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ABOVE-GROUND ENERGY RESERVES AND ANNUAL ACCUMULATION OF ENERGY IN SHRUB AND HERB LAYERS IN ASS. *QUERCUS FRMNETTO+ QUERCUS CERRIS - FESTUCA HETEROPHYLLA+POA NEMORAUS* IN THE VAKAREL MOUNTAINS

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ABSTRACT

Ljubenova, M. I. (1994). Above-ground energy reserves and annual accumulation of energy in shrub and herb layers in ass. *Quereus frainetto+Quercus cerris - Fastuca heterophylla+Poa nemoralis* in the Vakarel mountains. Ekol.Zašt.Život.Sred., Vol.2., No.l, Skopje.

The above ground phytomass energy reserves of the shrub layer ammounts to 3,1S4 • 10 ^{6} KJ • ha"^{1} with an increase of 1,63-10^{6} KJ -ha"^{1} down the slope, 71,46% of them being concentrated in the seedling phytomass. The herb layer reserves are 15,342 • 10 ^{6} KJ • ha"^{1} (down the slope they increase with o,38 • 10^{6} KJ •ha"^{1}); the contribution of grass species being 71,46 %, of mixo-herbosa -20,31 %, of sedges - 4,21 %, of legumes species - 4,09 %. The annual accumulation of energy in shrub and herb layers are 34,95 % and 73,46% of their reserves.

Key words: energy reserves, annual accumulation, shrub layer, herb layer

ИЗВОД

Љубенова, М. И. (1994). Резерви на енергија на надземната фитомаса и годишна акумулација на енергијата во катот на грмушките и зелјестите растенија во асе. *Quercus frainetto+Quercus cerris - Festuca heterophylla+Poa nemoralis* во Вакарелските планини. Екол. Зашт. Живот. Сред. ,Том 2.. Бр.1, Скопје-

Резервите на енергија на надземната фитомаса во катот на грмушките достигнуваат до 3,184 ■ 10 KJ • ha"^{1} со зголемување од 1,63 • 10^{6} KJ • ha"^{1} на поголема инклинација. 71,46% од резервите се концентрирани во фитомасата на дабовиот подраСток. Резервите во катот на зелјестите растенија изнесуваат 15.342 • 10^{6} KJ • ha"^{1} (со зголемување на инклинацијата тие се покачуваат за0,38 • 10^{6} KJ • ha"); граминеите учествуваат со 71,46%, другите тревести видови со 20,31%, циперацеите - 4,21%, легуминозните видови - 4,09%. Годишната акумулација на енергија во катот на грмушките и зелјестите растенија изнесува 34,95% и 73,46% од нивните резерви.

Клучни зборови: резерви на енергија, годишна акумулација, кат на грмушки, кат на зелјести растенија.

INTRODUCTION

When evaluating the functioning of forest ecosystems the greatest attention is given to the tree layer. Although the contribution of the lower layers to the build up of phytomass and energy reserves is weak, they are important for the cycling of matter. That is why a number of authors treat this subject with due attention when studying the reserves and the annual energy accumulation (Бондев et al, 1984; Велчев et al, 1987; Лкзбенова 1991 and Лк)бенова и Бондев 1991).

OBJECT AND METHODS

The present paper is the result of an overall study of the structure, reserves and the primary production of the ass. *Quercus frainetto+Quercus cerris - Festuca heterophylla +Poa nemoralis* which is the most wide spread in the Vakarel mountains (about 30 km south-east of Sofia). The study is carried out in two plots situated on a slope inclined at 12-14 °, facing south and south-west, at 950 m a.s.l. The soil is planasol (Лкзбенова 1991, Лкзбенова и Бондев 1991). A detailed description of the environmental conditions, vegetation and the methods applied are given in the references, cited above.

The study was carried out in 3 years course in two plots, each with an area of 0,25 ha, situated lower (plot 1) and higher (plot 2) on a slope.

