STUDY OF THE HEAT BALANCE OF THE FOREST

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REPORT GIVEN IN THE MEETING OF THE SOCIETY OF FORESTRY IN FINLAND, 5 APRIL, 1962

HELSINKI 1963

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Methods for studying heat and water balance of the system: underlying surface — lower layer of the atmosphere have so far been worked out for flat and open terrains and it is for such conditions that observations have been accumulated.

However, the earth's surface is for the most part rough and vast areas are rather rugged. Still vaster areas are occupied by forests; in the U.S.S.R., for instance, they cover more than one third of the whole territory.

The forest changes essentially the medium in which it develops. This results not only in forming up of a climate with specific features within a large forest but also in a noticeable influence on the climate of adjacent areas. Therefore our concepts of the heat balance of the earth's surface and of the energy regime of various geographical zones will remain incomplete until reliable data on the heat balance of woodlands are made available.

Systematic heat-balance observations were started by my co-workers and I in July 1957 in accordance with the I.G.Y. program. The observation site is the I.G.Y. network station Zagorsk (north of Moscow) situated in the region of the Uglich-Dmitrov chine. The forest is mixed, with crown height of 10—17 m, crown density of 0.85, and bonitet of 3.

A gradient tower 35 m high (which equals the double height of trees) was erected in the forest. Special care was taken to leave the natural conditions intact. Actinometric and gradient observations have been carried out also in the vicinity of the tower in 3 points under tree crowns (thick and rare underbrush and coniferous forest).

For heat balance observations distant-recording sensitive elements on semiconductors, were used and the actinometric instruments were of self-recording type. Direct readings were simultaneously registrated in control series. Periodic control series of psychrometric observations over the forest were carried out with the help of conventional Assman psychrometers, the readings being taken through optical instruments.

All the instruments on the tower are controlled from a special board in a laboratory built at a distance of 30 m from the tower. The self-recording equipment of actinometric sensors is also mounted here.

Each of observation series is repeated 3 to 5 times.

Simultaneously complete heat balance observations (up to H = 12.5 m) have been conducted in a glade at a distance of about 0.5 km. In the same area the Research Institute of Cryology has carried out detailed investigations of heat exchange in the soil.

The surface run-off was measured in the forest near the tower, in glades and in the adjacent open fields.

The arrangement of instruments in height and in relation to tree crowns is shown in Fig. 1.

