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VACCINIUM VITIS-IDAEA IN ESTONIA

2. BIOMASS, RESOURCES AND THEIR RATIONAL EXPLOITATION

One of the parameters characterizing the growth of the cowberry (*Vaccinium vitis-idaea* L.) is its biomass. The aim of the present work is to compare the biomass of the cowberry in different forest site types and to examine difficulties of its prognostication and relations with other growth parameters and site type conditions. Besides the estimation of drug resources it is also essential, from the viewpoint of the protection of the species, to know the restoration rate of the biomass and to determine the amount of gathering which would guarantee the preservation of resources. Considering the distribution and amount of drug resources, drug gathering regions are suggested which could also be regarded as suitable berry-gathering areas.

The mean weight of cowberry ramets, the weight of ramets per unit area and the biomass of ramets

The minimum mean fresh weight of one ramet in a coenopopulation (the mean of 100 ramets) was 0.13 g while the maximum exceeded 0.70 g. The occurrence frequency of ramets with the fresh weight from 0.41 g to 0.45 g was the greatest (28.3%) while about 80% of all ramets ranged between 0.31 g and 0.55 g (Fig. 1). The mean fresh weight of one ramet was the biggest in the *Calluna* (further *Call.*) site type (0.50 g) and slightly smaller in other forest site types, while its variation was small: $V=17$—23% (see Table 2, Pihlik, 1991). By fresh weight of ramets (further 10 dm² fresh weight) we refer to the total fresh weight of ramets cut from ten 1 dm² squares at the height of the moss or lichen layer. The

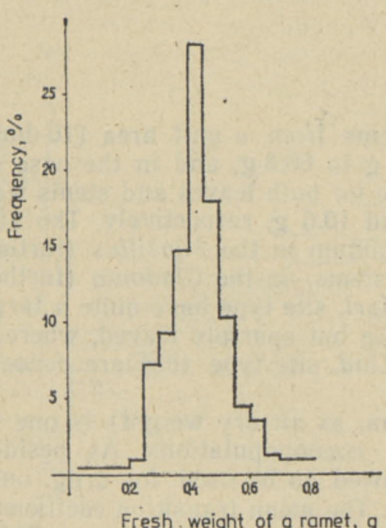

Fig. 1. Distribution of the mean fresh weight of one cowberry ramet, %.

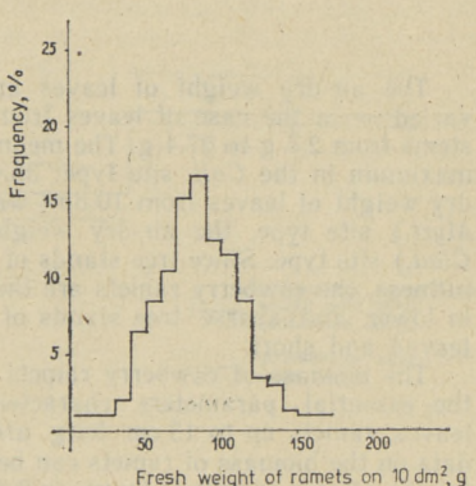

Fig. 2. Distribution of the fresh weight of cowberry ramets on 10 dm², %

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minimum 10 dm² fresh weight in coenopopulations was below 30.0 g and could reach up to 200.0 g, but its distribution differed from that of the previous parameter (Fig. 2). The 10 dm² fresh weight ranges mostly from 71 g to 80 g (15.2%) and from 81 g to 90 g (16.8%) and decreases quite evenly towards both extremes. Although the interval of the 10 dm² fresh weight is large, the mean values of different site types and variation are quite similar. The mean of this growth parameter was also greater in the *Call.* site type, 98.5 g. The relation between the 10 dm² fresh weight and the mean length of ramets is shown in Fig. 3.

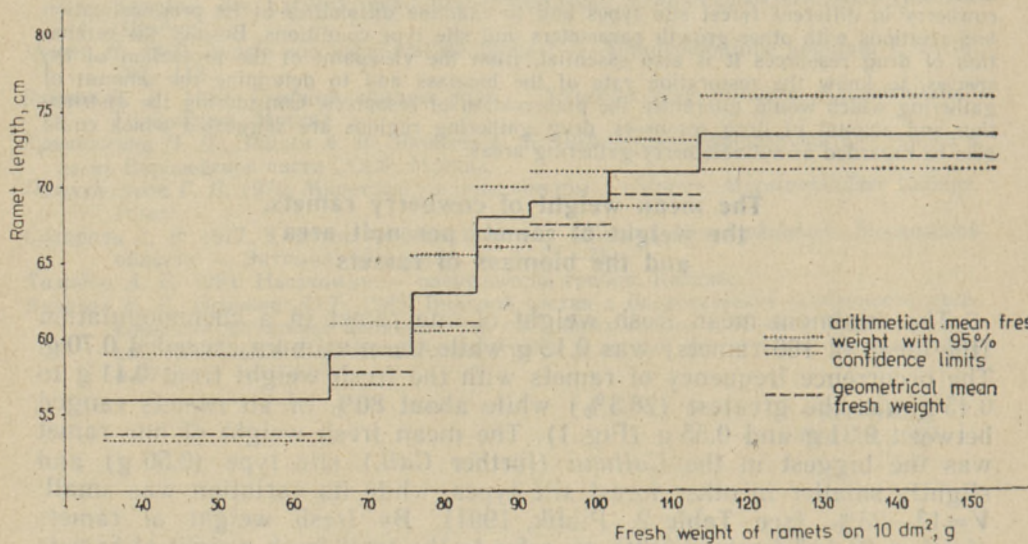

Fig. 3. Relation between the ramet length and the fresh weight of the cowberry ramets on 10 dm².

The air-dry weight of leaves and stems from a unit area (10 dm²) varied — in the case of leaves from 13.5 g to 66.8 g, and in the case of stems from 2.3 g to 27.4 g. The mean value for both leaves and stems was maximum in the *Call.* site type: 36.4 g and 10.6 g, respectively. The air-dry weight of leaves from 10 dm² was minimum in the *Myrtillus* (further *Myrt.*) site type, the air-dry weight of stems, in the *Cladonia* (further *Clad.*) site type. Since tree stands of the *Myrt.* site type have quite a large fullness, the cowberry ramets are there long but sparsely leaved, whereas in lower and sparse tree stands of the *Clad.* site type they are densely leaved and short.

The biomass of cowberry ramets (kg/ha, as air-dry weight) is one of the essential parameters characterizing coenopopulations. As besides leaves, ramets up to 13 cm long are allowed to be used for drug, only data on the biomass of ramets can be used. The mean transition coefficient for the air-dry weight of leaves is 0.36 (the mean of all analyses, $n=311$). The distribution of the biomass of ramets (Fig. 4) shows that in about 1/4 of the coenopopulations this parameter is under 100 kg/ha and in 2/3 of the coenopopulations, under 300 kg/ha. Coenopopulations in which the biomass of cowberry ramets is over 600 kg/ha should be considered rare in Estonia since their occurrence frequency is only 6%.