The total phytomass of the herb layer species is calculated according to Храмцова (1975); and of the shrub layer species - according to Ремезов et al. (1963) (using samples for each species - above ground branching of first order being taken as a sample).

The fractions of the phytomass caloriphic value were determined by burning out of absolutely dry samples in Gallencamp CBB 01t)L calorimeter.

A quantitative evaluation of the energy reserves accumulated in the phytomass of shrub and herb layer was made.

RESULTS

The energy equivalent of the seedling in the shrub layer is 19,1 KJ • g^{A}. The energy supplied by seedling leaves of *Quercus frainetto* Ten., *Quercus cerris* L. and *Quercus dalechampii* L. is lower than the energy of the leaves of the same species pertaining to the tree layer. For instance *Quercus cerris* L. leaves give off the highest calorific value (21,84 KJ • g"[1]) for tree and 19,67 for shrub layer, *Quercus, dalechampii* L. leaves come next (20,34 KJ • g"[1] and 19,22 KJ • g"[1] respectively) folowed by *Quercus frainetto* Ten. (19,66 KJ-g"[1] and 17,51 KJ ■ g"[1]) Seedling leaves of beech have energy equivalent amounting to 19,98 KJ • g"[1].

The energy of seedling branches (17,58 KJ • g"[1]) is lower than that for the tree layer (perennial - 20,70 KJ-g"[1]; annual 21,34 KJ-g"[1] and it approaches that obtained for trunk wood and tree bark 18,24 KJ • g"[1] and 17,99 KJ ■ g"[1] respectively).

The average calories for the brushwood branches are 19,89 KJ-g"[1], and for brushwood leaves - 19,63 KJ-g"[1]. Jumper leaves and branches give off the highest calorific value (20,15 and 20,53 KJ • g"[1] respectively), approaching those for the tree layer species (20,61 KJ-g" for leaves and 21,09 KJ-g"[1] for branches).

The average caloricity of above ground herb species phytomass is 18,61 KJ-g"[1] (Tab. 1).The phytomass of legumes species gives off the highest caloricity - 19,23 KJ-g"[1], followed by mixo-herbosa (18,60 KJ-g"[1]), grass species (18,36 KJ • g"[1]) and the sedges (18,01 KJ • g"[f]).

The bellowground phytomass (Лкзбенова 1991) gives off less caloricity (15,4 KJ-g"[1] on the average). For the bellowground phytomass the agrobiological group sequence is the same.

The calorific value of above ground herb species phytomass are in the range from 12,5 KJ • g"[1] *{Symphytumtuberosum* L.) to 22,106 KJ-g"[1] *{Teucrium chamaedrus* L.) - Tab. 1.

The energy equivalent of sprouts is 17,90 KJ-g"[1].

The dry phytomass gives off 18,42 KJ-g" for the shrub layer and 16,33 KJ-g"[1] for the herb layer on the average. The legumes species phytomass provides the highest caloricity followed by sedges (17,53 KJ-g"[1]), mixo-herbosa (16,19 KJ • g"[1]) and grass species 16,14 KJ • g"[1]).

The values obtained for the phytomass caloricity of the species are higher than those reported by other authors (Нинов et al. 1982) and close to those оґКовда(1973).

The average energy reserves of the shrub layer (Tab. 2) are 3,184 • 10^{6} KJ • ha"[1], with an increase in plot I and a decrease in plot II of 1,63 • 10^{6} Kg-ha"[1]. The greater part of the energy is concentrated in seedling phytomass - 77,29% and the energy accumulated in the branches (55,09%) prevails. Only 22,70% of shrub layer energy reserves are concentrated in brushwood phytomass, the graeter part of which are concentrated in the branches phytomass -13 %. The energy accumulated in dry phytomass is insignificant.

The annual accumulation is 1,11 ±0,38 • 10^{6} kg • ha"[1] and 80,85 % is assimilated by the seedling. In both groups (seedling and sprouts) leaves phytomass annualy accumulates greater amount of energy than branch phytomass but it does not build up great reserves because the leaves fall out every year:

for seedling-63,58% and sprouts-16,19%. Theannual energy accumulation is 34,95% of the energy reserves in the layer.