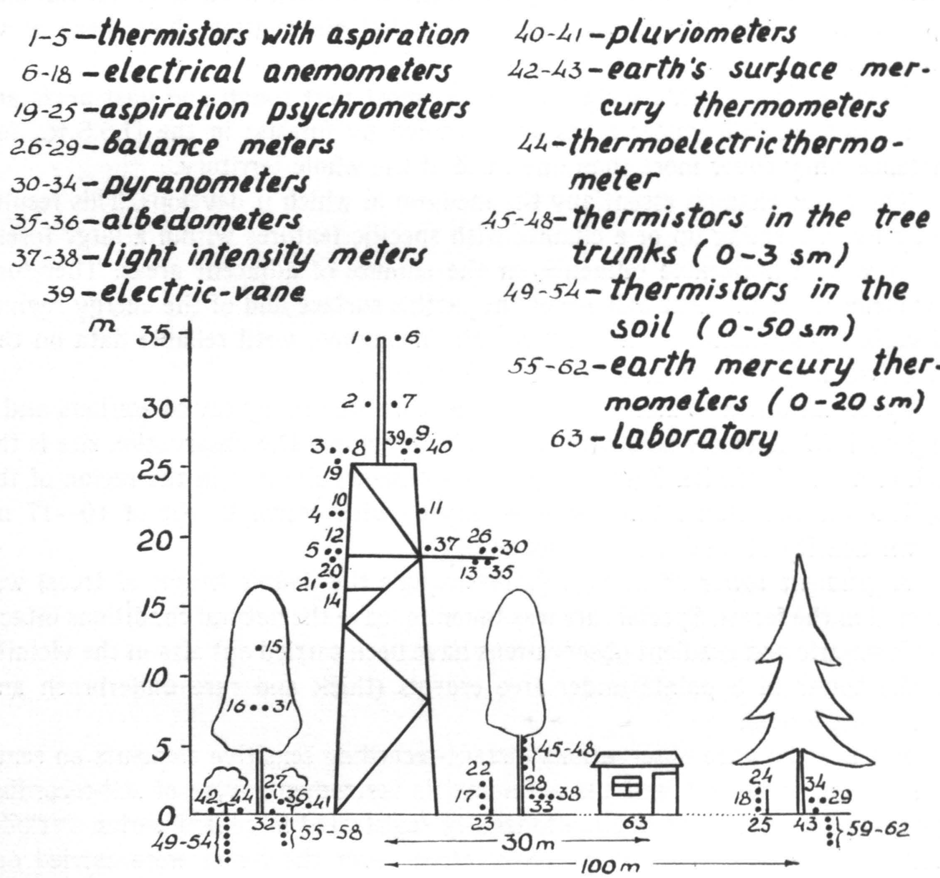

Fig. 1. Arrangement of instruments on the forest heat-balance measuring station.

Turbulent heat and moisture exchange between the forest and the atmosphere may be computed by the heat balance method and by the so called »turbulent diffusion» method. The advantage of the heat balance method consists in the fact that it eliminates the necessity of a preliminary estimate of roughness length Z_0 and of displacement layer d which often presents certain difficulties. The defect of this method is that it is necessary to know the profile of specific (absolute) humidity. In the forest and above it continuous long observations of such kind can be effected only with the help of distant-measuring instruments but they are not sufficiently reliable in measuring humidity. Therefore, it is more convenient to calculate turbulent heat exchange through turbulent diffusion and to determine moisture exchange from the equation of heat balance as the residual difference.

Analysis of a great number of observations of the wind profile shows that the value of the forest roughness Z_0 is approximately 2.0 m^s. The order of magnitude of $\frac{Z_0}{H}$ ratio was found to be approximately 0.1 which is also characteristic of other kinds of vegetation cover.

The average height of displacement layer is $d \approx 7.0$ m; the $\frac{d}{H}$ ratio is approximately 0.45, that is, it about equals the half height of trees. No clear dependance of Z_0 on wind velocity has been found. It is better expressed with respect to the layer of displacement: with the increase of wind velocity the value of d decreases noticeably.

A priori it was to be expected that the value of Z_0 changes in the periods immediately before the development and after the falling-off of leaves. In fact, an increase of Z_0 did take place in the latter case but it was less conspicuous than expected.

The value of turbulent heat exchange P between the forest and the atmosphere and loss of heat on total evaporation from the forest surface LE was computed by the formulas:

$$P = a \, \Delta \, T U_1 \left(1 + \frac{d \, \Delta \, T}{U_1^2}\right) \quad \text{cal/cm}^2\text{/min} \tag{1}$$

$$LE = a_1 \, \Delta \, e U_1 \left(1 + \frac{a_1 \, \Delta \, T}{U_1^2}\right) \quad \text{cal/cm}^2\text{/min} \tag{2}$$

where $a = \dfrac{\varkappa^2 \varrho C_P}{\ln \frac{Z'_2}{Z'_3} \cdot \ln \frac{Z'_1}{Z_0}} = 0.132$

$\varkappa$ — Kármán constant (= 0.38)
ϱ — air density (12.93·10-4 g/cm3)
C_P — specific heat capacity of air (0.24 cal/g/degree)

$$d_1 = \frac{\varkappa^2 L \varrho \cdot 0.623}{P \ln \frac{Z'_2}{Z'_3} \cdot \ln \frac{Z'_1}{Z_0}} = 0.270$$

where L — latent heat of vaporization of water (600 cal/g),
$P = 1000$ mb; $Z' = Z\text{-}d$

Indices 1, 2, 3 denote respectively the levels of 22.5, 16.5, and 32.0 m.
$\Delta T = T_2 - T_3$; $\Delta e = e_2 - e_3$ — temperature and absolute humidity differences between the levels;
U_1 — wind velocity at h = 22.5 m.

$$a = \frac{\ln \left(\frac{Z'_1}{Z_0}\right)^2}{\ln \frac{Z'_2}{Z'_3}} = 4.3 \; /a_1 = 5.3/$$

The turbulence coefficient value which enters implicitly l (1) and (2) is related to the middle of the layer for which ΔT and Δe were calculated, that is, to the level of wind velocity determination.

