S – square of woods of Finland for 86 years in dynamics in a period of 1921–2007 years, t/ha;

S_1 – stable wood square part in a period of wood measurements, t/ha;

S_2 – critical wood square part in a period of 1925–2035 years. By a duration per 110 years a part of woods, т. Га;

S_3 – oscillatory perturbation of woods on square, which is response to a behaviour of the people, t/ha;

A – amplitude half of wave perturbation of a wood as organism, t/ha;

p – half of variable period of oscillatory perturbation of a wood on square, years.

The period of oscillation in 1921 year was equal to 2·11,56241 ≈ 23,1 years or is approx-imately equal to two cycles of solar activity on Tchizhevsky effect [3–6]. In a period of 86 years the Finns have reduced in wood perturbation frequency increase, and this frequency in 2007 year was equal to 1/(2·10,66) = 0,0469 year–1 and by a 2100 year the half cycle of wood perturbation will decrease to 10,41 years, that is all on 100·(11,56 – 10,41)/11,56 = 9,95%. The woods of Fin-land on square and in XXI century will change within the limits of the double cycle of solar ac-tivity till 2035 year. It means, that the interference of the Finns in life of the woods is eco-logical-ly responsible, and they reach an economic acceptability of wood exploitation at the expense of import of sticks [6].

Hereafter it is possible to conduct a component analysis for revealing a complex of bio-technical regularities of dynamics of woods on such parameters as geostatistical distribution of subcompartment, pfytocenosis elements, specific structure of wood trees, their age structure, vo-lumes of trunk timber, category of a sanitary state and other.

a) wave component of model (6) b) the schedule on all triadic model (6)
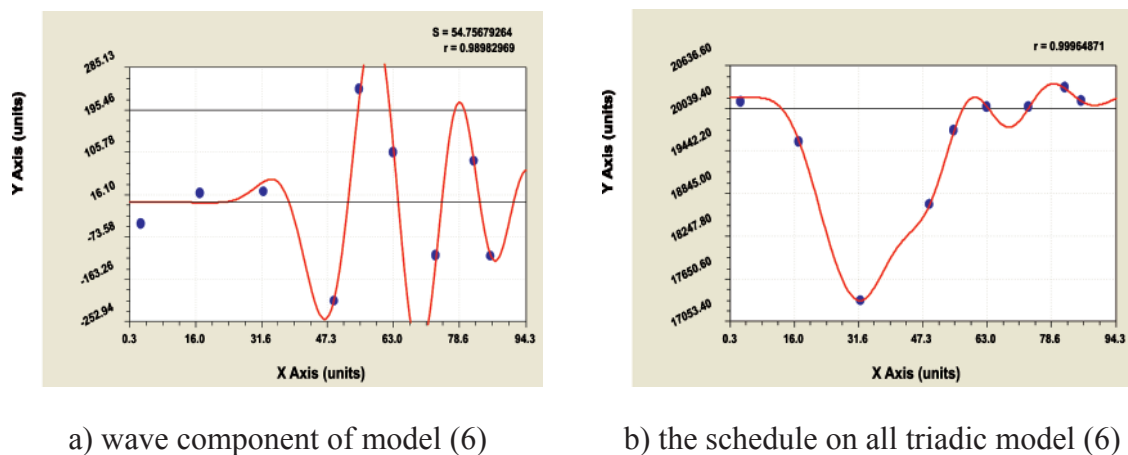
Fig. 6. Finland wood square dynamics in a period of 1921-2007 years

Though we have not found the publications under the wave wood theory of Finland and other countries, but the realized behaviour of the people, to begin with wood experts, in Finland is visible under the schedules in a fig. 6 as realized measures and outcomes in wood management.

Avareness of wood policy. The amplitude-frequency characteristic of wave component shows scientific validity forestry-based measures (fig. 7). Wood policy clearly preempts programs of timber trade, and it was visible 40 years back [2].

In the beginning XXI centuries the priorities of Finland were changed and timber trade has become active to develop. Experience of forestry management and, in particular, the reach-ings in wood statistics, can give new breathing to all wood economy sector of this wood country. In particular this experience will be useful to Russia.

Wood management dynamism. Dynamism coefficient $K_\text{д}$ is determined as the relation of the sum of a wave model co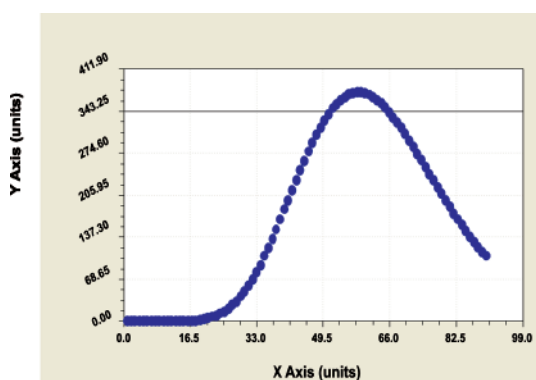mponent to a class of trend parts, that is not wave model compo-nents (6), that is on expression $K_\text{д} = S_3 / (S_1 - S_2)$.