Through the litter-fall 0,89±0,3 ■ 10^6KJ • ha^1 fall in the litter layer which, on the average, represent 27,86% of the reserves and 79,70% of the annual energy accumulation.

The total energy reserves in the above ground phytomass of the herb layer are 15,34±0,3· IO^{6}KJ • ha"^{1}. They vary weakly in the coenoses and are 9,7 • IO^6 K J • ha lower than the below ground reserves. Annualy 11,27 ■ 10^6 KJ-ha"^{1} are accumulated or 73,46% of the above ground energy reserves in the herb layer.

The energy reserves of the herb species are 11,202±0,3 • 1(T KJ -ha"^{1}, which increase at plots situated on the lower part of the slope. The reserves of the grass species are the greatest and here enter the dominants - 8,002 • 10^6 KJ-ha"^{1} or this represents 71,46 % of the layer reserves. The contribution of each species is 1,143-10^6 KJ-ha"^{1} on the average. The sedges group has relatively great reserves too - 0,473• 10^6 KJ-ha"^{1} or 4,21 %; each species containing 0,118-10^6 KJ-ha"^{1} on the average. The group of legumes species, although comprising more species (7) compared to the sedges group (4) has smaller energy reserves: 0,459 ■ 10^6 KJ ha"^{1} or 4,09% -.0,066-10^6 KJ-ha"^{1} for each species on the average. The mixo-herbosa energy reserves are 20,31 % of the layer energy reserves, each species gives off 0,060 • 10^6 KJ • ha"^{1}, because this group has the greatest number of species - 38.

The species giving the greatest contribution to the herb layer energy reserves are as follows: *Festuca heterophylla* Lam. *Poa nemoralis* L., *Calamagrostis arundinacea* (L.) Roth., (Tab. 1).

The energy reserves in the phytomass of tree and shrub sprouts are only 0,071 • 10 KJ ha"^{1} for the coenoses on the average.

The basic part of the total energy reserves of the herb layer (Tab. 3) are accumulated in the phytomass of the first three energy clases, i.e. 18 species or 32,14% of the available species build up 92,68% of the layer energy reserves. It is interesting to note that the species in these classes form 95,66% of the herb layer.

The energy reserves in the dry above ground phytomass of the herb layer are about 4,072 ■ IO^6 KJ •ha"^{1}, the contribution of dry phytomass of the grass species being the greatest (70,64 %), followed by sedges (17,49%), mixo-herbosa (10,11 %) and that of the legumes species is the lowest (1,76%). Keeping in mind that the mixo-herbosa group is the biggest one (38 species), the contribution of these species is rather weak (each one with 0,011 • 10^6 KJ •ha"^{1}), legumes grasses - 0,009-10^6 KJ-ha"^{1}, sedges-0,178-10 ^{6} KJ-ha"^{1} and grass species - 0,41 MO^6 KJ-ha"^{1}.

The energy reserves of the dry above ground phytomass calculated for each species are greatest for *Festuca heterophylla* Lam (1,512 ■ 10^6 KJ • ha"^{1}), *Poa nemoralis* L.(0,791 • 10^6 KJ • ha"^{1}), *Carex caryohpyllea* La Tourr. (0,587 • 10^6 KJ • ha"^{1}), *Calamagrostisarumdinacea* (L.) Roth. (0319• 10^6 KJ-ha"^{1}), *Stellariaholostea*L: (0,163'\Φ KJ-ha'^{1}), *Dactylisglomerata*L. (0,151 • 10^6KJ-ha"^{1},*Luzula luzuloides* Lam. (0,075 • 10^6 KJ • ha"^{1}) and lower in other species. The energy reserves of the cited 7 species amount to 88,39% of the total energy reserves ia the dry phytomass of the layer.