On the basis of data relating to the distribution of air humidity over the forest, the heat loss for total evaporation from the forest surface (LE_1) was calculated with the help of heat balance method; the analogous value (LE_2) was computed by the heat balance equation as the residual difference. Comparison has shown that LE_2 exceeds slightly LE_1. Average relative error in determination of LE_2 in relation to LE_1 is about 25 %. This is a satisfactory result for forest observations.

In a well developed forest the heat exchange in the active layer (B_Σ) is formed up by two components: heat exchange in the upper soil horizon B_S and the change of heat content in the biomass B_b, the biomass being determined as the mass of wood on a given area. The value of B_S can be conveniently calculated by Tseitin's formula (1953). The heat exchange of the biomass can be estimated from a simplified formula in which it is determined through the change of heat content of the biomass layer.

Assuming that the difference between the temperature of the biomass surface layer and that of the air in the crowns is not great, it is possible to use for calculations the latter value. More reliable results are obtained by direct temperature

Table 1. Diurnal trend of heat balance components (cal/cm²/min) of deciduous (mixed) forest.

Series	Components \ Hours	5	7	9	11	13	15	17	19	21	23	01
I	R	0.04	0.29	0.60	0.89	0.90	0.65	0.33	−0.02	−0,06	—	—
	P	0.00	0.07	0.17	0.25	0.24	0.18	0.11	−0.01	−0.00	—	—
	LE	0.06	0.18	0.36	0.57	0.63	0.48	0.26	0.04	0.00	—	—
	$B\Sigma$	−0.02	0.04	0.07	0.07	0.03	−0.01	−0.04	−0.05	−0.06	—	—
II	R	0.05	0.25	0.47	0.88	0.92	0.53	0.20	−0.05	−0.06	−0.05	−0.04
	P	−0.01	0.08	0.15	0.21	0.23	0.16	0.04	0.00	−0.01	−0.02	−0.01
	LE	0.05	0.10	0.23	0.60	0.66	0.42	0.20	0.01	0.00	0.00	−0.00
	$B\Sigma$	0.01	0.07	0.09	0.07	0.03	0.00	−0.06	−0.06	−0.05	−0.03	−0.03
III	R	−0.07	0.15	0.40	0.62	0.66	0.41	0.17	−0.10	−0.08	−0.08	—
	P	−0.06	0.05	0.18	0.29	0.29	0.16	+0.04	−0.06	−0.04	−0.04	—
	LE	0.01	0.08	0.17	0.38	0.34	0.25	0.17	0.01	−0.00	−0.01	—
	$B\Sigma$	−0.02	0.02	0.05	0.05	0.03	0.00	0.04	−0.05	−0.04	−0.03	—
IV	R	−0.02	0.00	0.23	0.38	0.36	0.09	−0.02	−0.03	−0.06	−0.02	—
	P	−0.01	0.00	0.09	0.19	0.25	0.06	−0.02	0.00	−0.03	−0.02	—
	LE	−0.00	−0.00	0.08	0.12	0.08	0.05	−0.02	0.00	−0.01	0.00	—
	$B\Sigma$	−0.01	0.00	0.06	0.07	0.03	0.02	−0.02	−0.03	−0.02	0.00	—

NOTE: The numerical values of LE (cal/cm²/min) are equivalent to the intensity of evaporation E (mm/hr.).

measurements in a conditional layer of the biomass heat exchange h, whose thickness is determined approximately by dividing the mean volume of biomass by the area of its growing (in our case $h \approx 2.5$ cm).

Temperature in this layer was measured by a thermistor driven into the trunk of a tree up to the middle of the layer (1.5 cm).

Comparison of the results obtained by these two methods has shown that the values of heat exchange in the forest stand determined by the former method are twice as great as those determined by the latter one. Its absolute value can not exceed ± 0.05 cal/cm²/min.