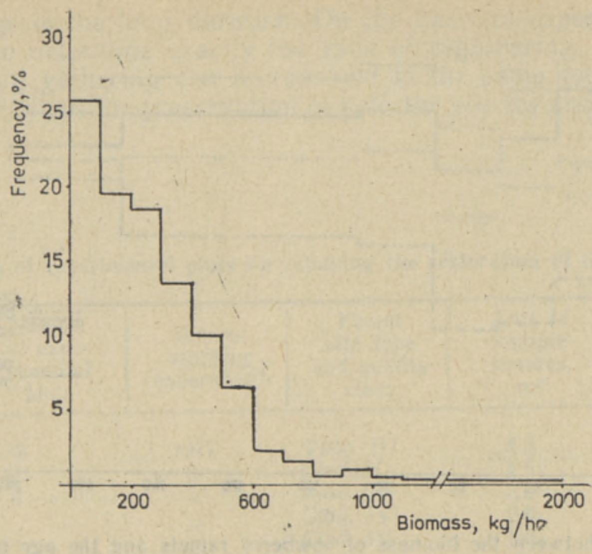

Fig. 4. Distribution of the biomass of cowberry ramets, %.

The comparison of cowberry biomass in Estonia and other regions is quite complicated as data in literature refer sometimes to the biomass of leaves, sometimes to that of ramets and references to the degree of drying may be lacking altogether. However, it can be said that the aboveground biomass of the cowberry is smaller in spruce forests and birch forests and is the greatest in larch forests in Siberia and in the Magadan Region where the mean values can reach up to 1500 kg/ha (Юдина et al., 1986).

The biomass of ramets varies to the greatest extent, according to our data, in the *Vaccinium* (= *Rhodococcum*, further *Vacc.*) site type ($V = 97.3\%$) where also the minimum and maximum values occurred.

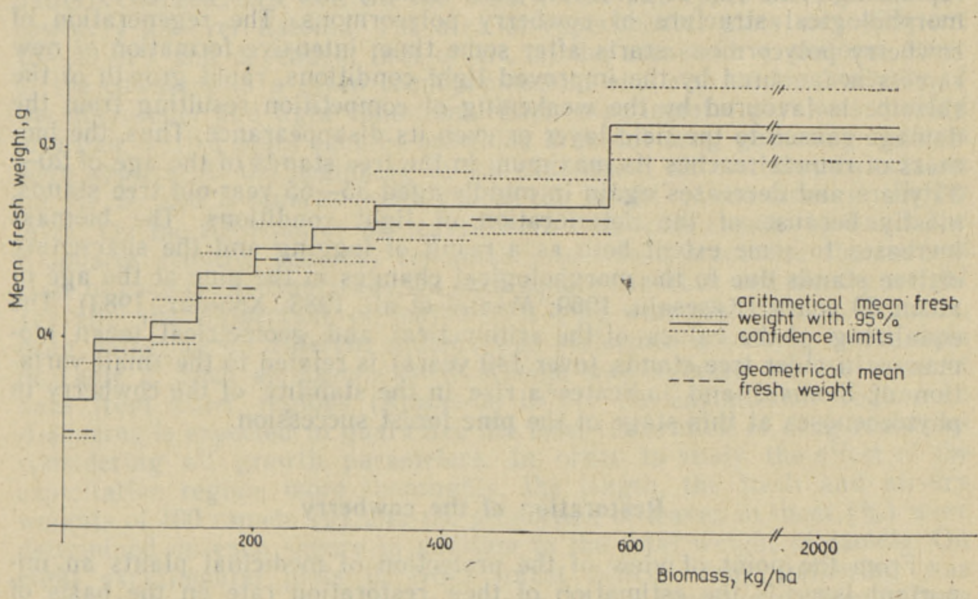

Fig. 5. Relation between the biomass of cowberry ramets and the mean fresh weight of one ramet.

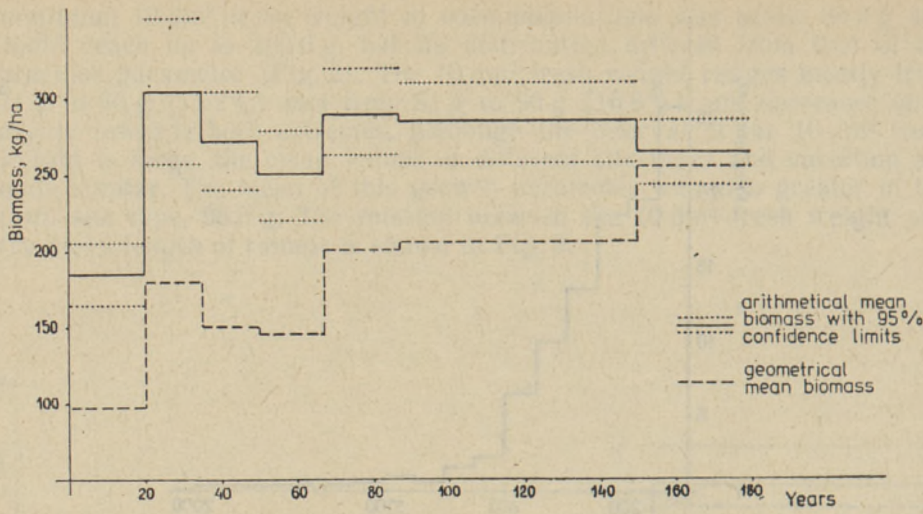

Fig. 6. Relation between the biomass of cowberry ramets and the age of the tree stand.

Ramet biomass was quite variable also in the *Myrt*, site type. The mean biomass of ramets was the smallest in the *Myrt.* site type, 139 kg/ha, the greatest in the *Call.* site type, 378.8 kg/ha; in other site types it ranged from 234 to 278 kg/ha. The relation between the biomass of cowberry ramets and the mean fresh weight of one ramet is shown in Fig. 5 and the relation between the biomass and the age of the tree stand in Fig. 6, where both the arithmetical mean together with the 95% confidence limits and the geometrical mean are given. If an increase in the mean weight of a ramet is accompanied by an increase in the biomass of ramets, the relation between the biomass and the age of the tree stand is much more intricate. The minimum biomass in tree stands of the age under 20 years is evidently due to the damage caused to the field layer in the course of logging and replanting. This can be estimated both visually and from the study of the morphological structure of cowberry polycormons. The regeneration of cowberry polycormons starts after some time; intensive formation of new ramets is favoured by the improved light conditions, rapid growth of the rhizome is favoured by the weakening of competition resulting from the damage caused to the field layer or even its disappearance. Thus, the biomass of ramets reaches its maximum in the tree stands of the age of 20—35 years and decreases again in middle-aged 35—65 year-old tree stands, mostly because of the deterioration of light conditions. The biomass increases to some extent both as a result of logging and the sparsening of tree stands due to the morphological changes in the pine at the age of about 60 years (Kasesalu, 1969; Малый et al., 1983; Хромых, 1983). The equalizing of the values of the arithmetical and geometrical mean biomasses in older tree stands (over 140 years) is related to the small variation of biomass and indicates a rise in the stability of the cowberry in phytocoenoses at this stage of the pine forest succession.

Restoration of the cowberry

From the point of view of the protection of medicinal plants an important issue is the estimation of their restoration rate on the basis of growth parameters (especially biomass) after gathering the drug. The most reliable data could be obtained through a natural experiment, but its disadvantage is the long duration. On the basis of experimental data it is possible to determine exactly the time of regathering, i. e. a period after which drug gathering can be repeated in the same coenopopulation and which guarantees the preservation of both the species and its resources in the habitat.