CONCLUSION

The energy equivalent of leaves of the brushwood (19,63 and 19,89-10^6KJ-ha"^{1} respectively) and of the seedling (19,106 ■ 10^6 KJ • ha"^{1} and 17,58 • 10^6 KJ-ha"^{1}) is lower then that of tree layer (21,61 • 10^6 KJ • ha^1 and 21,09 • III^6 K J• ha"^{1}). The leaves of *Quercus cerris* give off the higtest4;aloricity (21,84 • 10^6 KJ • ha"^{r}for the tree sad 19,67 • 1Q^5 KJ • ha"^{1} for the shrab layer.

The average caloricityof the-above ground phytomass of the herb species (18,61 • 10^6 KJ-ha"^{1}) is higher then that determined for the below ground phytomass (15,40 • 10^6 KJ ■ ha"^{1}) and that of sedges - the lowest (18,01 • 10^6 KJ-ha"^{1}).

The energy obtained per gram of absolutely dry phytomass corresponds to great extent to that reported by Тооминг (1977).

The average above ground energy reserves in the shrub layer are 3,147- 10^s KJ ha .The greater part of it (77,29%) is concentrated in seedling phytomass. The annual energy accumulation is 34,95% of the layer energy reserves. 27,86% of the reserves and 79,70% of the energy annualy accumulated in the layer enter the litter layer through the litter-fall.

The average above ground energy reserves in the herb of grass species is 71,46%, of mixo-herbosa - 20,31 %, of sedges - 4,21 and of legumes species - 4,09% of the total energy accumulated in the above ground phytomass of herb species.

The species, taking part with 1 and over 1 % in herb layer number of species build up 81,63 % of herb layer energy reserves.

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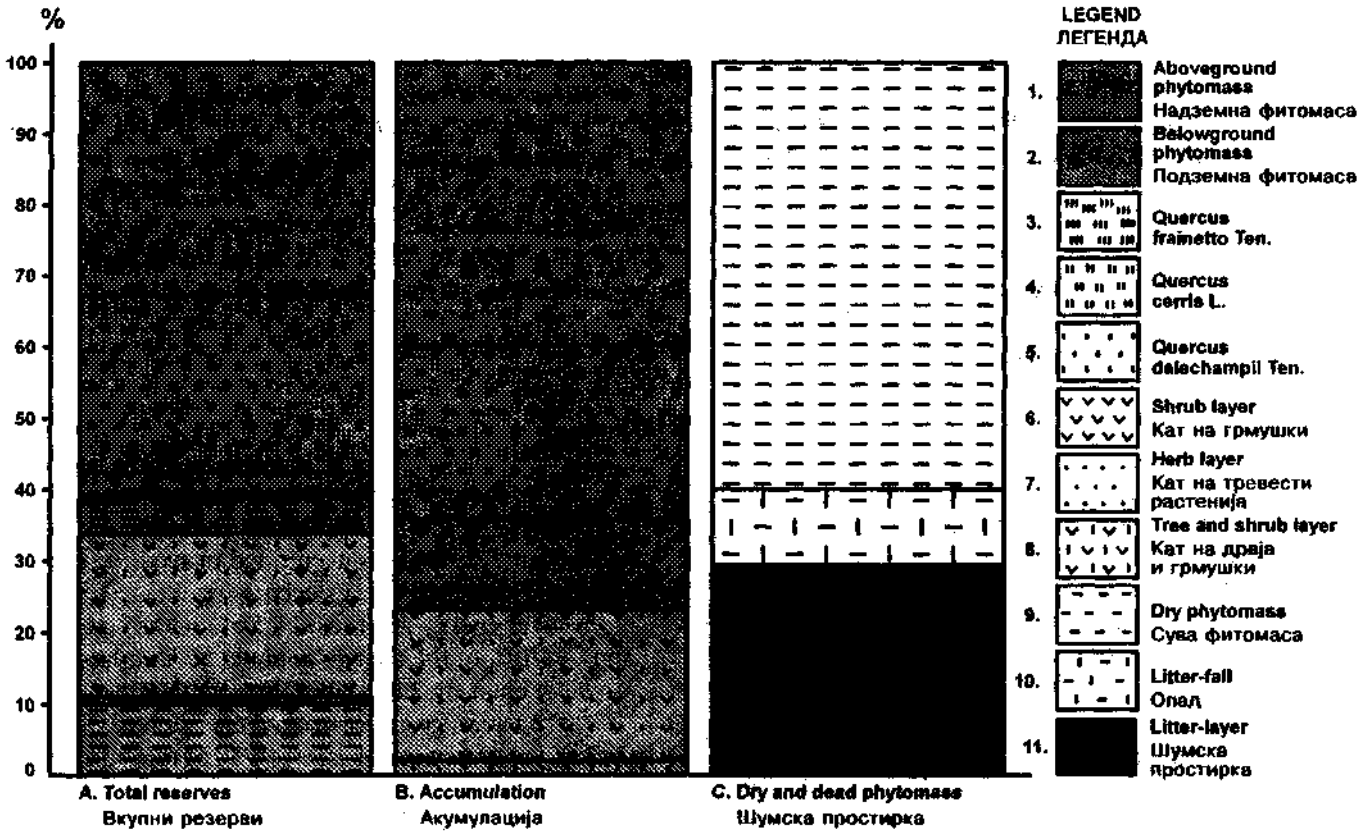