To bring out the main features of the seasonal trends of the heat balance components the data for the following periods were compared: a) beginning of vegetation on all the stories; b) midsummer; c) beginning of leaf-falling; d) period after complete defoliation and end of vegetation. For analyzing there were chosen 19 days with undisturbed conditions of diurnal trends of insolation, that is, with practically maximum possible values of radiation balance. The results of the analysis are shown in Table 1.

During the entire warm season there exists a well pronounced turbulent heat flow over the forest. Even at the beginning of vegetation, when the moisture content in the soil is great and transpiration capacity of forest is at a maximum, the value of P in the daytime constitutes a considerable part of the total evapotranspiration. Later on, the ratio $\frac{P}{LE}$ increases constantly and after the end of vegetation P exceeds considerably LE. The decrease of LE is connected not only with the complete cessation of transpiration but also with the decrease in evaporation from the surface of the soil covered with fallen leaves. The maximum values of LE near the noon are practically the same in the initial period of vegetation and in midsummer (0.57—0.66 cal/cm²/min), by the end of vegetation period they decrease almost by the factor of two (0.34—0.35 cal/cm²/min), and there is a still steeper decrease after defoliation (0.8—0.12 cal/cm²/min). The diurnal sums of evaporation within the same period change almost by the factor of 10.

The diurnal values of radiation balance on the upper surface of the forest and on the grass cover of a glade are very close (0.29 and 0.24 L. Cal/cm²). However, the heat balance structure for these different surfaces under different weather conditions varies (Fig. 2). The ratio $\frac{P}{LE}$ for a clover field on a glade changed but little after precipitation; the value of LE still constituted here the main used part of the heat balance and did not exceed the value of residual radiation. The value of P above the forest was considerable before the rainfall; after the rain the diurnal average P was found to be directed to the forest surface and the value of LE considerably exceeded R.

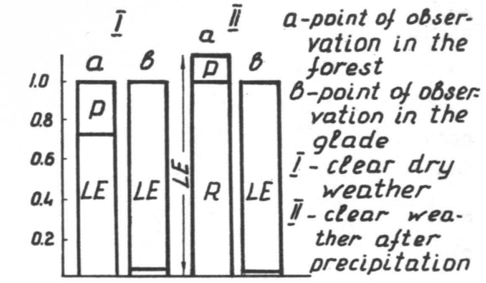

Fig. 2. Structure of heat balance of the forest and of a glade.

The heat balance method allows to determine more reliably the value of the transpiration proper of the forest stand E_T, which is equal to the difference between the total evapotranspiration of the forest E and evaporation under its canopy E_S. The value of E_S is determined as the residual difference from the equation of the heat balance under the forest canopy. Radiation balance in this equation (R_S) is found by direct measurement in several points. For the determination of the turbulent heat exchange under the forest canopy (P_S) a formula obtained from the equation of turbulent diffusion was employed.

To determine the proportionality factor for this formula the heat balance method is used for cases when $R_S - B_S > 0.10$ cal/cm²/min, that is, when the relative errors are comparatively small.

In Fig. 3 is shown, by way of illustration, the calculation of heat balance components under the forest canopy for 12 days with undisturbed diurnal trend of insolation. The almost strict inverse development of the curves P_S and B_S is evident; in case of a positive radiation balance practically the entire turbulent heat influx from the air was spent on the heat exchange in the soil. Thus, the diurnal variations of the evaporation values must almost completely coincide with the variations of the radiation balance (Fig. 3). The diurnal trends of

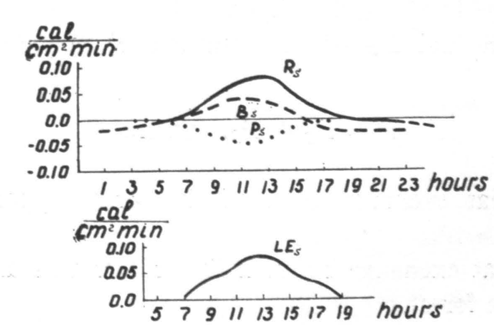

Fig. 3. Diurnal trend of heat balance components under the forest canopy.