Table 1

Characteristics of experimental plots for studying the restoration of the cowberry

Forest district	Number of experimental plots	Year of starting experiment	Forest site type and quality class	Area of sample squares, m^2	Number and indices of sample squares
Valgejõe	1—2	1977	*Vacc.* III	4.5	4(*C*, *B*, *A*, *K*)
	4—5	„	*Clad.* V	4.5	„
	3; 6	„	*Vacc.* III	3.0	„
	7	„	*Clad.* IV	2.6	„
	8	„	*Clad.* IV	1.0	„
Nõva	1; 4	1978	*Clad.* V^a	1.0	5(*C*, *B*, *A*, *KK*, *K*)
	3	„	*Clad.* V	1.0	„
	2; 6; 8	„	*Clad.* IV	1.0	„
	5	„	*Vacc.* III	1.0	„
	7	„	*Call.* IV	1.0	„
Lodja	1	1977	*Vacc.* II	1.5	5(*C*, *B*, *A*, *KK*, *K*)
	2; 3	1978	*Vacc.* III	1.0	„
	4	„	*Call.* IV	1.0	„
Taheva	1; 2	1978	*Vacc.* III	1.0	5(*C*, *B*, *A*, *KK*, *K*)

The experimental plots of our natural experiment were situated in four forest districts in a total of 22 coenopopulations (Table 1). Such a pattern characterizes well all the main forest site types suitable for the cowberry all over Estonia. The area of experimental plots was different (5—30 m^2) and depended, first of all, on the area with a uniform cover of the cowberry in a given coenopopulation, and also on the stability of the microrelief and light conditions. Each experimental plot was divided into four or five equal squares on which different drug gathering regimes were applied. At the beginning of the experiment all cowberry ramets on the *A*-, *B*- and *C*-squares were cut at the height of the moss or lichen layer. On the *KK*-squares all leaves were torn from ramets by hand, the *K*-squares (control squares) remained intact to characterize the natural state of each coenopopulation. On each square the fresh and air-dry weight (g) and the proportion of leaves in it (%) were determined. Further, drug gathering on different squares was performed according to the data in Table 2. Such an experimental scheme was selected on the basis of data from other regions (Крылова, 1976); the exploitation regime on *A*-squares is expected to guarantee the total restoration of drug resources considering all growth parameters. In order to study the effect of the exploitation regime more thoroughly, the length, the fresh and air-dry weights of 100 ramets (g) and the proportion of leaves in them (%) were determined on each square in addition to the total weight of ramets. On eight experimental plots in Nõva forest district drug gathering was repeated five years after the first series of the experiment, then ramets were cut from all squares (*C*, *B*, *A*, *KK*, *K*) with all the above growth parameters determined.

On the basis of natural experiments and indirect methods used for the determination of the optimum exploitation regime the period of time for the total restoration of cowberry resources in various parts of the Soviet Union is 3—8 years (Крылова, Трембаля, 1978; Богданова, 1980; Воронова, 1981; Зайцева, Белоногова, 1981; Юдина, Максимова, 1983; Борисова, Лошаков, 1986; Миронов, 1986; et al.) Evidently, the restoration rate is characteristic of the region and depends both on climatic and site type conditions. In most cases the time of the next gathering is determined by means of one series of experiments; the effect of repeated gathering has been studied only in Karelia (Юдина, Максимова, 1983).

Table 2

Experiment design for the determination of the restoration rate of the cowberry

Index of sample squares	*C*	*B*	*A*	*KK*	*K*
Year of drug gathering	1977 (or 78) 1978 (or 79) 1979 (or 80) 1980 (or 81)	1977 (or 78) — 1979 (or 80) —	1977 (or 78) — — 1980 (or 81)	1977 (or 78) — — 1980 (or 81)	— — — 1980 (or 81)
Interval of drug gathering	annual gathering	1-year interval	2-year interval	2-year interval	gathering at the end of experiment
Way of drug gathering	ramet cutting	ramet cutting	ramet cutting	leaf tearing	ramet cutting

In our experiment the weight of ramets on *C*-squares with annual gathering in Nõva, Lodja and Taheva forest districts was restored up to 14.3—55.4% of the original weight by the second year, up to 4.9—27.2% by the third year and up to 1.9—36.0% by the fourth year. On *B*-squares with the 1-year-interval exploitation regime the weight of ramets was restored up to 16.4—96.9% and on *A*-squares with the 2-year-interval exploitation regime up to 21.1—196.8%. On *KK*-squares where leaves were torn from ramets by hand the weight of leaves at the end of the experiment after four years was restored up to 16.2—131.7% of the original weight. Although data on the Valgejõe forest district, where the experiment was set up a year earlier, concern the weight of leaves only, the restoration rate on different squares was similar to that of the other districts: on *C*-squares 27.0—44.6%, 8.4—38.5% and 5.8—22.7%; on *B*-squares 30.9—61.4%; on *A*-squares 29.9—69.0%. It is obvious that the annual exploitation regime on *C*-squares leads to the decrease of resources and to the total degradation of the population. This conclusion was supported also by the second series of experiments performed 5 years after the end of the first experiment. On most experimental plots the viability of cowberry ramets on *C*-squares was considerably weaker than on the other plots, and they grew mostly in shade under *Calluna vulgaris*, *Empetrum nigrum* and *Vaccinium myrtillus*. After such an influence, i. e. the cutting of ramets in four consecutive years, the cowberry cannot compete with the above-mentioned species with intense vegetative reproduction during a long period of time. The restoration of the weight of cowberry ramets in a repeated experiment after five years on *C*-squares was 38.8—

138.0%, on *B*-squares 34.5—134.9% and on *A*-squares 30.5—145.0% of the original weight, and on *KK*-squares 38.5—226.5% of the original weight at the end of first series of the experiment. The weight of the beginning of the experiment on all squares was restored only in two coenopopulations out of eight.

Thus, we can see that in our conditions the weight of ramets was not restored totally on any of the 22 experimental plots during three years, and that the weight was restored in the repeated exploitation regime only on two experimental plots out of eight after a five-year period of time. Consequently, in our conditions the restoration of the biomass of cowberry ramets after drug gathering in most habitats takes 6—7 years and the interval of repeated gathering can be considered 8 years. Perhaps in the case of optimum growth conditions the interval of repeated gathering could be 6 years. As to the way of drug gathering, only the cutting of ramets is appropriate, since the tearing of leaves causes total destruction of ramets and the growth of new ramets takes more time than after ramet cutting.