Fig. 1. Distribution of the include energy in the association
Сл. 1. Дистрибуција на вградената енергија во асоцијацијата

Tab. 1. Energetic characterization (KJ • g' , absolutely dry substance) of the aboveground phytomass of the herb species. Average aboveground reserves in the grass layer (10 KJ • ha"^{1}) Таб. 1. Енергетска карактеристика (KJ • g абсолутно сува материја) на надземната фитомаса на видовите од зелјестиот кат и нивни просечни енергетски резерви (10^{8} KJ -ha"^{1})

SPECIES ВИД	KJ·g^{-1}	N accor. to particip. (%)-age N според учес-твото (%)	10^{6} KJ·ha^{-1}	%	N accor. to particip. (%)-age N според учес-твото (%)
1	2	3	4	5	6
GRASS SPECIES - ГРАМИНЕИ	128,533		8,003	71,45	
Poa nemoralis L.	21,085	10	1,232	11,00	2
Poa angustifolia L.	15,538	51	0,118	1,05	18
Festuca heterophylla Lam.	20,850	11	5,167	46,13	1
Dactylis glomerata L.	19,678	21	0,501	4,47	4
Calamagrostis arundinacea (L.)Roth.	17.024	43	0,924	8,25	3
Brachipodium pinnatum (L.)P.B.	20,147	18	0,060	0,54	23
Melica uniflora Retz.	14,211	53	0,001	0,01	53
SEDGES - ЦИПЕРАЦЕИ	72,003		0,473	4,22	
Luzula luzuloides (Lam.)Dandy	18,117	36	0,195	1,74	10
Luzula forsteri (Sm.)D.C.	18,276	34	0,025	0,22	31
Carex muricata L.	18,431	33	0,129	1,15	15
Carex cariophyllea Latourr	17,179	41	0,124	1,11	16
LEGUMES SPEC.-ЛЕГУМИНОЗИ	134,630		0,458	4,09	
Lathyrus laxiflorus (Desf.)O.Kuntze.	18,586	30	0,041	0,37	26
Lathyrus vernus (L.)Bernh.	18,820	29	0,094	0,84	20
Lathyrus niger (L.)Bernh.	19,678	22	0,069	0,62	22
Vicia cassubica L.	20,541	15	0,017	0,15	35
Trifolium medium L.	20,771	13	0,080	0,71	21
Trifolium alpestre L.	19,055	27	0,001	0,01	57
Chamaespartium sagittale (L.)Griseb.	17,179	42	0,156	1,39	13
MIXO-HERBOSA - МЕШАНИ ЗЕЛЈЕСТИ	706,798		2,268	20,25	
Campanula persicifolia L.	14,366	52	0,003	0,03	48
Campanula sparsa Friv.	16,840	44	0,035	0,31	27
Cardamine bulbifera (L.)Grantz.	17,259	40	0,001	0,01	52
Clynopodium vulgare L.	19,599	24	0,167	1,49	12
Cruciata glabra (L.)Ehrend.	15,928	50	0,263	2,35	6
Crocus flavus Westen.	18,586	31	0,010	0,09	42
Euphorbia cyparissias L.	21,863	3	0,005	0,04	46
Fragaria moshata Duchense	20,248	17	0,132	1,18	14
Galium apparine L.	16,241	49	0,123	1,10	17
Galium sylvaticum L.	21,629	5	0,030	0,27	28
Geum urbanum L.	20,850	12	0,112	1,00	19
Geranium sanguineum L.	20,302	16	0,001	0,01	54
Hieracium hoppeanum Shult.	21,708	4	0,009	0,08	43
Hieracium racemosum V.K.	22,022	2	0,048	0,43	25
Hieracium murorum L.	18,088	37	0,028	0,25	29
Hieracium pavichii Heuft.	18,858	28	0,008	0,07	45
Hypericum perforatum L.	16,631	45	0,02	0,18	33
Lactuca quercina L.	19,519	25	0,012	0,11	41
Lapsana communis L.	21,399	6	0,003	0,03	49
Lichnis coronaria (L.)Desr.	16,166	47	0,014	0,12	39
Melampyrum pratense L.	13,044	55	0,015	0,13	38
Muscari botryoides L.	19,682	20	0,001	0,01	55