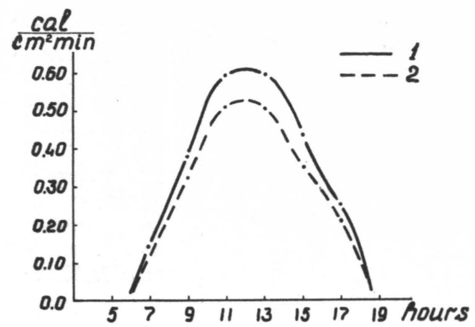

Fig. 4. Diurnal trend of total evapotranspiration (1) and of forest transpiration (2).

transpiration and of total evaporation of the forest are compared in Fig. 4. The parallel development of both curves with maximums at about noon time may be noted. Within the same period of time the maximum difference between these two curves is observed.

To calculate the components of forest heat balance in winter, we carried out a complete cycle of observations in March—May, 1960. These months were chosen because daytime radiation in this period increases, but snow is not yet melting. The snow cover was 60—70 cm deep.

The heat balance of the active layer of deciduous forest in winter was computed by the formula:

$$R = P + LE_\Sigma + B_\Sigma \text{ cal/cm}^2\text{/min} \qquad (3)$$

where:

R — radiation balance over the crown;
P — turbulent exchange between the forest and the atmosphere;
E_Σ — total evaporation of the forest;
h — latent heat of vaporization;
B_Σ — heat exchange in the active layer.

Components P, E and B_Σ of the equation (1) may be described by the following formulas.

$$P = P_c + P_s, \quad \text{where}$$

P_c — turbulent heat exchange between the forest upper surface and the atmosphere;
P_s — turbulent heat exchange between the tree crowns and the snow cover surface in the forest.

$$E_\Sigma = E_T + E_c + E_s \quad \text{, where}$$

E_T — transpiration of the trees;
E_c — evaporation of the snow clinging to the crowns;
E_s — evaporation from the snow cover surface in the forest.

As in the course of observations there was no snow in the tree crowns and transpiration of trees at low temperatures is of a negligible value, it is safe enough to presume E_Σ to be equal to E_s. A good enough agreement of the results of heat balance components calculation from the equation (3) and by method of diffusion, has confirmed the validity of such simplification.

B_Σ — may be described by the equation

$$B_\Sigma = B_b + B_s \quad \text{, where}$$

B_b — accumulation of heat in the mass of trees;
B_s — heat exchange in the snow cover.

P_s and LE_s (the values of heat and moisture exchange under the forest canopy) may be computed by heat balance method with the use of exchange coefficient D_c:

$$D_c = \frac{R_c - B_c}{0.019/T_0 - T/ + 0.033/e_0 - e/} \text{ cm/sec} \qquad (4)$$

$$P_s = 0.019\, D_c/T_0 - T/ \text{ cal/cm}^2\text{/min}$$
$$LE_s = 0.033\, D_c/e_0 - e/ \text{ cal/cm}^2\text{/min.}$$

R_s — radiation balance under the forest canopy near the snow surface which is equal to the average value of readings of two balance-meters installed in stands of different density;

T_0 and e_0 (mb) — temperature and absolute humidity which is equal to the maximum vapor pressure on the surface of snow cover; T and e — temperature and absolute humidity at the height of 2.0 m. The heat accumulation in the mass of trees was calculated in accordance with the change of average temperature of layer h, its thickness being obtained by dividing the wood mass by the forest area.

B_s — heat exchange in the snow — was computed by G. H. Tseitin's formula (1956):

$$B_s = \frac{c\varrho_1 H}{60\,\tau}\left[\alpha(\tau) + \frac{2K\tau}{H^2}\beta(\tau)\right] \text{ cal/cm}^2\text{/min} \qquad (5)$$

where $\alpha(\tau)$ and $\beta(\tau)$ — certain integral functions of temperature field of the snow cover, connected with the temperature changes in time and within different layers of the snow cover;

$C\varrho_1$ — volumetric thermal capacity of snow (cal/cm³);
C — specific thermal capacity of snow ($C = 0.5$ cal/g);
ϱ_1 — average density of a layer having thickness H, with well pronounced diurnal temperature variations ($H = 30$—40 cm);
K — temperature conductivity coefficient for snow cover, taken as an average for the layer H (cm²/h);
τ — period of time ($\tau = 1$ hour).