Table 3

Effect on repeated drug gathering on various growth parameters of the cowberry in different forest site types

Growth parameter	Index of sample squares	Forest site type and quality class		
		Clad., V—V^a	*Clad.*+*Call.*, IV	*Vacc.*, II—III
Mean length of ramets, cm	*K*	4.82±0.64	6.13±0.93	6.71±0.71
	KK	3.42±0.28	6.15±1.07	6.50±0.94
	A	4.07±0.78	5.00±0.51	5.53±0.39
	B	3.89±0.57	4.89±0.62	5.13±0.30
	C	3.00±0.32	3.20±0.30	3.58±0.18
Air-dry weight of 100 ramets, g	*K*	13.1±0.5	14.9±1.9	16.9±2.5
	KK	9.9±1.2	12.9±1.7	15.4±2.0
	A	10.8±1.7	13.4±1.3	13.9±1.0
	B	8.8±1.0	13.6±1.7	12.9±0.8
	C	6.5±0.4	7.9±0.9	7.3±0.3
Proportion of leaves in air-dry weight of ramets, %	*K*	76.1±3.4	72.8±2.8	66.3±2.7
	KK	81.8±0.2	69.7±4.5	66.7±1.9
	A	80.0±2.1	77.2±2.5	74.4±1.7
	B	78.7±2.0	79.3±1.7	76.8±0.7
	C	81.3±1.5	82.0±1.0	80.5±0.9

In order to examine the effect of drug gathering as an anthropogenic factor, we examined the effect of different exploitation regimes on the length and weight of cowberry ramets and on the percentage of the weight of leaves in the total weight. For this purpose we compared the mean length of 100 ramets from squares with different exploitation regimes with the mean length of 100 ramets from *K*-squares on the basis of the modified *t*-criterion (Tiit et al., 1977). It appeared that the gradual decrease in the mean ramet length on *C*-squares at the end of the experiment differed significantly ($P=0.05$) on all 22 experimental plots. On *B*- and *A*-squares the mean ramet length of 2/3 of the experimental plots and on *KK*-squares of 1/2 of the experimental plots turned out to be significantly different from the mean ramet length of *K*-squares (Table 3). The weight of ramets decreased, too, as a result of an intensive exploitation regime.

The smallest ramet weight and length occurred in the *Clad.* site type of quality class V—V[a] with its low soil fertility and humidity, the biggest values occurred in the *Vacc.* site type of quality class II—III. The proportion of leaves is, on the contrary, the largest just on *C*-squares, since there the stems are not lignified. The repeated gathering regime affects also the distribution curve of ramet lengths, as the experiment in the Nõva forest district showed. The distribution curve of ramet lengths characteristic of this area did not correspond to it even after a five-year interval.

Thus, it can be concluded that the restoration of the cowberry after drug gathering is slow even in its principal site types and that annual gathering in one and the same coenopopulation can destroy it totally.

Relations between the biomass of cowberry ramets and other growth parameters

Since the preliminary correlation analysis showed that the growth parameters of the cowberry are in correlation with soil fertility (content of carbonates) and soil humidity characterizing the forest site types, these relations were further analysed in the main forest site types separately. Data on carrying out the analysis are presented in the first part of the work (Pihlik, 1991); here we shall present the conclusions. In Fig. 7 only stronger correlations are shown where the correlation coefficient $r \geqslant 0.60$.

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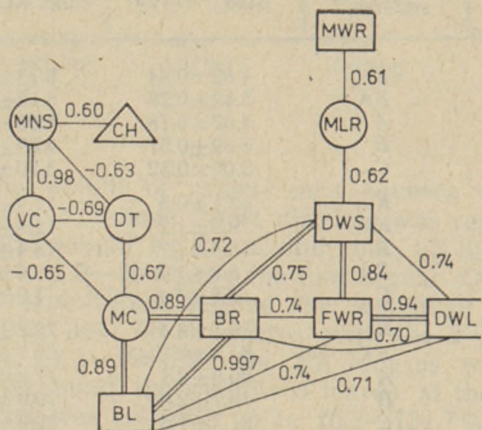

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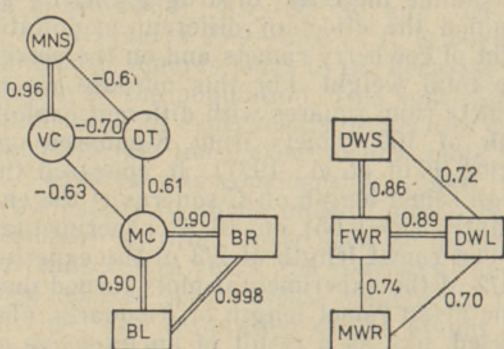

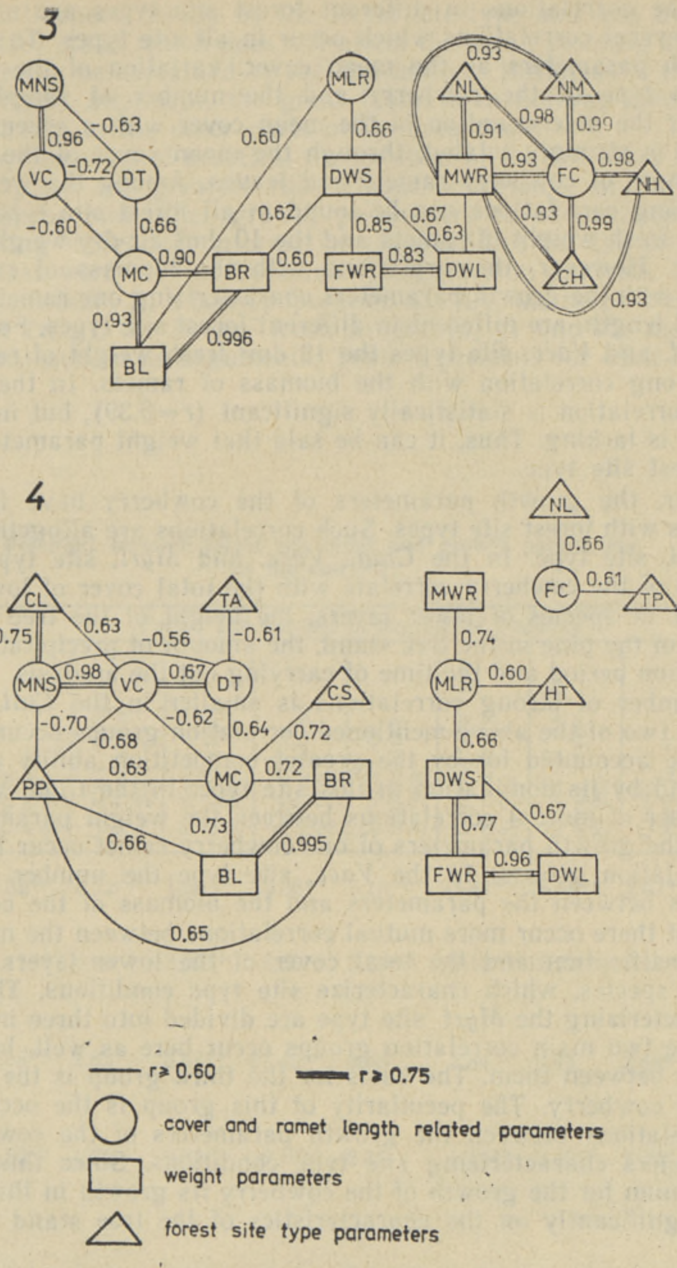

Fig. 7. Correlations between basic growth parameters of the cowberry and forest site type conditions in different site types ($r \geqslant 0.60$, significance level 0.05): *1 — Clad.*, *2 — Call.*, *3 — Vacc.*, and *4 — Myrt.* site type, MC — mean cover of cowberry, VC — variance of cowberry cover in the analysis, DT — distribution type of cowberry, MNS — minimum number of sample squares for the determination of mean cowberry cover with required accuracy, BR — biomass of cowberry ramets, BL — biomass of cowberry leaves, FWR — fresh weight of ramets on 10 dm², DWL — air-dry weight of leaves on 10 dm², DWS — air-dry weight of stems on 10 dm², MWR — mean fresh weight of one cowberry ramet, MLR — mean length of cowberry ramets, FC — fructification of cowberry, HT — height of tree stand, PP — proportion of pine in tree stand, CS — cover of dwarf-shrub layer, CH — cover of herb layer, CM — cover of moss layer, CL — cover of lichen layer, NH — number of species in herb layer, NM — number of species in moss layer, NL — number of species in lichen layer, TP — total precipitation in a given region, TA — time of analysis (month).