Tab. 1. (Continuing)
Таб. 1. (Продолжение)

SPECIES ВИД	$KJ \cdot g^{-1}$	N accor. to particip. (%)-age N според учес-твото (%)	$10^6 KJ \cdot ha^{-1}$	%	N accor. to particip. (%)-age N според учес-твото (%)
1	2	3	4	5	6
Melitis melissophylum L.	19,678	23	0,002	0,02	50
Physospermum cornubiense L.	19,837	19	0,204	1,82	9
Potentilla micrantha Ramond ex D.C.	17,648	38	0,022	0,20	32
Silene viridiflora L.	16,476	46	0,027	0,24	30
Silene cucubalus (L.)Wibel.	13,747	54	0,008	0,07	47
Scutellaria altissima L.	18,586	32	0,055	0,49	24
Stellaria holostea L.	16,087	48	0,417	3,72	5
Symphytum tuberosum L.	12,495	56	0,009	0,08	44
Teucrium hamaedrus L.	22,102	1	0,001	0,01	56
Verbascum phoeniceum L.	19,210	26	0,020	0,18	34
Verbascum thapsiforme Schrad.	21,244	7	0,013	0,12	40
Veronica chamaedrys L.	21,244	8	0,242	2,16	7
Veronica officinalis L.	17,522	39	0,176	1,57	11
Veronica hederifolia L.	21,202	9	0,002	0,02	51
Vincetoxicum hirundinaria Medic.	20,696	14	0,015	0,13	38
Viola reinchenbachiana Jord.et Ber.	18,196	35	0,015	0,13	38
SPROUTS - ПОНИЦИ	17,904	38	0,071	2,12	8
TOTAL FOR HERB SPECIES ВКУПНО ЗЕЛЈЕСТИ РАСТЕНИЈА	1041,964	56	11,202	100,01	56

Tab. 2. Average reserves and annual accumulation of the energy (10^6 KJ • ha^{-1}) in the bush storey
Таб. 2. Просечни резерви и годишна акумулација на енергија во катот на грмушките (10 KJ • ha)