The observations of A. V. Pavlov and Y. L. Rauner (1960) have shown that for snow cover 30—50 cm thick the value of B_S in daytime may be obtained from a simplified formula:

$$B_S = \frac{C\varrho H}{60\,\tau}\, a(\tau) \quad \text{cal/cm}^2\text{/min} \qquad (6)$$

The values of B_S for night hours were determined by interpolation (average values of B_S did not exceed 0.01 cal/cm²/min). The value of LE for the same night hours was assumed to be zero.

The values of turbulent exchange P were calculated by the diffusion method and by the equation (3) as a residual difference. For the determination of P by the turbulent diffusion method the values of Z_0 and d for winter conditions were found. These values were found to be 3.0 m and 7.0 m respectively. There was revealed also a noticeable change (increase) of Z_0 within the forest. (Fig. 5).

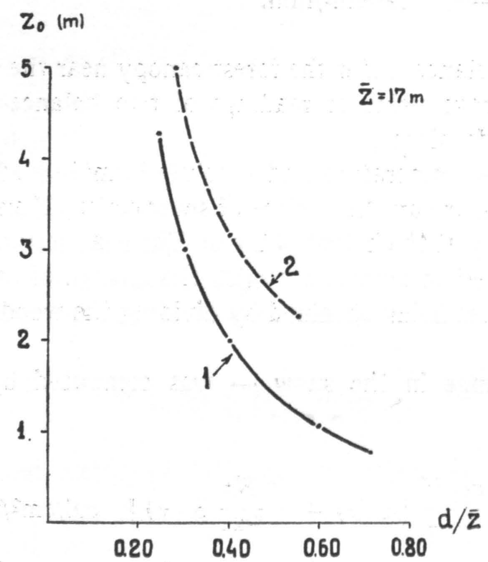

Fig. 5. Change of roughness length within a deciduous forest with foliage (1) and without it (2). $\bar{Z}$ is the hight of trees.

The results of observations and the calculations made on their basis are shown in Tables 2—5, taken from the report by Y. L. Rauner (1961). For the sake of comparison in Table 4 are presented the values of heat balance components in a deciduous forest and in a large glade. (See also Fig. 6).

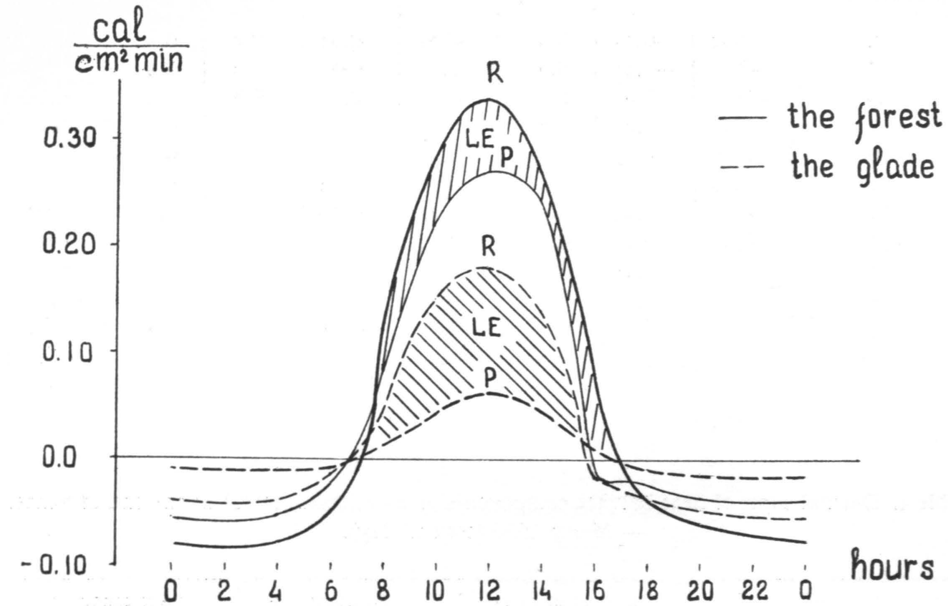

Fig. 6. Diurnal trend of heat balance components of a deciduous forest and of an open terrain with snow cover.