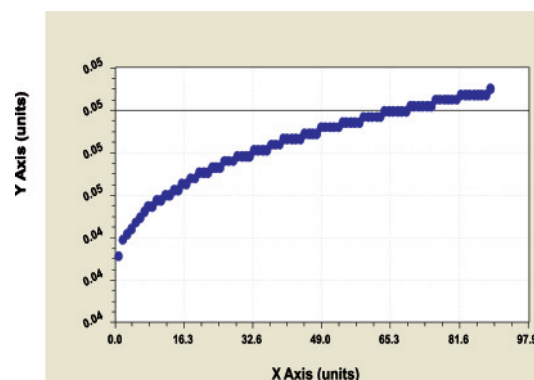After identification the model (fig. of 8) of wood dynamism coefficient is obtained

$$K_\text{д} = A\cos\left(\frac{\pi t}{p} - 1,66671\right);$$

$$A = 3,32793 \cdot 10^{-12} t^{7,26959} \exp\left(-0,10811 t^{1,03192}\right);$$

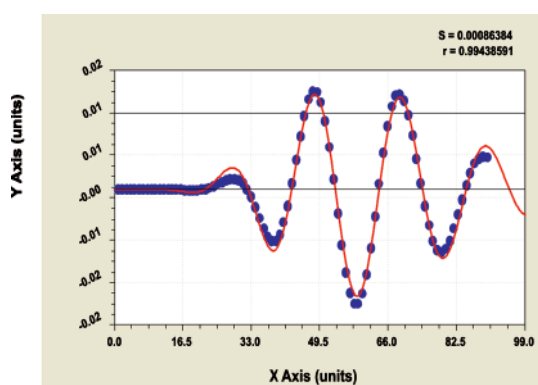$$p = 10,65031 - 0,00073133 t^{1,09209}.$$

Amplitude of oscillatory perturbation
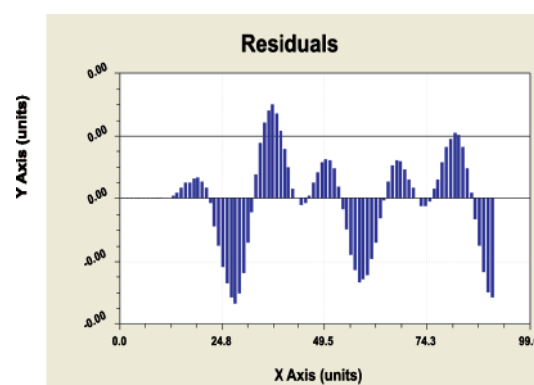of the Finnish woods

Frequency of wave wood behaviour

Fig. 7. Dynamics of amplitude and frequency of Finland wood oscillation on square

Dynamism coefficient
of the Finnish woods on (7)

Residuals after a model (7)

Fig. 8. Dynamics of Finland wood square dynamism coefficient

The high adequacy to a model (7) allows to approve, that management of woods in Finland re-sults in stabilization using decrease of dynamism coefficient on wood square (table 2).

From the residual schedule in a fig. 8 it is visible, that the microwaves begin since 1933 year. However, the data of wood statistics on wood farms are necessary for their identification. Models (6) and (7) are high-precision within the limits of a Finland wood square measurement error.

Table 2

Dynamism of Finland wood square

Years	Time t, years	Extremum $K_д$	
		growth	recession
basis of the prognosis			
1930	9	-	0,00001
1940	19	0,00048	-
1949	28	-	0,00360
1959	38	0,00994	-
1969	48	-	0,01563
1980	59	0,01724	-
1990	69	-	0,01518
2000	79	0,01114	-
Advance of the prognosis			
2010	89	-	0,00709
2021	100	0,00416	-
2031	110	-	0,00223
…	…	…	…
2078	157	-	0,00001

In data of table 2 the maxima (wood square recession) and minima (parameter growth) under the schedule in a fig. 8 are indicated. Let's remind that the wave perturbation in the formula (6) has negative sign. Therefore global minimum in a fig. 8 $\left| K_{д\,max\,max} \right| = 0,01724$ shows a forest yield.