Although the correlations in different forest site types are not similar, there are several correlations which occur in all site types. To one group belong such parameters as the mean cover, variation of the cover, the distribution type of the cowberry and the number of sample squares required for the determination of the mean cover with a given accuracy. This group is strongly related, through the mean cover of the cowberry, to the biomass of cowberry ramets and leaves. Among the weight parameters, strong correlations can be found in all forest site types between the 10 dm^2 fresh weight of ramets and the 10 dm^2 air-dry weight of stems and leaves. However, their relations with the biomass of ramets and leaves and with the growth parameters characterizing one ramet, the mean weight and length, are different in different forest site types. For example, in the *Clad.* and *Vacc.* site types the 10 dm^2 fresh weight of ramets is in a quite strong correlation with the biomass of ramets. In the *Call.* site type this correlation is statistically significant ($r=0.39$), but in the *Myrt.* site type it is lacking. Thus, it can be said that weight parameters depend on the forest site type.

However, the growth parameters of the cowberry have few strong correlations with forest site types. Such correlations are altogether lacking in the *Call.* site type. In the *Clad.*, *Vacc.* and *Myrt.* site types growth parameters of the cowberry correlate with the total cover of lower layers, the number of species of lower layers, the height of the tree stand, the proportion of the pine in the tree stand, the amount of precipitation during the vegetation period and the time of carrying out the analysis.

The number of strong correlations is smaller in the *Call.* site type where only two of the above-mentioned correlation groups occur. That can probably be accounted for by the greater competition ability of *Calluna vulgaris* and by its domination in this site type. In the *Clad.* site type, a large number of mutual correlations between the weight parameters, biomass and the growth parameters of one cowberry ramet occur besides the main correlation groups. In the *Vacc.* site type the number of mutual correlations between the parameters and the biomass of the cowberry is smaller, but there occur more mutual correlations between the mean ramet weight, fructification and the total cover of the lower layers and their number of species, which characterize site type conditions. The correlations characterizing the *Myrt.* site type are divided into three independent groups. The two main correlation groups occur here as well, but there is no relation between them. The basis for the third group is the fructification of the cowberry. The peculiarity of this group is the occurrence of many correlations between the growth parameters of the cowberry and the parameters characterizing site type conditions. Since this site type is not optimum for the growth of the cowberry its growth in this site type depends significantly on the characteristics of the tree stand and lower layers.

By means of the one-way analysis of variance, the dependence of the biomass of cowberry ramets and leaves as well as other growth parameters (cover and its variation, ramet length, fresh weight of one ramet, 10 dm^2 fresh weight of ramets) on site type conditions was examined (Table 4). Although the correlation between the biomass of ramets and leaves is very strong, there exist differences in the effect of site type conditions on the biomass of ramets and leaves. The differences are especially vivid in the case of such site type conditions whose effect is not very strong (e. g. age group of the tree stand, density of the understorey). In the case of a factor of a strong effect, however, no differences occur between the biomass of ramets and leaves (e. g. in the distribution type of the cowberry). In general, on the basis of this analysis it can be said that out of all the factors studied a large number of growth parameters are influenced mostly by the forest site type and less by the fullness of the tree stand which does not affect the mean biomass at all. This circumstance can be explained by the non-uniform thickness of tree stands within one forest allotment, the great biomass in hollows compensating for its small size in the other parts of the tree stand.

From the viewpoint of practical exploitation of the cowberry resources, its biomass plays the greatest role. Hence, knowledge of the relations between biomass and other growth parameters is of practical interest besides offering theoretical information. Possibilities for the prognostication of biomass were studied by means of regression analysis. The mean cover of the cowberry in a coenopopulation ($\bar{x}$, %), the mean fresh weight of one ramet (z, g), the 10 dm² fresh weight (u, g) and the mean ramet length (p, cm) served as arguments. Table 5 presents for each forest site

Table 4

Relations between forest site types and growth parameters of the cowberry

Growth parameter	Factor and number of degrees of freedom								
	Forest site type 3; 262	Quality class of tree stand 5; 260	Fullness of tree stand 7; 258	Age group of tree stand 2; 263	Density of understorey 2; 263	Distribution type of cowberry 3; 262	Cover of dwarf-shrub layer 8; 257	Cover of herb layer 8; 257	Cover of moss layer 9; 256
Mean cover of cowberry, %	7.32**	4.22**	1.50	3.86*	5.16**	73.81**	18.09**	2.67**	2.92*
Variance of cowberry cover in analysis	4.17**	4.98**	3.02**	6.56**	3.09*	176.52**	15.73**	2.17*	3.19*
Mean ramet length of cowberry, cm	10.38**	2.82*	5.57**	27.42**	3.68*	1.84	0.44	2.48*	10.94**
Mean fresh weight of one ramet of cowberry, g	4.82**	1.72	0.82	6.10**	2.35	5.83**	3.79**	2.12*	1.10
Fresh weight of ramets on 10 dm², g	3.08*	1.21	2.52*	0.88	3.06*	8.79**	2.07*	1.68	1.88
Biomass of cowberry ramets, kg/ha	6.12**	3.48**	0.99	3.41*	2.23	35.04**	12.98**	3.24**	3.35**
Biomass of cowberry leaves, kg/ha	5.19**	2.33*	1.10	2.52	4.77**	40.99**	11.81**	2.44*	3.21*

* effect on the significance level $P=0.05$
** $P=0.01$

Table 5

Prognostication of the cowberry biomass on the basis of its cover (x, %), mean fresh weight of one ramet (z, g), fresh weight of ramets on 10 dm^2 (u, g), and mean height of ramets (p, cm) in different forest site types

Regression equation	r^2	$T/T_{0.05}$	$F/F_{0.05}$
Cladonia			
$B=-43.003+50.3x$ (1)	0.792	14.59/2.00	212.75/4.02
$B=-278.182+39.571x+3.485u$ (2)	0.941	19.27/ „ 11.87	442.49/3.17
Calluna			
$B=-16.351+49.669x$ (3)	0.891	17.39/2.00	302.47/4.11
$B=-167.246+49.816x+300.329z$ (4)	0.916	19.61/ „ 3.28	196.59/3.26
$B=-288.505+48.002x+2.899u$ (5)	0.962	27.99/ „ 8.25	459.33/3.26
$B=-180.374+48.783x+25.705p$ (6)	0.913	18.71/ „ 3.00	188.39/3.26
Vaccinium			
$B=-27.662+49.94x$ (7)	0.768	23.23/2.00	539.6/ 3.91
$B=-289.325+44.092x+688.002z$ (8)	0.819	21.11/ „ 6.79	367.58/3.06
$B=-295.157+44.406x+3.407u$ (9)	0.888	28.52/ „ 13.16	641.43/3.06
$B=-195.628+49.971x+26.698p$ (10)	0.820	26.32/ „ 6.86	369.48/3.06
$B=-313.439+44.914x+3.099u+6.75p$ (11)	0.890	28.62/ „ 10.14 1.86	435.25/2.67
$B=-297.558+46.316x+428.658z+16.986p$ (12)	0.833	22.02/ „ 3.55 3.65	268.17/2.67
Myrtillus			
$B=-2.67+40.452x$ (13)	0.950	19.95/2.11	398.17/4.54
$B=-47.510+40.555x+100.508z$ (14)	0.957	21.16/ „ 1.88	224.68/3.74
$B=-53.438+37.91x+0.725u$ (15)	0.969	21.37/ „ 3.56	316.45/3.74
$B=-40.576+41.579x+4.488p$ (16)	0.962	22.19/ „ 2.48	250.80/3.74
Uliginosum			
$B=-71.257+54.169x$ (17)	0.771	4.85/2.36	23.51/6.61
$B=-288.746+47.561x+2.856u$ (18)	0.940	7.44/ „ 4.10	46.74/6.94
Total			
$B=1.681+42.262x$ (19)	0.715	27.83/1.96	774.54/3.87
$B=-229.49+39.253x+569.309z$ (20)	0.768	27.70/ „ 8.42	510.22/3.03
$B=-295.217+39.214x+3.671u$ (21)	0.883	39.75/ „ 20.98	1157.93/3.03
$B=-184.147+45.45x+27.858p$ (22)	0.801	34.99/ „ 11.58	621.3/3.03
$B=-312.029+40.456x+3.241u+7.737p$ (23)	0.887	39.11/ „ 15.25 3.45	803.16/2.63
$B=-238.535+43.759x+214.19z+22.973p$ (24)	0.806	30.78/ „ 2.78 2.77	425.85/2.63