KIND OF PHYTOMASS ТИП НА ФИТОМАСА	RESERVES РЕЗЕРВИ $KJ \cdot ha^{-1}$	%	ANNUAL ACCUMULATION ГОДИШНА АКУМУЛАЦИЈА $KJ \cdot ha^{-1}$	%
1	2	3	4	5
SEEDLING - ДАБОВ ПОДРАСТОК	2,486	77,29	0,899	80,85
Branches - гранчиња	1,754	55.09	0,192	17,27
Leaves - листови	0,707	22,20	0,707	63,58
BRUSHWOOD - ГРМУШКИ	0,723	22,70	0,213	19,16
Branches - гранчиња	0,414	13,00	0,033	2,97
Leaves - листови	0,180	5,65	0,180	16,19
DRY PHYTOMASS - СУВА ФИТОМАСА	0.129	4,05	/	/
TOTAL - ВКУПНО	3.184	99,99	1,112	100,00

Tab. 3. Energetic structure of the herb layer species
Таб. 3. Енергетска структура на видовкте од катот на зелјестите растенија

ENERGETIC CLASS ЕНЕРГЕТСКА КЛАСА (10^6 $KJ \cdot ha^{-1}$)	SPECIES ВИД number/број	%	AVERAGE ENERGETIC RESERVES ПРОСЕЧНИ ЕНЕРГЕТСКИ РЕЗЕРВИ 10^6 $KJ \cdot ha^{-1}$	%
1	2	3	4	5
> 1	2	3,57	6,399	57,13
1 - 0,5	2	3,57	1,425	12,72
0,5 - 0,1	14	25,00	2,558	22,83
0,1 - 0,05	5	8,93	0,358	3,20
0,05 - 0,01	18	32,14	0,407	3,63
< 0.01	15	26,79	0,055	0,50
TOTAL - ВКУПНО	56	100,00	11,202	100,00

РЕЗЕРВИ НА ЕНЕРГИЈАВОНАДЗЕМНАТАФИТОМАСАИГОДИШНА АКУМУЛАЦИЈА НА ЕНЕРГИЈАТАВОКАТОТНА ГРМУШКИТЕ И ЗЕЛЈЕСТИТЕ РАСТЕНИЈА ВО *ACC.QUERCUS FRAINETTO+QUERCUS CERRIS - FESTUCA HETEROPHYLA+POA NEMORAUS* ВО ВАКАРЕЛСКИТЕ ПЛАНИНИ

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Р е з и м е

Енергетскиот еквивалент во листовите и гранките од грмушестиот кат (19,63 и 19,89 -10 KJ • ha' респективно) и од дабовиот подраст ок (19,11 '10 KJ ha" и 17,58-10 KJ-Jга^епонизокотколкуистиот во катот на дрвјата (21,61 • 10^6 KJ • ha" и 21,09 • 10^6 KJ * ha"^{1}). Листовите од *Quercus cerris* се карактеризи-раат со највисока калорична вредност.

Просечната калорична вредност на надземната фитомаса кај зелјестите растенија (18,61 • 10^6 KJ • ha"^{1}) е повисока отколку таа определена за подземната фитомаса (15,40 -10 KJ • ha"). Фитомасата на легуминознитевидовисекарактеризирасонајвисокакалоричнавредност (19,23 • 10^6KJ 'ha"^{1}) додекатаа од дабовиот подраст ок - со најниска (18,01 • 106 KJ • ha").

Просечните енергетски резерви на надземната фитомаса во катот на грмушките изнесуваат 3,15 • 10^6 KJ • ha"^{1}. Најголемиот дел од тоа (77,29%) е концентриран во фитомасата на дабовиот подраст ок. Го-дишната акумулација на енергија во овој кат изнесува 34,95% од неговите енергетски резерви. 27,86% од резервите на енергија и 79,70% од годишно акумулираната енергија во овој кат доаѓа во шумската прос-тирка преку опадот.

Просечните енергетски резерви на надземната фитомаса во катот на зелјестите растенија изнесува 15,34 ■ 10^6 KJ • ha"^{1}. Од тоа граминеите заземаат 71,46%, другите тревести видови - 20,31%, циперацеите -4,21% и легуминозите - 4,09%. Видовите кои вв енергетските резерви на тревестиот кат заземаат 1 или повеќе од 1% прават 81,63% од вкупните резерви енергија во тој кат.