Table 2. Heat balance components (cal/cm²/min) of a deciduous forest at the end of winter — March 1960.

Hours	Partly cloudy sky					Overcast				
	R	P	$LE\Sigma$	$B\Sigma$	B_b	R	P	$LE\Sigma$	$B\Sigma$	B_b
0	—0.13	—0.11	—0.0	—0.02	—0.01	—0.03	—0.02	0.0	—0.01	—0.01
4	—0.13	—0.11	0.0	—0.02	—0.01	—0.03	—0.02	0.0	—0.01	0.0
6	—0.08	—0.07	0.0	—0.01	0.0	—0.02	—0.02	0.0	0.0	0.0
8	0.17	0.11	0.02	0.04	0.02	0.06	0.04	0.0	0.02	0.01
10	0.40	0.32	0.02	0.06	0.03	0.17	0.14	0.01	0.02	0.01
11	0.44	0.36	0.03	0.05	0.02	0.18	0.15	0.01	0.02	0.01
12	0.47	0.39	0.04	0.04	0.02	0.20	0.16	0.02	0.02	0.01
13	0.43	0.37	0.03	0.03	0.01	0.19	0.16	0.02	0.01	0.01
14	0.39	0.35	0.02	0.02	0.01	0.18	0.16	0.01	0.01	0.01
16	0.11	0.11	0.00	0.0	0.0	0.05	0.06	0.0	—0.01	0.0
18	—0.07	—0.04	0.0	—0.08	—0.01	—0.02	0.0	0.0	—0.02	—0.01
20	—0.09	—0.06	0.0	—0.03	—0.01	—0.02	—0.01	0.0	—0.01	—0.01

Table 3. Heat balance components (cal/cm²/min) under the canopy of a deciduous forest at the end of winter — March 1960.

Hours	Fractional cloudiness				Overcast			
	R_s	P_s	LE_s	B_s	R_s	P_s	LE_s	B_s
0	—0.02	—0.01	0.0	—0.01	—0.01	—0.01	0.0	0.0
4	—0.02	—0.01	0.0	—0.01	0.0	0.0	0.0	0.0
6	—0.02	—0.01	0.0	—0.01	0.0	0.0	0.0	0.0
8	0.00	—0.02	0.0	0.02	0.0	—0.01	0.0	0.01
10	0.06	0.01	0.02	0.03	0.02	0.0	0.01	0.01
11	0.08	0.02	0.04	0.02	0.02	0.0	0.01	0.01
12	0.09	0.03	0.04	0.02	0.03	0.01	0.01	0.01
13	0.06	0.02	0.03	0.01	0.03	0.01	0.02	0.0
14	0.04	0.01	0.02	0.01	0.03	0.01	0.02	0.0
16	—0.01	—0.01	0.0	0.0	—0.00	0.01	0.0	—0.01
18	—0.02	0.0	0.0	—0.02	—0.01	0.0	0.0	—0.01
20	—0.02	0.0	0.0	0.0	—0.01	0.0	0.0	—0.01

Table 4. Diurnal sums of heat balance components of a deciduous forest at the end of winter — March 1960 (cal/cm²/day).

Heat balance components		Partly cloudy sky			Overcast			Average conditions		
		+	—	Σ	+	—	Σ	+	—	Σ
For the entire active layer of the forest	R	188	94	94	79	27	52	133	60	73
	P	148	65	83	65	13	52	106	39	65
	LE_Σ	15	0	15	5	0	5	10	0	10
	B_Σ	17	21	—4	7	12	—5	12	15	—3
	B_b	7	9	—2	4	4	0	6	7	—1
Under the canopy on the snow surface	R_s	25	19	6	9	5	4	17	12	5
	P_s	6	8	—2	3	3	0	4	6	2
	B_s	7	12	—5	2	2	0	4	7	—3

Table 5. Diurnal trend (cal/cm²/min) and diurnal sums (cal/cm²/day) of heat balance components of a deciduous forest (1) and of an open terrain with snow cover (2).