type first the regression equation in which the mean cover of the cowberry is the argument, followed by other equations in which the determination coefficient r^2 is greater than in the first equation and all regression coefficients are practically significant ($P=0.05$). We can see that in the case of the *Clad.* site type only one equation (2), in which the 10 dm^2 fresh weight of ramets is used as the second argument, proved to be suitable besides the basic equation; as a result, the accuracy of prognostication rises considerably. In the case of the *Call.* site type it is possible to use, besides the basic equation, also equations (4—6) in which the other growth parameters are used as the second argument. In the *Vacc.* site type equations (7—12) with three arguments (11—12) are also suitable but the simpler equation (9) is preferable whose prognostication accuracy ($r^2=0.888$) is practically not different from that of (11). In the *Myrt.* site type the situation is similar to that of the *Call.* site type while the prognostication accuracy here is somewhat higher. In the *Ulig.* site type (17—18) the results are close to those of the *Clad.* site type. Thus, we can see that the prognostication of the biomass of cowberry ramets on the basis of the mean cover of the coenopopulation is rather accurate ($r^2=0.715$—0.950) in all forest site types. For a still more accurate prognostication equations with two arguments can be used in which, in addition to the mean cover, the fresh weight of ramets per a square unit ($r^2=0.888$—0.969) is used. Table 5 also presents regression equations on the basis of summary data (19—24). We were interested if the difference between the basic equation of the biomass obtained from summary data (the mean cover of the cowberry being the argument) and the basic equations for various forest site types was significant. It appeared that the difference between the equations is significant since the *F*-relation calculated from the dispersion analysis (Pao, 1968) exceeds the critical value ($F_{(8;\,292)}=6.32 \gg F_{cr} \sim 3$). Consequently, in the prognostication of the biomass of cowberry ramets the regression equations corresponding to the above-given forest site types should be preferred.

Cowberry resources and their rational exploitation

In this work cowberry resources are presented as the air-dry weight. The biological resources in forest districts (Fig. 8) were determined according to the total area of the above forest site types (excl. forest site types with an area under 30 ha as nontypical in a given forest district). Since one of the principal problems in production biology is avoiding the overestimation of resources, we based our study on the geometrical mean biomass of each forest site type, which diminishes the effect of a few exceptionally large biomasses. The mean values used were the following: *Call.* site type 325.4 kg/ha, *Clad.* site type 196.7 kg/ha, *Vacc.* site type 151.5 kg/ha, *Ulig.* site type 139.9 kg/ha, and *Myrt.* site type 54.4 kg/ha.

The total biological resources of the cowberry in Estonia are, according to our data, 36.9 thousand tons (Table 6). Among the forest enterprises the greatest resources are to be found in the Valgamaa forest enterprise (over 3000 t) followed by Alutaguse, Aegviidu, Rakvere, Hiiumaa, Võru, Läänemaa and Räpina forest enterprises (3000—2500 t) and by Saaremaa and Kilingi-Nõmme forest enterprises (over 2000 t).

However, biological resources are not the most essential from the point of view of exploitation since here belong also forest allotments of low cowberry productivity. Thus, forest allotments of economic value, where the mean cover of cowberry coenopopulations was over 5%, formed about 55% of the tree stands studied. Therefore, we estimated economic

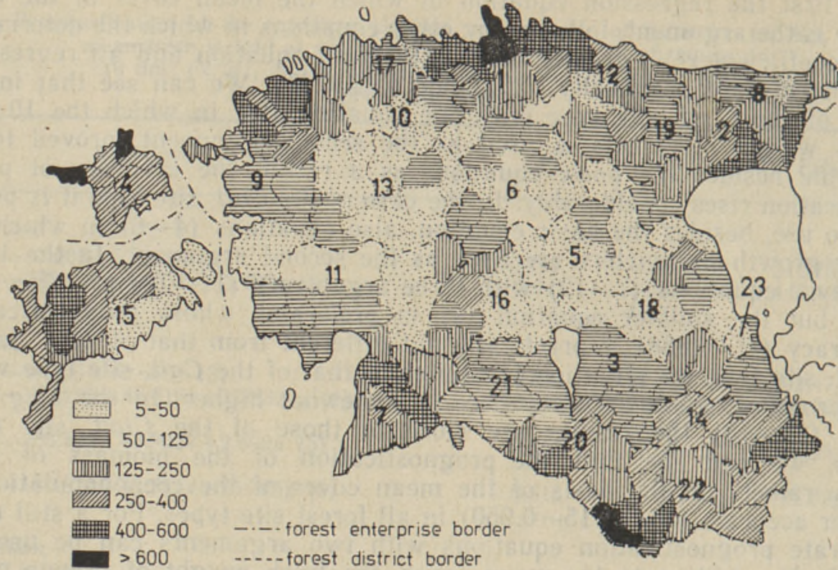

Fig. 8. Biological resources of the cowberry ramets biomass per forest district, t. 1—23 forest enterprises (see Table 6).