The half-cycle of dynamism coefficient have a remarkable property. They in time period of 1990–2010 years almost coincide with the solar activity cycle beginnings. Finnish foresters have managed actively to use Tchizhevsky effect on 23-th cycle of solar activity in a period of 1999–2009 years, most force from measured by the astronomers. Apparently, concurrence is not casual, and quite realized. System of wood statistics and data vsk 08_01 pdf help revelation this coincidence.
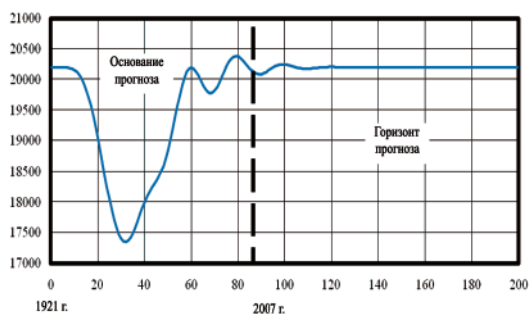
Prognostic model. Under the formulas (6) and (7), and also data of table 2, the cycle of modern wood policy of Finland on a wood square parameter will be finished in a 2078 year and will proceed 148 years. Dynamism coefficient is extremely small in relation to an allowable

condition $K_{д} \leq 1$. At that it the maximum significance of wave component in the formula (6) is equal to 1,84% for 1980 year, and zero significance is achieved by 2055 year.
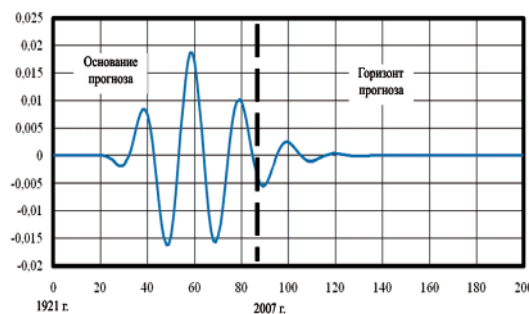
Therefore for an evaluation macroeconomic parameters of a wood sector it is enough to accept trend of the formula (6) for drawing up prognostic model. In an outcome is received, that the 1921 year wood square level Finland will achieve by 2020 year. Hereafter national wood can qualitative be improved without square growth. But the dynamic numbers on oth-

er wood para-meters are necessary for the analysis.

Finland wood square forecasting. When model (6) adequacy with a coefficient of cor-relation 0,9996 (see fig. 6) is high it is quite possible to accept horizon of the prognosis equal to prognosis basis length. The basis is equal to 86 years, therefore under horizon of the prognosis also in a period of 86 years the limit of all time series per 192 years or per 1921 + 192 = 2113 years is received. The schedules in a fig. 9 and fig. 10 are constructed in a period of 200 years, that is till a 2121 year.
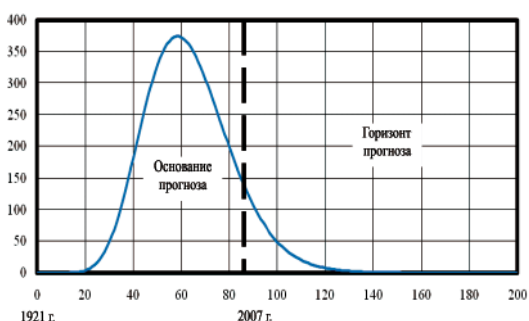
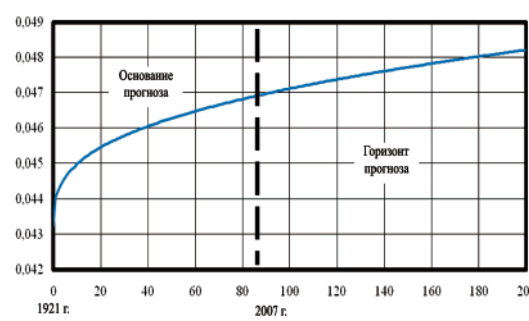a) schedule on all triadic model (6)

b) dynamism coefficient of wood on square

Fig. 9. Prognostic Finland wood square dynamics

Amplitude of oscillatory Finnish wood perturbation

Frequency of a wave wood behaviour

Fig. 10. Prognostic dynamics of amplitude and frequency of Finland wood oscillation on square

Two variants prognostic models are possible: at first, by forecasting till a 2040 year all construction of a model (6) is accepted; secondly, since 2040 year it is possible to accept only equation $S = S_1 = 20198{,}054$ without second and third components.

Conclusions. It is possible to suppose, that on other parameters of Finland woods the sta-tistical models with high adequacy to appropriate dynamic numbers accepted from wood statis-tics of this country will determined.

On wood square dynamics we formulate the following main conclusions:

1) The territorial principle is precisely executed and recovery for 86 years with 1921 for a 2007 years specifies on that. At that rather small significance crisis trend and oscillatory compo-nents of dynamics model on wood square confirms excellence of long-term wood management;

2) Adaptability of Finland to the woods is very high, at that without high society tug, and the crisis on wood square was overcome on regularity of aperiodic oscillation;

3) Small on amplitude the wave perturbations will cease in the near future, though force the microoscillations will possible at a level of separate composite of wood farms; prognostic model shows an approximation of national wood square to constant significance, and it specifies high skill Finnish foresters, and their centenary wood management experience will be distributed and to other wood countries, including Russia;

4) For revealing a full limit of growth on square and other wood parameters it is necessary to conduct a component analysis in an annual mode and on other parameters all wood sub-compartments, and also to reveal biotechnical regularities of dynamics in geostatistical distribu-tions of country territory on land cadastre categories.

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