Components	Hours												Days
	0	4	6	8	10	11	12	13	14	16	18	20	
R_I	—0.08	—0.08	—0.05	0.12	0.28	0.31	0.34	0.31	0.28	0.08	—0.04	—0.06	73
R_{II}	—0.03	—0.04	—0.04	0.04	0.15	0.16	0.18	0.16	0.14	—0.02	—0.04	—0.05	29
ΔR_{I-II}	—0.05	—0.04	—0.01	0.08	0.13	0.15	0.16	0.15	0.14	0.06	0.0	—0.01	44
P_I	—0.06	—0.06	—0.05	0.08	0.22	0.25	0.27	0.27	0.24	—0.02	—0.02	—0.04	65
P_{II}	—0.01	—0.02	—0.01	—0.01	0.04	0.05	0.06	0.05	0.04	0.01	—0.02	—0.02	1
ΔP_{I-II}	—0.05	—0.04	—0.04	—0.09	0.18	0.20	0.22	0.22	0.20	0.07	0.0	—0.02	64
LE_I	—0.0	0.0	0.0	0.01	0.02	0.02	0.03	0.02	0.02	0.0	0.0	0.0	10
LE_{II}	—0.0	0.0	0.0	0.03	0.07	0.08	0.09	0.08	0.08	0.02	0.01	0.0	34
ΔLE_{I-II}	—0.0	0.0	0.0	—0.02	0.05	0.06	0.06	0.06	0.06	0.02	0.01	0.0	24
B_I	—0.02	—0.02	0.0	0.03	0.04	0.04	0.03	0.02	0.02	0.0	—0.02	—0.02	—3
B_{II}	—0.02	—0.02	—0.01	—0.02	0.04	0.04	0.03	0.02	—0.01	—0.03	—0.03	—0.03	—6
ΔB_{I-II}	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.03	0.03	0.01	0.01	3

Summary

The diurnal trend of heat balance components of the entire active layer is well pronounced in winter. The same tendency is observed under the forest canopy.

When the sky is overcast the values of heat flows over the forest decrease almost by the factor of 2.

During the last winter months the maximum amount of heat is used for turbulent heat exchange with the atmosphere *(P)*. (The maximum value — 0.32—0.39 cal/cm²/min — is observed in daytime. At night the value of P is close to the value of effective radiation (0.10—0.11 cal/cm²/min).

The loss of heat on evaporation (LE_{Σ}) does not exceed 0.05 cal/cm²/min, which is less than the values of the total heat exchange.

The loss of heat on evaporation E_S under the forest canopy is greater than the value of turbulent heat exchange P_S. Incidentally, the absolute values in both cases are very small.

As the temperature of snow surface in daytime is higher than that of the air, the turbulent exchange during daytime is directed into the atmosphere.

Maximum values of heat flux through the snow surface B_S are observed before noon (up to 0.03 cal/cm²/min). At the same time the accumulation of heat in the mass of trees takes place. In the evening these values do not exceed 0.02 cal/cm²/min.

If taken as an average for a day, the radiation balance *(R)* is positive, the turbulent heat exchange *(P)* is close to the radiation balance *(R)*, the loss of heat on evaporation (LE_{Σ}) constitutes but 10—15 per cent of R. When the sky is partly cloudy, the value of evaporation for a day reaches 0.23 mm. The heat exchange in the active layer (B_{Σ}) is negative.

Comparing the heat balance components in the forest and on an open glade, let us note that the radiation balance R in daytime for the forest is twice as great as that for a glade. This is caused, mainly, by the difference in albedo for these two areas: the albedo of the forest is 0.25—0.35 and that of a snow-covered open glade 0.70—0.80. The fact that the difference between the radiation balance values is less than the difference between the albedos of these two areas may be explained by the influence of higher temperatures in the forest and, consequently, by greater values of effective radiation.

The value of P over the forest in daytime was found to be four to five times greater than that over an open glade.

Average diurnal value of heat loss on evaporation (LE_{Σ}) in the forest constitutes less than 30 per cent of the respective value for a glade.

Taken on an average for a day, the heat loss of the forest is twice as little as the heat loss of an open glade, the phenomenon being caused by the screening action of trees.

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