Table 6

Distribution and resources of the biomass of cowberry ramets in Estonia

Forest enterprises	Biological resources, t					Economic resources, t	Maximum annual resources of drug, t
	Clad.	*Call.*	*Vacc.*	*Myrt.*	*Ulig.*		
1. Aegviidu	455	988	772	284	407	1567.1	190.1 + (5.6)
2. Alutaguse	112	1030	627	518	647	1609.8	191.6 + (9.5)
3. Elva	0	119	1048	298	67	798.9	61.3 + (38.4)
4. Hiiumaa	334	1528	353	366	166	1508.2	188.5
5. Jõgeva	3	56	128	393	128	305.0	29.3 + (8.7)
6. Järvamaa	16	52	194	257	71	268.8	0 + (33.6)
7. Kilingi-Nõmme	9	213	244	1160	508	1164.6	120.7 + (24.8)
8. Kohtla-Järve	162	125	155	216	133	380.7	15.9 + (31.6)
9. Läänemaa	311	987	648	437	241	1404.0	136.1 + (39.3)
10. Mahtra	0	2	39	60	17	36.2	0 + (4.5)
11. Pärnu	222	130	372	509	166	711.3	44.5 + (44.4)
12. Rakvere	335	687	1155	489	224	1561.9	177.8 + (17.4)
13. Rapla	0	8	25	228	48	37.8	0 + (4.7)
14. Räpina	36	230	1540	653	86	1391.0	127.0 + (10.0)
15. Saaremaa	209	924	986	134	199	1309.6	163.7
16. Suure-Jaani	8	133	83	292	161	319.6	33.6 + (6.3)
17. Tallinn	183	546	259	106	136	648.3	69.5 + (10.7)
18. Tartu	2	234	317	384	43	426.0	40.5 + (12.6)
19. Tudu	1	38	163	561	87	449.8	12.5 + (43.6)
20. Valgamaa	77	574	1904	627	106	1798.2	218.2 + (6.5)
21. Viljandi	0	96	231	437	176	475.3	23.7 + (35.7)
22. Võru	56	323	1449	775	29	1433.8	152.3 + (26.7)
23. Järvselja	0	5	14	26	0	0	0

Note: In brackets resources of forest districts of category *R* (reserve) are presented.

resources to be 55% of the biological resources. When the economic resources of a forest district were under 30 t, they were not included in the economic resources of the forest enterprise. The reasons for such calculations were both the noneconomic drug gathering in the case of scanty and mostly scattered resources and nature conservation. As a result, the economic resources of the cowberry in Estonia were estimated as 19.6 thousand tons. Since, however, the cowberry should be evaluated, first of all, as a berry plant, this value should be regarded as potential economic resources. For the gathering of the drug only these forest allotments are suitable where the cowberry does not fructify. Potential economic resources are again the largest in the Valgamaa forest enterprise (about 1800 t) followed by the other above-given forest enterprises in the same order.

As it was mentioned above, the time for repeated gathering guaranteeing total restoration of the cowberry resources in our conditions, is considered to be 8 years. Thus, the annual (potential) gathering capacity is only 1/8 of the economic resources. In further calculations the forest districts whose annual (potential) gathering capacity is less than 4 t are neglected since their resources have only local importance and can satisfy solely local needs. According to the annual potential gathering capacity the forest districts were divided into the so-called economic categories which show how promising an area is for picking berries and gathering the drug under a special management regime: I — above 40 t, II — 30—40 t, III — 21—30 t, IV — 11—20 t and *R* (reserve)-category — 4—10 t. In Table 6 the resources of *R*-category are not included in the total resources of forest enterprises but are given separately in brackets. According to our analysis only 4 forest districts belonged to category I, 12 forest districts to category II, 23 forest districts (from 13 forest enterprises) to category III, 46 forest districts (from 18 forest enterprises) to category IV. The total annual (potential) gathering capacity of cowberry ramets in Estonia is approximately 2000 t. It is the greatest in the forest enterprises of Valgamaa, Alutaguse, Aegviidu, Hiiumaa, Rakvere, Saaremaa, Võrumaa and Läänemaa forest enterprises and satisfactorily big in the forest enterprises of Räpina and Kilingi-Nõmme.

It would be advisable to set up areas with a special management regime within the forest districts of categories I and II (in the presence of other necessary preconditions also categories III or IV). Main attention here should not be paid to obtaining timber; such areas would be managed (at least partially) as habitats of berry and medicinal plants where also apiculture could be developed. The first such special area in Estonia was set up in the Nõva forest district in 1985 (Селарт et al., 1989). Such a practice would be advantageous within a certain distance (about 50—100 km) from greater towns and cities since it enables to collect medicinal drugs of reliable quality and preserve the best berry-gathering areas through the dispersion of human influence, let alone the diversification of recreation facilities in nature.

Conclusion

It can be concluded, on the basis of our data, that the fresh weight of one cowberry ramet, the fresh weight of ramets from 10 dm^2, the air-dry weight of leaves and stems from 10 dm^2 as well as the air-dry biomass of ramets fluctuate within quite a large range. However, in comparison with other forest site types the mean value of all these parameters is the greatest in the *Call.* site type. It became clear that the biomass of ramets depends on the age of the tree stand since ecological conditions under a tree stand change with its age.

On the basis of a natural experiment carried out for the determination of the restoration rate of cowberry ramets (in 4 different forest districts, altogether in 22 coenopopulations) it can be concluded that the restoration of the cowberry in our conditions is rather slow. Annual gathering of the drug had an especially harmful effect, which could lead to total destruction of the population. We consider the proper interval of repeated gathering to be 8 years, i. e. gathering of the drug in the same population can be repeated only in the 8th year. This period is somewhat longer than most of those suggested in literature, but it guarantees safe restoration of cowberry resources.

Among stronger correlations occurring between the biomass of ramets and other more significant parameters ($r \geqslant 0.60$) the four forest site types studied showed certain similarities as well as essential differences. Reliable prognostication of the biomass of ramets is possible on the basis of several parameters of a coenopopulation. The simplest and at the same time quite an exact way to do this is to use the mean cover of the coenopopulation applying the regression equation corresponding to the forest site type.

According to our data the air-dry biological resources of cowberry ramets in Estonia are 36.9 thousand tons while the essential economic resources are 19.6 thousand tons. Since, however, the cowberry is valued first of all as a berry plant, the real drug gathering capacity is considerably smaller.

Considering the annual potential drug gathering capacity, the forest districts are divided into 5 categories. Proposals are made as to the setting up of new areas with a special management regime in higher-category forest districts, which would enable a more rational exploitation of the resources of the cowberry both as a berry and medicinal plant. On such special areas it would also be possible to arrange the gathering of the drug of other medicinal plants which grow there.

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Ulve PIHLIK

POHL EESTIS

2. Biomass ja varud ning nende ratsionaalne kasutamine

Töö eesmärk oli võrrelda pohla biomassi erinevates kasvukohtades, selgitada selle prognoosimise võimalusi ning uurida seoseid teiste kasvukohanäitajate ja -tingimustega. Lisaks droogivarude määramisele on oluline kindlaks teha ka biomassi taastumiskiirus, et määrata varude säilimist tagav varumismahu suurus. Vastavalt droogivaru suurusele on välja toodud perspektiivsed varumisrajoonid, mis on arvestatavad ka marjaaladena.

Pohla ühe võrse keskmine toormass kõikus 0,13—0,70 g, kuid enamasti oli vahemikus 0,31—0,55 g. Suurim oli see kasvunäitaja kanarbiku kasvukohatüübis — 0,50 g. Võrsete toormass 10 dm² ulatus 30—200 grammini, kuid jaotus ühtlasemalt kui eelmine näitaja. Metsakasvukohatüüpidest oli keskmine kõrgeim kanarbiku kasvukohatüübis — 98,5 g. Lehtede ja varte õhukuiv mass samalt pinnalt varieerus lehtedel 13,5—66,8 g ning vartel 2,3—27,4 g.

Pohla võrsete biomass on üks olulisi tsönopopulatsioone iseloomustavaid suurusi. Võrsete biomassi jaotumise analüüs näitas, et veerandis tsönopopulatsioonides on see alla 100 kg/ha ning tsönopopulatsioone biomassiga üle 600 kg/ha tuleb Eestis pidada haruldaseks (esinemissagedus ainult 6%). Biomassi absoluutne maksimum esines pohla kasvukohatüübis. Keskmine võrsete biomass oli madalaim mustika kasvukohatüübis (139 kg/ha) ning maksimaalne kanarbiku kasvukohatüübis (378,8 kg/ha). Võrsete biomassi ja puistu vanuse vaheline sõltuvus on üsnagi keerukas: minimaalne on biomass noorendikes, saavutab maksimumi umbes 20—35 aasta vanustes puistutes, väheneb uuesti keskealistes ning suureneb mõningal määral jälle vanemaealistes puistutes.

Ravimtaimede varude kaitse seisukohalt on oluline biomassi taastumiskiiruse määramine. Loodusliku eksperimendi põhjal võib järeldada, et pohla biomassi taastumine Eesti männikutes (22 tsönopopulatsioonis) on aeglane. Varude täieliku taastumise tagamiseks nii biomassi, võrsete pikkuse, ühe võrse massi, lehtede osa massis kui ka võrsete pikkuste jaotumiskõvera alusel tuleb taasvarumisajaks arvestada kaheksa aastat. Droogi varumise viisidest sobib ainult võrsete lõikamine.

Pohla võrsete biomassi korrelatiivseid seoseid teiste kasvunäitajate ja -tingimustega analüüsiti neljas peamises metsakasvukohatüübis eraldi. Tuli ilmsiks küllalt tugevaid ($r \geqslant 0{,}60$) seoseid. Kõigis metsakasvukohatüüpides esines kaks põhilist seoste gruppi. Ühe moodustavad pohla katvuse poolt määratud tunnused, teise aga mõned kaalulised näitajad. Korrelatiivsed seosed metsakasvukohatüüpides on erinevad. Ühefaktorilise dispersioonanalüüsi põhjal võib järeldada, et uuritud faktoritest mõjub pohla kasvunäitajatele enam metsakasvukohatüüp ning vähe puistu täius.

Biomassi üsna tõepärane prognoosimine on võimalik ainult ühe argumenttunnuse — pohla populatsiooni keskmise katvuse — alusel kõigis metsakasvukohatüüpides ($r^2 = 0{,}715—0{,}950$). Täpsema prognoosi saab, kui lisada teise argumenttunnusena võrsete toormass 10 dm² ($r^2 = 0{,}888—0{,}969$). Statistiline analüüs näitas, et eelistada tuleb metsakasvukohatüübile vastavat regressioonvõrrandit.

Et produktsioonibioloogia üks põhiprobleeme on varude ülehindamise vältimine, siis kasutati arvestustes pohla võrsete geomeetrilist keskmist biomassi igas metsakasvukohatüübis: kanarbikutüübis — 325,4, samblikutüübis — 196,7, pohlatüübis — 151,5, sinikatüübis — 139,9 ja mustikatüübis — 54,4 kg/ha. Pohla võrsete bioloogiline varu Eestis on 36 900 t, majanduslikku huvi pakkuva kasutusvaru suurus on 19 600 t ning aastane potentsiaalne varumismaht ligikaudu 2000 t. Metskondade aastase potentsiaalse varumismahu alusel jagati metskonnad nn. majanduskategooriatesse, mis näitavad nende perspektiivikust majandamisel marja- ja ravimtaimede hooldusaladena: I — üle 40 t, II — 31—40 t, III — 21—30 t, IV — 11—20 t ja *R*(reserv)-kategooria — 4—10 t.

Ульве ПИХЛИК

БРУСНИКА В ЭСТОНИИ

2. Биомасса и запасы сырья и их рациональное использование

Целью данной работы было сравнение биомассы брусники в разных типах местопроизрастания леса, возможность ее прогнозирования и изучение связей с показателями местопроизрастаний и условий роста. Кроме определения запасов сырья важно установить скорость восстановления их, чтобы определить объем возможных заготовок сырья, гарантирующих сохранение запасов. На основе объема запасов сырья отмечены перспективные районы заготовок, которые также можно использовать как ягодники.

Средняя сырая масса одного побега брусники колеблется от 0,13 до 0,70 г, чаще от 0,31 до 0,55 г. Максимум этого показателя в вересковом типе леса достигает 0,50 г. Сырая масса побегов на участке величиной 10 дм^2 колебалась от 30 до 200 г, причем распределение ее было равномернее. Этот показатель был выше в вересковом типе леса — 98,5 г. Воздушно-сухая масса листьев на 10 дм^2 колебалась в пределах 13,5—66,8 г и у стеблей в пределах 2,3—27,4 г.

Биомасса побегов — один из существенных показателей ценопопуляций. На основе анализа распределения биомассы побегов брусники можно сказать, что в 1/4 ценопопуляций она менее 100 кг/га. Ценопопуляции с биомассой более 600 кг/га являются редкими (их частота 6%). Абсолютный максимум биомассы побегов брусники отмечается в брусничном типе леса, максимальные количества биомассы наблюдаются в вересковом типе леса (378,8 кг/га), а минимальные — в черничном типе (139,0 кг/га). Связь между биомассой побегов брусники и возрастом древостоя довольно сложная: биомасса минимальна в молодняках, достигает максимума в лесах 20—35-летнего возраста, уменьшается резко в средневозрастных и повышается опять в старых древостоях.

С точки зрения охраны запасов сырья очень важно знать скорость восстановления биомассы. На основе экспериментов в 22 ценопопуляциях можно сделать вывод, что восстановление запасов идет медленно. Для полного восстановления запасов сырья побегов брусники (на основе биомассы, высоты побегов, массы одного побега, доли листьев в общей массе, распределения высоты побегов) требуется 8 лет. При заготовке можно использовать только стрижку.

Корреляционные связи между биомассой побегов брусники и другими показателями и условиями роста исследовались в 4 основных типах леса. Отмечены довольно тесные корреляционные связи ($r \geqslant 0{,}60$). Для всех типов леса установлены две группы корреляционных связей, из которых одна основывается на проективном покрытии брусники, а другая — на некоторых весовых показателях. Необходимо отметить, что по разным типам леса связи различаются. На основе однофакторного дисперсионного анализа установлено, что из изученных факторов на показатели роста брусники больше всего влияет тип местопроизрастания леса, а меньше — полнота древостоя.

Прогнозирование биомассы побегов брусники на основе одного признака — среднего проективного покрытия брусники в ценопопуляции — довольно точное ($r^2 = 0{,}715$—$0{,}950$). Более точный прогноз можно получить путем включения в уравнение в качестве второго аргументного признака сырой массы побегов на 10 дм^2 ($r^2 = 0{,}888$—$0{,}969$). На основе дисперсионного анализа выяснилось, что предпочитаются регрессионные уравнения, установленные отдельно для каждого типа леса.

Так как главная проблема продукционной биологии — избежание переоценки запасов сырья, то использовали среднюю геометрическую биомассу, которая в вересковом составляла 325,4, лишайниковом — 196,7, брусничном — 151,5, голубичном — 139,9 и черничном типе леса — 54,4 кг/га. Итак, биологический запас сырья побегов брусники в лесах Эстонии 36,9 тыс. т, эксплуатационные запасы сырья 19,6 тыс. т и объем возможных (потенциальных) ежегодных заготовок сырья около 2000 т. На основе объема возможных ежегодных заготовок брусники лесничества разделены на 5 хозяйственных категорий: I — более 40 т, II — 31—40 т, III — 21—30 т, IV — 11—20 т и Р (резервная) — 4—10 т.